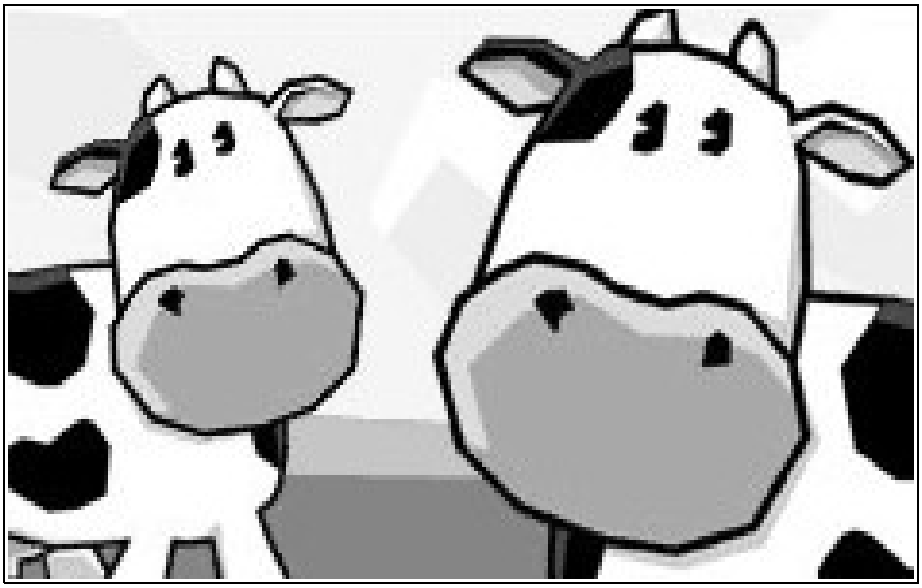
Biology Questions and Answers

1800+ Biology Questions

written and organized in a logical way

to make the learning of basic Biology easier



Biology Questions and Answers

Biology Questions and Answers

Foreword

This is the simplest and the most useful Biology book ever made.

Your brain doesn't need complex stuff to learn basic Biology. It needs logic, organized and well-written content. You don't need a sophisticated book to study Biology. You need pure information.

We haven't even put any illustration in the ebook. You can easily find all the related drawings and pictures on the internet. Your brain learns better if you try to create abstract images in your mind instead of looking passively to given illustrations.

By studying this ebook you will get a complete overview of all main Biology subjects. You can read this ebook at school, at home and everywhere you think that is suitable (even in the park or at the beach).

Think of every question as a brick of knowledge you are cementing to build your Biology culture. And indeed these questions and answers were written to build your biological knowledge step-by-step.

If you are a teacher, you can use this book as a study guide for your students and also to evaluate their learning.

You are free to print one copy of this ebook and turn it into a paper book for your own use. Whenever another copy is needed, please, refer who needs a copy to our website www.biology-questions-and-answers.com for downloading it from there; the download is very cheap and keeps the entire process legal.

We are very proud of offering this educational resource to you!

The Biology Questions and Answers team

Disclaimer

Although the information contained within the ebook is periodically revised and updated, no guarantee is given that the information provided here is entirely correct, complete, and/or up-to-date. The texts contained on this ebook are provided for general information purposes only and do not constitute legal or other professional advice on any subject matter. This ebook and its contents are provided "AS IS" without warranty of any kind.

Biology Questions and Answers

Biology Questions and Answers

Table of Contents

Biology Questions and Answers

Biology Questions and Answers

Biology Questions and Answers

Biochemistry

Biology Questions and Answers

Biology Questions and Answers

Biochemistry Introduction

1. What are the chemical elements that form most of living biological matter?

The chemical elements that form most of the molecules of living beings are oxygen (O), carbon (C), hydrogen (H) and nitrogen (N).

2. Living beings are made of organic and inorganic substances. According to the complexity of their molecules how can each of those substances be classified?

Inorganic substances, like water, mineral salts, molecular oxygen and carbon dioxide, are small molecules made of few atoms. Organic substances, in general, like glucose, fatty acids and proteins, are much more complex molecules made of sequences of carbons bound in carbon chains. The capacity of carbon to form chains is one of the main chemical facts that permitted the emergence of life on the planet.

3. What are the most important inorganic molecular substances for living beings?

The most important inorganic substances for living beings are water, mineral salts, carbon dioxide and molecular oxygen. (There are several other inorganic substances without which cells would die.)

4. What are mineral salts? Where in living beings can mineral salts be found?

Mineral salts are simple inorganic substances made of metallic chemical elements, like iron, sodium, potassium, calcium and magnesium, or of non-metallic elements, like chlorine and phosphorus.

They can be found in non-solubilized form, as part of structures of the organism, like the calcium in bones. They can also be found solubilized in water, as ions: for example, the sodium and potassium cations within cells.

5. What are the most important organic molecules for living beings?

There are many types of organic molecules that are important for the living beings. Especially important are amino acids and proteins, carbohydrates (including glucose), lipids and nucleic acids (DNA and RNA).

Biochemistry Introduction Review - Image Diversity: amino acid molecule protein molecule carbohydrate molecule lipid molecule nucleic acid molecule

Biology Questions and Answers

6. What are the main functions of the organic molecules for living beings?

Organic molecules, like proteins, lipids and carbohydrates, perform several functions for living organisms. Noteworthy functions are the structural function (as part of the material that constitutes, delimits and maintains organs, membranes, cell organelles, etc.), the energetic function (chemical reactions of the energetic metabolism), the control and informative function (genetic code control, inter and intracellular signaling, endocrine integration) and the enzymatic function of proteins (facilitation of chemical reactions).

7. What are some examples of the structural function of organic molecules?

Organic molecules have a structural function as they are part of cell membranes, cytoskeleton, organ walls and blood vessel walls, bones, cartilages and, in plants, of the conductive and support tissues.

8. What are some examples of the energetic function of organic molecules?

Since they are complex molecules, presenting many chemical bonds, organic molecules store large amount of energy. Glucose, for example, is the main energy source for the formation of ATP (adenosine triphosphate), a molecule that is necessary in several metabolic reactions. ATP is an organic molecule too and is itself the energy source for many biochemical reactions. Fat, proteins and some types of organic polymers, like starch and glycogen, that are polymers of glucose, are energy reservoirs for the organism.

9. What are some examples of the control and informative function of organic molecules?

Based on genetic information, organic molecules control the entire work of the cell. The nucleic acids, DNA and RNA, are organic molecules that direct the protein synthesis, and proteins in their turn are the main molecules responsible for the diversity of cellular biological tasks. In membranes and within the cell, some organic molecules act as information receptors and signalers. Proteins and lipids have an important role in the communication between cells and tissues, acting as hormones, substances that transmit information at a distance throughout the organism.

10. What are biopolymers?

Polymers are macromolecules made by the union of several smaller identical molecules, called monomers. Biopolymers are polymers present in the living beings. Cellulose, starch and glycogen, for example, are polymers of glucose.

Biology Questions and Answers

Water and Mineral Salts

1. What is the approximate percentage (in mass) of water in the human body? Is this percentage expected to be larger in the adult or in the old individual?

Approximately 65% of the human individual mass is water. The brain, for example, has around 90% of water in mass, the muscles, 85%, and the bones have between 25% and 40% of water.

Younger adult individuals have proportionally more water in mass than older individuals.

2. What are the main biological functions of water?

Water is the fundamental solvent for chemical reactions of living beings; it is the main means of substance transportation in the cell and between cells and tissues and it is responsible for the maintenance of adequate temperature for the functioning of the organism. Water is also the reagent or the product of many biochemical reactions, like photosynthesis, cellular respiration, peptide bond for protein formation, etc.

3. Water has key participation in organic reactions. What are examples of two types of organic reactions in which water is respectively incorporated or liberated in the products of these reactions?

Photosynthesis is a biochemical process in which water is incorporated into organic molecules. In the reaction, the hydrogen atoms from water go to the produced glucose and the oxygen atoms from water form the molecular oxygen liberated: carbon dioxide + water + light = glucose + molecular oxygen. Aerobic respiration is an example of biochemical reaction in which water is produced: glucose + molecular oxygen = carbon dioxide + water.

4. Is water a polar or a non-polar molecule? What is the consequence of that characteristic for the function of water as solvent?

Water is made of two atoms of hydrogen attached by covalent bond with one central atom of oxygen making an angular spatial structure. The hydrogen atoms “lend” electrons to the oxygen and consequently this atom becomes more negative while the hydrogens become more positive. The spatial geometry of the water molecule makes it a polar molecule, with negative and positive poles.

Water is an excellent solvent for polar substances because the electrical activity (attraction and repulsion) of its poles helps the separation and the mixing of these substances, giving them more movement and thus increasing the number of molecular collisions and the speed of chemical reactions. On the other hand, water is not good as a solvent for non-polar substances.

Polarity is one of the water properties.

5. Which kind of polarity do water-soluble and fat-soluble substances respectively have?

Water-soluble substances are polar molecules, i.e., they have electrically charged areas. These molecules get the description "water-soluble" because they are soluble in water, a polar molecule too.

Fat-soluble substances are non-polar molecules, i.e., they are electrically neutral. They get the description "fat-soluble" because they dissolve other non-polar substances.

6. What is the importance of water for enzymatic activity?

Enzymes, biological catalysts, depend on water to reach their substrates and bind to them. There is no enzymatic activity without water. In addition, enzymes depend on adequate pH interval to work and the pH is a consequence of the liberation of hydrogen cations (H^+) and hydroxyl anions (OH^-) by acids and bases in water solution.

7. Can the heat capacity of water be considered small or large? What is the biological significance of that characteristic?

From Thermology it is known that the quantity of exchanged heat (Q) is equal to the mass (m) multiplied by the specific heat of the substance (c) multiplied by the variation of temperature (T), $Q = m.c.\Delta T.$, and that heat capacity is Q/T, hence, m.c. Heat capacity, however, relates to a specific body, since it considers mass, whereas specific heat relates to the general substance. Therefore it is more correct to refer to specific heat in this problem.

Water has a specific heat of 1 cal/g.°C which means that 1 oC per gram is changed in its temperature with the addition or subtraction of 1 cal of energy. This is a very elevated value (for example, the specific heat of ethanol is 0,58 cal/g.°C, and mercury, a metal, has a specific heat of 0,033 cal/g. °C) making water an excellent thermal protector against variations of temperature. Even if sudden external temperature changes occur, the internal biological conditions are kept stable in organisms which contain enough water.

High specific heat is one of the most important water properties.

Biology Questions and Answers

8. What are the main water properties that make water special for life?

The water properties that make water biologically important are molecular polarity, thermal stability (elevated specific heat), fusion and ebullition points that allow water to be liquid in most environments, acid-base neutrality, small molecular size and low chemical reactivity. (Compared to other substances, like ethanol or hydrogen sulfide.)

9. What are ions? What are the two types of molecules into which ions are classified?

Ions are atoms or substances electrically charged by means of loss or gain of electrons.

The two types of ions are the cations and the anions. Cations are ions with positive total electric charge and anions are ions with negative total electric charge.

10. Which are the main positive ions found in living beings?

The main cations found in living beings are the sodium cation (Na^+), the potassium cation (K^+), the calcium cation (Ca^{++}), the iron cations (Fe^{++}, Fe^{+++}), the magnesium cation (Mg^{++}), the zinc cation (Zn^{++}) and the manganese cation (Mn^{++}).

11. What are the main negative ions found in living beings?

The main anions found in living beings are the chlorine anion (Cl^-), the phosphate anion (PO_4^{--}), the bicarbonate anion (HCO_3^-), the nitrate anion (NO_3^-) and the sulfate anion (SO_4^-).

12. How do mineral salts participate in osmotic regulation?

Osmotic pressure depends on the number of particles dissolved in a solution and not on the nature of such particles. Mineral salts, glucose, proteins and urea are the main regulating particles for the osmolarity of the organism. These molecules along with other particles inside and outside the cell generate the larger or smaller osmotic gradient between the intracellular and the extracellular space.

13. What is the role of mineral salts in the creation of electric tension (voltage) at the cellular level?

The electric activity of the cell, for example, in neurons, depends on the different concentrations of positive and negative ions between the inner and the outer surfaces of the cell membrane. Mineral salts are responsible for that voltage.

The cell membrane of non-excited cell has commonly a negative inner side and

a positive outer side. This electrical situation is maintained by ion transport across the membrane.

14. Why is pH regulation important for living beings? How do mineral salts participate in this regulation?

The potential of hydrogen (pH) is a measure of the amount of hydrogen ions (H^-) in a solution. The regulation of the pH according to the necessities of each organ or tissue is extremely important for the organism since enzymes act only under some pH ranges and many proteins are only active under some pH ranges. Therefore biochemical reactions depend on correct levels of pH to occur.

Neutral pH is one of the water properties.

15. How do mineral salts participate in enzymatic activity?

Many mineral salts are cofactors of enzymes, i.e., they are substances without which enzymes do not work.

16. What are the main biological processes in which calcium participates?

Calcium is present in almost all cells and has several functions.

Calcium has an important role in muscular contraction, in the blood coagulation process, in the structure of bone tissue, in teeth, in the motility of the sperm cell flagellum and in the nervous transmission.

17. What is hemoglobin? What is the inorganic element that is fundamental in the composition of hemoglobin?

Hemoglobin is the protein present in the blood responsible for the transport of oxygen from the lungs to the tissues and cells.

The hemoglobin molecule is composed of four protein chains, each with a heme group containing an iron atom. The iron is responsible for the binding of oxygen in the lungs and also for the red color of hemoglobin and thus of the blood.

18. What is the importance of magnesium for plants? What are the other main biological functions of magnesium?

Magnesium is fundamentally important for plants because it is part of the chlorophyll molecule (and chlorophyll is essential for photosynthesis).

Magnesium also acts as a cofactor of several enzymes and it is important the muscle relaxation and for the nervous transmission.

19. What is phosphorylation? What are some biological processes in which phosphorylation plays a critical role?

Phosphorylation is the name given to processes of the addition of phosphates to some molecules thus making these molecules more energized. Phosphorylation has an important role, for example, in photosynthesis (the photophosphorylation of the light phase) and in aerobic respiration (oxidative phosphorylation of the respiratory chain). In general the phosphate used in phosphorylation comes from ATP molecules.

20. Why is iodine important for human beings?

Iodine is a fundamental chemical element for the proper functioning of the thyroid since it is part of the hormones produced by this gland. Iodine deficiency creates a kind of hypothyroidism, a disease known as endemic goiter.

21. What are the main biological functions in which chlorine ions participate?

Like sodium cations, chlorine anions actively participate in the regulation of the osmolarity of tissues and cells by crossing the cellular membrane and avoiding entrance of water into the cell or excessive loss of water from the cell. Chlorine anions have an important role for the acid-base balance of the organism since they participate, along with bicarbonate anions, in the pH buffer system of the body. Another function of chlorine is in the digestive physiology: inside the gastric lumen, hydrochloric acid secreted by stomach cells ionizes itself into hydrogen and chlorine ions lowering the pH of the gastric juice and then permitting the enzymatic digestion to take place.

Biology Questions and Answers

Carbohydrates

1. What are the organic chemical groups that characterize carbohydrates? How are carbohydrates classified according to the presence of those groups?

Carbohydrates are also known as sugars (starches, cellulose and other substances are carbohydrates too).

Carbohydrates are polyhydroxylated aldehydes or polyhydroxylated ketones (polyalcohol aldehydes or polyalcohol ketones).

Polyhydroxylated aldehydes are called aldoses and polyhydroxylated ketones are called ketoses.

2. What is the molecular formula of glucose? How can its structural formula be described?

The molecular formula of glucose is $C_6H_{12}O_6$.

Structurally glucose is a hexagonal ring formed by one atom of oxygen and five atoms of carbon; a hydroxyl radical and a hydrogen atom bind in each carbon of the ring, except for one of the carbons bound to the oxygen of the ring; this carbon binds to a CH_2OH radical. Spatial sides of hydroxyl bonds are alternated.

3. What are monosaccharides, oligosaccharides and polysaccharides?

Monosaccharides are simple molecules of carbohydrates that cannot be broken into smaller molecules of other carbohydrates. Oligosaccharides are carbohydrates made by union of a maximum of 10 monosaccharides. Polysaccharides are polymers of monosaccharides made of more than 10 units of such monomers. The most important polysaccharides are cellulose, starch, glycogen and chitin.

4. What is the difference between monosaccharides and disaccharides? What are some examples of disaccharides and of monosaccharides that form them?

Monosaccharides are simple molecules of carbohydrates that cannot be broken into other carbohydrates. Glucose and fructose are examples of monosaccharides. Disaccharides are carbohydrates made of two monosaccharides and with the loss of one molecule of water (dehydration). The chemical bond between two monosaccharides is known as a glycosidic bond.

Sucrose (table sugar) is a disaccharide made by the union of one molecule of glucose with one molecule of fructose. Maltose is a disaccharide made by two glucose molecules. Lactose (milk sugar) is another disaccharide and it is created

by the union of one molecule of galactose with one molecule of glucose.

5. What are hexoses? What are some examples of hexoses with important biological functions?

Hexoses are carbohydrates made of six carbons. Glucose, fructose and galactose are examples of hexoses. Hexoses have an important biological role as energy sources for the metabolism.

6. What are pentoses? What are the roles of pentoses in DNA and RNA molecules?

Pentoses are carbohydrates made of five carbons.

The DNA molecule is made of a sequence of molecules called nucleotides. Each nucleotide is formed by the association of one pentose called deoxyribose with a phosphoric acid and a nitrogen-containing base (A, T, C or G). RNA is also formed by a sequence of nucleotides. The RNA nucleotides are made by association of one ribose (a pentose) with one phosphoric acid and one nitrogen-containing base (A, U, C or G).

So pentoses are fundamental components of DNA and RNA.

7. What are the main biological functions of the polysaccharides?

Polysaccharides have an energy storage function and a structural function. Polysaccharides incorporated by living beings along the food chain are important sources of carbohydrates for the energetic metabolism of organisms of the next trophic levels.

Starch is the polysaccharide used for energy store by plants. Glycogen is a macromolecule responsible for the storage of glucose in the liver and muscles. Chitin is a polysaccharide with structural functions that constitutes the exoskeleton of the arthropods and the cell wall in fungi.

Biology Questions and Answers

Lipids

1. What are the main types of lipids?

The main types of lipids are triglycerides (fats and oils), phospholipids, waxes and steroids.

2. What is the structural formula of glycerol? To which organic function do these molecules belong?

Glycerol is a linear chain of three carbons; the central carbon is bound to one hydroxyl radical and to one hydrogen and the two other carbons in the extremities are bound to a hydroxyl radical and to two hydrogens. Spatial sides of the hydroxyls are the same.

3. How are triglycerides made?

Triglycerides, fats or oils, are made of three molecules of fatty acids bound to one molecule of glycerol. Hydroxyls of each one of the three fatty acids and each hydrogen of the hydroxyls of the glycerol bind to form three molecules of water that are liberated.

4. What are phospholipids?

Phospholipids are molecules made of glycerol bound to two long molecules of fatty acids and to one phosphate group. Therefore, phospholipids are amphipathic molecules, i.e., they have a non-polar portion, due to the long fatty acid chains, and a polar portion, due to the group phosphate.

Phospholipids are the main component of cell membranes. Sphingomyelin, the substance that forms the myelin sheath of axons in the nervous system, is a phospholipid too.

5. What are steroids? What are some examples of steroids with a biological function?

Steroids are lipids based in an angular combination of four carbon rings, three of them made of six carbons and one ring made of five carbons in the extremity. The union of each ring to the adjacent ring is made by the sharing of two adjacent carbons belonging to both rings.

Bile salts, cholesterol, the sexual hormones estrogen, progesterone and testosterone, the corticosteroids and the pro-vitamin D are examples of steroids.

Biology Questions and Answers

6. What are hydrophobic molecules (or hydrophobic molecular regions)? What are hydrophilic molecules? How can they be characterized in relation to their polarity?

Hydrophobic molecules are those that have little or no propensity to dissolve in water (hydro = water, phobia = fear). Hydrophilic molecules are those that have great propensity to dissolve in water (philia = friendship).

Water is a polar substance. Remembering the rule that "equal dissolves equal" one can conclude that hydrophobic substances are non-polar molecules while hydrophilic molecules are polar molecules.

7. Are organic solvents like benzene and ether polar or non-polar substances?

Benzene and the ethers are molecules without electrically charged portions and thus they are non-polar substances.

8. Regarding solubility, how are lipids classified?

Fats and oils are hydrophobic molecules, i.e., they are non polar and insoluble in water. Lipids in general are molecules with a large non-polar extension and so they are soluble in non polar solvents, like benzene, ether and chloroform.

There are some amphipathic lipids, i.e., lipids whose molecules have a hydrophilic portion, like the phospholipids, giving them the property of being dragged by water, and a hydrophobic portion (non polar).

9. What is meant by saturation or unsaturation of oils and fats?

When it is said that a triglyceride is saturated it means that in its molecule the carbon chain is bound in its maximum capacity to hydrogens, i.e., there are no double or triple bonds between carbons. These saturated molecules are generally solid fats at normal temperature.

Unsaturated triglyceride molecules are those in which there are double or triple bonds between carbons and so they do not accomplish their maximum capacity of hydrogenation. These unsaturated molecules in general are oils, liquid at normal temperature.

The terms saturated or unsaturated refer then to the saturation of the carbonic chain by hydrogen atoms.

Biology Questions and Answers

Proteins

1. What are proteins? How can the protein diversity of living beings be explained?

Proteins are molecules made of sequences of amino acids bound by a peptide bond.

The genetic code codifies twenty different amino acids that can compose proteins. So there are numerous combinations of amino acid which can form polypeptide chains and for this reason protein molecules can be immensely diverse.

2. What is the importance of proteins for living beings?

Proteins play a fundamental role in nearly all biological processes. Due to their diversity they can assume many different configurations and they can play varied roles in cells and tissues.

Some protein functions are noteworthy: the structural function (cell membrane proteins, cytoskeleton proteins, proteins of the connective tissue), the enzymatic function (enzymes are proteins), the energy storage function (proteins can be degraded into acetyl-CoA and "cycle" the Krebs cycle), the osmotic regulation function (albumin), the transportation function (membrane channels, respiratory pigments), the immune protection function (antibodies), the movement function (contractile proteins), the endocrine integration function (hormones) and the informative function (membrane receptors, intracellular signalers). There are also many proteins whose biological functions are not yet known.

3. What is the constitutional unit of proteins?

The constitutional units of proteins are the amino acids.

4. What is an oligopeptide? How is it different from a polypeptide?

Peptide is the molecule formed by the union of amino acids through the peptide bond. Oligopeptide is a peptide made of few amino acids (oligo = few). Polypeptides are peptides with many amino acids (poli = many), in general more than 50.

5. How many are the known amino acids that form proteins in living beings?

There are twenty different known amino acids that form proteins related to the genetic code of the living beings.

There are still many other amino acids as yet not known.

Biology Questions and Answers

6. Does every amino acid have a central carbon? To which organic group is that central carbon bound?

A carboxyl group –COOH, an amine group – NH_2, an atom of hydrogen –H and a variable radical -R necessarily are bound to the central carbon of an amino acid.

7. How can amine groups be classified?

Amines can be classified into primary amines, those to which one –R (variable radical) is attached to a $–NH_2$, secondary amines, those where one hydrogen of NH_2 is substituted by another –R, thus having two –R, and tertiary amines, those with no hydrogen bound to the nitrogen and with three –R.

8. What is the structural representation of a carboxyl group?

Carboxyl groups have a carbon attached to one hydroxyl group by a simple bond and to one oxygen by a double bond. The other site of binding in the carbon is available to other chemical entities.

9. What is the structural flat representation of an amino acid molecule?

An amino acid has a central carbon to which a carboxyl group binds on a side and to which a –R (variable radical) binds on the opposite side. In the perpendicular direction of those ligands an amine group binds the central carbon on one side and a hydrogen binds on the opposite side.

The bind of the carboxyl group to a carbon where a hydrogen is laterally attached is responsible for the name "acid" in amino acids. The bound of an amine group in the central carbon provides the name "amino".

10. What is the importance of the –R group (variable radical) in an amino acid molecule?

The –R group, also called a lateral chain, is the variable part of the amino acid molecule. The –R group can be a complex carbonic chain, a substituting methyl group (forming then the amino acid alanine) or even only a hydrogen (forming glycine, the simplest amino acid). So the –R group is important because it is the differentiation factor of amino acids.

11. How can the binding of two amino acids for the peptide formation be described?

A peptide is formed when a carbon from the carboxyl group of one amino acid is connected to the nitrogen of the amine group of another amino acid. During

that binding the hydroxyl of the carboxyl and one hydrogen of the amine is lost resulting in the liberation of one water molecule.

12. What is the binding between two amino acids called?

The chemical bond between two amino acids is called a peptide bond.

13. Do the –R groups bound to the central carbons participate in the union between amino acids?

The peptide bond attaches the nitrogen of the amine group of one amino acid to the carbon of the carboxyl group of another amino acid liberating one molecule of water. So the –R groups do not participate in that bond.

14. Do the –H groups bound to the central carbons participate in the peptide bond?

The central carbons themselves, the –R groups and the hydrogens attached to the central carbons do not participate in the peptide bond.

15. Do the amine and the carboxyl groups attached to central carbons participate in the union between amino acids?

Yes. The nitrogen of the amine group of one amino acid binds to the carbon of the carboxyl group of the other amino acid. The water molecule liberated from the formation of the peptide bond thus has a hydrogen from the amine and an oxygen and another hydrogen from the carboxyl.

16. Does the chemical reaction to unite amino acids incorporate or liberate atoms? What are the chemical entities incorporated or liberated in this reaction?

The union of amino acids by peptide bond liberates atoms. They are liberated as constituents of one molecule of water.

17. Are there different proteins made by the same total number of amino acids?

Different proteins with the same total number of amino acids may exist. In such cases the differentiation is given by the types of amino acids or by the sequence in which they form the protein.

Biology Questions and Answers

18. Are proteins with the same number of each different amino acid that form them necessarily identical proteins?

Even if many proteins have the same number of each different amino acid that form them, for example, 50 alanines, 70 glycines and 20 histidines, the sequences in which these amino acids are connected may be very different. So if two or more proteins are in such condition of numeric similarity for each type of their constituent amino acids, they are not necessarily identical.

19. What is the essential condition for a protein to be identical to another protein?

For a protein to be identical to another protein it is necessary for the sequence of amino acids that form them to be identical.

20. What is the primary structure of a protein? What is the importance of the primary structure?

The primary protein structure is the linear sequence of amino acids that form the molecule.

The primary structure is the basis of the protein identity. Modification of only one amino acid of the primary structure creates a different protein. This different protein can be inactive or can even have other biological functions.

21. What is the secondary structure of a protein?

The secondary protein structure is generated by the manner its amino acids interact through the intermolecular bond. These interactions create a spatial conformation of the polypeptide filament. The two most studied secondary conformations of proteins are the alpha-helix and the beta-sheet.

22. What is the difference between the alpha-helix and the beta-sheet protein conformations?

Alpha-helix and beta-sheet conformations are the two main types of secondary structure of a protein molecule. According to the primary protein structure its secondary structure can be of one type or the other.

In the alpha-helix structure the polypeptide curls longitudinally by the action of hydrogen bonds forming a spiral, or helix. In the beta-sheet conformation the protein is more distended and the hydrogen bonds form a zig-zag-shaped protein structure called B-strand. Many assembled beta-strands make a beta-sheet.

23. What is the tertiary structure of a protein? What are the main types of tertiary structure?

The tertiary protein structure is a spatial conformation additional to the secondary structure in which the alpha-helix or the beta-sheet folds itself up. The forces that keep the tertiary structure generally are interactions between the –R groups of the amino acids and between other parts of the protein and water molecules of the solution.

The main types of tertiary structure of proteins are the globular proteins and the fibrous proteins.

24. What is the quaternary structure of a protein? Do all proteins have quaternary structure?

The quaternary protein structure is the spatial conformation due to interactions among polypeptide chains that form the protein.

Only those proteins made of two or more polypeptide chains have quaternary structure. Insulin (two chains), hemoglobin (four chains) and the immunoglobulins (antibodies, four chains) are some examples of protein having quaternary structure.

25. What is protein denaturation? Is there any change in the primary structure when a protein is denatured?

Secondary, tertiary and quaternary structures of proteins are spatial structures. Denaturation is modification in any of these spatial structures that makes the protein deficient or biologically inactive.

After denaturation the primary protein structure is not affected.

26. How can denaturation be classified regarding its reversibility?

Protein denaturation can be a reversible or an irreversible process, i.e., it may be possible or impossible to make the protein regain its original spatial conformation.

27. What are some factors that can lead to protein denaturation?

Protein denaturation can be caused by temperature variation, pH change, changes in the concentration of surrounding solutes and by other processes. Most proteins denature after certain elevation of temperature or when in very acid or very basic solutions. This is one of the main reasons that it is necessary for the organisms to keep stable temperature and pH.

Biology Questions and Answers

28. Is it expected that a change in the primary, in the secondary or in the tertiary structure of a protein will produce more functional consequences?

Any change of the protein structure is relevant if it alters its biological activity. Changes in the primary protein structure are more important because they are modifications in the composition of the molecule and such composition determines all other structures of the protein.

29. In sickle cell anemia, a hereditary disease, there is substitution of one amino acid by another in one of the four polypeptide chains of hemoglobin. In this case are all of the structural levels of the protein modified?

In sickle cell disease there is a change in the primary protein structure of one of the polypeptide chains that form hemoglobin: the amino acid glutamic acid is substituted by the amino acid valine in the β chain. The spatial conformation of the molecule in addition is also affected and modified by this primary "mistake" and the modification also creates a different (sickle) shape to the red blood cells.

Modified, sickled, red blood cells sometimes aggregate and obstruct the peripheral circulation causing tissue hypoxia and the pain crisis typical of sickle cell anemia.

30. What is the difference between essential and natural amino acids?

Essential amino acids are those that the organism is not able to synthesize and that need to be ingested by the individual. Natural amino acids are those that are produced by the organism.

There are living species that produce every amino acid they need, for example, the bacteria Escherichia coli, that does not have essential amino acids. Other species, like humans, need to obtain essential amino acids from the diet. Among the twenty different known amino acids that form proteins humans can make twelve of them and the remaining eight need to be taken from the proteins they ingest with food.

The essential amino acids for humans are phenylalanine, histidine, isoleucine, lysine, methionine, threonine, tryptophane and valine.

31. What are respectively some remarkable functions of myosin, CD4, albumin, keratin, immunoglobulin, reverse transcriptase, hemoglobin and insulin?

Myosin is a protein that when associated with actin produces a muscular contraction. CD4 is a membrane protein of some lymphocytes, the cells that are infected by HIV. Albumin is an energy storage protein and also an important regulator of the blood osmolarity.

Keratin is a protein with structural function present in the epidermis and skin appendages of vertebrates. Immunoglobulins are the antibodies, specific proteins that attack and inactivate strange agents that enter the body. Reverse transcriptase is the enzyme responsible for the transcription of RNA and formation of DNA in the life cycle of retroviruses. Hemoglobin is the protein that carries oxygen from the lungs to the cells. Insulin is a hormone secreted by the pancreas that participates in the metabolism of glucose.

Biology Questions and Answers

Enzymes

1. What are catalysts?

Catalysts are substances that reduce the activation energy of a chemical reaction, facilitating it or making it energetically viable. The catalyst increases the speed of the chemical reaction.

2. What amount of catalyst is consumed in the reaction it catalyzes?

Catalysts are not consumed in the reactions they catalyze.

3. Is there a difference between the initial and the final energy levels in catalyzed and non-catalyzed reactions?

The catalysis does not alter the energetic state of reagents and products of a chemical reaction. Only the energy necessary for the reaction to occur, i.e., the activation energy, is altered.

4. What are enzymes? What is the importance of enzymes for living beings?

Enzymes are proteins that are catalysts of chemical reactions. From Chemistry it is known that catalysts are non-consumable substances that reduce the activation energy necessary for a chemical reaction to occur.

Enzymes are highly specific to the reactions they catalyze. They are of vital importance for life because most chemical reactions of the cells and tissues are catalyzed by enzymes. Without enzymatic action those reactions would not occur or would not happen in the required speed for the biological processes in which they participate.

5. What is meant by substrates of enzymatic reactions?

Substrates are reagent molecules upon which enzymes act.

The enzyme has spatial binding sites for the attachment of its substrate. These sites are called activation centers of the enzyme. Substrates bind to theses centers forming the enzyme-substrate complex.

6. What are the main theoretical models that try to explain the formation of the enzyme-substrate complex?

There are two main models that explain the formation of the enzyme-substrate complex: the lock and key model and the induced fit model.

In the lock and key model the enzyme has a region with specific spatial conformation for the binding of the substrate. In the induced fit model the binding of the substrate induces a change in the spatial configuration of the enzyme for the substrate to fit.

7. How does the formation of the enzyme-substrate complex explain the reduction of the activation energy of chemical reactions?

The enzyme possibly works as a test tube within which reagents meet to form products. With the facilitation of the meeting provided by enzymes it is easier for collisions between reagents to occur and thus the activation energy of the chemical reaction is reduced. This is one of the possible hypotheses.

8. On what structural level of the enzyme (primary, secondary, tertiary or quaternary) does the enzyme-substrate interaction depend?

The substrate binds to the enzyme in the activation centers. These are specific three-dimensional sites and thus they depend on the protein tertiary and quaternary structures. The primary and secondary structures, however, condition the other structures and so they are equally important.

9. What is the activation center of an enzyme? Is it the key or the lock of the lock and key model?

The activation center is a region of the enzyme produced by its spatial conformation to which the substrate binds. In the lock and key model the activation center is the lock and the substrate is the key.

10. Why can it be said that the enzymatic action is highly specific?

The enzymatic action is highly specific because only specific substrates of one enzyme bind to the activation center of that enzyme. Each enzyme generally catalyzes only a specific chemical reaction.

11. What happens to a denatured enzyme regarding its functionality? How can that result be explained with the help of the lock and key model?

According to the lock and key model the enzyme functionality depends entirely on the integrity of the activation center, a molecular region with specific spatial characteristics. After the denaturation the spatial conformation of the protein is modified, the activation center is destroyed and the enzyme loses its catalytic activity.

Biology Questions and Answers

12. What are the main factors that alter the speed of enzymatic reactions?

The main factors that change the speed of enzymatic reactions are temperature, pH and substrate concentration (quantity).

13. How does the substrate concentration affect the speed of enzymatic reactions?

Initially as substrate concentration increases, the speed of the reaction increases; this happens because free activation centers of the enzyme bind to free substrates. Once all activation centers of the available enzymes become bound to their substrates new increments of the substrate concentration will have no effect on the speed of the reaction.

14. How does temperature affect the action of enzymes upon their substrates?

There are defined temperature ranges under which enzymes operate and there is a specific temperature level (optimum temperature) in which enzymes have maximum efficiency. Therefore temperature variations affect enzymatic activity and the speed of the reactions they catalyze.

In addition, as proteins, enzymes can be denatured under extreme temperatures.

15. Concerning enzymatic reactions, how different are the graphic curve of the variation of the speed of a reaction as function of substrate concentration and the curve of variation of the speed of a reaction as function of temperature?

The curve of variation of speed of the enzymatic reaction as a function of growing substrate concentration is a growing curve until the point where it stabilizes due to the saturation of the activation centers of the enzymes.

The curve of variation of speed of the enzymatic reaction as a function of growing temperature has a crescent portion and reaches a peak (the optimum temperature) then it decreases and reaches zero in the point of inactivity of the enzymes by denaturation.

16. How is the cooling of organs and tissues for medical transplants associated with the effect of temperature upon enzymatic reactions?

The molecular degradation during the decomposition of organs and tissues is catalyzed by enzymes. The cooling to adequate temperatures of some organs and tissues destined for transplantation reduces that enzyme activity and thus lessens the natural decomposition process. By the same rationale, the cooling reduces the metabolic work of cells and prevents degradation of their

own structures to obtain energy. Elevation of temperature later reverts denaturation of enzymes and the organs and tissues also preserved by other specific techniques may be grafted into the receptors.

17. Does pH affect the enzyme activity?

The concentration of hydrogen ions in solution affects the enzyme activity. Each enzyme has maximal efficiency under an optimum pH.

Since pH is one of the factors for the denaturation of proteins, if an enzyme is submitted to a pH level under which it is denatured there will be no enzymatic activity.

18. Do enzymes act better under acid or basic pH?

Most enzymes act in pH between 6 and 8, a range that corresponds to the general acidic level of cells and blood. There are enzymes, however, that act only under very acid or very basic pH. So enzyme activity depends on pH interval.

In the stomach, for example, the gastric juice has a very low pH, around 2, and there the enzyme pepsin acts to intensively digest proteins. In the duodenum, pancreatic secretions increase the pH of the enteric juice for the action of other digestive enzymes, for example, trypsin.

19. Since pepsin is a gastric enzyme does it have an acid or basic optimum pH? What happens to pepsin when it passes into the duodenum?

Pepsin acts within the stomach so its optimum pH is around 2, an acid pH. When the enzyme passes into the duodenum it meets a higher pH and its enzyme activity ends.

20. What are enzyme cofactors?

Some enzymes need other associated molecules to work. These molecules are called enzyme cofactors and they can be, for example, organic ions like mineral salts, or organic molecules.

Inactive enzymes which are not bound to their cofactors are called apoenzymes. Active enzymes bound to their cofactors are called holoenzymes.

21. What is the relationship between vitamins and enzyme cofactors?

Many vitamins are enzyme cofactors that cannot be synthesized by the organism and must be obtained from the diet.

Biology Questions and Answers

22. For the enzymatic reaction what is the effect of a substance with the same spatial conformation as an enzymatic substrate? How is this type of substance known?

Substances that "simulate" substrates can bind to the activation center of enzymes thus blocking the true substrates to bind to these enzymes and paralyzing the enzymatic reaction. Such "fake substrates" are called enzyme inhibitors.

The binding of enzyme inhibitors to enzymes can be reversible or irreversible.

Many medical drugs, for example, some antibiotics, antivirals, antineoplastics, antihypertensives and even sildenafil (trade name Viagra), are enzyme inhibitors that block enzyme activity.

23. What is the action mechanism of the antibiotic penicillin?

Penicillin, discovered by the Scottish doctor Alexander Fleming in 1928, is a drug that inhibits enzymes necessary for the synthesis of peptidoglycans, a constituent of the bacterial cell wall. With the inhibition the bacterial population stops growing because there is no new cell wall formation.

Fleming won the Nobel prize in Medicine for the discovery of penicillin.

24. What is the action mechanism of the antiretroviral drugs called protease inhibitors which are used against HIV infection?

Protease inhibitors are some of the antiretroviral drugs used to treat HIV infection. Protease is an enzyme necessary for the assembling of HIV after the synthesis of its proteins within the host cell. The protease inhibitor binds to the activation center of the enzyme blocking the formation of the enzyme-substrate complex and the enzyme activity thus impairing the viral replication.

25. What are allosteric enzymes?

Allosteric enzymes are those that have more than one activation center and to which other substances, called allosteric regulators, bind.

Allosteric regulators can be allosteric inhibitors or allosteric activators. The interaction between an allosteric enzyme and the allosteric inhibitor disallows the binding of the substrate to the enzyme. The interaction between the allosteric enzyme and the allosteric activator allows the binding of the substrate to the enzyme and sometimes increases the affinity of the enzyme for the substrate. This regulatory phenomenon of the enzyme activity is called allosterism.

Biology Questions and Answers

26. What are zymogens?

Zymogens, or proenzymes, are enzymes secreted in inactive form. Under certain conditions a zymogen shifts to the active form of the enzyme. Zymogen secretions in general happen because the enzyme activity can harm the secretory tissue.

For example, the pepsinogen secreted by the stomach becomes active under acid pH turning into the enzyme pepsin. Other well-known zymogens are trypsinogen and chymotrypsinogen, enzymes that are secreted by the exocrine pancreas and which become trypsin and chymotrypsin respectively.

Biology Questions and Answers

Nucleic Acids

1. What are nucleic acids? What is the historic origin of this name?

DNA and RNA, the nucleic acids, are the molecules responsible for the hereditary information that commands the protein synthesis in living beings. The name "nucleic" derives from the fact that they were discovered (by the Swiss biochemist Friedrich Miescher, in 1869) within the cell nucleus. In that time it was not known that those substances contained the hereditary information.

2. Of what units are nucleic acids constituted? What are the chemical entities that compose that unit?

Nucleic acids are formed by sequences of nucleotides.

Nucleotides are constituted by one molecule of sugar (deoxyribose in DNA and ribose in RNA) bound to one molecule of phosphate and to one nitrogen-containing base (adenine, uracil, cytosine or guanine, in RNA, and adenine, thymine, cytosine and guanine, in DNA).

3. What are pentoses? To what organic group do pentoses belong? Are nucleotides formed of only one type of pentose?

Pentoses are carbohydrates made of five carbons. Deoxyribose is the pentose that constitutes DNA nucleotides and ribose is the pentose that is part of RNA nucleotides.

4. Into which two groups can the nitrogen-containing bases that form DNA and RNA be classified? What is the criterion used in that classification?

The nitrogen-containing bases that form DNA and RNA are classified as pyrimidine and purine bases.

By the analysis of the structural formulae of those nitrogen-containing bases it is possible to realize that three of them, cytosine, thymine and uracil, have only one nitrogenized carbon ring. The others, adenine and guanine, have two nitrogenized associated carbon rings.

5. Concerning the nitrogen-containing bases that participate in nucleotides, what is the difference between DNA and RNA?

Biology Questions and Answers

In DNA nucleotides can be formed of adenine (A), thymine (T), cytosine (C) or guanine (G). In RNA nucleotides can also contain adenine (A), cytosine (C) or guanine (G), however, instead of thymine (T) there is uracil (U).

6. Which are the nucleotides "portions" that bind in the formation of nucleic acids? What is meant by the 5' and 3' extremities of nucleic acids?

The phosphate group of one nucleotide binds to the pentose of the other nucleotide and so on to make the polynucleotide chain.

Each extremity of a DNA or RNA chain can be distinguished from the other extremity according to their terminal chemical entity. The phosphate-ended extremity is called 5'-extremity and the pentose-ended extremity is called 3'-extremity. So DNA or RNA chains can be run along the 5'-3' way or along the 3'-5' way. These ways are important in several biological functions of DNA and RNA since some reactions specifically occur following one way or the other way.

7. Bacteria are prokaryotic cells, i.e., they do not have a membrane-delimited nucleus. Eukaryotes have cells with a delimited nucleus. Where in these types of cells can DNA be found?

In eukaryotic cells DNA is found within the cell nucleus. In prokaryotic cells DNA is found dispersed in the cytosol, the fluid space inside the cell.

Other DNA molecules can also be found within mitochondria and chloroplasts, specialized organelles of eukaryotic cells.

8. Who were James Watson, Francis Crick and Maurice Wilkins?

Watson (North American), Crick (British) and Wilkins (New Zealander) were the discoverers of the molecular structure of DNA, the double helix made of two polynucleotide chains paired by their nitrogen-containing bases. They won the Nobel prize in Medicine in 1962 for the discovery.

9. According to the Watson-Crick model how many polynucleotide chains does a DNA molecule have?

The DNA molecule is formed by two polynucleotide chains bound in antiparallel mode (5'-3' to 3'-5') and forming a helical structure.

10. What is the rule for the pairing of nitrogen-containing bases in the DNA molecule? And in the RNA? Is this last question appropriate?

The rule for the pairing of nitrogen-containing bases of the polynucleotide chains that form the DNA molecule is pyrimidine base binds to purine base, under the condition that thymine (T) binds to adenine (A) and cytosine (C) binds to guanine (G).

In RNA there is no binding between nitrogen-containing bases. That is because RNA is formed of only one polynucleotide chain; differently, DNA is formed of two chains. It is therefore not correct to question base pairing in RNA.

11. What is the numeric relation between pyrimidine and purine bases in the DNA molecule? Is that relation valid in RNA molecules?

The DNA molecule is made of two bound polynucleotide chains that form a helical structure (the double helix). The binding of the two chains is between their nitrogen-containing bases and it always obeys the following rules: adenine (A), a purine base, binds with thymine (T), a pyrimidine base, and guanine (G), a purine base, binds to cytosine (C), a pyrimidine base. Therefore in one molecule of DNA there will be the same number of adenine (A) and thymine (T) and same number of cytosine (C) and guanine (G). The quantities of purine and of pyrimidine bases then will also be the same in a 50% proportion for each type. The relation A = T and C = G, or A/T = C/G = 1, is called Chargaff's relation and the pairing rules described above are known as Chargaff's rules.

In RNA there are not two nucleotide chains. RNA is a simple chain molecule and there is no necessary proportionality of nitrogen-containing bases to form it.

12. Which type of chemical bond maintains the pairing of each chain in the DNA molecule?

To form the DNA molecule, purine bases bind to pyrimidine bases by intermolecular bonds called hydrogen bonds. Hydrogen bonds occur when there is hydrogen near one of these electronegative elements: fluorine, oxygen or nitrogen.

In such conditions hydrogen looks like having lost electrons for those elements and a very strong polarization is created. The highly positive hydrogen attracts pairs of electrons of other molecules making a hydrogen bond.

13. What is the completing sequence of nitrogen-containing bases for a AGCCGTTAAC fragment of a DNA chain?

TCGGCAATTG.

14. What is the name of the DNA duplication process? What is the main enzyme that participates in it?

The process of copying, or duplication, of the DNA molecule is called replication. The enzyme that participates in the formation of a new DNA chain is the DNA polymerase. There are also other important enzymes in the replication process, the helicase, the gyrase and the ligase.

15. Why is it not correct to assert that DNA self-replicates?

DNA is not completely autonomous in its duplication process because the replication does not occur without enzymatic activity. So it is not entirely correct to assert that DNA self-replicates.

16. How do the two complementary nucleotide chains of the DNA facilitate the replication process of the molecule?

The fact that the DNA molecule is made of two polynucleotide chains whose nitrogen-containing bases form hydrogen bonds facilitates the duplication of the molecule. During the DNA replication, the binding of the two chains is broken and each of them serves as a template for the formation of a new nucleotide sequence along it, with the help of the enzyme DNA polymerase and obeying the pairing rule A-T, C-G. At the end of the process two double helix of DNA are produced, each made of an original template chain and of a new synthesized polynucleotide chain.

17. What are the chemical bonds of the DNA molecule that are broken for the replication process to occur?

During the DNA replication process, hydrogen bonds between nitrogen-containing bases of the polynucleotide chains are broken.

18. As a result of DNA replication two DNA molecules come into existence. Why is it not correct to assert that two "new" DNA molecules are created? What is the name given to the process concerning that fact?

During replication each chain of the DNA molecule acts by pairing new nucleotides and after the process two newly formed chains made with the union of these nucleotides appear. Then two DNA molecules are created, each with one chain from the original molecule and one new chain formed by new nucleotides. Thus it is not entirely correct to assert that the replication produces two new molecules of DNA. It is better to affirm that two new half-molecules are created.
For this phenomenon DNA replication is called semiconservative replication.

Biology Questions and Answers

19. Does DNA replication occur in cell division?

Yes. DNA replication occurs in mitosis as well in meiosis.

20. One characteristic of the DNA molecule is its replication capability. What are the consequences of failures during DNA replication?

Ideally a DNA molecule should replicate in a perfect way. Sometimes however failures in the duplication occur, with alteration (deletion, addition or substitution) of one or more nucleotides in the molecule.

Those mistakes, or mutations, therefore make changes in the protein synthesis process too. For example, the production of an important protein for cells or tissues may be suppressed, new utile or inutile proteins can be created, etc. The mistake in the DNA duplication and the resulting production of altered genetic material are some of the main creative forces for the biological evolution and the diversity of species.

21. Mistakes may happen during every copying process. The same is true for DNA replication. Are there correction systems in cells that try to fix those mistakes? Under which situation are the mistakes carried only by the individual owner of the cell within which the mistake has occurred and in which situation are they transmitted to other individuals?

The cell is equipped with an enzymatic system that tries to fix mistakes of the DNA replication process. This system however is not completely efficient.

DNA replication mistakes are kept in the original individual where the failure occurred when the phenomenon affects somatic cells. If a replication mistake occurs in the formation of a germline cell (e.g., in gametes) the DNA alteration may be transmitted to the offspring of the individual.

22. Where can RNA be found within cells?

In the eukaryote cell nucleus RNA can be found dispersed in the nuclear fluid, along with DNA, and as the main constituent of the nucleolus. In cytosol (in eukaryotes or in bacteria) RNA molecules can be found free, as structural constituent of ribosomes (organelles specialized in protein synthesis) or even associated to them in the process of making proteins.

Mitochondria and chloroplasts also have their own DNA and RNA.

23. Does RNA molecule have two polynucleotide chains like DNA?

Only DNA has two polynucleotide chains. RNA is formed by just one polynucleotide chain.

24. What is the production of RNA called and what is the enzyme that catalyzes the process?

The making of RNA from information contained in DNA is called transcription. The enzyme that catalyzes the process is the RNA polymerase.

25. What are similarities and differences between the transcription process and the replication processes?

A DNA polynucleotide chain serves as a template in replication (DNA duplication) as well as in transcription (RNA formation). In both processes the pairing of the two polynucleotide chains of the original DNA molecule is broken by the breaking of hydrogen bonds for the chains to be exposed as templates. The reaction is catalyzed by specific enzymes in transcription and in replication.

In replication the enzyme DNA polymerase catalyzes the formation of a new polynucleotide chain using free nucleotides in solution and putting them in the new chain according to the DNA template exposed and to the rule A-T, C-G. In transcription the enzyme RNA polymerase makes a new polynucletide chain according to the DNA template exposed obeying, however, the rule A-U, C-G.

In replication the original template DNA chain is kept bound by hydrogen bonds to the newly formed DNA chain and a new DNA molecule is then created. In transcription the association between the template DNA chain and the newly formed RNA is undone and RNA constituted of only one polynucleotide chain is liberated.

26. What are the three main types of RNA? What is meant by heterogeneous RNA?

Messenger RNA, or mRNA, transfer RNA, or tRNA, and ribosomal RNA, or rRNA, are the three main types of RNA.

The newly formed RNA molecule, a precursor of mRNA, is called heterogeneous RNA (hnRNA). The heterogenous RNA bears portions called introns and portions called exons. The hnRNA is processed in many chemical steps, introns are removed and mRNA is created formed only of exons, the biologically active nucleotide sequences.

Biology Questions and Answers

27. Concerning their biological function what is the difference between DNA and RNA?

DNA is the source of information for RNA production (transcription) and thus for protein synthesis. DNA is still the basis of heredity due to its replication capability.

The messenger RNA is the template for protein synthesis (translation). In this process tRNA and rRNA also participate since the first carries amino acids for the polypeptide chain formation and the second is a structural constituent of ribosomes (the organelles where proteins are made).

28. Is there any situation in which DNA is made based on a RNA template? What is the enzyme involved?

The process in which DNA is synthesized having as template a RNA chain is called reverse transcription. In cells infected by retroviruses (RNA viruses, like the AIDS or SARS viruses) reverse transcription occurs and DNA is made from information contained in the viral RNA.

Viral RNA within the host cell produces DNA with the help of an enzyme called reverse transcriptase. Based on that DNA the host cell then makes viral proteins, new viruses are assembled and viral replication occurs.

29. Do the phosphate and the pentose groups give homogeneity or heterogeneity to the nucleic acid chains? What about the nitrogen-containing groups? Supported by that, which of those groups is expected to directly participate in the highly diverse and heterogeneous genetic coding, i.e., which of those groups is the basis of the information for protein production?

The phosphate and the pentose groups are the same in every nucleotide that forms the nucleic acid and so they give homogeneity to the molecule. The nitrogen-containing bases however can vary among adenine, thymine, cytosine, guanine (in DNA) and uracil (in RNA). These variations provide the heterogeneity of the nucleic acid molecule.

Homogeneous portions of a molecule seldom would store any information, by the same reason that a sequence of the same letter of the alphabet cannot make many words with different meanings. The nitrogen-containing bases, on the other hand, because they are different (four different types for RNA or DNA), can make different sequences and combinations that allow the diversity of the genetic code.

Biology Questions and Answers

Biology Questions and Answers

Cell Biology

Biology Questions and Answers

Biology Questions and Answers

Cell Structure

1. What is cell theory?

Cell theory asserts that the cell is the constituent unit of living beings.

Before the discovery of the cell, it was not recognized that living beings were made of building blocks like cells.

The cell theory is one of the basic theories of Biology.

2. Are there living beings without cells?

Viruses are considered the only living beings that do not have cells. Viruses are constituted by genetic material (DNA or RNA) enwrapped by a protein capsule. They do not have membranes and cell organelles nor do they have self-metabolism.

3. In 1665 Robert Hooke, an English scientist, published his book Micrographia, in which he described that pieces of cork viewed under the microscope presented small cavities similar to pores which were filled with air. Based on later knowledge, of what were the walls of those cavities constituted? What is the historical importance of that observation?

The walls of the cavities observed by Hooke were the walls of the plant cells that form the tissue. The observation led to the discovery of the cells, a fact only possible after the invention of the microscope. In that work, Hooke established the term “cell”, now widely used in Biology, to designate those cavities seen under the microscope.

4. What are the two big groups into which cells are classified?

Cells can be classified as eukaryotic or prokaryotic.

Prokaryotic cell is that without a delimited nucleus. Eukaryotic cells are those with nucleus delimited by membrane.

Biology Questions and Answers

5. Do bacteria cells have a nucleus?

In bacteria the genetic material is dispersed in the cytosol and there is no internal membrane that delimits a nucleus.

6. Are there any bacteria made of more than one cell?

There are no pluricellular bacteria. All bacteria are unicellular prokaryotic.

7. What is the plasma membrane of the cell? What are its main functions?

The plasma membrane is the outer membrane of the cell, it delimits the cell itself and a cell interior with specific conditions for the cellular function. Since it is selectively permeable, the plasma membrane has an important role for the passage of substances inwards or outwards.

8. What are the chemical substances that compose the plasma membrane?

The main constituents of the plasma membrane are phospholipids, proteins and carbohydrates. The phospholipds, amphipathic molecules, are regularly organized in the membrane according to their polarity: two layers of phospholipids form the lipid bilayer with the polar part of the phospholipids pointing to the exterior of the layer and the non-polar phospholipid chains in the interior. Proteins can be found embedded in the lipid bilayer and there are also some carbohydrates bound to proteins and to phospholipids in the outer face of the membrane.

9. What is the difference between plasma membrane and cell wall?

Plasma membrane and cell wall are not the same thing. Plasma membrane, also called cell membrane, is the outer membrane common to all living cells and it is made of a phospholipid bilayer, embedded proteins and some appended carbohydrates.

Because cell membranes are fragile, in some types of cells there are even outer structures that support and protect the membrane, like the cellulose wall of plant cells and the chitin wall of some fungi cells. Most bacteria also present an outer cell wall made of peptidoglycans and other organic substances.

10. What are the main respective constituents of cell walls in bacteria, protists, fungi and plants?

In bacteria the cell wall is made of peptidoglycans; among protists algae have cell walls made of cellulose; in fungi, the cell wall is made of chitin (the same substance that makes the

exoskeleton of arthropods); in plants, the cell wall is made of cellulose too.

11. Do membranes form only the outer wrapping of cells?

Lipid membranes do not form only the outer cover of cells. Cell organelles, such as the Golgi complex, mitochondria, chloroplasts, lysosomes, the endoplasmic reticula and the nucleus, are delimited by membranes too.

12. Which type of cell came first in evolution - the eukaryotic cell or the prokaryotic cell?

This is an interesting problem of biological evolution. The most accepted hypothesis asserts that the more simple cell, the prokaryotic cell, appeared earlier in evolution than the more complex eukaryotic cell. The endosymbiotic hypothesis, for example, affirms that aerobic eukaryotic cells appeared from the mutualist ecological interaction between aerobic prokaryotes and primitive anaerobic eukaryotes.

13. Concerning the presence of the nucleus what is the difference between animal and bacterial cells?

Animal cells (cells of living beings of the kingdom Animalia) have an interior membrane that delimits a cell nucleus and thus they are eukaryotic cells; in these cells the genetic material is located within the nucleus. Bacterial cells (cells of living beings of the kingdom Monera) do not have organized cellular nuclei and so they are prokaryotic cells and their genetic material is found dispersed in the cytosol.

14. What are the three main parts of a eukaryotic cell?

The eukaryotic cell can be divided into two main portions: the cell membrane that separates the intracellular space from the outer space physically delimiting the cell; the cytoplasm, the interior portion filled with cytosol (the aqueous fluid inside the cell); and the nucleus, the membrane-delimited internal region that contains the genetic material.

15. What are the main structures within the cell nucleus?

Within the cell nucleus the main structures are: the nucleolus, an optically dense region, spherical shaped, where there are concentrated ribosomal RNA (rRNA) associated to proteins (there may be more than one nucleolus in a nucleus); the chromatin, made of DNA molecules dispersed in the nuclear matrix during the cell interphase; the karyotecha, or nuclear membrane, the membrane that delimits the nucleus.

Biology Questions and Answers

16. What are the substances that constitute the chromatin? What is the difference between chromatin and chromosome?

The chromatin, dispersed in the nucleus, is a set of filamentous DNA molecules associated to nuclear proteins called histones. Each DNA filament is a double helix of DNA and thus a chromosome.

17. What is the fluid that fills the nucleus called?

The aqueous fluid that fills the nuclear region is called karyolymph, or nucleoplasm. In the fluid there are proteins, enzymes and other important substances for the nuclear metabolism.

18. Of what substances is the nucleolus made? Is there a membrane around the nucleolus?

Nucleolus is a region within the nucleus made of ribosomal RNA (rRNA) and proteins. It is not delimited by membrane.

19. What is the name of the membrane that delimits the nucleus? To which component of the cell structure is that membrane contiguous?

The nuclear membrane is also called karyotheca. The nuclear membrane is continuous to the endoplasmic reticulum membrane.

20. What are the main cytoplasmic structures present in animal cells?

The main cytoplasmic structures of the cell are the centrioles, the cytoskeleton, lysosomes, mitochondria, peroxisomes, the Golgi apparatus, the endoplasmic reticula and ribosomes.

21. What are cytoplasmic inclusions?

Cytoplasmic inclusions are cytoplasmic molecular aggregates, such as pigments, organic polymers and crystals. They are not considered cell organelles.

Fat droplets and glycogen granules are examples of cytoplasmic inclusions.

Biology Questions and Answers

22. Where in the cell can ribosomes be found? What is the main biological function of ribosomes?

Ribosomes can be found free in the cytoplasm, adhered to the outer side of the nuclear membrane or associated to the endoplasmic reticulum membrane defining the rough endoplasmic reticulum. Ribosomes are the structures where protein synthesis takes place.

23. What is the difference between smooth and rough endoplasmic reticulum?

The endoplasmic reticulum is a delicate membranous structure contiguous to the nuclear membrane and present in the cytoplasm. It forms an extensive net of channels throughout the cell and is classified into rough or smooth types.

The rough endoplasmic reticulum has a great number of ribosomes attached to the external side of its membrane. The smooth endoplasmic reticulum does not have ribosomes attached to its membrane.

The main functions of the rough endoplasmic reticulum are synthesis and storage of proteins made in the ribosomes. The smooth endoplasmic reticulum plays a role in the lipid synthesis and, in muscle cells, it is important in the conduction of the contraction stimulus.

24. A netlike membranous complex of superposed flat saccules with vesicles detaching from the extremities seen in electronic microscopy. What is the observed structure? What is its biological function?

What is being observed is the Golgi complex, or Golgi apparatus. This cytoplasmic organelle is associated with chemical processing and modification of proteins made by the cell and with storage and branding of these proteins for posterior use or secretion. Vesicles seen under the electronic microscope contain material already processed, ready to be exported (secreted) by the cell. The vesicles detach from the Golgi apparatus, travel across the cytoplasm and fuse with the plasma membrane then secreting their substances to the exterior.

25. On which organelle of the cell structure does intracellular digestion depend? What is the chemical content of those organelles?

Intracellular digestion occurs by the action of lysosomes. Lysosomes have digestive enzymes (hydrolases) that are made in the rough endoplasmic reticulum and stored in the Golgi apparatus. Lysosomes are hydrolase-containing vesicles that detach from the Golgi apparatus.

Biology Questions and Answers

26. Why are lysosomes known as "the cleaners" of the cell waste?

Lysosomes carry out autophagic and heterophagic digestion: autophagic digestion by digesting residual substances from the cellular metabolism; heterophagic digestion by digesting substances that enter the cell. Lysosomes enfold the substances to be degraded forming digestive vacuoles, or residual vacuoles, that later migrate toward the plasma membrane fusing with it and liberating (exocytosis) the digested material to the exterior.

Cell Structure Review - Image Diversity: lysosomes

27. Which are the cell organelles that participate in cell division and in the formation of cillia and flagella of some eukaryotic cells?

The organelles that participate in the cell division and in the formation of cilia and flagella of some eukaryotic cells are the centrioles. Some cells have cillia (paramecium, the bronchial ciliated epithelium, etc.) or flagella (flagellate protists, sperm cells, etc.); these cell structures are composed of microtubules originated from the centrioles. Centrioles also make the aster microtubules that are very important for cell division.

28. What are the morphological, chemical and functional similarities and differences between lysosomes and peroxisomes?

Similarities: lysosomes and peroxisomes are small membranous vesicles that contain enzymes and enclose residual substances from internal or external origin degrading them. Differences: lysosomes have digestive enzymes (hydrolases) that break substances to be digested into small molecules; peroxisomes contain enzymes that degrade mainly long-chained fatty acids and amino acids and that inactivate toxic agents including ethanol; within peroxisomes there is the enzyme catalase, responsible for the oxidation of organic compounds by hydrogen peroxide (H_2O_2) and, when this substance is in excess, by the degradation of the peroxide into water and molecular oxygen.

29. What are mitochondria? What is the basic morphology of these organelles and in which cells can they be found?

Mitochondria are the organelles in which the most important part of the cellular respiration occurs: the ATP production.

Mitochondria are organelles delimited by two lipid membranes. The inner membrane invaginates to the interior of the organelle forming cristae that delimitate the internal space known as mitochondrial matrix and where mitochondrial DNA (mtDNA), mitochondrial RNA (mt RNA),

mitochondrial ribosomes and respiratory enzymes can be found. Mitochondria are numerous in eukaryotic cells and they are even more abundant in those cells that use more energy, like muscle cells. Because they have their own DNA, RNA and ribosomes, mitochondria can self-replicate.

30. Why can mitochondria be considered the power plants of the aerobic cells?

Mitochondria are the "power plants" of aerobic cells because within them the final stages of the cellular respiration process occurs. Cellular respiration is the process of using organic molecule (mainly glucose) and oxygen to produce carbon dioxide and energy. The energy is stored in the form of ATP (adenosine triphosphate) molecules and later used in other cellular metabolic reactions. In mitochondria the two last steps of the cellular respiration take place: the Krebs cycle and the respiratory chain.

31. What is the endosymbiotic hypothesis about the origin of mitochondria? What are the molecular facts that support the hypothesis? To which other cellular organelles can the hypothesis also be applied?

It is presumed that mitochondria were primitive aerobic prokaryotes that were engulfed in mutualism by primitive anaerobic eukaryotes, receiving protection from these beings and offering energy to them. This hypothesis is called the endosymbiotic hypothesis on the origin of mitochondria.

The hypothesis is strengthened by some molecular evidence such as the fact that mitochondria have their own independent DNA and protein synthesis machinery, with their own RNA and ribosomes, and that they can self-replicate.

The endosymbiotic theory can be applied to chloroplasts too. It is supposed that these organelles were primitive photosynthetic prokaryotes because they have their own DNA, RNA and ribosomes and they can self-replicate too.

32. What are the main components of the cytoskeleton?

The cytoskeleton is a network of very small tubules and filaments distributed throughout the cytoplasm of eukaryotic cells. It is made of microtubules, microfilaments and intermediate filaments.

Microtubules are formed by molecules of a protein called tubulin. Microfilaments are made of actin, the same protein that participates in the contraction of muscle cells. Intermediate filaments are made of protein too.

33. What are the functions of the cytoskeleton?

As the name indicates, the cytoskeleton is responsible for the support of the normal shape of the cell; it also acts as a facilitator for substance transport across the cell and for the movement of cellular organelles. For example, the sliding between actin-containing filaments and the protein myosin creates pseudopods. In cells of the phagocytic defense system, like macrophages, cytoskeleton is responsible for the plasma membrane projections that engulf the external material to be interiorized and attacked by the cell.

34. What are chloroplasts? What are the main function of chloroplasts?

Chloroplasts are organelles present in the cytoplasm of plant and algae cells. Like mitochondria, chloroplasts have two boundary membranes and many internal membranous sacs. Within the organelle there are DNA, RNA and ribosomes and also the pigment chlorophyll, responsible for absorption of photic energy that is used in photosynthesis.

The main function of chloroplasts is photosynthesis: the production of highly energetic organic molecules (glucose) from carbon dioxide, water and light.

35. What is the molecule responsible for the absorption of photic energy for photosynthesis? Where is that molecule located in photosynthetic cells?

The chlorophyll molecules are responsible for the absorption of light energy for photosynthesis. These molecules are found in the internal membranes of chloroplasts.

36. What are the colors (of the electromagnetic spectrum) absorbed by plants? What would happen to photosynthesis if the green light waves that reach a vegetable were blocked?

Chlorophyll absorbs all other colors of the electromagnetic spectrum but it practically does not absorb the green. The green color is reflected and such reflection provides the characteristic color of plants. If the green light that reaches a plant is blocked and exposure of the plant to other colors is maintained there would be no harm to the photosynthesis process. Apparent paradox: the green light is not important for photosynthesis.

There is a difference between the optimum color frequency for the two main types of chlorophyll, the chlorophyll A and the chlorophyll B. Chlorophyll A has an absorption peak at approximately 420 nm wavelength (anil) and chlorophyll B has its major

absorption in 450 nm wavelength (blue).

37. What is the path followed by the energy absorbed by plants to be used in photosynthesis?

The energy source of photosynthesis is the sun, the unique and central star of our planetary system. In photosynthesis the solar energy is transformed into chemical energy, the energy of the chemical bonds of the produced glucose molecules (and of the released molecular oxygen). The energy of glucose is then stored as starch (a glucose polymer) or it is used in the cellular respiration process and transferred to ATP molecules. ATP is consumed in metabolic processes that spend energy (for example, in active transport across membranes).

38. Of what substance is the plant cell wall made? Of which monomer is it made?

The plant cell wall is made of cellulose. Cellulose is a polymer whose monomer is glucose. There are other polymers of glucose, like glycogen and starch.

39. What is the function of the plant cell wall?

The plant cell wall has structural and protective functions. It plays an important role in the constraint of the cell size, preventing the cell to break when it absorbs a lot of water.

40. What are plant cell vacuoles? What are their functions? What is the covering membrane of the vacuoles called?

Plant cell vacuoles are cell structures delimited by membranes within which there is an aqueous solution made of various substances like carbohydrates and proteins. In young plant cells many small vacuoles can be seen; within adult cells the most part of the internal area of the cell is occupied by a central vacuole.

The main function of the vacuoles is the osmotic balance of the intracellular space. They act as "an external space" inside the cell. Vacuoles absorb or release water in response to the cellular metabolic necessities by increasing or lowering the concentration of osmotic particles dissolved in the cytosol. Vacuoles also serve as a storage place for some substances.

The membrane that delimits the vacuoles is called tonoplast, named after the osmotic function of the structure.

Biology Questions and Answers

Cell Membrane

1. What is a membrane?

Membrane is any delicate sheet that separates one region from another blocking or permitting (selectively or completely) the passage of substances. The skin, for example, can be considered a membrane that separates the exterior from the interior of the body; cellophane, used in chemical laboratories to separate solutions, acts as a membrane too.

2. Concerning their permeability how are membranes classified?

Membranes can be classified as impermeable, permeable, semipermeable or selectively permeable.

An impermeable membrane is that through which no substance can pass. Semipermeable membranes are those that let only solvents, like water, to pass through it. Permeable membranes are those that let solvent and solutes, like ions and molecules, to pass across it. There are also selectively permeable membranes, i.e., membranes that besides allowing the passage of solvent, let only some specific solutes to pass while blocking others.

3. What is diffusion?

Diffusion is the spreading of substance molecules from a region where the substance is more concentrated to another region where it is less concentrated. For example, during the boiling of water in a kitchen gaseous water particles tend to uniformly spread in the air by diffusion.

4. What is meant by concentration gradient? Is it correct to refer to "concentration gradient of water"?

Concentration gradient is the difference of concentration of a substance between two regions.

Concentration is a term used to designate the quantity of a solute divided by the total quantity of the solution. Since water in general is the solvent in this situation it is not correct to refer to "concentration of water" in a given solution.

5. What is the difference between osmosis and diffusion?

Osmosis is the phenomenon of movement of solvent particles (in general, water) from a region of lower solute concentration to a region of higher solute concentration. Diffusion, on the other hand, is the movement of solutes from a region of higher solute

concentration to a region of lower solute concentration.

One can consider osmosis as movement of water (solvent) and diffusion as movement of solutes, both concentration gradient-driven.

6. What is osmotic pressure?

Osmotic pressure is the pressure created in an aqueous solution by a region of lower solute concentration upon a region of higher solute concentration forcing the passage of water from that to this more concentrated region. The intensity of the osmotic pressure (in units of pressure) is equal to the pressure that is necessary to apply in the solution to prevent its dilution by the entering of water by osmosis.

It is possible to apply in the solution another pressure in the contrary way to the osmotic pressure, like the hydrostatic pressure of the liquid or the atmospheric pressure. In plant cells, for example, the rigid cell wall makes opposite pressure against the tendency of water to enter when the cell is put under a hypotonic environment. Microscopically, the pressure contrary to the osmotic pressure does not forbid water to pass through a semipermeable membrane but it creates a compensatory flux of water in the opposite way.

7. Can solutions with the same concentration of different solutes have different osmotic pressures?

The osmotic pressure of a solution does not depend on the nature of the solute, it depends only on the quantity of molecules (particles) in relation to the total solution volume. Solutions with same concentration of particles even containing different solutes exert the same osmotic pressure.

Even when the solution contains a mixture of different solutes its osmotic pressure depends only on its total particle concentration regardless of the nature of the solutes.

8. How are solutions classified according to their comparative tonicity?

Comparative to another, a solution can be hypotonic (or hyposmotic), isotonic (or isosmotic) or hypertonic (or hyperosmotic).

When a solution is less concentrated than another the adjective hypotonic is given and the more concentrated is called hypertonic. When two compared solutions have the same concentration both receive the adjective isotonic. So this classification makes sense only for comparison of solutions.

9. Concerning permeability what type of membrane is the cell membrane?

The cell membrane is a selectively permeable membrane, i.e., it allows the passage of water and some selected solutes.

10. What are the basic constituents of the cell membrane?

The cell membrane is formed of lipids, proteins and carbohydrates.

The membrane lipids are phospholipids, a special type of lipid to which one extremity a phosphate group is bound thus assigning electrical charge to this region of the molecule. Since phospholipids have one electrically charged extremity and a long neutral organic chain they can organize themselves in two layers of associated molecules: the hydrophilic portion (polar) of each layer faces outwards in contact with water (a polar molecule too) of the extracellular and the intracellular space and the hydrophobic chains (non polar) face inwards isolated from the water. Because this type of membrane is made of two phospolipid layers it is also called a bilipid membrane.

Membrane proteins are embedded and dispersed in the compact bilipid structure. Carbohydrates appear in the outer surface of the membrane associated to some of those proteins under the form of glycoproteins or bound to phospholipids forming glycolipids. The membrane carbohydrates form the glycocalix of the membrane.

This description (with further explanations) is known as the fluid mosaic model about the structure of the cell membrane.

11. What are the respective functions of phospholipids, proteins and carbohydrates of the cell membrane?

Membrane phospholipids have a structural function, they form the bilipid membrane that constitutes the cell membrane itself.

Membrane proteins have several specialized functions. Some of them are channels for substances to pass through the membrane, others are receptors and signalers of information, others are enzymes, others are cell identifiers (cellular labels) and there are still those that participate in the adhesion complexes between cells or between the internal surface of the membrane and the cytosketeleton.

Membrane carbohydrates, associated to proteins or to lipids, are found in the outer surface of the cell membrane and they have in general labeling functions for recognition of the cell by other cells and substances (for example, they differentiate red blood cells in relation to the ABO blood group system), immune modulation functions, pathogen sensitization functions, etc.

Biology Questions and Answers

12. What are differentiations of the cell membrane?

In some types of cells, the cell membrane presents differentiations that are necessary for the specific functions of the cells. The main differentiations are the microvilli and the structures for reinforcement of adhesion or union between cells (cell junctions).

Microvilli are multiple external projections of the membrane resembling glove fingers. This differentiation is found in cells of tissues where it is advantageous to increase the size of the surface area in contact with the exterior, for example, in the enteric (intestinal) epithelium for absorption of nutrients.

Membrane differentiations for reinforcement of adhesion between cells occur mainly in epithelial tissues where the need for coverage and impermeability requires cells to be "glued" to neighboring cells. These differentiations can be interdigitations, desmosomes, tight junctions (zonula occludens), zonula adherens (adherens junctions) and gap junctions.

13. What is the relationship between concentration gradient and active and passive transport?

Passive transport is the movement of substances across membranes in favor of their concentration gradient, i.e., from a more concentrated region to a less concentrated region. Active transport, on the other hand, is the transport of substances across membranes against their concentration gradient, from a less concentrated to a more concentrated region. In passive transport, because it is spontaneous, there is no energy spent; the active transport however requires energy (work) to occur.

Active transport works to maintain or increase the concentration gradient of a substance between two regions while passive transport acts in a manner to reduce the concentration gradient.

14. What are the three main types of passive transport?

The three main types of passive transport are simple diffusion, osmosis and facilitated diffusion.

15. What is the energy source used in active transport through biological membranes?

The energy necessary for active transport (against the concentration gradient of the transported substance) to occur comes from ATP molecules. The active transportation uses chemical energy from ATP.

16. What is the difference between simple and facilitated diffusion? Facilitated by which type of molecule does the term "facilitated" mean?

Simple diffusion is the direct passage of substances across the membrane in favor of their concentration gradient. In facilitated diffusion the movement of substances is also in favor of their concentration gradient but the substances move bound to specific molecules that act as "permeabilizers", i.e., facilitators of their passage through the membrane.

17. How does the intensity of simple diffusion vary in relation to the concentration gradient of the moved substance?

The higher the concentration gradient of a substance the more intense its simple diffusion will be. If the concentration gradient diminishes the intensity of simple diffusion diminishes too.

18. How does the intensity of facilitated diffusion vary in relation to the concentration of the moved substance? What is the limiting factor?

Like simple diffusion facilitated diffusion is more intense when the concentration gradient of the substance increases and less intense when the gradient lessens. In facilitated diffusion however there is a limiting factor: the quantity of the permeases that facilitate the transport through the membrane. Even in a situation in which the concentration gradient of the diffusing substance increases, if there are not enough permeases to perform the transport there will be no increase in the intensity of the diffusion. This situation is called saturation of the transport proteins and it represents the point at which the maximum transport capacity of the substance across the membrane is achieved.

19. Without saturation of transport proteins and under the same concentration gradient how can the speed of simple diffusion be compared to the speed of facilitated diffusion?

The action of facilitator proteins in facilitated diffusion makes this type of diffusion faster than simple diffusion under equal concentration gradients of the moved substance.

20. How does facilitated diffusion present similarities with enzymatic chemical reactions?

One of the main examples of facilitated transport is the entrance of glucose from the blood into cells. Glucose from blood binds to specific permeases (hexose-transporting permeases) present in the cell membrane and by diffusion facilitated by these proteins it enters the cell to play its metabolic functions.

Facilitated diffusion resembles chemical catalysis because the transported substances bind to permeases like substrates bind to enzymes and in

addition, after one transport job is concluded, the permease is not consumed and can perform other successive transports.

21. What are some examples of biological activities in which osmosis plays an important role?

Hemolysis (destruction of red blood cells) by entrance of water, the hydric regulation in plants and the entrance of water in the xylem of vascular plants are all examples of biological phenomena caused by osmosis.

Excessive dilution of the blood plasma causes, by osmosis, the entrance of too much water into red blood cells and then the destruction of these cells (hemolysis). Osmosis is also the main process for maintenance of the flaccid, turgid or plasmolytic states of plant cells. Osmosis is one of the forces responsible for the entrance of water into plant roots since root cells are hypertonic in comparison to the soil.

22. What do facilitated diffusion and active transport have in common? What are the differences between them?

Facilitated diffusion can be confused with active transport because in both processes there is participation of membrane proteins.

In active transport however the transported substance moves against its concentration gradient and with energy spent. Facilitated diffusion is a passive transport in favor of the concentration gradient and it does not require energy.

23. Which are the molecules that make possible active transport through membranes?

Active transport is made by specific membrane proteins. These proteins are called "pumps" because they "pump" the moving substance through the membrane using energy from ATP molecules.

24. How does the sodium-potassium pump present in the cell membrane work? What is the importance of this protein for the cell?

The sodium-potassium pump is the transport protein that maintains the concentration gradient of these ions between the intra and the extracellular spaces. This protein is phosphorylated in each pumping cycle and then it pumps three sodium ions outside the cell and puts two potassium ions inwards. The phosphorylation is made by the binding of a phosphate donated by one ATP molecule that then is converted into ADP (adenosine diphosphate).

The job of the sodium-potassium pump, also known as sodium-potassium

ATPase, is fundamental to keep the characteristic negative electrical charge in the intracellular side of the membrane of the resting cell and to create adequate conditions of sodium and potassium concentrations inside and outside the cell to maintain the cellular metabolism.

25. What is mass transportation across the cell membrane?

Mass transportation is the entrance or the exiting of substances in or from the cell engulfed by portions of membrane. The fusion of internal substance-containing membranous vesicles with the cell membrane is called exocytosis. The entrance of substances into the cell after they have been engulfed by projections of the membrane is called endocytosis.

26. What are the two main types of endocytosis?

Endocytosis is the entrance of material in the cell engulfed by portions of the cell membrane.
Endocytosis can be classified as pinocytosis or phagocytosis. In pinocytosis small particles on the external surface of the membrane stimulate the invagination of the membrane inwards and vesicles full of that particles then detach from the membrane and enter the cytoplasm. In phagocytosis bigger particles on the external surface of the membrane induce the projection of pseudopods outwards enclosing the particles; the vesicle then detaches from the membrane and enters the cytoplasm receiving the name phagosome.

27. How does the plant cell wall react when it is placed under hypotonic medium?

The plant cell wall (the covering of the cell external to the cell membrane) is made of cellulose, a polymer of glucose.

When the cell is put under hypotonic medium it absorbs too much water through osmosis. In that situation the cell wall pressure acts to compensate the osmotic pressure thus forbidding excessive increase of the cellular volume and the cell lysis.

28. What is meant by suction force of the plant cell? Does the suction force facilitate or make difficult the entrance of water into the cell?

The suction force (SF) is the osmotic pressure of the plant cell vacuole, i.e., of the vacuolar internal solution.
Since the vacuolar solution is hypertonic in comparison to cytosol it attracts water thus increasing the cytosol concentration. With the osmotic action of the vacuole the cytosol becomes hypertonic in relation to the exterior and more water enters the cell.

Biology Questions and Answers

29. What is the wall resistance of plant cells? Does this resistance facilitate or make difficult the entrance of water into the cell?

Wall resistance, or turgor pressure (TP), is the pressure made by the distension of the plant cell wall in opposition to the increase of the cell volume. The wall resistance works against the entrance of water in the cell, i.e., it acts forcing the exiting of water and compensating the entrance of the solvent by osmosis.

30. What does the formula DPD = SF – TP mean?

DPD is the abbreviation of diffusion pressure deficit, SF (suction force) is the vacuolar osmotic pressure and TP is the turgor pressure.

The difference between SF and TP determines whether water tends or not to enter the cell. If SF > TP, DPD > 0 and water tends to enter the cell by osmosis. If TP > SF, DPD < 0 and water cannot enter the cell by osmosis.

31. What are the values of DPD for plant cells under hypertonic, isotonic and hypotonic media?

In plant cells under hypertonic medium there is loss of water for the exterior, SF > 0 (the vacuolar pressure is high because it is concentrated) and TP = 0 (there is no distension of the cell wall since the cellular volume is reduced) so DPD = SF. These cells are called plasmolysed cells, situation characterized by the retraction of the cell membrane that detach from the cell wall.

In plant cells under isotonic medium there is no increase of the internal water volume, SF > 0 and TP = 0 (since the cell wall is not distended). The cell membrane slightly touches the cell wall and in this situation the cell is called a flaccid cell.

In plant cells under hypotonic medium there is tendency of water to enter, SF = TP (since the osmotic pressure is totally compensated by the distension of the cell wall) and DPD = 0. The cell that has expanded itself to this point is called a turgid cell.

32. What is the formula of the DPD for withered (shrunken) plant cells? How is that situation possible?

Withered plant cells are those that have shrunk due to loss of water by evaporation without enough replacement. In this situation the cell membrane retracts and detaches from the cell wall. The cell wall moreover expands in length to stimulate the entrance of water making TP < 0. Since DPD = SF – TP and TP is negative (< 0) its formula becomes DPD = SF + |TP|.

33. What is deplasmolysis of plant cells?

The plant cell when placed under hypertonic medium loses a great amount of water and its cell membrane detaches from the cell wall. In that situation the cell is called a plasmolysed cell. When the plasmolysed cell is placed under hypertonic medium it absorbs water and becomes a turgid cell. This phenomenon is called deplasmolysis.

34. Why are salt and sugar used in the production of dried meat and dried fruits?

Substances that maintain a highly hypertonic environment, like sugar and salt, are used in the production of dried meat, fruits or fish (for example, cod) because the material to be conserved is then dehydrated and the resulting dryness prevents the growth of populations of decomposer beings (since these beings also lose water and die).

Biology Questions and Answers

Cytoskeleton and Cell Movement

1. What is a cytoskeleton? What are its main constituents in animal cells?

Cytoskeleton is the cytoplasmic structure that supports the cell, keeps its shape and fixates and moves the cell organelles. It is made of an extensive network of fibers dispersed in the cytoplasm and anchored in the plasma membrane. Its components are microtubules, microfilaments and intermediate filaments.

2. Of which substance are microtubules made? In which structures and cellular processes do microtubules participate?

Microtubules are made of consecutive dimers of the protein tubulin (each dimer has an alpha and a beta tubulin associated). Microtubules participate in cell division, they are constituents of cilia and flagella and they also form the centrioles.

3. Of which substance are microfilaments made? What are the properties of these elements that give motility to cells?

Microfilaments are made of actin (a protein). The contractile association of actin with myosin and other cytoplasmic proteins give to microfilaments the ability to promote cell movement.

4. What are cell movements? How are these movements created?

Cell movements are movements performed by cell structures, like the movements of cilia and flagella, the pseudopod movements (in amoeba, macrophages, etc.), the cyclosis of the cytoplasm and the sarcomere contraction in muscle cells.

Cell movements can be created by the cytoskeleton action, by differences of viscosity among cytoplasmic regions and by intracellular contraction systems.

5. What are cilia and flagella? How do these structures acquire movement? What are some examples of ciliated and flagellated cells in humans?

Cilia and flagella are structures found in some prokaryotes as well in some eukaryotic cells. They play defense, nutrition and movement roles for the

cell. In eukaryotic cells of protists and animals they originate from centrioles that migrate towards the plasma membrane and differentiate into structures projected outside the cell. Each cilium or flagellum is made of nine peripheral pairs of microtubules and one central pair all covered by membrane. (In bacteria, flagella are made of a protein named flagellin and there can also be fimbria made of pilin.)

In the fixation base of each cilium or flagellum in the plasma membrane there are proteins that work as molecular motors providing movement for these structures with energy spending. Due to this energy spending ciliated or flagellated eukaryotic cells have a large number of mitochondria.

In humans ciliated cells can be found, for example, in the bronchial and tracheal epithelium. In these tissues the cilia have the defensive function of sweeping mucous and foreign substances that enter the airways. Sperm cells are a typical example of flagellated cells, their flagellum is the propulsion equipment for the movement towards the ovule.

6. How does the amoeboid movement occur? What are examples of beings and cells that use such movements for locomotion?

Amoeboid movements are created by cytoplasmic movements and plasma membrane projections called pseudopods. Their formation actively changes the external shape of some portions of the cell surface making it move along a substratum. Pseudopods appear from differences of viscosity among neighboring regions of cytoplasm near the plasma membrane and from the contractile action of microfilaments.

Amoeboid movements occur, for example, in amoebas (a protozoan), organisms that use their movement to find food. The leukocytes, cells of the immune system, when attracted by chemical substances (immune mediators) use amoeboid movements to get out from capillaries in regions of tissue damage to participate in the inflammatory process.

7. What are some examples of movement created by the contraction of sarcomeres of the muscle cells?

The handling of a cup of coffee, the peristaltic movements of the bowels, the cardiac beats and even a smile are examples of movement created by contraction of the sarcomeres of the muscle cells. This contraction is a type of cell movement.

8. What is cyclosis?

Cyclosis is a type of internal cell movement in which an oriented flow of circulating material is created and maintained in the cytoplasm by the action of microfilaments. Cyclosis is more easily observed in plant cells.

Biology Questions and Answers

Cell Secretion

1. What is meant by cellular secretion?

Cell secretion is the elimination to the exterior of substances produced by the cell (for example, hormones, mucus, sweat, etc.)

2. Which cell organelles are well-developed in secretory cells?

In secretory cells, like the secretory cells of endocrine glands, organelles related to production, processing and "exportation" of substances are widely present and well-developed. These organelles are the rough endoplasmic reticulum and the Golgi apparatus.

The nuclear membrane of the secretory cells generally has more pores to allow the intense traffic of molecules related to protein synthesis between the cytoplasm and the nucleus.

3. How do the rough endoplasmic reticulum and the Golgi apparatus act in the production and releasing of proteins?

The rough endoplasmic reticulum has in its outer membrane numerous ribosomes, structures where translation of messenger RNA and protein synthesis occur. These proteins are stored in the rough endoplasmic reticulum and later they go to the Golgi apparatus. Within the Golgi apparatus proteins are chemically transformed and when ready they are put inside vesicles that detach from the organelle. These vesicles fuse with the plasma membrane (exocytosis) in the right place and its content is liberated outside the cell.

4. What are some examples of secretory cells?

Endocrine and exocrine pancreatic cells, thyroid and parathyroid endocrine cells, adenohypophysis, adrenal and pineal endocrine cells, the many types of gastric exocrine and endocrine cells, the mucus secretory cells of the lungs and of the bowels, the salivary gland cells, the lacrimal gland cells, the sebaceous gland cells, the secretory cells of the ovaries and testicles, etc., are all examples of secretory cells.

Biology Questions and Answers

Cell Digestion

1. What is extracellular digestion?

Extracellular digestion is that in which food breaking into utile molecules that can be internalized by the cell is done in the extracellular space, i.e., outside the cell. In extracellular digestion, the cells secret substances that break big molecules into smaller ones in the external environment. Later the cell can benefit from these products of digestion.

2. What is intracellular digestion?

Intracellular digestion, or cellular digestion, is the breaking in the interior of the cell of big molecules coming from outside or even from its own cell metabolism into smaller molecules. Products and residues of the intracellular digestion are used by the cell or excreted.

Intracellular digestion is classified into two types: heterophagic intracellular digestion and autophagic intracellular digestion.

3. What is the main cell organelle involved in cell digestion? What are the properties of that organelle that enable it to do the task?

The organelles responsible for intracellular digestion are the lysosomes. Lysosomes are vesicles that contain digestive enzymes capable of breaking big molecules into smaller ones. These vesicles fuse with others that carry the material to be digested and then digestion takes place.

4. What is heterophagic intracellular digestion? How is this process accomplished?

Heterophagic intracellular digestion is the breaking into smaller substances of external substances engulfed in the cell by pinocytosis or phagocytosis. Phagosomes or pinosomes fuse with lysosomes making the digestive vacuoles. Within the digestive vacuoles the molecules to be digested are hydrolyzed and the products of the digestion cross through the membrane and reach the cytoplasm or they are kept inside the vacuoles. The vacuole with residues from digestion is called residual body and by exocytosis it fuses with the plasma membrane and liberates its “waste” in the exterior space.

5. What is autophagic intracellular digestion? Why is this type of intracellular digestion intensified in an organism undergoing starvation?

Autophagic intracellular digestion is the cellular internal digestion of waste and residual materials. In general it is done by lysosomes.

Autophagic intracellular digestion is intensified in situations of starvation because in such condition the cell tries to obtain from its own constituent materials the nutrients necessary to stay alive.

6. What are some biological examples in which lysosomic enzymes play a fundamental role?

The remodelation of the osseous tissue, the function of acrosomes in sperm cells and the elimination of the tadpole tail are examples of biological processes in which lysosomic enzymes are key factors.

The bone is a tissue made of osteoblast-containing matrix (osteoblasts are the secretory cells of the osseous matrix), osteocytes (mature bone cells) and osteoclasts (the remodeling cells). Osteoclasts are responsible for the continual renovation of the osseous tissue since their lysosomic enzymes digest the osseous matrix.

The sperm acrosome, for carrying digestive enzymes within, is responsible for the perfuration of the egg cell membrane in the fertilization process. The acrosome, located in the anterior end of the sperm cell, is a specialized region of the Golgi apparatus that accumulates a great amount of digestive enzymes.

In tadpoles the tail regresses while the organism develops into an adult frog. This tissue destruction is a digestion of the tail's own cells and extracellular materials and it is made by lysosomes and their enzymes. The complete digestion of a cell by its own mechanisms is called autolysis, a type of apoptosis (cell suicide).

Biology Questions and Answers

Cell Nucleus

1. What are cells with a delimited nucleus called ? What are the main elements of the nucleus?

Cells with delimited nucleus are called eukaryotic cells. Organisms composed of one or more eukaryotic cells are called eukaryotes.

The mains elements of the nucleus are the chromatin (made of DNA molecules), the nucleolus, the karyolymph, or nucleoplasm, and the nuclear membrane (or karyotheca).

2. Do all eukaryotic cells have nucleus and only one nucleus?

There are eukaryotic cells without a nucleus and others with more than one nucleus. Osteoclasts, the cells responsible for resorption of the osseous matrix, for example, are multinucleate cells; striated muscle fibers are multinucleate too. Red blood cells are an example of enucleated specialized cells.

3. Of which substances is chromatin made?

Chromatin is made of DNA molecules associated to proteins called histones.

4. What are heterochromatin and euchromatin?

Chromatin is uncondensed nuclear DNA, the typical DNA morphology in interphase (the phase of the cell cycle in which the cells is not dividing itself). In this phase of the cell cycle chromatin can be found as heterochromatin, more condensed and dark (in electronic microscopy) portions of DNA molecules, and as euchromatin, less condensed and lighter portions of DNA molecules.

Since it is uncondensed the euchromatin is the biologically active portion of the DNA, i.e., the region that has active genes to be transcripted into RNA. The heterochromatin represents the inactive portions of the DNA molecule.

5. What is the relation between the concepts of chromatin and chromosome? Are euchromatin and heterochromatin part of chromosomes?

Every filament of chromatin is a complete DNA molecule (a complete double helix), i.e., a complete chromosome. A DNA molecule may form euchromatin and heterochromatin portions thus both are part of chromosomes.

Biology Questions and Answers

6. In the phase when the cell is not dividing (interphase) is there activity within the cell nucleus?

In the interphase there is intense metabolic activity in the cell nucleus: DNA is duplicating, euchromatin is being transcripted and RNA is produced.

7. How are the concepts of chromosome, chromatin and chromatids related? In which phase of the cell cycle does DNA duplicate?

Chromatin is a set of filamentous DNA molecules dispersed in the karyoplasm forming euchromatin and heterochromatin portions. Each chromatin filament is a complete chromosome (a DNA molecule, or double helix). The chromatin of the human somatic cell is formed by 46 DNA molecules (22 homologous chromosomes and 1 pair of sex chromosomes).

In interphase the cell prepares itself for division and duplication of DNA molecules occurs. The duplication of every DNA molecule forms two identical DNA double helix bound by a structure called centromere. In this phase each identical chromosome of these pairs is called chromatid. It is also during the interphase that the chromatids begin to condensate assuming the thicker and shorter shape typical of chromosome illustrations. So the phase of the cell cycle in which DNA duplicates is the interphase.

Some Biology textbooks call the chromosome a unique filament of chromatin as well as the condensed structure made of two identical chromatids after the DNA duplication. Rigorously the pair of identical chromatids bound in the centromere are two copies of the same chromosome and therefore they are two identical chromosomes (and not only one).

8. What is the structure that maintains identical chromatids bound?

The structure that maintains identical chromatids bound is the centromere.

9. How is the chromosome region where the centromere is located called? How are chromosomes classified in relation to the position of their centromere?

The chromosome region where the centromere is located is called primary constriction. In microscopic view this region is narrower (a stricture) than most part of the chromosome.

According to the position of the primary constriction the chromosomes are classified as telocentric, acrocentric, submetacentric or metacentric.

Biology Questions and Answers

10. What are the primary and the secondary constrictions of a chromosome? What is the other name given to the secondary constriction?

Primary constriction is the narrower region of a condensed chromosome where the centromere, the structure that unites identical chromatids, is located. Secondary constriction is a region similar to the primary constriction, narrower than the normal thickness of the chromosome too, and in general it is related to genes that coordinate the formation of the nucleolus and control the ribosomic RNA (rRNA) synthesis. For this reason the secondary contrictions (that can be one or more in chromosome) is called nucleolus organizer region (NOR).

11. What are homologous chromosomes? Which are the human cells that do not have homologous chromosomes?

Chromosomes contain genes (genetic information in the form of nucleotide sequences) that command the protein synthesis thus regulating and controlling the activities of the cell. In the nucleus of somatic cells of diploid beings every chromosome has its correspondent homologous chromosome, both containing alleles of the same genes related to same functions. This occurs because one chromosome of one pair comes from the father and the other comes from the mother of the individual. The chromosomes that form a pair with alleles of the same genes are called homologous chromosomes. In humans, there are 22 pairs of homologous chromosomes plus the pair of sex chromosomes (the sex chromosomes are partially homologous).

The only human cells that do not have homologous chromosomes are the gametes since during meiosis the homologous chromosomes are separated.

12. What is the difference between the concepts of karyotype and genome?

Genome is the set of DNA molecules that characterizes each living being or each species. The concept then includes the specific nucleotide sequence of the DNA molecules of each individual or species. Karyotype is the set of chromosomes of individuals of a given individual or species concerning morphology and number of each chromosome or pair of homologous.

13. Can two normal individuals of the same species with sexual reproduction have identical genomes and identical karyotypes? How is the human karyotype usually represented?

Except for clones (individuals created from nucleus transplantation, like the Dolly sheep) and monozygotic twins, it is very improbable the genomes of two individuals of the same species and

generated by sexual reproduction to be identical. Nevertheless the karyotypes of two normal individuals of the same species and of the same sex are always identical. The human normal karyotype is represented by the formula 44+XX for women and 44+XY for men.

14. What is the other name given to sex chromosomes? What is the function of sex chromosomes?

Sex chromosomes are also called allosomes (the other chromosomes that are not sex chromosomes are called autosomes).

Sex chromosomes get such name because they have genes that determine the sex (male or female) of an individual. Sex chromosomes also have genes related to other biological functions.

15. How many chromosomes does a human normal haploid cell have? How many chromosomes does a human normal diploid cell have? How many are the sex chromosomes within each of them?

The human haploid cell is the gamete (egg cell and sperm cell). The human gamete has 22 autosomes and 1 allosome, i.e., 23 chromosomes. The diploid cell is the somatic cell and it has 44 autosomes and 2 allosomes, i.e., 46 chromosomes.

Gametes have one sex chromosome and somatic cells have two sex chromosomes.

16. Do phylogenetically proximal species have cells with proximal chromosome counts?

The number of chromosomes typical of each species is proximal for phylogenetically proximal species (for example, orangutan, gorilla, chimpanzee and human). But it is not impossible that evolutionary distant species, like rat and oat, bears similar karyotypes and the same total number of chromosomes.

Even presenting equal number of chromosomes evolutionary distant species have radically different characteristics since the quantity and the sequence of nucleotides that compose their respective DNA molecules are quite different.

17. What is the nucleolus?

The nucleolus is a small and optically dense region in the interior of the cell nucleus. It is made of ribosomic RNA (rRNA) and proteins. One nucleus can have one or more nucleolus.

18. Of which structures is the nuclear membrane composed?

Biology Questions and Answers

Eukaryotic cells have nucleus delimited by two juxtaposed membranes that continue with the membrane of the endoplasmic reticulum. The nuclear membrane, or karyotheca, presents pores through which substances pass. There are also ribosomes adhered to its external surface.

Biology Questions and Answers

Cell Division

1. What is mitosis? What is the importance of mitosis?

Mitosis is the process in which one eukaryotic cell divides into two cells identical to the parent cell (generally identical, since alterations in genetic material can occur, more or less organelles may be distributed between the daughter cells, etc.)

Mitosis is fundamental for asexual reproduction of eukaryotes, for the embryonic development, for the growth of pluricellular beings and for tissue renewal.

2. Why in some cases is mitosis a synonym of reproduction?

In some living beings asexual reproduction occurs by many means: binary division, schizogony, budding, grafting, etc. In asexual reproduction of eukaryotes mitosis is the mechanism by which the constituent cells of the new beings are made.

The term mitosis does not apply to prokaryotes since it involves nuclear division and eukaryotic structures.

3. What is the importance of mitosis for the embryonic development?

Every embryo grows from a single cell that suffers mitosis and generates other cells that also divide themselves by mitosis forming tissues and complete organs. The perfect regulation and control of each of those cell divisions are fundamental for the creation of a normal individual. Without mitosis the embryonic development would be impossible.

4. What are some examples of organs and tissues where mitosis is more frequent, less frequent or practically absent?

Generally in vertebrates mitosis is more frequent in tissues that require intense renewing due to their functions, like epithelial tissues and the bone marrow. In plants the meristem tissue has numerous cells undergoing mitosis.

Mitosis take place with low frequency in tissues of slow renovation, like the bones in adults and the connective tissues.

In some adult tissues mitosis is almost absent, like the nervous tissue and the striated muscle tissue (skeletal and cardiac). The nervous tissue develops from stimulus by development of new electrical networks between cells and the striated muscle tissue grows by cellular hypertrophy.

Biology Questions and Answers

5. How does mitosis participate in the growth of pluricellular organisms?

All pluricellular beings grow with the increase in quantity of their cells. This increase is produced by mitosis (although some types of growth occur by cellular hypertrophy or by deposition of substances in interstitial spaces).

6. What is the uncontrolled mitotic process that occurs as disease in pluricellular beings called?

Uncontrolled mitotic cell division is called neoplasia. Neoplasia (the formation of new strange tissues) occurs when a cell suffers mutation in its genetic material, loses the ability to control its own division and the failure is transmitted to its descendants.

Cancers are malignant neoplasias. The term malignant means that neoplastic cells can disseminate to distant sites invading other organs and tissues. Neoplasias whose cells cannot disseminate to distant sites are called benign neoplasias.

7. Is the internal epithelium of the bowel the same as it was one month ago?

The internal epithelial covering of the intestine acts as protective barrier and also as means of nutrient absorption. The traffic of ingested material inside the intestinal lumen is very intense and the consequent tissue damage requires incessant epithelial renovation through cell division. The tissue renovation is completed in two to three days and is made by mitosis.

8. What is cellular regeneration? How is mitosis related to this process?

Some tissues are able to regenerate when injured. The liver, for example, regenerates when small pieces of hepatic tissue are removed, bones make new tissues in fracture regions, etc. Some animals, like planarias, are capable of regenerating their bodies when sectioned. In tissue regeneration cellular proliferation happens by mitosis.

9. What is cell cycle?

Cell cycle, or mitotic cycle, is the time period that begins when the cell is created and finishes when it is divided by mitosis creating two daughter cells. The cell cycle is divided into interphase and the mitotic phase.

10. Is cell division happening during the entire cell cycle? What is interphase?

Cell division properly occurs during the mitotic phase of the cell cycle. During interphase processes that are a preparation to cell division take place, like the duplication of DNA and centrioles. Interphase is the preceding

phase and the mitotic is the following phase.

11. What are the three periods into which interphase is divided?

Interphase is the preceding phase to the mitotic division. It is divided into three periods, G1, S and G2 (the letter G comes from "gap", meaning interval or breach, and the letter S comes from "synthesis", indicating the period in which DNA replicates).

In fact, "gap" is not totally appropriate for the periods immediately before and after the DNA synthesis. The idea of "growth" would be more adequate since in those periods (G1 and G2) the cell is growing to divide later in mitosis.

12. In general which phase of the cell cycle has longer duration?

The interphase comprises approximately 4/5 of the cell cycle and the mitotic phase has quite a shorter length.

13. What are the events that mark the beginning and the end of the first interphase period? What happens within the cell in this period?

The first interphase period is the G1. It begins with the end of the preceding cell division, i.e., with the formation of the new cell and it ends with the beginning of DNA replication. In the G1 period the cell is growing.

14. What are the events that mark the beginning and the end of the second interphase period? What happens in the cell in this period?

The second interphase period is the S. It starts with the beginning of DNA replication and finishes with the end of that process. The main event in this period is the synthesis of new polynucleotide chains, each bound to each DNA chain that served as a template, i.e., the duplication of the original set of DNA molecules.

15. What are the events that mark the beginning and the end of the third interphase period? What happens in the cell in this period?

The third interphase period is the G2. It begins with the end of DNA replication and ends with the beginning of the first period of the mitotic phase. On G2 the cell is growing too and the duplication of centrioles occurs (only in cells that have these structures).

Biology Questions and Answers

16. Does mitosis properly occur before or after the interphase? Is it a mere "point of view" issue?

Mitosis must be considered a succeeding phase after interphase since this is a preparation step to mitosis. Thus it is not merely a point of view issue.

17. Into which periods is mitosis divided?

Mitosis is divided into four periods: prophase, metaphase, anaphase and telophase.

18. What are centrioles? In which type of cell are they present?

Centrioles are tiny cylindrical structures made of nine microtubule triplets. They appear in pairs in the cell. Centrioles participate in the making of cytoskeleton and of cilia and flagella. In cell division they play a role in the formation of the aster fibers.

Centrioles are structures present in animal cells, in most protists and in some primitive fungi. There are no centrioles in cells of superior plants and in general it is considered that plant cells do not have centrioles (although this is not entirely correct since some plants have centriole-containing cells).

The region where the centrioles are located is called the centrosome of the cell.

19. What are the main events of the first mitotic period?

The first mitotic period is prophase. During prophase the following events occur: migration of each centriole pair (centrioles were duplicated in interphase) to opposite cell poles; aster formation around the centriole pairs; formation of the spindle fibers between the two centriole pairs; end of chromosome condensation; disintegration of the nucleolus; breaking of the karyotheca; dispersion of condensed chromosomes in the cytoplasm; binding of chromosomes to the spindle fibers.

20. What is the mitotic apparatus?

Mitotic apparatus is the set of aster fibers, radial structures around each centriole pair, plus the spindle fibers, fibers that extend across the cell between the two centriole pairs located in opposite cell poles. The mitotic apparatus appears in prophase and has important role in the orientation and gripping of chromosomes and other cellular elements causing them to separate and migrate to opposite cell poles.

Substances that disallow the formation of the mitotic apparatus, like colchicine, a molecule that binds to tubulin molecules and prevents the synthesis of microtubules, interrupt cell division. Colchicine is used to study chromosomes since it paralyzes mitosis when chromosomes are condensed and so are more easily viewed under the microscope.

Biology Questions and Answers

21. What are the main events of the second mitotic period?

The second mitotic period is metaphase. In metaphase the following events occur: condensed chromosomes bind (in their centromere region) to the spindle fibers and get concentrated in the middle of the cell; the formation of the mitotic apparatus is completed. Metaphase ends with the breaking of the binding of identical chromatids and then anaphase begins.

22. What are the main events of the third mitotic period?

The third mitotic period is anaphase. In anaphase the following events occur: duplication and breaking of centromeres with separation of identical chromatids; traction (by the spindle fibers) of identical chromatids each to opposite cell poles; beginning of chromosome decondensation.

23. During mitotic anaphase is there separation of homologous chromosomes or separation of identical chromatids?

In the anaphase of mitosis the identical chromatids separate and complete pairs of homologous chromosomes continue to exist in each daughter cell. The separation of the homologous chromosomes occurs in the anaphase of the cell division by meiosis.

24. What are the main events of the final mitotic period?

The final mitotic phase is telophase. In telophase the following events occur: decondensation of chromosomes, each set located in opposite cell poles; karyotecha formation around each set of chromosomes forming two nuclei; destruction of the mitotic apparatus; reappearing of the nucleoli; beginning of cytokinesis (the division of cytoplasm to ultimately separate the new cells).

25. What is the name of the cytoplasm division in the end of mitosis? What are the differences in this process between animal and plant cells?

Cytoplasm division occurs after telophase and it is called cytokinesis. In animal cells an invagination of the plasma membrane toward the cell center appears in the equator of the parent cell and then the cell is strangulated in that region and divided into two daughter cells. This type of division is called centripetal cytokinesis (from outside).

In plant cells the cytokinesis is not centripetal since the division happens from the inside. Membranous sacs full of pectin concentrate in the internal central region of the cell and propagate to the periphery toward the plasma membrane. The pectin-containing sacs fuse themselves and form a central structure called phragmoplast. On the phragmoplast cellulose deposition occurs and a true cell wall is created to

separate the daughter cells. Plant cells thus present centrifugal cytokinesis.

The phragmoplast has "failures", or pores, to permit cytoplasmic communications between the daughter cells. These openings are called plasmodesms.

26. Why is it important for chromosomes to be condensed during mitosis and decondensed during interphase?

During mitosis the main problem to be solved is the correct separation of chromosome sets between daughter cells. If chromosomes were decondensed long tiny fibers of DNA would be dispersed in cytoplasm after the karyotheca breaking and chromosomes could not be easily organized and pulled by the spindle fibers.

During interphase the function of chromosomes, i.e, of DNA molecules, is the synthesis of RNA and thus of proteins. For this task it is necessary for functional molecular regions to be decondensed (these regions form the euchromatin). During interphase in addition DNA replication occurs as a preparatory step for cell division. In this process it is fundamental for the exposition of DNA molecules to serve as templates to new DNA chains under production.

27. How does the quantity of genetic material vary within the cell during the sequential phases of the cell cycle?

The first period of the first phase (interphase) of the cell cycle is the G1, followed by S and G2 and then by the mitotic phase.

In G1 the ploidy (the quantity of DNA molecules in the cell) can be represented by the formula 2n (n is the number of DNA molecules in a gamete cell of a given species). In S DNA duplicates and the quantity of genetic material increases from 2n to 4n. In G2 that quantity is constant: 4n. After the mitotic phase the quantity of genetic material decreases to 2n in each daughter cell.

28. What are the differences between astral and anastral mitosis?

Astral mitosis is that in which there is formation of the aster, a structure made by the centrioles. Anastral mitosis is that in which there is no formation of the aster; it occurs in cells without centrioles, like plant cells (superior plants).

29. Can mitosis occur in haploid (n) cells? And in triploid cells?

The mitotic cell division can occur in haploid (n) cells, diploid (2n) cells, triploid (3n) cells, etc. Mitosis is a

copying process that does not interfere with cell ploidy.

30. Concerning their final products (daughter cells and their ploidies) what are the differences between mitosis and meiosis?

In mitosis one cell, for example, with 2n chromosomes, duplicates its chromosomal set and divides generating two other cells, each with 2n chromosomes too. In meiosis, one diploid cell (2n) duplicates its chromosomes too, but four cells with n chromosomes are generated.

31. Concerning their biological function what is the difference between mitosis and meiosis?

The main biological function of mitosis is cellular multiplication, a fundamental process for the growth and development of multicellular organisms, tissue renewing, asexual reproduction, etc. The biological function of meiosis is gamete formation (in gametic meiosis) or spore formation (in sporic meiosis), i.e., the production of cells qualified for sexual reproduction with half the quantity of chromosomes compared to the original cell.

There is a special type of meiosis that happens in zygotes of some algae, protozoans and fungi. This meiosis, called zygotic meiosis, has the function of reducing to a half the number of chromosomes of adult individuals that will be formed from the zygote. In species with zygotic meiosis the adult individuals are haploid and they form gametes by mitosis. These gametes fuse in pairs with others and generate a diploid zygote that, then, undergoes meiosis to restitute the normal ploidy of adult individuals.

32. For the biological diversity is mitosis or meiosis the more important process?

Meiosis is the cell division process that allows the formation of gametes to sexual reproduction, with aleatory separation of each chromosome of the individual homologous pairs. These gametes can fecundate gametes from other individuals promoting combination of homologous chromosomes from different individuals. In that manner the chromosomal recombination provided by meiosis and sexual reproduction creates individuals with dissimilar genetic patrimony from their fathers and thus promotes biological diversity.

Some fungi species and plants, for example, present sporic meiosis, i.e., a structure where half of the chromosomes of the species is generated from meiosis. This structure, by mitosis, forms gametes. Even in this case diversity comes from meiosis. Meiosis then is the cell division process that in conjunction with genetic mutations is responsible for the biological diversity.

Even in species having zygotic meiosis the aleatory separation of homologous chromosomes in meiosis creates biological diversity.

33. What are the respective ploidies of gamete, zygote and somatic cells in a species with gametic meiosis?

Adopting as pattern an "x" quantity of chromosomes for gametes, zygotes will have 2x chromosomes and somatic cells will have 2x too.

34. Why is meiosis important for the maintenance of the normal quantity of chromosomes of a species with sexual reproduction?

A reduction to a half of the maximum normal quantity of chromosomes is mandatory in some phase of the life cycle of a species that reproduces sexually. If that could not happen in each generation, whenever a zygote is formed by fusion of gametes there would be duplication in the quantity of chromosomes in a geometric progression.

35. What is the difference between sexual spores and gametes? Do humans present sexual spores or gametes?

Sexual spores are structures generated from meiosis with ploidy (number of chromosomes) reduction to a half compared to the spore mother cell. Spores germinate and give existence to gametophytes, individuals that by mitosis form gametes. The meiosis that generates sexual spores is called sporic meiosis; it is, for example, the type of meiosis that occurs in plants.

Gametes are also cells with half the number of chromosomes of the normal cell of the species, but they are specialized in fecundation, the fusion with another gamete that generates the zygote, a cell with double the number of chromosomes than gametic cells. Gametes can appear from gametic meiosis or by mitosis in gametophytes originated from sexual spores.

In humans as well in most animals the meiosis is gametic. There are no spores nor alternation of generations. The male gamete is the sperm cell, and the female gamete is the egg cell.

36. Is the interphase of meiosis different from the interphase of mitosis?

The interphase that precedes meiosis is similar to the interphase that precedes mitosis. In them the main event is DNA replication (chromosome duplication).

37. What are the two divisions of meiosis? What are the main events that occur in those divisions?

Meiosis is divided into first meiotic division, or meiosis I, and second meiotic division, or meiosis II. During meiosis I the separation of homologous chromosomes occurs, with formation of two haploid cells. In meiosis II there is separation of identical chromatids of

each of the two haploid cells created in meiosis I, giving birth to four haploid cells.

Meiosis II is a process identical to mitosis.

38. In which meiotic division does the separation of the homologous occur? What are the ploidies of the generated cells after the end of that process?

The separation of the homologous chromosomes occurs in the first division of meiosis, or meiosis I. After the end of this cell division two haploid cells are made, each having different chromosomes (with no set of homologous). Note that in the cells generated after meiosis I each chromosome is still duplicated since the homologous chromosomes and not the identical chromatids were separated.

39. In which meiotic division does the separation of identical chromatids occur? After the end of this process what are the ploidies of the new cells?

The separation of identical chromatids occurs in the second meiotic division, or meiosis II. After this cell division (similar to mitosis and that does not alter ploidy) the cells are still haploid (they have become haploid after meiosis I).

40. How many cells are made after meiosis I and meiosis II?

After meiosis I two cells with already separated homologous are created. After meiosis II four cells are created.

41. What are the periods of the first meiotic division?

Meiosis I is divided into prophase I, metaphase I, anaphase I and telophase I.

42. In which period of meiosis does the pairing of homologous chromosomes occur?

The pairing of homologous chromosomes is a vital step for meiosis because the rightness of the homologous separation depends on the process. This event occurs in prophase I of the cell division.

43. What is crossing over? In which period of meiosis does this event occur?

Crossing over is the eventual exchange of chromosomal fragments between homologous chromosomes. The phenomenon occurs in prophase I when homologous chromosomes are paired. Crossing over is of great importance for evolution and biodiversity since it

provides recombination of alleles (of different genes) linked in the same chromosome during cell divison by meiosis.

44. What are the "chiasms" of homologous chromosomes seen in prophase I?

Chiasms are intersections of two tracts in the form of X.

The chiasms seen in prophase I are chromosome arms crossing over same arms of their homologous. In fact when chiasms are seen under the microscope chromatids are exchanging chromosomal segments with other chromatids of its homologous.

45. Is there interphase again between meiosis I and meiosis II?

There is no interphase nor DNA duplication between the divisions of meiosis. Only a short interval called diakinesis occurs.

46. What are the periods of the second meiotic division?

Meiosis II is divided into prophase II, metaphase II, anaphase II and telofase II.

47. What are the respective functions of the separation of homologous chromosomes and of the separation of identical chromatids in meiosis?

The separation of homologous chromosomes in meiosis I has two main functions: to reduce to a half the total number of chromosomes, generating haploid daughter cells at the end of the process, and to make possible genetic recombination since the separation is aleatory, i.e., each pair of daughter cells can be different from the other pair relating chromosomal combination from paternal and maternal origins. (And if crossing over is considered each of the four resulting cells can be different from the others.)

The separation of identical chromatids in meiosis II has the same function it has in mitosis: to separate the chromosomes already duplicated to the daughter cells.

48. During which meiosis division does ploidy reduction occur? Does ploidy reduction occur in mitosis?

In the cell division by meiosis ploidy reduction occurs in meiosis II. Initially, taking as example a 2n somatic cell, ploidy increases to 4n (duplication of DNA) during interphase. During meiosis I, since homologous chromosomes are separated, ploidy falls to 2n (the original number) and then during meiosis II ploidy finally falls to n in the resulting daughter cells.

Ploidy reduction does not occur in mitosis. This fact shows that, although in meiosis ploidy is decreased from its original number, in meiosis II, a process similar to mitosis, the cause of that reduction is what happens in meiosis I, i.e., the separation of the homologous chromosomes.

Biology Questions and Answers

Photosynthesis

1. What is the primary source of energy for living beings on earth?

The sun, center of our planetary system and star of the milky way galaxy (our galaxy), is the source of the energy that is processed and consumed by living beings. Intense nuclear reactions in the sun liberate light and other energetic radiations into the surrounding space. Some of this energy reaches our planet.

2. How is light from the sun transformed into chemical energy to be used by the living beings on earth?

Light from the sun is transformed into chemical energy contained in organic material by the photosynthesis process. In photosynthesis light, water and carbon dioxide react and highly energetic glucose molecules and molecular oxygen are made.

3. What is the chemical equation of photosynthesis?

The chemical equation of photosynthesis is the following:

$6\ CO_2 + 6\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6\ O_2$

4. Which are the living beings that carry out photosynthesis? Which is the cell organelle responsible for the absorption of light for the photosynthesis process in plants and algae?

There are many beings (including all animals) that do not carry out photosynthesis. There are also autotrophic beings that do not perform photosynthesis but they perform chemosynthesis. Plants, algae and cyanobacteria are photosynthetic beings.

In plants and algae, light is absorbed by chlorophyll, a molecule present in cytoplasmic organelles called chloroplasts.

5. Are there chloroplasts in cyanobacteria?

In cyanobacteria there are no chloroplasts and the chlorophyll layers are dispersed in cytosol.

6. Which chemical element is central in the chlorophyll molecule?

The chemical element that is central in the chlorophyll molecule is magnesium. One atom of magnesium is present in the center of an amalgam of eight nitrogen-containing carbon rings.

Biology Questions and Answers

7. How do chloroplasts multiply?

Like mitochondria chloroplasts have their own DNA, RNA and ribosomes and they self-replicate through binary division.

8. How can the hypothesis that asserts that chloroplasts as well as mitochondria were primitive prokaryotes that associated in mutualism with primitive anaerobic eukaryotic cells be corroborated?

The described hypothesis is known as the endosymbiotic hypothesis about the evolutionary origin of mitochondria and choloroplasts.

Mutualism is explained as: mitochondria and chloroplasts can offer energy and nutrients to the cell in exchange for protection. The hypothesis is strengthened since those organelles have their own DNA, RNA and protein synthesis machinery and they divide themselves through binary division like bacteria do.

9. What are the main structures of chloroplasts?

Chloroplasts are involved by two membrane layers, the outer and the inner membranes. Inside the organelle the formative unit is called the granum, a coin-shaped structure that, piled with others grana, forms several structures called thylakoids. The thylakoids fill the chloroplast and an intergrana membrane permeates the interior of the organelle.

10. In which chloroplast structure are chlorophyll molecules found?

Chlorophyll molecules are placed in an organized manner in order to enhance the exposure to light on the thylakoid surfaces.

11. What do ATP and ADP mean? What are the roles of these molecules for the cellular energetic metabolism?

ATP is an abbreviation of adenosine triphosphate, a molecule made of adenosine bound to three inorganic phosphates. ADP is an abbreviation of adenosine diphosphate, two molecules of phosphate bound to adenosine. ATP is a molecule that stores energy for the cell. When ATP hydrolyzes and becomes ADP energy is liberated and then consumed by several metabolic reactions of the organism.

12. What is ADP phosphorylation? What respectively are photophosphorylation and oxidative phosphorylation?

ADP phosphorylation is the addition of one inorganic phosphate in the molecule of adenosine diphosphate thus creating ATP (adenosine triphosphate) and incorporating energy. The phosphorylation is oxidative when the energy incorporated comes from the breaking of organic molecules having oxygen as reagent, as in aerobic cellular respiration. The reaction is called photophosphorylation when the energy source is light, as in photosynthesis.

The energy incorporated into ATP is disposable (liberated) to other cellular reactions when ATP hydrolyzes and ADP is formed again.

13. What are the stages into which photosynthesis is divided?

Photosynthesis is divided into the photochemical stage, or light reactions, and the chemical stage.

14. What are the processes of the photochemical stage of the photosynthesis process?

Photolysis of water, with liberation of molecular oxygen, and photophosphorylation of ADP, with production of ATP and NADPH, are the processes that occur during the photochemical stage of photosynthesis.

15. How is the photic energy absorbed by chlorophyll transfered to ATP molecules in photophosphorylation? How will be the resulting ATP used?

Light excites chlorophyll and energizes electrons that jump off the molecule. The energy liberated when these electrons escape is used in the phosphorylation of ADP, forming ATP. The enzyme that catalyzes the reaction is the ATP synthase.

The resulting ATP is then consumed in the next chemical stage of photosynthesis to energetically enrich carbon dioxide for the formation of glucose.

16. Is it correct to consider water decomposition by the action of light the basis of the photosynthesis process?

Besides ADP photophosphorylation, photic energy is also responsible for the breaking of water molecules during photosynthesis in a process known as water photolysis. In this reaction water molecules are exposed to photic energy and liberate protons (hydrogen ions), highly energetic electrons and molecular oxygen (O_2). Later the hydrogen atoms will be incorporated into carbon dioxide molecules to form glucose. Since water is the hydrogen donor for photosynthesis it is correct to say that the water photolysis is the basis of the process.

Biology Questions and Answers

17. What are the chemical substances produced by water photolysis? What is the destination of each of those substances?

Free electrons, hydrogen ions and molecular oxygen are liberated, after the water photolysis.

The electrons will replace those electrons lost by chlorophyll molecules in photophosphorylation. The hydrogen ions will be incorporated into hydrogen acceptor molecules (NADP) and later will be used in the synthesis of glucose during the chemical stage. Molecular oxygen is liberated to the atmosphere.

18. In sulfur photosynthetic bacteria what is the molecule that donates hydrogen for photosynthesis?

In sulfur photosynthetic bacteria the substance that donates hydrogen is hydrogen sulfide (H_2S) and not water. Therefore there is no liberation of molecular oxygen but there is production of molecular sulfur (S_2). (Oxygen and sulfur have same number of valence electrons.)

19. Why is it said that during photosynthesis carbon dioxide is enriched to form glucose?

During photosynthesis carbon dioxide is energetically enriched with hydrogen from water. Water broken by photolysis is the hydrogen donor of the reaction. Glucose is made of carbon and oxygen atoms obtained from carbon dioxide and of hydrogen atoms obtained from water.

20. What is the complete chemical equation of photosynthesis?

The complete chemical equation of photosynthesis is the following:

$6\ CO_2 + 12\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6\ H_2O + 6\ O_2$

21. What is an example of a lab experiment that shows the variation of the photosynthesis efficiency in relation to different photic energy frequencies to which the reaction is exposed? Was it expected that green light frequency favored the reaction?

The experiment: Plants of same species and ages are placed each under (respecting their photoperiods) light sources emitting only one of the colors of the light spectrum (violet, anil, blue, green, yellow and red). The experiment is executed with each of the colors and after days each plant's development is compared. Those plants whose development was normal performed satisfactory photosynthesis while those with abnormal development underused the offered light.

Chlorophyll is green because it reflects the green light frequency, i.e., it does not "use" the green range of the electromagnetic spectrum. Thus green light does not favor photosynthesis (curiously green is the light that plants "dislike").

22. What are the divisions of white light according to the electromagnetic spectrum? Which are the two most efficient colors for photosynthesis?

The color divisions of the electromagnetic spectrum in decreasing order of frequency are: red, orange, yellow, green, blue, anil and violet. When mixed together these colors generate white.

Experimentally it is verified that the most useful colors for photosynthesis are blue and red.

23. What is NADP and NADPH?

NADP is the abbreviation of the nicotinamide adenine dinucleotide phosphate cation, a hydrogen acceptor. NADPH is made when NADP binds to one hydrogen atom and it is the form that actually transports hydrogen.

24. Photosynthesis is the most important producer of molecular oxygen (O_2) on our planet. From which molecule do oxygen atoms liberated by photosynthesis come? From which other molecule could one suspect they have come? What are the destinations of those oxygen atoms?

The oxygen atoms liberated as molecular oxygen by the photosynthesis process come from water.

One indeed could suspect that those oxygen atoms would have come from carbon dioxide. Oxygen atoms from carbon dioxide however are incorporated into glucose molecules and into water molecules liberated in the chemical stage of photosynthesis.

25. Where do the photochemical and the chemical stages of photosynthesis occur?

The photochemical stage of the photosynthesis process occurs mainly on the thylakoids (the green part) and the chemical stage occurs in the stroma (the colorless framework) of the chloroplasts.

Biology Questions and Answers

26. Which are the subproducts of the photochemical stage that are essential for the chemical stage of photosynthesis?

The chemical stage of photosynthesis depends on NADPH and ATP produced in the "light reactions" (photochemical stage).

27. What are the roles of NADPH and ATP in the chemical stage of photosynthesis?

NADPH acts as reductant of carbon dioxide, it delivers highly energetic hydrogens to precursor molecules during the glucose formation process. ATP is an energy source for the reactions of chemical stage.

28. Why is the nickname "dark reactions" not entirely correct for the chemical stage of photosynthesis?

"Dark reactions" is not a correct name for the chemical stage of photosynthesis since the reactions of the chemical stage also occur in the presence of light.

29. What is the general chemical equation of photosynthesis? Why doesn't that equation clearly show the real origin of the molecular oxygen liberated?

The general equation of photosynthesis is:

$6\ CO_2 + 6\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6\ O_2$.

Water molecules are also produced in the chemical stage of photosynthesis as the following complete equation reveals:

$6\ CO_2 + 12\ H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6\ H_2O + 6\ O_2$

Water molecules are present in the reagent side as well in the product side of the equation. Pure mathematical simplification of stoichiometric coefficients however leads to elimination of water from the product side and it then seems that 6 molecules of molecular oxygen (O_2), i.e., 12 atoms of oxygen, are made for each 6 molecules of water, i.e., 6 oxygen atoms, in the reagent side. Thus a false impression that 6 other oxygens come from carbon dioxide is created.

30. What are the three main limiting factors of photosynthesis?

The three main limiting factors of photosynthesis process are light intensity, carbon dioxide concentration and temperature.

Biology Questions and Answers

31. Photosynthesis rate varies according to the photic energy intensity. Does the same occur in aerobic respiration? What happens to the glucose balance as a result of these variations?

In a photosynthetic being the aerobic respiration rate can be superior, inferior or equal to the photosynthesis rate. Respiration rate depends on the energetic needs of the plant while the photosynthesis rate varies, as other conditions are maintained, with the variation of light energy.

In a situation in which the respiration rate is greater than the photosynthesis rate glucose consumption is higher than glucose production. In a situation in which the respiration rate is lower than photosynthesis rate there is accumulation of glucose (positive balance). In a situation in which the rates are equal all molecular oxygen produced by the photosynthesis process is used in respiration and all carbon dioxide liberated by respiration is consumed in photosynthesis and so there is no positive balance of glucose nor depletion of carbohydrate stores.

32. What is the compensation point? What is the implication of the compensation point for the plant growth?

The (photic) compensation point is the photic energy intensity under which aerobic respiration rate equals photosynthesis rate. In this situation all produced glucose is consumed and there is no incorporation of material into the plant and thus the plant growth discontinues.

33. Why is the carbon dioxide concentration a limiting factor of the photosynthesis process? When the carbon dioxide concentration is increased indefinitely is photosynthesis also increased indefinitely?

The availability of carbon dioxide is a limiting factor for the photosynthesis process because this gas is a reagent of the reaction.

Since enzymes catalyze the building of organic molecules with carbon atoms from carbon dioxide photosynthesis stops as soon as these enzymes become saturated, i.e., when all their activation centers are bound to their substrates. In that situation an increase of the carbon dioxide concentration will not increase the photosynthesis rate.

34. Why do some trees lose their green color in the autumn?

In autumn days become shorter and nights longer thus there is a reduction of the photosynthesis rate and some plants prepare themselves for the winter making nutrient stores. In this process, nutrients from the leaves travel towards storage sites: limbs, trunk and roots. With less chlorophyll produced in leaves the typical green color of the plant fades.

Biology Questions and Answers

Cell Respiration

1. How do cells obtain energy for their functioning?

Cells obtain energy for their metabolic reactions from the breaking of organic molecules with high energetic content. This energy is mostly stored as ATP molecules.

The process of obtaining energy in order to produce ATP molecules is named cellular respiration.

2. What is the compound that is phosphorylated for ATP formation? What is the resulting compound when ATP liberates energy?

ATP, or adenosine triphosphate, is formed after the binding of one phosphate (phosphorylation) to one ADP (adenosine diphosphate) molecule. This is a process that stores energy into the produced ATP molecule.

When ATP gives energy to the cellular metabolism it loses one of its phosphates and ADP reappears.

ADP can also lose more phosphates and generate AMP (adenosine monophosphate) or even non-phosphorylated adenosine. Adenosine production from ATP is a solution used in tissues that need urgent oxygen supply, for example, in the heart during myocardial infarction (heart attack), since adenosine has a local vasodilator effect thus providing faster vasodilation than other physiological methods.

3. What are the types of cell respiration?

There are two types of cell respiration: aerobic cell respiration, a reaction with participation of molecular oxygen (O_2), and anaerobic cell respiration, without participation of molecular oxygen but with other inorganic molecules as oxidant. There are several varieties of anaerobic cell respiration, the main one is fermentation.

4. Under which conditions do aerobic cells carry out fermentation?

Some cells that usually obtain energy from aerobic cellular respiration can carry out fermentation when oxygen is not available.

There are bacteria and fungi that under absence of oxygen use their anaerobic metabolic capability for energetic supply. Muscle cells carry out fermentation too when oxygen is scarce.

5. What is the difference between aerobic and anaerobic beings?

Aerobic organisms are those whose cells do not survive without oxygen since

they depend on aerobic cell respiration to obtain energy for ATP production. Anaerobic organisms are those that live or can live under oxygen-lacking environments.

6. What is the difference between facultative anaerobic beings and obligate anaerobic beings?

Facultative anaerobic beings, like the fungi Saccharomyces cerevisiae, a brewing yeast, can survive under oxygen-poor environments carrying out fermentation. However when oxygen is available these beings carry out aerobic respiration.

Obligate anaerobic beings are those that cannot survive when oxygen is present. Some fungi, some bacteria (like the agent of botulism Clostridium botulinum, and the agent of tetanus, Clostridium tetani) and some protozoans are examples of obligate anaerobes.

7. What are the two types of fermentation? What are their chemical equations?

The two main types of fermentation are alcoholic fermentation and lactic fermentation.

In alcoholic fermentation pyruvic acid, an intermediate molecule, is converted into ethanol with liberation of carbon dioxide. The alcoholic fermentation equation is as follows:

$C_6H_{12}O_6 + 2\ ADP + P \rightarrow 2\ C_2H_5OH + 2\ CO_2 + 2\ ATP$

In lactic fermentation pyruvic acid is transformed into lactic acid and there is no production of carbon dioxide. The lactic fermentation equation is:

$C_6H_{12}O_6 + 2\ ADP + P \rightarrow 2\ C_3H_5OOH + 2\ ATP$

8. In general what are the reagents and products of fermentation?

In fermentation glucose (sugar) is degraded into pyruvic acid (each glucose molecule forms two pyruvic acid molecules). In this process two molecules of ATP are produced.

According to the type of fermentation, pyruvic acid can produce ethanol and carbon dioxide (in alcoholic fermentation) or lactic acid (in lactic fermentation). There are other varieties of fermentation in which pyruvic acid can generate acetic acid (acetic fermentation), propionic acid, isopropanol (an alcohol too), etc. The type of fermentation depends on the species of the involved organisms.

9. Why in cake and bread manufacture are alcoholic fermenting organisms used and not lactic fermenting organisms?

Fermentation has the function of making cakes and breads grow. This is

accomplished by liberation of carbon dioxide in alcoholic fermentation as the gas passes through the dough and makes it grow. In lactic fermentation there is no liberation of carbon dioxide and the desired result would not be obtained.

10. To what substance is the acidic flavor of fermented milk due?

Some bacteria ferment milk lactose by lactic fermentation producing lactic acid. This product is responsible for the acidic flavor of yogurts, curd and milk.

11. How can the knowledge about fermentation explain the origin of muscle cramps and pains after intense physical exertion?

A typical fermentation process due to oxygen scarcity happens in the muscle tissue. Under intense use muscles demand too much energy (ATP) and consume much more oxygen to produce that energy. High consumption leads to oxygen scarcity and the muscle cells begin to make lactic fermentation trying to satisfy their energetic needs. In this situation muscle pain, cramps and fatigue are due to the lactic acid released by fermentation.

12. How many ATP molecules are produced for each glucose molecule used in fermentation? How many ATP molecules are produced for each glucose molecule used in aerobic respiration?

In fermentation from one glucose molecule two ATP molecules are produced. In aerobic respiration, a much more productive process, from one glucose molecule 36 ATP molecules are made.

13. Which is the cell organelle that is specialized in aerobic respiration?

The cell organelles that are specialized in aerobic respiration are the mitochondria.

14. Of which main compounds is the mitochondrion structure made?

Mitochondria are organelles delimited by two lipid membranes. The inner membrane invaginates to the interior of the organelle forming cristae and delimiting an internal space known as the mitochondrial matrix.

Biology Questions and Answers

15. What are the three phases into which the cell respiration is divided?

The three phases of aerobic cell respiration are glycolysis, Krebs cycle and respiratory chain (also known as the electron transport chain).

16. What is glycolysis? What are the products of this process?

Glycolysis, the first stage of the aerobic cell respiration, is a process in which glucose is degraded (broken) to form two pyruvic acid molecules along with the formation of two ATP and two NADH.

Glycolysis is a complex reaction implying the formation of several intermediate molecules until pyruvic acid molecules are made. Although two ATP molecules are consumed in the reaction, there is also production of four molecules of ATP, thus a positive balance of two ATP molecules is obtained. Two NADH molecules are also produced. In glycolysis the 6-carbon structure of glucose is broken and two organic chains of three carbons each are made; these chains give birth to two pyruvic acid molecules.

17. Does glycolysis occur within the mitochondria?

Glycolysis happens in the cytosol and not within the mitochondria. Pyruvic acid molecules later enter mitochondria to participate in the next phase of the aerobic cell respiration.

18. How many ATP molecules are made after glycolysis?

Glycolysis is a process similar to glucose degradation in fermentation. It produces (final balance) two molecules of ATP for each broken glucose.

19. What is NAD? What is the role of the NAD molecule in glycolysis?

NAD (nicotinamide adenine dinucleotide) is a hydrogen acceptor necessary as reductant (to receive hydrogen) in some reactions in which it is reduced and converted into $NADH_2$. During glycolysis two NAD molecules retrieve hydrogens liberated after an intermediate reaction thus forming $NADH_2$.

20. What happens during aerobic respiration to the pyruvic acid molecules made by glycolysis? What is the sequence of reactions that then follows?

The pyruvic acid molecules made in cytosol by glycolysis enter into the mitochondria.

Within the mitochondria each pyruvic acid molecule is converted into one molecule of acetyl-CoA (acetyl

coenzyme A) with liberation of one carbon dioxide. The Krebs cycle (also known as citric acid cycle), the second stage of aerobic respiration, then begins.

21. What is the official name of pyruvic acid?

Pyruvic acid is 2-oxopropanoic acid. It is thus a molecule made of three linearly bound carbons with one extremity forming the organic acid function (COOH) and the middle carbon binding to an oxygen atom by double bond.

22. Why can it be said that each glucose molecule runs the Krebs cycle twice?

Each glucose molecule "cycles" the Krebs cycle twice because after glycolysis each used glucose has generated two pyruvic acid molecules and each pyruvic acid is converted in a 1:1 proportion into acetyl CoA. Each acetyl CoA then cycles the Krebs cycle once.

23. Why is the Krebs cycle also called the final common pathway of the degradation of organic compounds?

The Krebs cycle is called the final common pathway of the degradation of organic compounds because it is also possible to generate acetyl CoA from the degradation of lipids and proteins.

Since acetyl CoA is the substrate that triggers the Krebs cycle, this process is called the final common pathway for being activated by other organic molecules (lipids and proteins) and not only by glucose.

The organism uses energetic reserves of fat and proteins to cycle the Krebs cycle when undergoing malnutrition or when there is no glucose available for the cells.

24. What are the final energetic products of each round of the Krebs cycle? Where is most part of the utile energy at the end of Krebs cycle found?

After each round of the Krebs cycle two carbon dioxide molecules, eight protons (hydrogen ions) captured by NAD and FAD (a hydrogen acceptor too) and one ATP molecule are produced.

During the Krebs cycle acetyl CoA is degraded. At the end the utile energy is incorporated into hydrogens transported by $FADH_2$ and $NADH_2$ molecules.

25. How many carbon dioxide molecules are liberated after each cycle of the Krebs cycle? For a single glucose how many carbon dioxide molecules were already liberated by the aerobic respiration at that point?

Each round of the Krebs cycle liberates two carbon dioxide molecules.

At the end of the cycle all carbon atoms from the original glucose molecule degraded in glycolysis are already liberated incorporated into carbon dioxide molecules. That occurs because for each glucose two pyruvic acid molecules were made by glycolysis. Each of these two pyruvic acids then is converted into acetyl CoA with liberation of one carbon dioxide molecule (two in total). Since each of the two produced acetyl CoA cycles the Krebs cycle once, from the initial glucose two rounds of the Krebs cycle is generated and so four other carbon dioxide molecules are made.

All of the six carbons of the glucose molecule are then incorporated into six carbon dioxide molecules (two made during acetyl CoA formation and four during the two cycles of the Krebs cycle).

26. Where in mitochondria does the process called respiratory chain occur? Which are the products of the Krebs cycle used in that final phase of the aerobic respiration?

Respiratory chain, or the electron transport chain, is performed by protein systems located in the inner membrane of the mitochondria. Energized electrons of hydrogen atoms transported by $NADH_2$ and $FADH_2$ are the products of the preceding phases used in the respiratory chain.

27. What are cytochromes?

Cytochromes are proteins of the internal mitochondrial membrane that are specialized in electron transfer and participate in the respiratory chain. Energized electrons liberated by the hydrogen donors $NADH_2$ and $FADH_2$ (then reconverted into NAD and FAD) pass through a sequence of cytochromes losing energy in each passage. The energy is then used in the synthesis of ATP.

28. How in the respiratory chain do electrons from $FADH_2$ and $NADH_2$ passing through cytochromes liberate energy for the ATP synthesis? What is this ATP synthesis called?

$FADH_2$ and $NADH_2$ oxidate into FAD and NAD and liberate hydrogen ions and highly energized electrons in the beginning of the respiratory chain.

The energy lost by electrons that pass through the cytochromes is used to pump protons (hydrogen ions) out of the inner mitochondrial membrane (to the region between the inner and the outer membranes of the mitochondrion). Hydrogen concentration gradient between the inner and the outer spaces delimited by the inner membrane forces protons (hydrogen ions) to return to the mitochondrial matrix (the region inside the inner membrane) however that return is only possible if hydrogen ions pass through an enzymatic complex called ATP synthetase embedded in the inner membrane. In that passage the ATP

synthetase phosphorylates ADP and then ATP molecules are produced.

Hydrogen liberated in the mitochondrion then combines with oxygen to form water. As a reaction that depends on oxygen this type of ATP synthesis is called oxidative phosphorylation.

29. Until the Krebs cycle, aerobic respiration can be described without mentioning oxygen, the chemical element after which the reaction gets its name. Where in the process does this chemical element take part? What is its importance?

Oxygen enters the aerobic respiration in its final phase, the respiratory chain. It is of fundamental importance because it is responsible for the maintenance of the hydrogen concentration gradient between the spaces separated by the inner mitochondrial membrane. This gradient promotes the functioning of the ATP synthetase and thus the phosphorylation of ADP to form ATP. In the space inside the inner membrane oxygen binds to free hydrogens to form water and this hydrogen consumption keeps the hydrogen gradient and the proton traffic through the ATP synthetase.

The entire aerobic respiration process has the intent to make the ATP synthetase work. Aerobic beings, for example, we humans, need to breathe oxygen to maintain that hydrogen concentration gradient and keep the ATP synthetase working.

30. How does the poison cyanide act upon the aerobic respiration?

Cyanide is a poison that inhibits the last cytochrome of the respiratory chain, interrupting the ATP formation and thus leading the cell to death.

31. What is anoxia?

Anoxia is a situation in which there is no available oxygen in the cell. Whitout oxygen the respiratory chain stops, there is no ATP production, the cell does not obtain energy and dies.

Anoxia can be caused, for example, by pulmonary insufficiency (drowning, extensive pulmonary injuries, etc.), by obstructions, halts and deficiencies in tissue circulation (atherosclerosis of the coronary arteries that irrigate the myocardium, tourniquets, heart arrest), by hemolysis (lysis of red blood cell) or hemoglobin diseases (anemias, fetal erythroblastosis), etc.

32. How many ATP molecules are made after the aerobic respiration and what is the net energetic gain of the process?

After aerobic respiration 38 ATP molecules are made with the consumption of one glucose molecule (but two of these ATP are consumed by glycolysis). The net gain of the process is then 36 ATP molecules per glucose molecule.

33. What is the general equation of the aerobic respiration (also representing ADP and phosphate)?

The general equation of the aerobic respiration is:

$C_6H_{12}O_6 + 6\ O_2 + 36\ ADP + 36\ P \rightarrow 6\ CO_2 + 6\ H_2O + 36\ ATP$

34. Why can the consumption of molecular oxygen indicate the metabolic rate of aerobic organisms?

Molecular oxygen (O_2) consumption has direct relation to the cell metabolic rate in aerobic cells and so to the metabolic rate of the organisms. Cells having higher metabolic activity demand more energy and such energy comes from ATP molecules. As there is need for ATP production, the intensity of aerobic cell respiration is also higher and then more oxygen is consumed.

Biology Questions and Answers

Protein Synthesis

1. What is the genetic code?

Genetic code is the key for the conversion of DNA nucleotide sequences (and thus RNA nucleotide sequences) into amino acids sequences that will compose proteins.

2. Which is the biological molecule that contains the genetic information that is transmitted hereditarily and controls the cellular functioning?

The hereditary molecule that controls the cellular functioning is the DNA (deoxyribonucleic acid). The DNA contains information for protein synthesis in cells.

3. How are the concepts of DNA, gene, proteins and characteristics of living beings related?

Characteristics of organisms depend on chemical reactions that occur in them. These reactions are catalyzed by enzymes, highly specific proteins. Every protein of an organism is made from information contained in RNA molecules that are made according to a template sequence of nucleotides of a DNA chain.

A gene is a DNA polynucleotide sequence that contains information for the production of a protein.

4. What is the role of messenger RNA and ribosomes for the protein synthesis?

The mRNA is produced within the cellular nucleus and migrates to the cytoplasm where associated to ribosomes it guides the building of amino acid sequences that will compose proteins. Ribosomes are sites for the meeting and binding of mRNA and transfer RNA (tRNA), they are the structures where amino acids transported by tRNA are united by peptide bonds forming polypeptide chains (proteins).

5. Of what subunits are ribosomes are made?

Ribosomes are made of two subunits, the small subunit and the large subunit. These subunits are made of ribosomic RNA (rRNA) and proteins. Ribosomes have three binding sites, one for mRNA and two for tRNA.

Biology Questions and Answers

6. How different are the location of ribosomes in eukaryotic and in prokaryotic cells?

In prokaryotes ribosomes are found free in cytoplasm. In eukaryotic cells they can also be found free in cytoplasm and mainly adhered to the external membrane of the karyotheca and of the rough endoplasmic reticulum.

7. How is the finding of ribosomes inside mitochondria and chloroplasts explained?

It is a strong hypothesis that mitochondria and chloroplasts were prokaryotes that associated to primitive eukaryotic cells under mutualism (gaining protection and offering energy). This explains why within those organelles there are DNA and protein synthesis machinery, including ribosomes. This hypothesis is known as the endosymbiotic hypothesis on the origin of mitochondria and chloroplasts.

8. What are some examples of human cells that produce proteins for exportation? Which cytoplasmic organelle is expected to be well-developed and abundant in those cells?

Specialized cells of the glands, like the Langerhans cells of the pancreas (that produce insulin) or the saliva-producing cells, are examples of secretory cells. In cells specialized in secretion, the endoplasmic reticulum and the Golgi apparatus are well-developed since they participate in the storage and processing of proteins for exportation.

9. Which are the more abundant ribosomes in secretory cells - the free cytoplasmic ribosomes or those associated with the rough endoplasmic reticulum?

Free cytoplasmic ribosomes are more related to protein production for internal cellular consumption while those adhered to the rough endoplasmic reticulum are more important in protein synthesis for exportation. Proteins made by adhered ribosomes enter the rough endoplasmic reticulum and are later transferred to the Golgi apparatus. So in secretory cells ribosomes adhered to the endoplasmic reticulum are more notable.

10. Where in eukaryotic cells does mRNA synthesis occur? To where do these molecules migrate?

Messenger RNA molecules are synthesized within the nucleus, pass through pores of the nuclear membrane and gain the cytoplasm to reach the ribosomes where protein synthesis occurs.

Biology Questions and Answers

11. After the fact that it is based on information from mRNA what is the process of protein synthesis called?

Protein synthesis is called translation (of genetic information into proteins).

12. What is the difference between transcription and translation?

Transcription is the name given to the formation of DNA molecules from an open DNA chain used as a template. Translation is the making of polypeptides (amino acids bound in sequence) and thus of proteins based on information encoded in the mRNA molecule.

In eukaryotic cells transcription occurs in the nucleus and translation occurs in ribosomes. Transcription precedes translation.

13. How do nucleotides of mRNA chains encode information for the formation of the amino acids sequences of a protein?

There are only four types of nitrogen-containing bases that can compose RNA nucleotides: adenine (A), uracil (U), guanine (G) and cytosine (C). Amino acids however are 20 different ones. Considering only one nucleotide (a 1:1 coding) it would be impossible to codify all amino acids.

Considering two nucleotides there would be an arrangement of 4 elements, 2 x 2, resulting in a total of only 16 possible codifier units (4 x 4). Nature may know combinatory analysis since it makes a genetic code by arrangement of the 4 RNA bases, 3 x 3, providing 64 different triplets (4 x 4 x 4).

So each triplet of nitrogen-containing bases of RNA codifies one amino acid of a protein. As these triplets appear in sequence in the RNA molecule, sequential amino acids codified by them are bound together to make polypeptide chains. For example, a UUU sequence codifies the amino acid phenylalanine, as well the UUC sequence; the ACU, ACC, ACA and ACG sequences codify the amino acid threonine; and so on for all possible triplet sequences and all other amino acids.

14. What is the name of an RNA sequence that codifies one amino acid?

Each sequence of three nitrogen-containing bases of RNA that codifies one amino acid is called a codon. The codon is the codifier unit of the genetic code.

Biology Questions and Answers

15. Since among the 64 codons of mRNA 61 codify amino acids that form polypeptide chains what are the functions of the three remaining codons?

Since there are 20 amino acids and 64 possibilities of mRNA codons, it is expected some amino acids to be codified by more than one codon. And that really happens.

Not all 64 codons however codify amino acids. Three of them, UAA, UGA and UAG, work on information that the last amino acid of a polypeptide chain under productions was already bound, i.e., they signal the end of the polypeptide synthesis. These codons are called terminal codons. The codon AUG codifies the amino acid methionine and at the same time it signals the beginning of the synthesis of a polypeptide chain (it is an initialization codon).

In prokaryotic cells there is a sequence called Shine-Dalgarno sequence (in general AGGAGG) in the position that antecedes the initialization codon AUG. The function of this sequence is distinctness between the initialization AUG and other AUG codons of the RNA.

16. What is the cellular structure to which mRNA molecules bind to start the protein synthesis?

To make proteins mRNA molecules necessarily associate to ribosomes. Ribosomes have two sites for the binding of two neighboring mRNA codons and where anticodons of tRNA bind by hydrogen bond. Thus ribosomes are the structure responsible for the positioning and exposure of mRNA codons to be translated. In ribosomes the peptide bond between two amino acids brought by tRNA molecules also occurs. The peptide bond happens when tRNAs carrying amino acids are bound to exposed mRNA codons.

17. How are amino acids brought to the cellular site where translation takes place? What is an anticodon?

Amino acids are brought to ribosomes by RNA molecules known as transfer RNA, or tRNA. One tRNA associated to its specific amino acid binds by a special sequence of three nucleotides to a mRNA codon exposed in the ribosome. This sequence in the tRNA is known as anticodon. The tRNA anticodon must be complementary to the mRNA codon to which it binds, according to the rule A-U, CG. The ribosome then slides along the mRNA molecule (a process called translocation) to expose the following codon to the binding of other tRNA. When amino acids corresponding to neighboring codons bind by peptide bond the first tRNa is liberated.

Biology Questions and Answers

18. Why is the proximity between ribosomes and amino acids important for the protein formation? What is the enzyme that catalyzes that reaction?

The proximity between ribosomes and amino acids is important because the enzyme that catalyzes the peptide bond resides in ribosomes. As substrates of these enzymes, amino acids need to bind to the enzyme activation centers.

The enzyme that catalyzes the peptide bond is the peptidyl transferase.

19. Why do ribosomes move along mRNA during translation?

During translation the ribosome always exposes two mRNA codons to be translated by moving along the mRNA. When a peptide bond is made the ribosome moves to expose the next codon. This moving is called ribosomal translocation. (In the rough endoplasmic reticulum ribosomes are attached outside the membrane and mRNA molecules rather moving through them).

20. How many of the same proteins are made at the same time by each ribosome in the translation of one mRNA molecule? How does consecutive protein production occur in translation?

Ribosomes do not make several different proteins simultaneously. They make them one after another.

Along one single mRNA molecule however many ribosomes may move in a real mass manufacturing of the same protein. The unit made of many ribosomes working upon the same mRNA molecule is called polysome.

21. An mRNA molecule codifies only one type of protein?

Eukaryotic cells have monocistronic mRNA, i.e., each mRNA codifies only one polypeptide chain. Prokaryotes can present polycistronic mRNA.

At the end of the assembling of amino acids into a polypeptide chain, the mRNA, by one of its terminal codons, signals to the ribosome that the polypeptide is complete. The ribosome then liberates the produced protein. In prokaryotes after this conclusion the information for the beginning of the synthesis of another different protein may follow in the same mRNA.

22. If a tRNA anticodon is CAA what is its corresponding mRNA codon? For the genetic code which amino acid does this codon codify?

According to the A-U , C-G rule, the corresponding codon to the CAA anticodon is GUU.

The genetic code table for translation is related to codons and not to anticodons. The amino acid codified by GUU, according to the genetic code, is valine.

23. If a fragment of nucleic acid has a nucleotide sequence TAC can one assert that it is a codon or an anticodon?

A nucleic acid having a TAC sequence surely is not tRNA, it is DNA since RNA does not present the nitrogen-containing base thymine. Since it is not RNA it cannot be a codon or an anticodon.

24. Why can the genetic code be qualified as a "degenerate code"?

The genetic code is a degenerate code because there are amino acids codified by more than one type of codon. It is not a system in which each element is codified by only one codifying unit.

For example, the amino acid arginine is codified by six codons: CGU, CGC, CGA, CGG, AGA and AGG.

25. What is the concept of universality of the genetic code? What are the exceptions to this universality?

The genetic code is universal because the rules of protein codification based on mRNA codons are practically the same for all known living beings. For example, the genetic code is the same for humans, for bacteria and for invertebrates.

The protein synthesis in mitochondria, chloroplasts and some protozoans however are accomplished by different genetic codification.

26. How does the universality of the genetic code make the recombinant DNA technology possible?

The universality of the genetic code refers to the fact that all living beings have their protein synthesis machinery functioning according to the same principles of storage, transmission and recognition of information, including translation of mRNA codons. This fact makes possible the exchanging of genes or gene fragments between different organisms and secures that these genes continue to command protein synthesis.

This universality, for example, makes feasible the insertion of a fragment of

human DNA containing a gene for the production of a given protein into the genetic material of bacteria. Since the bacterial transcription and translation systems work in the same manner as the correspondent human systems do, the bacteria will begin to synthesize the human protein related to the inserted DNA fragment. There are industries that produce human insulin (for use by diabetic patients) in this way, synthesized by bacteria with modified DNA. If the genetic code was not universal this kind of genetic manipulation would be impossible or very difficult to accomplish without new technological progresses.

Biology Questions and Answers

Biology Questions and Answers

Microbiology

Biology Questions and Answers

Biology Questions and Answers

Bacteria

1. What are bacteria?

Bacteria are prokaryotic and unicellular beings. Bacteria have simple organization, they present an external cell wall, plasma membrane, circular DNA within the cytoplasm and ribosomes for protein synthesis. Some bacteria are encapsulated, i.e., they have a polysaccharide capsule outside the cell wall.

2. Are bacteria the only prokaryotic beings?

Prokaryotic beings are classified into two big groups: archaebacteria and bacteria (this last also known as eubacteria).

Compared to bacteria, archaebacteria have basic differences, like the chemical compositions of their plasma membrane and cell wall and different enzymes related to DNA and RNA metabolism.

3. What are halophile, thermoacidophile and methanogen archaebacteria?

There are three peculiar types of archaebacteria. The halophile archaebacteria only survive in salt-rich environments (even salinity of the sea is not enough for them). Thermoacidophile archaebacteria are characterized by living under high temperatures and low pH. The methanogen archaebacteria are those that liberate methane gas (CH_4), they are found in swamps.

4. What are the main ecological roles of bacteria?

Bacteria are responsible for the decomposition process at the end of food chains and food webs; in this process, they also liberate utile gases and nutrients for other living beings. Bacteria that live within the digestive tube of ruminants and of some insects digest cellulose for these animals. Some bacteria also participate in the nitrogen cycle, making fixation of nitrogen, nitrification and denitrification, almost always in mutualist ecological interaction with plants. Bacteria present within living beings, for example, some that live inside the bowels, compete with other pathogenic bacteria so controlling the population of noxious agents. There are also bacteria that cause diseases and bacteria used in the production of medical drugs.

Excessive proliferation or mass destruction of bacteria can impact entire ecosystems. For example, when a river is polluted by organic material the population of aerobic bacteria increases since the organic material is food for them; the great number of bacteria then exhausts the oxygen dissolved in water and other aerobic beings (like fishes) undergo mass death.

Biology Questions and Answers

5. What are examples of human diseases caused by bacteria?

Some human diseases caused by bacteria are tuberculosis, pertussis, diphtheria, bacterial meningitis, gonorrhea, syphilis, bubonic plague, leptospirosis, cholera, typhoid fever, Hansen's disease, trachoma, tetanus, anthrax.

6. What are some industrial processes that use bacteria?

Bacteria are used by industry in various ways. There are vaccines made of attenuated pathogenic bacteria or of antigens present in bacteria. One of the most ancient uses of bacteria is the fermentation of milk to produce yogurt, cheese and curd (even before the knowledge of the existence of bacteria these microorganisms were already used in the making of those products). Some methods of antibiotic production involve bacteria. The recombinant DNA technology (genetic engineering) allows the industrial production and commercialization of human proteins, like insulin for diabetics, synthesized by mutant bacteria. Some bacteria can produce fuel, like methane gas.

7. What are some mechanisms by which pathogenic bacteria cause diseases? Why is this knowledge important?

Pathogenic bacteria have characteristics known as virulence factors that help them to parasite their host. Some bacteria have fimbriae, cilium-like structures that attach the bacterial cell to the host tissue. There are bacteria specialized in intracellular parasitism. Other bacteria secrete toxins, molecules that cause disease; in some cases, the bacterial population growth causes food contamination by toxins. Generally, bacterial disease is caused by bacterial population growth with invasion and destruction of tissues or by bacterial toxins that contaminate the organism.

8. In which environments do bacteria live?

Bacteria can be found in various environments throughout the planet. There are bacteria in the air, in fresh water, on the surface, in the intermediate depth and on the bottom of the sea, in soils, in our skin and practically in all terrestrial environments through which air circulates freely. Some bacteria can be found in volcanic craters under extremely high temperatures.

9. How are bacteria classified according to the production of organic material for the energetic metabolism?

Most bacteria are heterotroph, they do not produce their own food. There are also autotroph bacteria: chemosynthetic bacteria or photosynthetic bacteria.

Some photosynthetic bacteria, like cyanobacteria, make photosynthesis like plants do, using water. Others, the

sulfur photosynthetic bacteria, use hydrogen sulfide (H_2S) instead of water.

10. How are bacteria classified according to their need for oxygen?

According to their necessity of oxygen bacteria are classified into anaerobic (those that survive without oxygen) and aerobic (those that do not survive without oxygen).

11. What is meant when it is said that a bacteria is an obligate anaerobe?

Obligate anaerobes are those living beings that do not survive in the presence of oxygen. For example, the bacteria Clostridium tetani, agent of tetanus, is an obligate anaerobe.

In superficial wounds, it is commom to use hydrogen peroxide to expose anaerobic microorganisms to oxygen and kill them.

12. According to their morphology how are bacteria classified?

Bacteria present different morphological patterns. A bacterium can be classified into coccus, bacillus, vibrion or spirochete.

13. What is the main constituent of the cell wall of bacteria?

The bacterial cell wall is made of peptidoglycans.

14. Which are the intracellular organelles present in bacteria?

Considering typical eukaryotic cell organelles, heterotrophic bacteria have ribosomes, essential for protein synthesis.

15. What are plasmids? What is the importance of plasmids for the recombinant DNA technology?

Plasmids are circular fragments of DNA that are accessories to the main bacterial DNA. Plasmids are important for genetic engineering because genes from other organisms are inserted into them to produce recombinant beings, for example, mutant bacteria. These bacteria are made, for example, to produce utile proteins for humans on an industrial scale.

16. How do bacteria reproduce?

Bacteria reproduce by binary fission (scissiparity). Some bacteria however present a kind of sexual reproduction

(transformation, transduction or conjugation) with a combination of genetic material from different individuals.

17. How does sexual reproduction occur in bacteria? How different are the modalities of bacterial sexual reproduction?

Sexual reproduction occurs when bacteria incorporate genetic material into other bacteria of the same species; the inserted genetic fragment then becomes part of the genetic material of the second bacteria. This kind of reproduction can happen by means of transformation, transduction or conjugation.

Biology Questions and Answers

Protists

1. Which are the groups of living beings that form the protist kingdom?

The protist kingdom includes protozoans and algae. (Two groups of fungi with similar characteristics to protozoans, myxomycetes and oomycetes, have been classified as protists.)

Unicellular protozoans and algae are unicellular eukaryotes. The pluricellular algae are eukaryotes of simple structure too. It is believed that protists are phylogenetic ancestors of living beings of the other eukariotic kingdoms (fungi, animals and plants).

2. What is the fundamental difference between protozoans and algae?

The basic difference between protozoans and algae is the fact that protozoans are heterotrophs while algae are photosynthetic autotrophs.

3. What are the characteristics of protozoans that make them resemble animals?

Protozoans are unicellular beings with some similar characteristics to animal cells.

In comparison to pluricellular organisms protozoans are more proximal to the animal kingdom than to plants: they are heterotrophs, they have a rudimentary locomotion system (amoeboid movements, cilia, flagella), they do not have cell wall, some species present structures that resemble structures of a primitive digestive system, with cytostome (mouth) and cytopyge (anus), specialized in digestion and excretion.

The evolutionary hypothesis that animal cells have come from differentiation of protozoans is strong.

4. What is the basic morphology of a protozoan cell?

Protozoans are eukaryotic cells so they have organelles and structures common to this kind of cell: endoplasmic reticula, Golgi apparatus, digestive vesicles, ribosomes, mitochondria, nucleus with genetic material, karyotheca, etc. All these elements are found dispersed throughout the cytoplasm. Protozoans do not have cell walls.

Protozoans from the mastigophora group (like trichomonas) have flagella and others, others from the ciliated group (like paramecium) have cilia.

5. Do protozoans have a cellular nucleus?

All protozoans, as eukaryotes, have nucleus. Some species, like the

paramecium, have two nuclei: the macronucleus and the micronucleus.

6. What are the respective functions of the macronucleus and of the micronucleus in the paramecium?

The macronucleus is properly the cell nucleus, it has DNA and RNA and acts as the center of the cellular control and regulation. The micronucleus has reproductive functions and it is related to the conjugation process (sexual reproduction).

7. What do protozoans "eat"? Do they move in search for food?

Protozoans are heterotroph beings, i.e., they do not make their own food and thus they need to search for it in the environment. Protozans have developed several locomotion mechanisms and they actively move towards food.

8. How do amoebae, paramecia and trichomonas respectively move?

Amoebae move by amoeboid movements, small projections and invaginations of their plasma membrane (pseudopods) that alter the external morphology of the cell making it move on surfaces. Paramecia have the outer face of their plasma membrane covered by cilia that flap helping the cell to move. Trichomonas are flagellated protozoans, i.e., they have relatively long filaments outside the cell that beat and make possible active swimming in fluid environments.

9. How is digestion performed in protozoans?

Digestion in protozoans is intracellular digestion: organic material is internalized and degraded inside the cell.

Protozoans get food by phagocytosis and then the food is digested when phagosomes fuse with lisosomes within the cell, forming digestive vacuoles. The digestive vacuoles give origin to residual bodies that are eliminated from the cell by exocytosis.

In the paramecium the entrance of food into the cell and the excretion of digestive residuals occur at specialized regions of the plasma membrane, the cytostom and the cytopyge, respectively.

10. Are protozoans presenting contractile, or pulsatile, vacuoles easily found in fresh or in salt water?

Fresh water is the less concentrated of solutes than sea water and it (fresh water) tends to be less concentrated than the intracellular environment making cells to swell. Sea water, on the other hand, since it is very concentrated tends to dehydrate the cell.

The vacuoles of protozoans are internal structures specialized in water storage that when necessary liberate water to the cytoplasm. Vacuoles thus can dilute the cytoplasm for it to enter into osmotic equilibrium with the environment. Protozoans of fresh water then need vacuoles more since their intracellular is hypertonic in relation to the exterior. Without the dilution mechanism provided by the vacuoles, protozoans of fresh water would absorb too much water and would die.

11. Do protozoans have sexual or asexual reproduction?

In protozoans reproduction is sexual or asexual. The most frequent form of sexual reproduction is binary division, or scissiparity, in which the cell divides itself by mitosis originating two daughter cells. Some species, like the plasmodium, agent of malaria, reproduce asexually by schizogony (multiple fission); in this form of reproduction the cell becomes multinucleated, generally inside a host cell, and each nucleus is expelled out together with cytoplasm portions giving rise to new protozoans.

The sexual reproduction in protozoans can happen by conjugation, with incorporation of genetic material from one cell into another, or by gametes that fecundate others and form zygotes. In the plasmodium sexual reproduction happens in the mosquito, the definitive host, and the zygote undergoes mitosis (sporogony) creating many sporozoites.

12. Which is the form of protozoan reproduction that generates more variability?

Sexual reproduction always generates more genetic variability than asexual reproduction. That is because in sexual reproduction the fusion of genetic material from different individuals occurs and so the offspring is not genetically identical to the parent cell.

If the hypothesis that protozoans originated multicellular animals is strong, other hypotheses may be even stronger: that these protozoans were able to reproduce sexually, since only genetic variation can produce biological differentiation to the point of creating new types of living beings.

13. What are the four groups of protozoans?

The four main groups of protozoans are the sarcodines (that form pseudopods, like amoebae), the mastigophores (flagellated, like the trypanosome that causes Chagas' disease), the ciliated (like paramecia) and the sporozoans (spore-forming, like plasmodia).

14. Why are euglenas involved in polemics related to their taxonomic classification?

Euglenas are involved in taxonomic polemics because they tend to be classified sometimes as protozoans and sometimes as algae. Although they have chloroplasts and they are photosynthetic

autotrophic beings, euglenas do not have a cell wall and they can survive by "eating" substances from the environment when light is not available for photosynthesis. Curiously euglenas also have a photosensitive structure called stigma that orients the movement of the cell towards light. Nowadays euglenas are classified as algae, but it is suspected that they are common ancestors of algae and protozoans.

15. Do algae reproduce sexually or asexually?

There are algae that reproduce sexually and there are algae that reproduce asexually.

In unicellular algae reproduction is generally asexual by binary division.

In pluricellular algae asexual reproduction can occur by fragmentation or by sporulation.

In sexual reproduction of algae, uni or pluricellular, there is fusion of gametes (syngamy). There are algae in which all cells can become gametes and there are algae in which only some cells can play that role. Some species may present alternation of generations, forming gametophytes and sporophytes with different ploidies.

16. What is the commercial importance of algae?

Many algae have high nutritional value and are commercialized and consumed as human food, they are very popular food in the oriental world. Jelly compounds are extracted from some algae, like glues and pastes for industrial and commercial use.

The agar-agar, used as a medium for biological culture in laboratories and in medicines, and the substance known as carrageenin, a component of tooth pastes, cosmetics, paint and hygienic products, are extracted from rhodophyte algae. Diatom algae deposited on the bottom of the sea form diatomites, used in the production of filters, refractories, thermal isolation and cement. Some algae are used as agricultural fertilizers.

17. What is the phenomenon known as "red tide"? Which ambiental harms can it cause?

Red tide is a phenomenon that occurs when dinoflagellates (algae from the pyrrophyte group) proliferate excessively in the ocean. These algae liberate toxins that affect the nervous system and can cause death when ingested by marine animals and by humans that eat contaminated animals.

Biology Questions and Answers

Fungi

1. What are the main cellular features of fungi?

There are unicellular and pluricellular fungi. All fungi are eukaryotes and heterotrophs.

Fungi have cells with cell wall made of chitin, the same substance that constitutes the exoskeleton of arthropods. Fungi, likewise animals, characterize for storing glucose in the form of its polymer glycogen.

2. Are there photosynthetic fungi? How do fungi nourish themselves?

All fungi are heterotrophs (so, they do not perform photosynthesis). Fungi are typical decomposers, they eat and degrade organic material.

3. Fungi are classified in their own kingdom. Into which phyla is the fungi kingdom divided? Into which of those phyla are mushrooms classified?

The kingdom fungi is divided into four phyla: ascomycetes, basidiomycetes, zygomycetes and deuteromycetes.

Mushrooms are basidiomycetes.

4. What are the hyphae and the mycelium of pluricellular fungi?

The main structures of pluricellular fungi are the hyphae (threadlike filaments made of contiguous uni or multinucleated cells) and the mycelium (a set of hyphae).

5. What are the types of reproduction that occur in fungi?

In fungi there are asexual and sexual reproduction. Fungi reproduce asexually by fragmentation, gemmation and sporulation. Some species can reproduce sexually by fusion of hyphae from different individuals, even with metagenesis (alternation of generations).

6. What are the fruiting bodies present in some fungi?

Fruiting bodies are structures made of hyphae that project radially from the superior portion of the peduncle of some fungi. These structures contain the reproductive cells of the individual. They form the umbrella-like cap in mushrooms (basidiocarp) or the ascocarp in ascomycetes.

7. What is the ecological importance of fungi?

Fungi are heterotrophs and decomposers (they break down dead beings) and they actively participate in the recycling of organic material in ecosystems. Some fungi keep mutualist ecological interaction with algae or cyanobacteria, forming lichen, and with plant roots, forming mycorrhizas.

8. What is the utility of fungi for some industries?

Fungi are industrially used in the production of fermented beverage, bread, cheese, etc. Some fungi are very important for the production of medical drugs. There are fungi processed to serve as food for humans, like eatable mushrooms.

9. What are lichens? How do fungi participate in this ecological interaction?

Lichens are formed by mutualist ecological interaction between fungi and algae or between fungi and cyanobacteria. In this ecological interaction, the fungi absorb water that is then used by algae (or cyanobacteria), and algae (or cyanobacteria), as autotrophs, produce organic material in excess to serve as food for the fungi.

10. What are mycorrhizas? How does each participant benefit in this ecological interaction?

Mycorrhizas are mutualist ecological interactions between fungi and some plants roots. Fungi provide to the plant more water and mineral salts and obtain organic material from the vegetable.

11. What are the main human diseases caused by fungi?

The main human diseases caused by fungi are coccidioidomycosis, histoplasmosis, blastomycosis, paracoccidioidomycosis, or South American blastomycosis, sporotrichosis, aspergillosis and systemic candidiasis.

Fungi are also responsible for many dermatologic diseases (dermatomycosis) that affect the skin, the nails, the scalp, etc.

On the other hand, many fungi are able to produce antibacterial substances that combat diseases. In the second world war, in German jails, Russian prisoners that accepted to eat moldy bread had less skin infection than those that refused the food. In China, moldy soy sauce has millennial past use against infections. Penicillin, a potent antibiotic, was discovered in 1928 by Alexander Fleming when he observed the antibacterial activity of fungi from the genus Penicillium.

12. What is cyclosporin? How are fungi related to this substance?

Cyclosporin is a drug discovered in the 1970's that revolutionized organ transplantation in Medicine. It is a powerful immunosuppressor and so it lessens the immune activity of the receptor and reduces the risk of rejection of the transplanted organ.

Biology Questions and Answers

Viruses

1. Are viruses cellular beings?

Viruses are considered living beings but they do not have cellular structure.

There is some controversy regarding their classification as living beings. Their characteristics of self-reproduction and of having genetic material however reinforce that classification.

2. What is the basic structure of a virus?

Viruses are constituted of genetic material (DNA or RNA) covered by a protein capsule also known as a capsid. Some viruses, like HIV, have in addition an external envelope derived from the plasma membrane of the host cell from which it came.

3. Are there non-parasitic viruses?

All viruses are obligate intracellular parasites, i.e., they depend on the host cell to complete their life cycle. A virus does not have its own metabolism.

4. Why is it a strong evolutionary hypothesis that although viruses are the structurally simplest beings they were not the first living beings?

The fact that viruses are obligate intracellular parasites makes very weak the hypothesis that virus appeared before cellular beings in the evolution of life.

5. What is the genetic material of a virus? How does that material act in viral reproduction?

There are DNA viruses (double strand or single strand DNA) and RNA viruses (double strand or single strand RNA too). Viruses inoculate their DNA or RNA molecules into cells and these cells (by means of transcription or reverse transcription and translation) synthesize proteins for the assembling of a new virus. This synthesis is commanded by the viral DNA or RNA molecules.

6. What is the typical reproduction cycle of a DNA virus?

A typical virus has proteins on its capsid that bind to the outer membrane of the host cell. In the place where the virus adhered viral proteins act to break the cell membrane and then the virus

injects its DNA molecules into the host cell.

Within the host cell the viral DNA is transcripted and thus messenger RNA is produced. Viral mRNA then is translated and viral proteins are made.

Viral polypeptides made within the host cell are cut by enzymes called proteases and then copies of the virus are assembled with the newly formed proteins. When the assemblage of new viruses is completed the cell membrane breaks and the viruses are released to the outside. One sole infected cell can produce hundreds of viruses.

7. What are retroviruses? How do they reproduce and what is the role of the enzyme reverse transcriptase?

Retroviruses are viruses whose genetic material is RNA. HIV and the virus of SARS (severe acute respiratory syndrome) are examples of retrovirus.

These viruses inoculate their RNA into the host cell and within the cell the viral RNA is reversely transcripted into DNA. DNA made from the viral RNA then commands the synthesis of viral proteins for the assemblage of new viruses and the breaking of the host cell to liberate them outside.

The enzyme reverse transcriptase is the catalyst of the reverse transcription of RNA into DNA. The enzyme is part of the virus and it is also inoculated into the host cell.

8. What is the basic structure of the HIV virus? What is the function of the glycoproteins of its envelope?

HIV is an RNA virus. In its core there are two strands of RNA and reverse transcriptase molecules. The core is covered by a capsid, a layer of proteins. The capsid then is covered by an envelope having glycoproteins and lipids.

The glycoproteins of the HIV envelope are located on the outer surface of the virus and they are responsible for the recognition of the cells to be infected (the HIV host cell is the CD4 lymphocyte) and for the adhesion of the virus to the cell membrane. (CD4 is a receptor glycoprotein of the outer membrane of some lymphocytes).

9. What are bacteriophages?

Bacteriophages are viruses specialized in parasitism of bacteria. They are used in genetic engineering as molecular cloning vehicles to insert recombinant DNA into bacteria. They were also used in the former Soviet Union to treat bacterial infections.

Bacteriophages have a polyhedron-like capsid and DNA as genetic material. The "head" of the virus is connected to a tail that ends in small fibers that help the virus to attach to the bacterial cell wall and to inject its genetic material into the host.

Biology Questions and Answers

10. What is meant when it is said that a virus is in an inactive state?

Viruses considered in inactive state are those whose genetic material is within host cells without synthesis of viral proteins and assemblage of new virus. The life cycle of these viruses can be activated under certain conditions and then synthesis of viral proteins begins and new copies are made.

The virus that causes herpes (herpes virus) is an example of a virus that stays in an inactive state and is sometimes activated.

11. What are the main human diseases caused by virus?

Among diseases caused by virus are common cold, mumps, variola (considered eradicated nowadays), rubella, measles, AIDS, the viral hepatitis, human papillomatosis (HPV infection), rabies, dengue fever, yellow fever, poliomyelitis (an almost eradicated disease in developed countries), hemorrhagic fever from Ebola virus, SARS (severe acute respiratory syndrome).

Viruses also cause many other diseases in animals and plants.

12. SARS is a disease that appeared in 2003 with epidemic features in the province of Guangdong, in east China. What type of agent causes SARS?

SARS is caused by a virus from the coronavirus group, a RNA virus (retrovirus). SARS can be fatal.

13. What is crystallization of a virus? What is the importance of this process?

Crystallization is the process of transformation of viral components into organized solid particles.

Crystallization of biological macromolecules, including viral components, is used to study structural characteristics, for example, through X-rays, laser beams, etc.

Biology Questions and Answers

Zoology

Biology Questions and Answers

Biology Questions and Answers

Life Kingdoms

1. What is the Biology field that studies the classification of living beings?

The Biology field that studies the classification of living beings is called Taxonomy.

2. Into which categories are living beings classified?

Living beings are classified, from the broader to the more particular category, into kingdom, phylum, class, order, family, genus and species (KPCOFGS can be used as mnemonic). Kingdom is the broadest category and the others in sequence are encompassed by the previous one.

3. What is meant by binomial nomenclature and what are its basic rules?

Scientific nomenclature of a species must have, at least, two names: one that classifies it as genus and the other that identifies it as species. The name related to genus is the first and must begin in uppercase, the other following names must be written in lowercase. Besides this rule, scientific names of species must stand out and be written either in italics or underlined or still bolded or between quotation marks.

For example, the scientific name of the human species is "Homo sapiens", indicating that it belongs to the genus Homo.

Scientific nomenclature of species is important because it universalizes the way to refer to a species making it easier for people of different languages and cultures to understand each other. Same species that have very different names in different regions of the planet can be identified easily by their scientific binomial name.

4. What are the five kingdoms into which living beings are divided? Which group of living being is out of this classification?

The five kingdoms of living beings are the kingdom Monera, the kingdom Protista, the kingdom Fungi, the kingdom Plantae and the kingdom Animalia.

Viruses are out of this classification and sometimes they are said to belong to their own kingdom, the kingdom Virus.

5. According to cellular organization how are living beings divided into two groups?

Cellular beings are divided into two groups: the prokaryotes, unicellular beings whose sole cell does not have a delimited nucleus, and eukaryotes, uni

or multicellular beings with cells having delimited nucleus.

6. Which are the beings that constitute the kingdom Monera?

The kingdom Monera is the kingdom of the prokaryotes, composed of bacteria and archaebacteria.

7. Which are the beings that form the kingdom Protista?

The kingdom Protista comprises protozoans and algae.

8. Which are the beings that form the kingdom Fungi?

The kingdom Fungi is formed by fungi.

9. Which are the beings that form the kingdom Plantae? Are algae part of this kingdom?

The kingdom Plantae is composed of plants.

Algae are classified into the kingdom Protista and not into the kingdom Plantae (they are not plants).

10. Which are the beings that form the kingdom Animalia? What are the two big groups into which this kingdom is divided?

The kingdom Animalia is the animal kingdom. Commonly the kingdom Animalia is subdivided into invertebrates and vertebrates.

11. What are the nine phyla of the kingdom Animalia?

The nine phyla of the animal kingdom are: Porifera (poriferans), Cnidaria (cnidarians), Platyhelminthes (flatworms), Nematoda (roundworms), Annelida (annelids), Mollusca (molluscs), Arthropoda (arthropods), Echinodermata (echinoderms) and Chordata (chordates).

12. What are the two mains divisions of the chordate phylum?

Chordates are divided into protochordates (cephalochordates and urochordates) and vertebrates.

13. What are the differences between vertebrates and the other chordates?

Vertebrates are different because they have a spinal column (vertebral column). In these animals the

notochord of the embryonic stage is substituted by the vertebral column in adults.

14. What are the five classes of vertebrates? To which of these do human beings belong?

The five classes of vertebrates are: fishes (osteichthyes and chondrichthyes), amphibians, reptiles, birds and mammals. Humans classify as mammals.

15. What is an evolutionary tree? Is there a precise evolutionary tree known by science that explains the emergence and origin of every type of living being?

Evolutionary tree is the pictorial and schematic representation of evolutionary relations among species of living beings in which the trunk (or a preceding branch) represents common ascendants of species and groups of living beings that are distributed along its branches according to hypothesis on their origin. For example, today it is admitted that birds and mammals are two distinct branches of the same preceding reptile branch.

Biology cannot assures a definite evolutionary tree (phylogeny) on the species of living beings that live or have lived in our planet. There are many data to be discovered and many knowledge gaps to be filled. One of the most promising methods to study phylogeny is the comparison of DNA molecules from different groups of living beings researching similarities and differences in nucleotide sequences that may indicate more or less relatedness among species.

Biology Questions and Answers

Poriferans

1. What are poriferans?

The phylum Porifera contains the simplest creatures of the animal kingdom. Sponges are aquatic sessile beings (they are not able to move by themselves and they keep themselves attached to substrates), they do not have tissue diversity and their bodies have pores (feature after which their name comes).

They are multicellular, like all beings of the animal kingdom.

2. What is the way of life of sponges?

Sponges live exclusively in an aquatic environment and they are attached by their base to a substrate (fixation ground). Sponges are filtering animals, they nourish themselves from nutrients that enter their atrium brought in with water.

3. What is the typical shape of poriferans?

Sponges have bodies in the form of tubular vases or globes open in the upper extremity. They have an internal central cavity and porous walls. The central cavity is called spongocoel and the opening in the upper extremity is called osculum.

4. How does water move inside sponges? What is the function of the pores in these animals?

Sponges are filtering beings. They make water enter their bodies by their lateral pores. Water then circulates inside the central cavity and exits through the osculum.

5. How do sponges try to protect themselves against harm from the environment? Is that method efficient or rudimentary?

Sponges can close their pores to avoid the entrance of water into their bodies in the presence of stimulus that may mean danger. This method however is rudimentary but it is actually a protection attempt against nocent agents.

6. What are the main cells of which poriferans are made?

Sponges have their outer wall covered by flat cells called pinacocytes and having pores well-delimited by special cells called porocytes. The internal wall is filled with choanocytes, flagellate cells specialized in phagocytosis of food brought to the central cavity; the choanocyte flagella also maintains the water flux inside the sponge.

Between the outer and the inner coverage of the poriferan body there are

cells with amoeboid movement (by pseudopods), the amoebocytes; since they are embedded in connective matrix, amoebocytes move and distribute nutrients to other cells and they also produce spicules that like a primitive skeleton fill the tissue and support the body structure. (Some poriferans have an internal skeleton, an endoskeleton, made of spicules and organic fibers.)

7. Concerning digestion how are poriferans characterized?

Sponges are different from other animals since they present only intracellular digestion. They do not have a digestive system nor do they release digestive enzymes in the spongocoel to cause extracellular break down of nutrients.

8. How are animals divided according to their type of digestive process?

Apart from sponges, that do not have a digestive cavity where extracellular digestion takes place, all other animals have a digestive system with an internal cavity in which extracellular digestion occurs.

9. How are gases exchanged in sponges?

The gas exchange in sponges happens by diffusion from the exterior to the cells that absorb molecular oxygen and liberate carbon dioxide.

10. Do sponges have nervous, circulatory and excretory systems?

Sponges do not have a nervous system neither circulatory system nor excretory system.

11. Is reproduction in sponges sexual or asexual?

Reproduction in sponges can be asexual by budding, gemmation or fragmentation (regeneration) or sexual with larval stage (a ciliated amphiblastula larva).

12. What is the evolutionary advantage of the occurrence of sperm cells and larval stage in the life cycle of sponges?

The sexual reproduction in sponges, in addition to contributing to genetic variability, also facilitates the colonization of farther environments by these beings, since sperm cells and larvae are mobile and can swim in the exterior to compensate the immobility of the adult individual.

13. What is the economic importance of sponges?

Some chemical substances secreted by sponges have anti-inflammatory, antibiotic and anti-tumoral activities and they are used in the production of medicines. Since ancient times the endoskeleton of some sponges has had commercial value, they are used as cleansing implements for baths (bath sponges), to wash animals, objects and so on.

14. Sponge identity card. How are sponges characterized according to example of representing beings, basic morphology, type of symmetry, embryonic (germ) layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Example of representing beings: sponges. Basic morphology: tubular or globular body with spongocoel, sessile; choanocytes, pinacocytes and amoebocytes. Type of symmetry: not established. Germ layers and coelom: do not apply since poriferans do not have true tissue organization. Digestive system: nonexistent. Respiratory system: nonexistent. Circulatory system: nonexistent. Excretory system: nonexistent. Nervous system: nonexistent. Types of reproduction: asexual and sexual with larval stage.

Biology Questions and Answers

Cnidarians

1. What are some examples of cnidarians? In which environments can these animals be found?

Jellyfish, hydra, corals and sea anemones are good examples. All of them are aquatic and most live in the sea.

2. What are the two main morphological patterns of cnidarians? Concerning locomotion how do these forms differentiate from each other?

Morphologically, cnidarians classify as polyps or medusae. Polyps are cylindrical and medusae are circular convex, like an umbrella. Both shapes have tentacles.

In general polyps are sessile but some species, like hydra, can move by alternating contact points on the substrate and performing somersaults. Medusae can move expelling water jets by contraction of the body.

Some cnidarians alternate polypoid and medusoid forms in their life cycle.

3. Concerning tissue complexity how different are cnidarians from poriferans?

Cnidarians have true tissue differentiation, they present distinct organized tissues in the body. Poriferans present only some dispersed specialized cells with no tissue differentiation.

4. Which are the germ layers present in cnidarians? Which tissues of the animal do they originate?

These beings present ectoderm and endoderm, two germ layers. Animals with only two germ layers are called diploblastic animals.

The ectoderm gives birth to the epidermis and the endoderm originates the covering of the digestive cavity.

5. Why is the digestive system of these animals called incomplete?

Incomplete digestive system is that in which the digestive cavity has only one opening.

Biology Questions and Answers

6. What is the type of digestion that occurs in cnidarians?

These animals have a digestive cavity and they make extracellular and intracellular digestion. The extracellular digestion takes place within the digestive cavity.

7. What are cnidocytes? What is the name of the capsule inside the cnidocyte? What are the biological functions of this structure?

Cnidocytes are specialized cells present in coelenterates. They are found in the epidermis and contain toxic substances that can hurt, paralyze or even kill other animals.

Each cnidocyte has an internal capsule know as nematocyst where the actual urticating substance is stored. When a cnidocyte is excited it causes the nematocyst to expose a filament containing the toxic chemical.

Cnidocytes and their nematocysts have the biological functions of defending the individual from external aggression and of helping to capture their prey.

8. How is the nervous tissue distributed in cnidarians?

Their nervous system is diffuse, there are no brain or ganglia.

9. What are the types of reproduction presented by cnidarians?

They present asexual and sexual reproduction.

10. What is the type of asexual reproduction that occurs in hydras?

Hydras reproduce asexually by budding.

11. What is metagenesis? What are the other names of this process?

Metagenesis is the type of life cycle in which there are two different forms of individuals of the same species, one haploid and the other diploid. In one of these stages gametogenesis occurs and fecundated gametes give birth to the zygote that then develops into the other form. Metagenesis is also known as alternation of generations or as diplobiont life cycle. (All plants, for example, present metagenesis.)

12. In the metagenesis of Aurelia and Obelia what is the form that produces gametes? What is the form that reproduces asexually?

In the metagenesis of some coelenterates, like Aurelia and Obelia,

there is alternation between polypoid and medusoid forms. The polyps reproduce asexually originating medusae that then liberate gametes. The male and female gametes unite under water to form the zygote that then develops into larva and later originates another polyp.

The form that reproduces asexually is the polyp. Polyps give birth to medusae by budding in Obelia and by strobilization in Aurelia.

13. What is the name of the larva of corals and sea anemones? What is the biological importance of that larval stage?

Sexual reproduction in corals and sea anemones have a larval stage and the larva is called planula.

Many marine animals are sessile or practically sessile, like sponges, corals and sea anemones. The mobile larval stage of their life cycle provides better spatial distribution of these species.

14. What are the main classes into which the phylum is divided? What are some examples of each and in which form (polyp or medusae) are they found?

Coelenterates are divided into three main classes: hydrozoans, scyphozoans and anthozoans. In hydrozoans the polypoid form predominates and examples are hydras, by-the-wind-sailors and Obelia. In scyphozoans the main phase is the medusoid and the best known example is the common jellyfish (Aurelia). In anthozoans there is only the polypoid form and corals and sea anemones are notable in this group.

15. What does radial symmetry means? What is the type of symmetry found in chordates? Which are other phyla of the animal kingdom that present species with radial symmetry?

Radial symmetry means (biologically) that the animal structures are situated in a radial or circular pattern around a center point with nonexistence of sides, like right or left. An alternative type of symmetry in which structures are placed equally in the sides of a longitudinal axis is the lateral symmetry (the symmetry present in human beings, for example).

Chordates present lateral symmetry.

Besides cnidarians another animal phylum with species presenting secondary radial symmetry is the phylum Echinodermata. (It is considered that the simplicity of poriferans does not characterize any symmetry.)

16. What are corals?

Corals are characterized by their polypoid shape, sessility and slow growth and secretion of a solid skeleton

made of calcium carbonate. Numerous coral individuals associate in intraspecific harmonic ecological interaction forming colonies with hundreds, thousands and even millions of beings. Water-permeated solid structures of these colonies, known as reefs, work as true ecosystems for other living beings. The biggest known coral colony is the Great Barrier Reef in the northeast coast of Australia. There are however many coral species whose individuals live alone and do not form colonies.

17. Cnidarian identity card. How are they characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: jellyfish, corals, sea anemones, hydra. Basic morphology: polyp or medusa. Type of symmetry: radial. Germ layers and coelom: diploblastics, acoelomate. Digestive system: incomplete. Respiratory system: nonexistent. Circulatory system: nonexistent. Excretory system: nonexistent. Nervous system: diffuse. Types of reproduction: asexual and sexual with larval stage and metagenesis.

Biology Questions and Answers

Platyhelminthes

1. What are the best known representatives of the platyhelminth phylum?

The most popular representatives of the platyhelminthes are worms that cause human diseases, like taenia and schistosome. The planaria, since it is been extensively studied in Biology, is also well known.

2. What is the main external morphological feature that differentiates platyhelminthes from other worms (nematodes)?

Platyhelminthes are also known as flatworms because they are worms with a flat body. This is the main external morphological feature that differentiates them from nematodes (roundworms).

3. How many germ layers originate the body of platyhelminthes? In relation to this characteristic how are these animals classified?

Platyhelminthes are the first triploblastic animals (remember that cnidarians are diploblastic), i.e., they present three germ layers: ectoderm, mesoderm and endoderm.

4. What are the types of digestion and of digestive system of platyhelminthes?

Flatworms have incomplete digestive systems and they present extracellular and intracellular complementary digestions.

5. How are nutrients distributed by the digestive system in planarias?

Planarias have single opening digestive system (incomplete) with ramifications that transport nutrients to all areas of the body.

6. How is gas exchange done in flatworms?

Platyhelminthes exchange gases exclusively by diffusion through their body surface. This is only possible because all cells are localized relatively near to the exterior since gases diffuse cell by cell (the flat shape of these worms is a feature that allows this type of respiration).

7. Poriferans and cnidarians do not have excretory systems. Do platyhelminthes have an excretory system?

Platyhelminthes have a primitive excretory system made of flame cells

(also called solenocytes), excretory ducts and excretory pores.

8. What is an example of freshwater flatworm? Due to that habitat what is the physiological problem that these animals must solve?

Platyhelminthes of freshwater, like planarias, have an internal environment much more concentrated in solutes than the exterior and so they present a tendency to gain water. These organisms then need a drainage system to avoid cell death caused by excessive water.

The problem is solved by the presence of protonephridia located along longitudinal channels in the animal body. Protonephridia have ciliated cells, the flame cells, that push water outside the body through excretory pores.

9. Is the nervous system in platyhelminthes more or less sophisticated than in cnidarians? What are the main neural structures found in flatworms? How is this neural organization important for the diversity of biological niches explored by species of the phylum?

Platyhelminthes present a more sophisticated nervous system than cnidarians, as the first neural chords with ganglia (grouping of neurons) appear, a characteristic of the evolutionary process of increased nervous complexity. In platyhelminthes one can note the beginning of the cephalization process, with a concentration of neurons (nervous cells) in the anterior portion of the body and the appearance of photoreceptor cells in the ocelli.

With the increased capacity of these animals to perceive and to interact with the surrounds due to the increased complexity of their neural complexity, it is possible to find platyhelminthes in a variety of environments, including the terrestrial, and with diverse ways of life, like those that are parasites and those that are free-living.

10. What is cephalization? How does lateral symmetry favor cephalization?

Cephalization is the evolutionary tendency of concentration of the nervous command in central structures in which there are grouping of neurons (i.e, brain and ganglia formation). Evolutionarily the cephalization process begins with the appearance of ganglia (group of neurons) in platyhelminthes and reaches an apex in vertebrates, animals with a cranial box to protect the well-developed brain.

With lateral symmetry the body can be divided into lateral portions, superior, inferior, anterior and posterior. These portions must be integrated and controlled in some manner and this need stimulated the appearance of ganglial complexity and of beings with a head, a privileged extremity of the

bilateral body where the nervous central command and important sensory organs are located.

11. What is the type of reproduction, sexual or asexual, that occurs in platyhelminthes?

Platyhelminthes may present sexual or asexual reproduction.

12. How can asexual reproduction in planarias be described?

Planarias can divide themselves asexually by transversal bipartition due to the great regeneration capability of their tissues. When they attach to a substrate they can induce a constriction in their middle region and the body is then separated into two parts and each of these parts gives birth to a new individual as tissue regenerates.

13. Are flatworms monoecious or dioecious?

There are monoecious hermaphrodite flatworms, like planarias and taenias, and there are dioecious (having male and female individuals) species too, like schistosomes.

14. Is it possible for a hermaphrodite species to present cross-fecundation?

There are hermaphrodite species of animals and plants that present cross-fecundation mainly due to the maturation of female and male structures at different periods.

Cross fecundation occurs in planarias, hermaphrodites in which sexual fecundation takes place with male and female gametes from different individuals. These individuals approach their copulating structures and exchange gametes.

15. What is direct development? Is there a larval stage in planarias?

Sexual reproduction with direct development is that in which there is not a larval stage in the embryonic development. When a larval stage exists it is said to be indirect development.

In the sexual reproduction of planarias there is no larval stage.

16. Into which classes are platyhelminthes divided? How are these classes characterized and what are some representative beings of each of them?

Platyhelminthes are divided into three classes: turbellarians (or Turbellaria),

trematodes (or Trematoda) and cestodes (or Cestoda).

Turbellarians are free-living platyhelminthes and their main representative is the planaria (Dugesia tigrina). Trematodes are parasites, they live inside a host and the schistosome (Schistosoma mansoni) that causes schistosomiasis is an example. Cestodes are parasites too, they do not have digestive tubes and their cells are nourished by absorption of nutrients from the host; their most popular representative are the beef and pork taenias (Taenia saginata and Taenia solium) that parasite humans.

17. What are the main human diseases caused by platyhelminthes?

The main human diseases caused by platyhelminthes are schistosomiasis, tapeworm disease (cestodiasis) and cysticercosis.

(Note:Diseases are studied in the "Diseases" division of this e-book.)

18. Platyhelminth identity card. How are platyhelminthes characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: planarias, schistosomes, taenias. Basic morphology: flat worm. Type of symmetry: bilateral. Germ layers and coelom: triploblastics, acoelomates. Digestive system: incomplete. Respiratory system: nonexistent, respiration by diffusion. Circulatory system: nonexistent. Excretory system: protonephridia with flame cells. Nervous system: ganglial, beginning of cephalization. Types of reproduction: asexual and sexual.

Biology Questions and Answers

Nematodes

1. What are examples of nematodes?

Ascaris, hookworm and filaria, all parasites of humans, are examples of nematodes (also known as roundworms).

2. Are nematodes exclusively parasites?

There are parasitic roundworms, including parasites of plants, but there are also free-living nematodes.

3. What is the typical morphological feature of nematodes that differentiates them from platyhelminthes?

Nematodes are also known as roundworms. As the name indicates they are not flat like platyhelminthes. In evolutionary grounds with the nematodes the first complete digestive system appears, with mouth and anus, and the pseudocoelom is also a novelty.

4. What are the morphological similarities and differences between nematodes and annelids?

Nematodes, like annelids, have a cylindrical elongated body. Annelids differentiate from nematodes by presenting a segmented body (body divided into metameres) and so they are called segmented worms.

5. Are nematodes diploblastic or triploblastic animals?

Just like platyhelminthes, nematodes are triploblastics, i.e., they present three germ layers (ectoderm, mesoderm and endoderm).

6. What is the main evolutionary innovation presented by nematodes? What is the advantage of that innovation?

The main evolutionary innovation of nematodes is the complete digestive system, with two openings (mouth and anus).

Since the ingestion and the defecation processes can occur in different extremities of the digestive tube, beings with a complete digestive system have the advantage of ingesting new food while residuals of already eaten food are still inside the body and not yet eliminated.

Biology Questions and Answers

7. Compared to platyhelminthes which physiological problem have the cylindrical body of nematodes brought? How was that problem solved?

The cylindrical shape of nematodes made impossible the respiration exclusively by simple diffusion among cells since there are tissues far from the exterior. This problem was solved by the presence of an inner cavity in the body filled with fluid, the pseudocoelom. The pseudocoelom has the function of distributing gases and nutrients to the body and to collect residuals, besides serving as a hydrostatic base to keep the worm shape.

(For the fact that the pseudocoelom fluid and the pseudocoelom do not characterize a true circulatory system with blood and heart it is not said that in nematodes the respiration is cutaneous; it is considered that these animals still make respiration by diffusion).

8. How does the excretory system of nematodes work?

The metabolic residuals of nematodes are collected by two longitudinal lateral excretory channels that open in one single excretory pore near the mouth.

9. How is the nervous system of nematodes organized? Where are the neural chords located in their body?

Roundworms have a ganglial nervous system with an anterior neural ring representing (evolutionarily) a primitive cephalization.

Nematodes have two main longitudinal ganglial chords that extend one dorsally and the other ventrally under the epidermis. There may also be nerves lateral to these main chords. The nervous system of a free-living nematode, "Caenorhabditis elegans", has been well-studied in neurophysiological research and presents 302 neurons.

The nematode "C. Elegans" was the organism used in the research on the genetic regulation of organogenesis and apoptosis whose researchers won the Nobel prize of Medicine in 2002 (Brenner, Horvitz and Sulston).

10. What is the type of reproduction that occurs in roundworms? What typical feature do nematode sperm cells have?

Nematodes reproduce sexually. The nematode sperm cell does not have cilia nor flagella and they move by amoeboid movement forming pseudopods.

11. What are the main human diseases caused by roundworms?

The main human diseases caused by nematodes are ascariasis, ancylostomiasis (hookworm infection) and filariasis (commonly known by its consequence, elephantiasis).

12. Nematode identity card. How are nematodes characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: ascaris, hookworms, filaria, pinworms. Basic morphology: cylindric (round) body, not segmented. Type of symmetry: bilateral. Germ layers and coelom: triploblastics, pseudocoelomates. Digestive system: complete. Respiratory system: respiration by diffusion. Circulatory system: circulating fluid within the pseudocoelom. Excretory system: excretory channels and excretory pore. Nervous system: ventral and dorsal ganglial chord, primitive cephalization. Types of reproduction: sexual.

Biology Questions and Answers

Annelids

1. What are some examples of annelids?

Earthworms, leeches and lugworms.

2. Which are the morphological features that differentiate the beings of the phylum Annelida from nematodes and platyhelminthes?

Platyhelminthes are worms with flat bodies (flatworms), nematodes are worms with cylindrical but not segmented bodies (roundworms). Annelids are cylindrical worms with segmented bodies (they are metameric).

3. What is the main evolutionary novelty presented by annelids?

The main evolutionary novelty presented by the beings of the phylum Annelida is the coelom, the internal body cavity totally covered by mesoderm, a feature also present in arthropods, molluscs, echinoderms and chordates. Platyhelminthes are acoelomate and nematodes are pseudocoelomate (their internal cavity is partially covered by mesoderm).

Another important evolutionary novelty of the annelids is the closed circulatory system.

4. What is the morphological characteristic that evolutionarily approximates the beings of the phylum Annelida to arthropods?

The metameric feature, i.e., the body segmentation in metameres, approximates annelids to arthropods since these animals are segmented beings too. (Bristles present in oligochaete and polychaete annelids are also covered with chitin, the same substance of the arthropod exoskeleton.)

5. How does digestion in beings of the phylum Annelida work and which type of digestive system do they have?

Digestion in beings of the phylum Annelida is extracellular. These animals have a complete digestive system, with mouth and anus.

6. Which are the characteristics and organs of the digestive system of earthworms related to the type of diet of these animals?

Earthworms eat decomposing organic material and small organisms ingested together with soil particles. The digestive tubes of earthworms have special structures, like a muscular wall and a gizzard, that triturate the food and scratch it against the ingested soil particles. Since annelid digestion is exclusively extracellular earthworms also present in the posterior part of their digestive system structures like the cecum and the typhlosole that have the function of increasing the absorption surface of the intestine.

7. The vascular lesions caused by leeches upon the blood vessels of their host cause blood naturally to coagulate. How does the leech solve this problem since it could be expected that the ingested blood would coagulate inside its body?

Ingested blood does not coagulate inside the leech (Hirudo medicinalis) because in its saliva there is a potent anticoagulant substance, a protein called hirudin.

In the past leeches were largely used as medical treatment. Nowadays hirudotherapy is being used in patients with extensive and chronic inflammation of the skin, in prevention against tissue necrosis after some surgeries and in several others fields of Medicine.

8. How is the respiratory system of beings of the phylum Annelida characterized?

Respiration in annelids can be cutaneous or branchial. Cutaneous respiration occurs due to the rich vascularity under the epidermis. The gills, present in aquatic annelids, are located in the parapodia (false claws) that have an extensive capillary net.

9. What is meant when it is said that beings of the phylum Annelida are vascular beings? From which other phyla of the animal kingdom does this feature differentiate them?

The classification of these beings as vascular beings means that they have a circulatory system, with vessels that distribute substances throughout the body.

Poriferans, cnidarians and flatworms do not have a circulatory system. In nematodes there is circulation of gases and nutrients through the pseudocoelom fluid.

10. How are the circulatory systems of animals classified?

A circulatory system is classified as open or closed. In open circulatory systems blood gets out of vessels and flows also to large cavities that perfuse

the tissues to be irrigated. In closed circulatory systems blood circulates only within blood vessels and through the heart.

11. What is the type of circulatory system present in annelids?

In beings of the phylum Annelida the circulatory system is closed, i.e., blood circulation takes place only within specialized vessels.

12. Is there a respiratory pigment in the annelid blood?

The blood in beings of the phylum Annelida contains the respiratory pigment hemoglobin (the same found in chordates) and other pigments too.

13. How can the presence, localization and function of muscular tissue in beings of the phylum Annelida be explained?

In these beings there are a longitudinal muscular layer under the epidermis and, internally juxtaposed and perpendicular to it, another circular (radial to the axis) muscular layer. The circular muscle layer has the function of elongating the body while the longitudinal shortens it. By alternating actions both promote movement.

14. How can the excretory system of annelids be described?

In each segment (metamere) of the being a pair of complete excretory structures called metanephridium exists. The metanephridium has an extremity, the nephrostoma, which collects residuals from the coelom, filtering them and causing reabsorption along its extension (similar to human nephron tubules). The material to be excreted goes out through a pore, the nephridiopore, which opens in the body surface.

15. How is the nervous system characterized in beings of the phylum Annelida? How can one compare cephalization in annelids to cephalization in nematodes and platyhelminthes?

Annelids have a nervous system made of two ventral chords and one relatively big nervous cell concentration in its anterior portion resembling a primitive brain.

Nematodes have an anterior neural ring connected to two neural chords, a ventral and a dorsal one, while in planarias (platyhelminthes) there are only two small anterior “cerebral” ganglia from which neural chords split. Cephalization in annelids thus is more outstanding than in nematodes or in flatworms.

Biology Questions and Answers

16. What is the clitellum of earthtworms and where it is located?

The clitellum is a special region of the annelid constituted by rings (metameres) with reproductive function. It can be found in the anterior portion of the animal and it is characterized by a lighter color in comparison to the normal color of the other segments.

17. Concerning the occurrence of separated sexes how are the beings of the phylum Annelida classified?

These beings may be dioecious (the majority of polychaetes) or hermaphrodite monoecious (oligochaetes and hirudineans).

18. Is the embryonic development in earthworms direct or indirect?

In earthworms there is no larval stage, so the embryonic development is direct.

19. What is the name of the larval stage of polychaetes?

Among the annelid classes only polychaetes present a larval stage. Their larva is called trocophore.

20. What is the ecological role of earthworms?

Earthworms have an important ecological role as they eat decomposing organic material. They also dig tunnels in the subsoil allowing the entrance of gases and nutrients that are useful for plant roots and other living beings. So they act as decomposers and as fertilizers too.

21. Into which classes is the phylum Annelida divided?

The phylum is divided into three classes: oligochaetes (for example, earthworms), hirudineans (e.g., leeches) and polychaetes (these are mostly marine aquatic with parapodia, like nereis).

22. Annelid Identity card. How are they characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: earthworms, leeches, lugworms. Basic morphology: cylindrical body, segmented (metameric). Type of symmetry: bilateral. Germ layers and coelom: triploblastics, coelomates.

Digestive system: complete. Respiratory system: cutaneous or branchial. Circulatory system: closed, with hemoglobin. Excretory system: a pair of metanephridia in each metamere. Nervous system: neural chords, a pair of ganglia per metamere, anterior concentration of neurons (primitive brain). Types of reproduction: sexual, with dioecious and monoecious beings.

Biology Questions and Answers

Arthropods

1. What are some examples of arthropods?

Ants, flies, cockroaches, shrimps, crabs, spiders and scorpions are examples of arthropods.

2. What are the classes into which the phylum Arthropoda is divided? What are the three main ones and some of their representative species?

The three main classes of arthropods are: insects (cockroachs, ants, flies, bees, beetles, butterflies), crustaceans (crabs, lobsters, shrimps, barnacles) and arachnids (scorpions, spiders, mites). Other classes are onychophorans (velvet worms), diplopods (millipedes) and chilopods (centipedes).

3. What are the main morphological features of arthropods?

Arthropods present three distinguishing features: they are metameric beings (segmented body), they have an exoskeleton made of chitin and they present articulated limbs.

4. Concerning germ layers and the presence of coelom how are arthropods characterized?

Arthropods are triploblastic (they have three germ layers) and coelomate beings.

5. Considering the presence of segmentation (metameres) in their body to which other already studied phylum are arthropods proximal?

Considering their metameric feature arthropods are proximal to annelids that also have segmented bodies. In the embryonic development of some arthropods there are fusions of metameres forming structures like, for example, the cephalothorax of arachnids.

6. What is the external rigid carapace of arthropods called? Of which substance is it made? Which type of organic molecule is that substance?

The external carapace of arthropods is called exoskeleton. The arthropod exoskeleton is made of chitin, a nitrogen-containing polysaccharide.

Biology Questions and Answers

7. How do arthropods grow?

Due to the presence of exoskeleton the growth of an arthropod is periodical. During the growth period the animal loses the exoskeleton, grows and develops a new exoskeleton. This process is named ecdysis, or molting.

8. How does the presence of exoskeleton explain the general small size of arthropods?

Since they have exoskeleton and periodic ecdysis, the growth of arthropods is limited to avoid the animal becoming vulnerable to environmental harm. There are however some arthropod species with relatively large-sized individuals, like "giant" cockroaches, crabs and spiders.

9. How can the features of the arthropod exoskeleton explain the terrestrial adaptation of some species of the phylum?

In the arthropod exoskeleton there is a layer of wax which is impermeable. This feature was fundamental for primitive arthropods from the sea to survive on dry land without losing excessive water to the environment.

10. What is the type of digestive system present in beings of the phylum Arthropoda? Are these animals protostomes or deuterostomes?

The digestive tube of arthropods is complete, containing mouth and anus. Arthropods are protostome animals, i.e., in their embryonic development the blastopore originates the mouth.

11. How is the extracorporeal digestion associated to predation in arachnids?

Arachnids can inoculate poison to paralyze or kill their preys using structures called chelicerae. The prey is partially digested outside the body of the arachnid by digestive enzymes inoculated together with the venom or injected posteriorly. After this extracorporeal digestion the food is ingested and gains the digestive tube of the predator where the extracellular digestion continues.

12. Which organs or respiratory adaptations do aquatic and terrestrial arthropods respectively present?

In crustaceans, typical aquatic beings, there are richly vascularized gills that make contact with water and permit gas exchange. In terrestrial insects the respiration is tracheal and gases flow

inside small tubes that connect the animal external surface and ramify to tissues and cells without the participation of blood. In arachnids, besides the tracheal respiration, book lungs (thin folds resembling leaves in a book) may also exist.

13. In arthropods why isn't gas exchange done through cutaneous diffusion?

In arthropods the impermeability of the exoskeleton makes the passage of gases difficult. In addition the new methods of respiration present in arthropods were preserved by evolution because they were more efficient for those animals.

14. What is the type of circulatory system present in arthropods? Do these animals have heart and respiratory pigments?

In arthropods the respiratory system is open (lacunar). Blood, also known as hemolymph, is pumped by a heart and falls into cavities (lacunas) irrigating and draining tissues.

All arthropods have a heart. Crustaceans and arachnids have respiratory pigments. Insects do not have respiratory pigments since their blood does not carry gases (in them gases reach tissues and cells through tracheal structures).

15. What are respiratory pigments? What is the respiratory pigment present in some arthropods? Which is the analogous molecule in humans?

Respiratory pigments are molecules able to carry oxygen and other respiratory gases present in circulatory fluids.

In crustaceans and in arachnids hemocyanin is the respiratory pigment. In humans the analogous pigment is hemoglobin.

16. How is the respiratory system of insects (with its independence between circulation and respiration) related to the motor agility of some species of this arthropod class?

Even having low speed and low pressure circulatory system, since it is a lacunar (open) circulatory system, insects perform extremely fast and exhaustive movements with their muscle fibers, like wing beating. This is possible because in these animals the respiration is independent from the open circulation. Gas exchange is done with great speed and efficiency by the tracheal system that puts cells in direct contact with air. Muscles can then work fast and hard.

Biology Questions and Answers

17. How are the excretory systems of the three main arthropod classes constituted?

In crustaceans a pair of excretory organs called green glands exists. The green glands collect residuals from the blood and other parts of the body. They are connected by ducts to excretory pores located under the base of the antennae and these pores release the excretions outside.

In insects small structures called malpighian tubules gather wastes from the blood and throw them into excretory ducts that open in the intestine. In these animals excretions are eliminated together with feces.

In arachnids, besides malpighian tubules, there are coxal glands located in the cephalothorax near the limbs that also participate in excretion.

18. What are the noteworthy features of the nervous system of arthropods?

In arthropods the nervous system has more sophisticated sensory receptors with well-advanced cephalization. In the anterior region of the body there is a fusion of ganglia forming a brain connected to two ventral ganglial chains having motor and sensory nerves.

The boosted development of the sensory system of arthropods provides more adaptive possibilities for these animals to explore many different environments.

19. What are compound eyes?

Arthropods have compound eyes made of several visual units called ommatidia. Each ommatidium transmits visual information through the optic nerve to the brain, which interprets the image. Because they are round and numerous, these ommatidia, whose external surfaces point in different directions creating independent images, cause arthropod eyes have a large visual field, larger than the visual field of vertebrates. Some insects have one or more simple eye besides their pair of compound eyes.

20. How is arthropod reproduction characterized?

Reproduction in beings of the phylum Arthropoda is sexual, with larval stage in some insects and crustaceans (arachnids present only direct development).

21. What are the types of fecundation that occur in arthropods? What is the predominant type?

In arthropods there are species having external fecundation and other species having internal fecundation. Internal fecundation is predominant.

Biology Questions and Answers

22. How is fecundation done in insects (external or internal)? Is there copulation between insects?

Fecundation in insects is internal, with copulation.

23. How are the main classes of arthropods classified according to the presence of larval stage in their embryonic development?

In crustaceans there are species with direct and others with indirect development. In insects there are species without larval stage (ametabolic insects), others undergoing indirect development beginning with an egg stage followed by a nymph stage (hemimetabolic insects) and others with indirect development beginning with the larval stage (holometabolic insects).

The transformation of a larva into an adult individual is called metamorphosis. Hemimetabolic insects undergo incomplete metamorphosis while holometabolic insects undergo complete metamorphosis.

24. What are nymph and imago?

Nymphs are larvae of hemimetabolic insects (like grasshoppers). They are very similar to the adult insect although smaller. In holometabolic insects (like butterflies) the larva makes a cocoon (chrysalis, pupa) where it lives until emerging into the adult form. Imago is the name given to the adult form of insects with indirect development.

25. Is the stage when an insect larva is within a cocoon a stage of total biological inactivity?

The period when the larva is within its cocoon is a time of intense biological activity since the larva is being transformed into an adult animal.

26. How are the three main arthropod classes characterized according to the presence of wings?

Crustaceans and arachnids do not have wings. Most insects have wings.

27. Most insects have wings. Which is the other animal phylum that contains creatures with analogous organs?

Besides the phylum Arthropoda another animal phylum with flying creatures is the chordate phylum, birds and chiropterans mammals (bats) have wings. In the past some reptiles that possibly originated the aves had wings too. There are also amphibians and fishes that jump high exploring the aerial environment.

28. How are the three main arthropod classes characterized according to the presence of antennae?

Crustaceans have two pairs of antennae; insects have one pair; arachnids do not have antennae.

29. How are the three main arthropod classes characterized according to the body division?

In crustaceans and arachnids the head is fused with the thorax forming the cephalothorax. Their body thus is divided into cephalothorax and abdomen.

In insects there are head, thorax and abdomen.

30. How are the three main arthropod classes characterized according to the number of limbs?

Most crustaceans have five pairs of limbs. Insects have three pairs and arachnids present four pairs of limbs.

31. Which arthropod class is the most diversified animal group of the planet? How can this evolutionary success be explained?

The insects are the animal group with most diversity of species. Almost 750000 insect species are known, about 55% of the total already cataloged species of living beings (compare with mammals, with no more than 4000 known species). It is calculated however that the number of unknown species of insects may be over 2 million. The insect population on the planet is estimated to be more than 10 quintillion (1000000000000000000) individuals.

The great evolutionary success of insects is due to factors such as: small size and alimentary diversity, making possible the exploration of numerous different ecological niches; wings that provided more geographic spread; the tracheal respiration that gave them motor agility; high reproductive rates with production of great numbers of descendants.

32. What are some examples of beings of the phylum Arthropoda that present a high level of behavioral sophistication?

Insects like some species of bees, wasps, ants and termites form societies that include hierarchy and job division among members. Spiders build sophisticated external structures, webs, mainly to serve as a trap for capturing prey. Another example is the

communication mechanism in some bees known as the bee dance by which an individual signal to others information about the spatial position of flower fields and other nectar sources.

33. Arthropod identity card. How are arthropods characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: cockroaches, flies, crabs, lobsters, shrimps, spiders, scorpions, mites. Basic morphology: segmented body (metameric), articulated limbs, chitinous exoskeleton, periodic ecdysis. Type of symmetry: bilateral. Germ layers and coelom: triploblastics, coelomates. Digestive system: complete. Respiratory system: tracheal in insects, branchial in crustaceans, tracheal and book lungs in arachnids. Circulatory system: open, hemocyanin in crustaceans and arachnids. Excretory system: malpighian tubules in insects, green glands in crustaceans, malpighian tubules and coxal glands in arachnids. Nervous system: ganglial. Types of reproduction: sexual, with or without larval stage in insects and crustaceans, metamorphosis in some insects, no larval stage in arachnids.

Biology Questions and Answers

Molluscs

1. What are some representatives of the phylum Mollusca?

Snails, octopuses, squids and oysters are examples of molluscs.

2. In which habitats do molluscs live?

Molluscs can be found in the sea, freshwater and in terrestrial environments.

3. What is the morphological feature of molluscs after which the phylum is named?

The word "mollusc" means "soft thing". Molluscs have soft bodies and this feature explains the name of the phylum.

4. What are the biological troubles that molluscs face due to their soft body?

Because molluscs have a soft body they are more fragile. They also have more difficulty to support their bodies in terrestrial environments or to fixate to substrates in aquatic habitats. Many species solve these problems by secreting a calcareous carapace, or shell, an exoskeleton to support and protect them and to prevent dehydration.

5. Are mollusc metameric beings? Exclusively analyzing this feature could it be said that molluscs are evolutionarily proximal to nematodes or to annelids?

In molluscs there is not a body divided into segments. Considering just this feature it could be said that evolutionarily they are more proximal to nematodes than to annelids.

6. Into which classes are mollusc divided? What are some representing beings of each class?

The phylum Mollusca is divided into five main classes: pelecypods, or bivalves (Pelecypoda, or Bivalvia), includes oysters, clams, mussels; gastropods (Gastropoda), snails, sea slugs; cephalopods (Cephalopoda), squids, octopuses; scaphopods (Scaphopoda), tooth shells; Polyplacophora, chitons. There are a few other mollusc classes.

7. How is the body of gastropods divided?

The body of gastropods is divided into three main portions: head, the visceral mass and foot.

8. What is the type of digestive system in molluscs?

Molluscs present extracellular digestion and a complete digestive system, with mouth and anus.

9. What is the radula? What is the function of this organ?

Some molluscs have a tongue-like structure with harsh saliences similar to small teeth. This structure is called radula. The radula projects outside and helps to scrape food.

10. How is the respiratory system in aquatic molluscs characterized? What adaptive respiratory structure do terrestrial molluscs present?

Aquatic molluscs oxygenate their blood through gills in direct contact with water. In terrestrial molluscs the rich vascularity under the mantle cavity absorbs air doing the role of a primitive lung.

11. Which type of circulatory system do molluscs have? How can it be compared to the respiratory system of annelids?

Molluscs, with the exception of cephalopods, have an open circulatory system, i.e., the blood circulates within vessels, from the heart, but it also fills open lacunas or cavities. In annelids the circulatory system is closed, i.e., the blood circulates only inside blood vessels.

12. How is the large size of some cephalopods related to the type of circulatory system they present?

In cephalopods the circulatory system is closed and this provides more speed and pressure for the blood circulation allowing the existence of species with large bodies, like octopuses and giant squids.

13. How is the excretory system of molluscs characterized?

Molluscs have one or two pair of spongelike nephridia, similar to kidneys.

Biology Questions and Answers

14. What type of exoskeleton do some molluscs present?

Some molluscs, like bivalves and gastropods, secrete an external calcareous carapace (the shell). Calcium carbonate is secreted by the mantle, a fold in the epidermis, forming the shell.

In pelecypods, the shell is made of two valves that articulate and contain the individual body within. In gastropods the shell contains only part of the body, the visceral mass.

15. Do octopus and squids have exoskeleton?

Octopus and squids generally do not produce external shell (some squid species can have an internal shell). One cephalopod group, the nautiluses, produces an external spiral shell.

16. Which other phylum of the animal kingdom present species with exoskeleton?

Arthropods present exoskeleton made of chitin. Echinoderms do not have exoskeleton but they present a calcareous endoskeleton. Some chordates also have an external carapace.

17. What is the function of the feet in molluscs? How is the mollusc foot related to the name given to the classes of the phylum?

The mollusc foot has the function of locomotion, support, fixation, digging in the environment and sometimes of holding prey.

The terminations of the names given to the main mollusc classes come from the Greek word “podos” that means foot. Gastropods have feet in their ventral region (as the name indicates); pelecypods have ax-shaped feet (ax in Greek is “pelekys”); in cephalopods the feet are near the head.

18. How is the nervous system of molluscs organized?

Molluscs have well-developed sensory structures. It is accepted that cephalopods, like octopus and squid, have eyes with image formation. Snails have antennae and a pair of well-defined eyes. Bivalves do not present eyes but they have photosensitive and tactile cells.

Cephalization is evident in molluscs and neurons concentrate in a ganglial pattern.

19. What are examples of the ecological and economic importance of molluscs?

Molluscs are important players in several food chains in ecosystems. Many marine molluscs are part of a common human diet, like octopus and squid, very appreciated in the East, and oysters and mussels, consumed all around the world. Besides molluscs that are part of the food industry, pearls made by oysters have high commercial value.

20. How are natural and artificial pearls created?

Pearls are made from small strange particles that deposit between the shell and the mantle of the oyster. These particles trigger a defense process by the organism and they are gradually covered by calcium carbonate layers secreted by the oyster thus giving birth to pearls.

In the artificial production of pearls a small fragment of shell covered with mantle pieces is inserted between the shell and the mantle of an oyster and a pearl is formed around the graft.

21. Mollusc identity card. How are molluscs characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: snails, sea slugs, octopuses, squids, mussels, oysters. Basic morphology: soft body, with or without calcareous shell. Type of symmetry: bilateral. Germ layers and coelom: triploblastics, coelomates. Digestive system: complete. Respiratory system: branchial or, in terrestrial gastropods, lungs. Circulatory system: open or, in cephalopods, closed. Excretory system: nephridia. Nervous system: ganglial, advanced cephalization in cephalopods. Types of reproduction: sexual.

Biology Questions and Answers

Echinoderms

1. What are some representatives of the echinoderm phylum?

Starfishes, sea cucumbers (holothurians), sea urchins and brittle stars are examples of echinoderms.

2. Under which environments do echinoderms live?

Echinoderms are marine animals, they live in salt water.

3. What are the basic morphological features of echinoderms?

Echinoderms, as the name indicates (echino = spiny, derma = skin), are creatures with spines originated from an endoskeleton. Their endoskeleton is made of calcareous plaques that besides spines contain pedicellaria, small pincers used to clean the body and to help the capturing of prey. They also present a hydrovascular system known as the ambulacral system. Adult echinoderms have pentaradial symmetry; the radial symmetry in these animals is secondary, present only in adults.

4. How can the endoskeleton of echinoderms be characterized in comparison to analogous structures present in vertebrates, arthropods and molluscs?

The echinoderm skeleton is internal, i.e., it is an endoskeleton. It is made of calcium carbonate (calcareous).

Vertebrates also have internal skeleton made of bones and cartilages. Arthropods have an external carapace made of chitin, a chitinous exoskeleton. Some molluscs present a calcareous shell that works as exoskeleton.

5. What is the system that permits movement and fixation to echinoderms?

The system that permits movement and fixation to substrates in echinoderms is called the ambulacral system. In these animals water enters through a structure called madreporite, passes through channels and reaches the ambulacral feet in the undersurface of the body. In the ambulacral region in contact with the substrate, there are tube feet filled and emptied by water thus acting as suckers.

Biology Questions and Answers

6. What is the type of digestive system of echinoderms?

Echinoderms present a complete digestive system, with mouth and anus.

7. Do sea urchins have teeth?

Sea urchins have a teeth-like structure juxtaposed to the mouth and made of five teeth connected to ossicles and muscle fibers. This structure, known as Aristotle's lantern, is use to scratch food, mainly algae, from marine rocks.

8. What is the embryonic characteristic that evolutionarily makes echinoderms proximal to chordates?

Echinoderms and chordates are deuterostomes, i.e., in their embryonic development the blastopore turns into the anus. All other animals with complete digestive system are protostomes, i.e., their blastopore originates the mouth.

The blastopore is the first opening of the digestive tube that appears in the embryonic development.

9. Do echinoderms have respiratory and circulatory systems?

In echinoderms there are not well-defined respiratory (with the exception of the holothurian group) and circulatory systems. The ambulacral hydrovascular system plays the function of these systems.

10. Do echinoderms have an excretory system? How is excretion done in these animals?

Echinoderms do not have an excretory system. Their excretions are eliminated by diffusion.

11. How are the symmetry and the nervous system characterized in echinoderms?

Adult echinoderms, along with cnidarians, are the animals that present radial symmetry, i.e., their body structures are distributed around a center. The radial symmetry in echinoderms however is a secondary radial symmetry, since their larval stage has bilateral symmetry and the radial pattern appears only in adult individuals (there are some few adult echinoderms with lateral symmetry). All other animals have lateral symmetry with exception of poriferans (no symmetry is defined for them).

Echinoderms do not present cephalization and they have a diffuse network of nerves and neurons made of a neural ring around the mouth and of radial nerves that ramify to follow the pentaradial structure of the body.

Biology Questions and Answers

12. Do echinoderms present internal or external fecundation? Is there sex division among individuals?

The fecundation in echinoderms is external, gametes are liberated in water where fecundation occurs.

The majority of echinoderms are dioecious with male and female individuals.

13. Is there a larval stage in echinoderms?

In echinoderms embryonic development is indirect, with ciliated larvae.

14. What are the classes into which the phylum Echinodermata is divided?

The five echinoderm classes are: asteroids (starfishes), ophiuroids, crinoids, holothuroids (sea cucumbers) and echinoids (sea urchins and sand dollars).

15. Echinoderm identity card. How are echinoderms characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: sea cucumber, sea urchin, starfishes. Basic morphology: calcareous endoskeleton with spines, ambulacral system. Type of symmetry: secondary radial. Germ layers and coelom: triploblastics, coelomates. Digestive system: complete, deuterostomes. Respiratory system: nonexistent. Circulatory system: nonexistent. Excretory system: nonexistent. Nervous system: simple, nerve network without ganglia or cephalization. Types of reproduction: sexual, with larval stage.

Biology Questions and Answers

Chordates

1. What are the two main subdivisions of the phylum Chordata?

The phylum Chordata is divided into protochordates (urochordates and cephalochordates) and vertebrates (cyclostomes, fishes, amphibians, reptiles, birds and mammals).

2. What are the three structures shared by every chordate that characterize the group?

All beings of the phylum Chordata have branchial clefts in the pharynx (in some species present only in the embryo), notochord (substituted by the spinal column in vertebrates) and dorsal neural tube.

3. What is the destination of the branchial clefts in humans?

In humans the branchial clefts located in the anterior region of the pharynx (also known as pharyngeal clefts) are present only in the embryonic stage and disappear later.

4. What is the destination of the notochord in vertebrates and in protochordates?

In vertebrates the notochord disappears and gives birth to the spinal column (vertebral column). In protochordates the notochord remains for the rest of the life.

5. Is the tubular-dorsal nervous system of chordates associated to radial or lateral symmetry? How does that explain the complexity level of the nervous system reached by the vertebrate evolutionary branch?

The tubular and dorsal nervous system of chordates is related to the cephalization in these animals and to bilateral symmetry.

The presence of neural integrating centers with concentration of neurons in the brains and the spinal cord (central nervous system, CNS) allowed the increase of the interaction complexity between these animals and the environment. Receptor (afferent conduction) and efferent (motor, regulatory and behavioral reactions) functions come out more sophisticated in chordates due to the presence of more well-developed neural networks. These features have been preserved by evolution as they provide adaptive advantage to their owners.

6. How can the tubular-dorsal nervous system in chordates be compared to the nervous pattern present in invertebrates?

In chordates the nervous system is dorsal and highly cephalized while in most invertebrates the nervous system is ganglial and ventral.

7. What is the group of the phylum Chordata that first colonized the terrestrial environment? From which habitat did they come?

Amphibians, partially aquatic partially terrestrial animals, were the first chordates that colonized the dry land. They came from the aquatic habitat and were originated from fishes. (Nevertheless the first completely terrestrial chordates were the reptiles).

8. How do chordates reproduce?

Reproduction in beings of the phylum Chordata is sexual, with the exception of urochordates that can also reproduce asexually. In some classes (cyclostomes, osteichthyes fishes and amphibians) there is larval stage. With rare exceptions, fishes, amphibians, reptiles and monotreme mammals are oviparous, egg-laying (embryos develop within eggs and outside the mother's body) and marsupial and placental mammals are viviparous (embryos develop inside the mother's body, feeding from her).

9. Into which subphyla are the protochordates divided? What are some representatives of each protochordate subphylum?

Urochordates (or tunicates) and cephalochordates are the two subphyla into which protochordates are divided.

Ascidians, sessile animals similar to sponges, are examples of tunicates. The amphioxus, well-studied in Embryology, is an example of cephalochordate.

10. What are the six criteria used to build a complete evolutionary branch of vertebrates?

Dichotomy in each of the six following criteria builds the vertebrate evolutionary branch: absence of mandibles separates cyclostomes from others; absence of limbs separates fishes from the remaining; absence of osseous skeleton separates chondrichthian (cartilaginous) fishes from osteichthyes; absence of impermeable skin separates amphibians from the terrestrial vertebrates; absence of warm blood (homeothermic body) separates reptiles from birds and mammals; absence of mammary glands and hair separates birds from mammals.

Biology Questions and Answers

11. Evolutionarily protochordates may be intermediate animals between invertebrates and vertebrates. Imagine a scientist is testing the hypothesis that vertebrates evolved from echinoderms. Having as research object a newly found protochordate species, what is an example of a discovery that would weaken the hypothesis? What is an example of a discovery that would strengthen it?

Hypothesis to be tested: Vertebrates evolved from echinoderms. Testing material: A newly found protochordate species (i.e., a vertebrate forerunner).

Example of weakening observation (that puts the new protochordate species evolutionarily far from echinoderms): "The new species is protostome", as opposed to echinoderms, that are deuterostomes. This observation brings the suspicion that deuterostomy in vertebrates is independent in origin from echinoderms.

Example of strengthening observation (that nears the new protochordate species to echinoderms): "The new species has secondary radial symmetry", similar to echinoderms. This observation makes stronger the hypothesis that echinoderms and vertebrates are relatives.

(This item shows how science works, beginning with the placement of hypothesis and further observational testing.)

12. Chordate identity card. How are they characterized according to examples of representing beings, basic morphology, type of symmetry, germ layers and coelom, digestive system, respiratory system, circulatory system, excretory system, nervous system and types of reproduction?

Examples of representing beings: protochordates (ascidians, amphioxus), vertebrates. Basic morphology: branchial clefts, notochord, neural tube. Type of symmetry: bilateral. Germ layers and coelom: triploblastics, coelomates. Digestive system: complete, deuterostomes. Respiratory system: branchial (in aquatic), cutaneous (in adult amphibians), pulmonary (others). Circulatory system: open in protochordates, closed in vertebrates. Excretory system: diffusion and flame cells in protochordates, kidneys in vertebrates. Nervous system: neural tube in embryos, cerebral vesicle and single ganglion in protochordates, brain within the cranium and spinal cord within the spinal column in vertebrates. Types of reproduction: sexual, with or without larval stage.

Biology Questions and Answers

Fishes

1. What are the two main classes into which fishes are divided?

Fishes are divided into two main classes: chondrichthyes, fishes with cartilaginous skeletons (sharks, rays, dog-fishes), and osteichthyes, bony fishes (tuna, sardines, salmons).

2. From which features do condrichthyes and osteichthyes get these names?

"Chondros" means cartilage, "ictis" means fish (both from the Greek); the name chondrichtians is for fishes with cartilaginous endoskeleton. The name osteichthyes comes from the existence of a bony endoskeleton in these fishes ("osteo" means bone, from the Greek too).

3. What are the main features of fishes associated to the habitat where they live?

Fishes are all aquatic animals and thus they have a hydrodynamic elongated body suitable to move under water, without limbs and with fins. The habitat conditions the branchial respiration too.

4. Comparing to cyclostomes (primitive vertebrates) what are the main novelties presented by fishes?

Compared to cyclostomes, evolutionary novelties presented by fishes are: pectoral and pelvic fins, symmetric and paired; the presence of mandibles.

5. How different are the swimming strategies in osteichthyes and in chondrichthyes? Why do sharks need to agitate their body to swim while bony fishes do not?

Bony fishes have a specialized organ called a gas bladder, or swim bladder, whose interior can be filled with gas liberated from gas glands. The swim bladder works as a hydrostatic organ since it varies the relative density of the body regulating buoyancy and the depth of the animal in water.

Chondrichthyes do not have swim bladders and thus they must continuously agitate their body to keep swimming and maintain their depth in water. As an additional swimming aid, in chondrichthyes the liver is big and oily; this feature helps to reduce their body density relative to water.

Biology Questions and Answers

6. How does the swim bladder of fishes work allowing fishes to control their depth under water?

From Hydrostatics it is known that an object does not sink if its density is equal or less than the density of the fluid in which it is immersed.

When the swim bladder is filled by gas it reduces the density of the fish body and when it is emptied this density is increased. So this mechanism controls the fish depth under water.

7. How do fishes do gas exchange?

Fishes "breath" through gills. Gills, or branchiae, are highly vascularized organs specialized in gas exchange under water and present in aquatic animals (marine annelids, crustaceans, fishes and tadpoles). Gills are a respiratory organ (analogous, for example, to lungs) containing very thin lamellae with many apparent blood vessels in direct contact with water.

In osteichthyes the gills are covered by a bony flap that protects them called operculum. In chondrichthyes there are no opercula.

8. Do fishes present an open or closed circulatory system? How many chambers does a fish heart have? How does blood flow throughout the fish body?

As in every vertebrate the circulatory system of fishes is closed, i.e., blood flows only within blood vessels.

The fish heart has only two consecutive chambers: a thin-walled atrium and a muscular ventricle. The arterial (oxygenated) blood comes from the gills and gains arteries towards tissues, then venous blood is collected by veins and reaches the atrium of the heart passing to the ventricle that pumps the venous blood towards the gills to be again oxygenated.

9. How is excretion done in fishes?

Fishes have a pair of kidneys that filtrate the blood. Bony fishes excrete nitrogen as ammonia, NH_3, (they are ammoniotelic) and cartilaginous fishes excrete urea as nitrogen waste (they are ureotelic, like adult amphibians and mammals).

10. What are the lateral lines of fishes?

The lateral lines of bony fishes are sense organs that extend along both sides of the animal body. They make contact with the environment by a series of specialized scales that transmit

information about pressure variation and vibrations in the surrounding water.

11. How different are fecundation in osteichthyes and in chondrichthyes?

In chondrichthyes fecundation is internal by means of copulation. In osteichthyes fecundation generally is external and the gametes are released in the water, where they can fecundate their counterpart and form the zygote.

12. Fish identity card. How are fishes characterized according to examples of representing beings, basic morphology, skin, respiration, circulation, nitrogen waste, thermal control and types of reproduction?

Examples of representing beings: sharks, rays, sardines, tuna, salmons. Basic morphology: hydrodynamic body, fins; cartilaginous skeleton in chondrichthyes, bony skeleton in osteichthyes. Skin: with scales in osteichthyes and placoid scales in chondrichthyes. Respiration: branchial. Circulation: closed, incomplete, heart with two chambers. Nitrogen waste: urea in chondrichthyes, ammonia in osteichthyes. Thermal control: heterothermic. Types of reproduction: sexual, internal fecundation in chondrichthyes, external in osteichthyes.

Biology Questions and Answers

Amphibians

1. Which is the chordate class considered an evidence of the transition of the vertebrates from the aquatic to the dry land environment?

The amphibians are totally aquatic in the larval stage and partially terrestrial animals as adults and for these facts they are considered intermediate beings in the evolutionary passage of vertebrates from the aquatic to the dry land habitat. Amphibians are also the first tetrapod animals, i.e., the first with two pair of limbs, a typical feature of terrestrial vertebrates. The name "amphibian" comes from the double life (aquatic as larvae and partially terrestrial as adults) of these animals.

2. What are the amphibian features that make them dependent on water to survive?

Permeable skin, body subject to dehydration, external fecundation, eggs without shells and larval stage with branchial respiration are features that make amphibians dependent on water to survive.

3. Do amphibians have direct development?

In amphibians the embryonic development is indirect (there is a larval stage).

4. How different are the respiration in fishes and the respiration in adult amphibians?

In fishes gas exchange is done by direct contact of water with the branchiae (gills). Gases gain and exit the circulation through the gills.

In adult amphibians gas exchange is done through the moist and permeable skin (cutaneous respiration) and also through the lungs, a set of tiny airway terminations associated to a highly vascularized tissue specialized in gas exchange.

The axolotl is an exotic amphibian found in Mexico that lives in water and "breathes" through gills even as an adult.

5. How is respiration performed by the larva of amphibians?

The larva of amphibians has exclusively branchial respiration. This is one of the reasons why it depends on water to survive.

6. How different is the amphibian heart from the fish heart?

The fish heart has only two chambers, an atrium and a ventricle, and the blood that comes to it is purely venous.

In amphibians there are three heart chambers (a second atrium is present) and there is arterial blood coming from the lungs; in these animals the heart has two atria (one that gets blood from the body and other that gets blood from the lungs) and one ventricle; arterial blood mixes with venous blood within the ventricle which in turn pumps the blood to the lungs and to the systemic circulation.

7. How is excretion done in amphibians?

Adult amphibians have kidneys that filter blood. Nitrogen waste is excreted as urea (so amphibians are ureotelic beings). The larvae, aquatic, excrete ammonia.

8. Is fecundation in amphibians external or internal? In this aspect are amphibians evolutionarily proximal to fishes or to reptiles?

In the majority of the amphibian species fecundation is external. This feature is common to bony fishes too and it shows that the reproductive system and the embryonic development of amphibians are a heritage from osteichthyes.

Curiously although having external fecundation amphibian male and female copulate to stimulate the liberation of sperm and egg cells. This phenomenon does not characterize internal fecundation since the gametes unite in water.

9. Why is the occurrence of eyelids in amphibians in comparison to their absence in fishes an adaptation to terrestrial life?

Eyelids associated to lacrimal glands protect and keep eyes lubricated against damage from the great luminosity of terrestrial environments. Fishes do not have eyelids since their eyes are in constant contact with the fluid medium.

10. What are the problems that vertebrates needed to solve to adapt to the terrestrial environment since they came from the aquatic habitat? How does evolution solved those problems?

The main problems vertebrates coming from water needed to solve to adapt to the terrestrial environment were the following: the problem to avoid dehydration; the problem of elimination of wastes in a medium where water is less available; the problem of protection against nocent solar radiation; the problem of gamete locomotion in the

environment for fecundation; the problem of gas exchange, earlier done by direct contact of water with gills; the problem of body support, since it was water that played this role in fishes.

Solutions for the dehydration problem: thicker and impermeable skin, to lose less water, or moist and permeable skin, like in amphibians. Solution for the excretion problem: excretion of urea (also excreted by chondrichthyes) or uric acid, substances that need less water to be dissolved. Solutions for the problem of protection against radiation: skin pigments that filter harmful radiation, feathers, hair or carapaces. Solution for the gamete movement problem: internal fecundation (except for most amphibians, that have external fecundation). Solution for the gas exchange problem: appearing of airways and lungs. Solution for the body support problem: further development of muscular and bony structures, like limbs and claws.

11. Amphibian identity card. How are amphibians characterized according to examples of representing beings, basic morphology, skin, respiration, circulation, nitrogen waste, thermal control and types of reproduction?

Examples of representing beings: frogs, toads, salamanders. Basic morphology: two pairs of limbs, eyelids, hydrodynamic larvae. Skin: moist and permeable, mucous glands. Respiration: cutaneous and pulmonary, branchial in larval stage. Circulation: closed, incomplete, heart with three chambers without interventricular septum. Nitrogen waste: urea. Thermal control: heterothermic. Types of reproduction: sexual, water dependant, external fecundation and aquatic larval stage.

Biology Questions and Answers

Reptiles

1. Which is the vertebrate class that is considered the first entirely terrestrial?

The first entirely terrrestrial vertebrate class, totally independent from the aquatic habitat, is the class Reptilia.

2. Compared to amphibians what is an example of evolutionary novelty present in beings of the class Reptilia against the loss of water through the skin?

The reptile skin is keratinized and impermeable to water while the amphibian skin is permeable. The skin impermeability made impossible the cutaneous gas exchange performed by amphibians and respiration became dependent on internal organs like airways and lungs.

3. What are examples of a carnivorous and a herbivorous reptile?

Snakes are carnivorous. Iguanas are herbivorous.

4. Do beings of the class Reptilia perform gas exchange in the same way amphibians do?

These beings do not have permeable skin so they do not make cutaneous respiration like amphibians do. Just like in birds and in mammals, their respiration is pulmonary.

5. How is the circulatory system of reptiles characterized? What is the basic difference between the reptile and the amphibian heart?

The circulatory system of beings of the class Reptilia is similar to the amphibian, closed and incomplete. Although the heart presents three chambers (two atria and one ventricle) in reptiles there is a beginning of ventricular septation and the mixture of arterial with venous blood is lessened.

6. Which is the type of nitrogen waste eliminated by beings of the class Reptilia?

These beings excrete mainly uric acid. This substance is less toxic than ammonia and it can be kept stored for a longer time inside the individual, including within eggs. In addition uric acid is practically insoluble and it depends less on water to be eliminated.

Biology Questions and Answers

7. How has the importance of the brain evolved from fishes to reptiles?

From the least to the most complex brain structure, it is evident that the brain, from fishes to beings of the class Reptilia, became larger and predominant in the central nervous system.

8. How is reproduction done in beings of the class Reptilia?

These beings reproduce sexually through internal fecundation by means of copulation between male and female individuals. They lay eggs with shell and extraembryonic membranes. The embryo thus develops within the egg and outside the mother's body (there are also ovoviviparous reptiles that retain the egg within the body until hatching).

9. Do beings of the class Reptilia have direct or indirect development?

In beings of the class Reptilia the embryonic development is direct. So there is no larval stage.

10. Compared to amphibians what are the two reproductive novelties of beings of the class Reptilia for the survival in dry environments?

Compared to amphibians the two main reproductive innovations of beings of the class Reptilia for the terrestrial habitat are internal fecundation and shelled eggs.

11. Concerning the maintenance of body temperature how do beings of the class Reptilia classify?

Like fishes and amphibians, beings of the class Reptilia are heterothermic animals (also known as poikilothermic, or ectothermic), i.e., they are not able to control by themselves their body temperature and thus they depend on external warm sources (mainly the sun).

12. What is an example of a hypothesis which may explain why there is not a big representation of the class Reptilia found in polar regions?

Beings of the class Reptilia are abundant and more diverse in hot climate regions and they are rare in intensely cold regions like close to the earth poles. This is explained because these animals are heterothermic, i.e., they have "cold blood" and they need an

external heat source to warm their bodies.

The heterothermic feature also explains why reptiles are more active during the day, a period when they can use the sun heat to warm their bodies.

13. Class Reptilia identity card. How are they characterized according to examples of representing beings, basic morphology, skin, respiration, circulation, nitrogen waste, thermal control and types of reproduction?

Examples of representing beings: snakes, turtles, crocodiles, lizards, dinosaurs (extinct). Basic morphology: tetrapods, some with carapaces (like turtles). Skin: impermeable keratinized, corneous plates (known as scales). Respiration: pulmonary. Circulation: closed, incomplete, heart with three chambers and partial interventricular septation. Nitrogen waste: uric acid. Thermal control: heterothermic. Types of reproduction: sexual, internal fecundation, shelled eggs with extraembryonic membranes.

Biology Questions and Answers

Birds

1. What are the main morphological features of birds?

Birds are animals that present aerodynamic bodies covered with feathers, anterior limbs transformed into wings, pneumatic bones and horny (corneous) beaks.

2. In which habitat do birds live?

Birds are terrestrial animals but the majority of species also explore the aerial environment by flying.

3. What are flight adaptations present by birds?

Wings associated to a well-developed pectoral musculature, pneumatic bones, less accumulation of feces in the bowels due to the absence of the colon, absence of the bladder (no urine storage), aerodynamic body and lungs with specialized air sacs are all adaptations which enable birds to fly.

4. What are pneumatic bones?

Birds have lightweighted bones with internal spaces filled with air. These bones are called pneumatic bones. This feature reduces the corporal density of the animal facilitating the flight.

5. How is the respiratory system of birds characterized?

Like reptiles and mammals, they make gas exchange through lungs.

6. How is the circulatory system of birds characterized?

Birds, like every vertebrate, have a closed circulatory system. The heart is similar to the mammalian heart, having four chambers (two atria and two ventricles) and with no mixture of venous and arterial blood. (In mammals, however, the aorta curves down to the left and in birds it curves down to the right).

7. Which is the type of nitrogen waste birds produce? Why does this feature, besides being an adaptation to the terrestrial environment, also mean an adaptation to flight?

Birds are uricotelic, i.e., like reptiles, they excrete uric acid. This substance needs less water to be eliminated and so it helps to reduce the body weight thus aiding in flight.

Biology Questions and Answers

8. What similarities do birds and reptiles share regarding external coverage, reproduction and excretion?

Regarding external coverage, birds are similar to reptiles as they present impermeable keratinized coverages. Concerning reproduction, in both fecundation is internal and the embryo develops within a shelled egg. Regarding excretion, both excrete uric acid.

9. How do birds reproduce?

Birds, like every vertebrate, have sexual reproduction. Their embryos develop within shelled eggs containing extraembryonic membranes and outside the mother's body.

Birds copulate. Fecundation is internal and it occurs only before the female gamete is involved by the calcareous eggshell.

10. Is the embryonic development in birds direct or indirect?

The embryonic development is direct, there is no larval stage.

11. What are the predominating chemical compounds respectively in eggshell, white and yolk?

The eggshell is basically made of calcium carbonate. The white, or albumen, is composed by albumin, a protein. The yolk is predominantly constituted of lipids but it also contains proteins and vitamins.

12. How different are reptiles and birds concerning the maintenance of body temperature? Are birds rare in polar regions?

Reptiles are heterothermic, i.e., they do not control their body temperature. Birds however are the first homeothermic animals, they are able to maintain their body temperature constant.

There are many birds that live in intense cold regions. Penguins are examples of birds that live in polar region.

13. What are zoonoses? What are some examples of zoonoses transmitted by birds?

Zoonoses are human diseases transmitted by animals. Psittacosis, a bacterial disease, hystoplasmosis and cryptococcosis, fungal diseases, are examples of zoonoses transmitted by birds.

14. Bird identity card. How are birds characterized according to examples of representing beings, basic morphology, skin, respiration, circulation, nitrogen waste, thermal control and types of reproduction?

Examples of representing beings: chickens, sparrows, parrots, ostriches, penguins. Basic morphology: aerodynamic body, feathers, pneumatic bones, horny beaks. Skin: impermeable keratinized, feathers, uropygial gland. Respiration: pulmonary. Circulation: closed and complete, heart with four chambers. Nitrogen waste: uric acid. Thermal control: homeothermic. Types of reproduction: sexual, internal fecundation, shelled eggs with extraembryonic membranes.

Biology Questions and Answers

Mammals

1. What are the typical features of mammals?

The typical features of mammals are: body (more or less) covered with hair; presence of the diaphragm muscle (that separates the thorax from the abdomen); mammary glands that produce milk (in females); enucleated blood red cells; middle ear with three ossicles.

2. What are the three main groups into which mammals are divided?

The three groups into which mammals are divided are: monotremes (or prototherian, e.g., platypus), marsupials (or metatherian, for example, kangaroos) and placental (or eutherian, such as humans).

3. Do all mammals have a placenta?

Mammals of the monotreme group (platypus, echidnas) are oviparous, egg-laying, and they do not have a placenta. Mammals of the marsupial group (kangaroos, koalas, opossums) do not have a placenta either; females of this group give birth to embryonic young that then continue development within the mother's pouch. Placenta only forms in female placental mammals.

4. What are the main orders of placental mammals? What are some representative species and distinguishing features of each of those orders?

The orders into which placental mammals are divided are the following:

Artiodactyls, mammals with an even number of fingers in claws or paws like, e.g., cows, sheep, giraffes. Carnivorous, predators with canine teeth like dogs, lions, tigers. Cetaceans, aquatic animals without posterior limbs and similar to fishes, like whales and dolphins. Edentates, creatures with rare or absent teeth, like sloths, armadillos, anteaters. Lagomorphs, small-sized mammals having three pairs of continuously growing incisive teeth specialized in gnawing, like rabbits and hares. Perissodactyls, also known as ungulates (hooved), big-sized animals with an odd number of fingers in each paw, e.g., horses and rhinos. Primates, characterized by the big cranium and well-developed brain, like humans and apes. Proboscideans, big-sized animals whose nose and superior lip form the trunk (snout), e.g., elephants. Chiropterans, flying nocturnal mammals (bats). Rodents, animals with two pairs of continuously growing incisive teeth, e.g., mice, rats, castors, squirrels. Sirenians, aquatic mammals of freshwater, deprived of posterior limbs, like dugongs and manatees.

Biology Questions and Answers

5. How is gas exchange done in mammals?

Mammals breathe through lungs, their respiration is pulmonary.

6. How is circulation characterized in mammals?

Mammals present a closed and complete circulatory system. The heart has four chambers and the arterial blood does not mix with venous blood.

7. What is the type of nitrogen waste that mammals eliminate?

Like chondrichtian fishes and adult amphibians, mammals are ureotelic, i.e., they excrete urea.

8. How do placental mammals reproduce?

Placental mammals reproduce sexually, they have internal fecundation and they are viviparous, i.e., their embryo develops within the mother's body and from her it gets the nutrients through the placenta.

9. Is fecundation in mammals internal or external?

Fecundation in mammals is internal, with copulation. In the contemporary world human technology is able to promote artificial external fecundation of human gametes and of gametes of other animals.

10. Is the mammalian embryonic development direct or indirect?

In mammals the embryonic development is direct, without larval stage.

11. Are there aquatic and flying mammals?

Cetaceans (whales, dolphins) and sirenians (dugongs, manatees) are aquatic mammals. Chiropterans (bats) are flying mammals.

12. Are the limbs modified into wings of bats and the wings of birds examples of evolutionary analogy or homology? What about whale fins compared to fish fins?

Bat and bird wings have the same function and the same origin (they are modified limbs) so they are analogous and homologous organs. Whale fins are a modification of the posterior limbs

while fish fins although having the same function do not come from modified limbs; so they are analogous but not homologous structures.

Evolutionary homology suggests common ancestry while biological analogy relates to the concept of evolutionary convergence, the appearance of similar features in evolutionarily distant species that explore the same type of environment (in the mentioned case, the aquatic habitat).

13. Mammal identity card. How are mammals characterized according to examples of representing beings, basic morphology, skin, respiration, circulation, nitrogen waste, thermal control and types of reproduction?

Examples of representing beings: dogs, cats, horses, giraffes, elephants, apes, humans, bats, whales, dolphins, opossums, kangaroos, platypus. Basic morphology: hair, diaphragm muscle, mammary glands, enucleated red blood cells. Skin: impermeable, hairy. Respiration: pulmonary. Circulation: closed and complete, heart with four chambers. Nitrogen waste: urea. Thermal control: homeothermic. Types of reproduction: sexual, internal fecundation, oviparous monotremes (prototherians), marsupials (metatherians), placental (eutherians).

Biology Questions and Answers

Physiology

Biology Questions and Answers

Biology Questions and Answers

Basic Histology

1. What is the logical order in which the concepts of atoms, molecules, cells... up to biosphere are associated?

Atoms form molecules that form cells that form tissues that form organs that form systems. Systems, in their turn, constitute individuals that form populations that compound (biological) communities that form the biotic components of ecosystems. All ecosystems of earth form the biosphere.

2. From the zygote, pluricellular organisms are formed by serial mitosis. Would this formation be possible if each cell made by mitosis had an identical life in relation to its antecedent cells? How did evolution solve that problem?

The formation of complex and distinct pluricellular organisms would not be possible if mitosis in embryos produced only daughter cells with an identical life history as the mother cell, since there would not be differentiation and structural or functional specialization among cells.

Evolution solved the problem creating the cellular differentiation process by which, motivated by stimulus not yet well-known by science, different and specialized cell lineages gave birth to different tissues, organs and systems that, as a whole, form the pluricellular organisms.

Cellular differentiation probably is a very intricate process that activates and inactivates some genes within the cell in response to some stimulus.

3. What are the main types of animal tissue?

The main animal cell tissues are the epithelial tissue, the nervous tissue, the muscle tissue and the connective tissue.

4. What are epithelial tissues? What are their general function and how is that function associated to the features of the tissue?

Epithelial tissues, also called epithelia, are tissues specialized in the covering of external and internal surfaces of the body.

The general function of the epithelium is to provide protection and impermeability (or selective permeability) to the covered structure. This justifies the epithelium's typical features: the cellular juxtaposition forming layers of very proximate cells with diminished or none intercellular space between each two neighbor cells.

Biology Questions and Answers

5. Of which cells is the nervous tissue constituted? How is the generic function of this tissue related to the characteristics of the main cell type that forms it?

The nervous tissue is formed of neurons and glial cells.

The function of the nervous tissue is to receive and to transmit neural impulses (reception and transmission of information). This function justifies the characteristic morphology of neurons, with membrane projections (dendrites) to get information and an elongated membrane projection (axon, or nerve fiber) to transmit information at distance. In their turn, the glial cells support the neurons and facilitate their work (sometimes acting as insulators).

6. What are muscle tissues? How is the function of this tissue related to the typical characteristics of its cells?

Muscle tissues are tissues made of cells able to perform contractions and thus to generate movement.

The function of the muscle tissue is to pull bones (skeletal striated muscle), to contract and move viscera and vessels (smooth muscle) and to make the heart to beat (cardiac striated muscle). The muscle cells have internal structures called sarcomeres where there are myosin and actin molecules disposed to create contraction and distension (movement).

7. What is the typical biological function of the connective tissues? How is this function associated to the main features of its cells?

The typical function of the connective tissues is to fill empty spaces among other body tissues.

This function is related to the great capability of the cells of the connective tissue to secrete substances that constitute extracellular material, like collagen and elastic fibers, creating a significant spacing between these cells.

(There are other important biological features of the connective tissues, such as substance transportation, defense of the organism, etc.)

8. Of which type of tissue are cartilages and bones made?

Bones and cartilages, tissues with great amount of intercellular material, are formed of connective tissue.

9. Are the cells of the connective tissue far or near to the others?

The relative great spacing between cells is a typical feature of the connective tissue. There are much intercellular material generally secreted by the tissue cells.

Biology Questions and Answers

10. What are the general functions of the connective tissues?

The main functions of the connective tissues are: supporting and filling of spaces; cellular nutrition; energetic storage (fats); hematopoiesis (formation of blood, blood cells and blood components); immune defense (specialized cells).

11. What is connective tissue proper?

The name connective tissue proper is used to designate the connective tissue that fills interstitial spaces as opposed to the specialized connective tissues (blood, bones, cartilage, adipose tissue, etc.). The connective tissue proper secretes collagen, elastin and reticular fibers.

12. What are the main cells of the connective tissue proper? What is the name given to the intercellular material that surround these cells?

The main cells of the connective tissue proper are the fibroblasts, cells that secrete the intercellular material. These cells are the majority of cells of the tissue. Fibroblasts later are transformed into fibrocytes, mature cells with restricted secretory role.

The intercellular substance that fills the interstice is called interstitial matrix, or just matrix.

13. What are the three types of protein fibers of the connective tissue proper?

The matrix of the connective tissue proper is made of collagen fibers, elastic fibers and reticular fibers.

14. What is the function of the collagen fibers of the connective tissue?

There are different collagen types. The main function of these proteins is to keep the shape and the structural rigidity of the tissue. (Collagen is the most abundant protein of the human body.)

15. Of which substance do elastic fibers of the connective tissue are made? What are some functions of these fibers?

The elastic fibers are made of a protein called elastin.

Elastic fibers abound in artery walls, helping the maintenance of the arterial blood pressure in these vessels. They are also present in the lungs, providing them with elasticity (some respiratory diseases are caused by destruction of these fibers). In many other organs and tissues the elastic fibers are found in the interstitial matrix.

16. What are the reticular fibers of the connective tissue and where can they be found?

The reticular fibers are very delicate interstitial fibers made of a special type of collagen known as collagen type III. They can be found in many organs and tissues such as in lymphnodes, in the spleen, in the liver, in blood vessels and also covering muscle fibers.

17. What are diseases of the connective tissue? What are some of them?

Diseases of the connective tissue are hereditary or acquired diseases(many of autoimmune cause) characterized by deficiency in structure or function of components of the connective tissue, for example, deficiencies of collagen, elastin, etc. Some of such diseases are lupus, dermatomyositis, cheloid, scleroderma, mixed connective tissue disease, mucinosis and Marfan's syndrome.

Biology Questions and Answers

Blood

1. What are the main functions of the blood?

The blood is a means of substance transportation throughout the body. The blood distributes nutrients, oxygen, hormones, antibodies and cells specialized in defense to the tissues and collects residuals like nitrogen wastes and carbon dioxide from them.

2. What are the constituent elements of the blood?

The blood is made of a liquid and a cellular part. The fluid part is called plasma and in it there are several substances, like proteins, lipids, carbohydrates and mineral salts. The cellular constituents of the blood are also known as blood corpuscles and they comprise the erythrocytes (red blood cells), leukocytes and platelets.

3. What is hematopoiesis?

Hematopoiesis is the formation of blood cells and other constituent elements of the blood.

4. Where does hematopoiesis occur?

Hematopoiesis occurs in the bone marrow (mainly within flat bones), where erythrocytes, leukocytes and platelets are made, and in the lymphoid tissue, responsible for the maturation of leukocytes and found in the thymus, spleen and lymphnodes.

5. In which bones can bone marrow chiefly be found? Is the bone marrow made of osseous tissue?

Bone marrow can mainly be found in the internal cavities of flat bones, like the vertebrae, the ribs, the scapulae, the sternum and the hips.

The bone marrow is not made of osseous tissue, although it is a connective tissue as bone tissue is.

6. What are blood stem cells?

Stem cells are undifferentiated cells able to differentiate into other types of specialized cells.

The stem cells of the bone marrow originate the differentiated blood cells. According to stimulus from specific growth factors the stem cells are turned into red blood cells, leukocytes and megakaryocytes (cells that form platelets). Research shows that stem cells of the bone marrow can also differentiate into muscle, nervous and hepatic cells.

Biology Questions and Answers

7. What are the other names by which erythrocytes are known? What is the function of these cells?

Erythrocytes are also known as red blood cells (RBCs), or red corpuscles. Red blood cells are responsible for oxygen transport from the lungs to the tissues.

8. What is the name of the molecule that transports oxygen in red blood cells?

The respiratory pigment of the red blood cells is hemoglobin.

9. What is the molecular composition of hemoglobin? Does the functionality of hemoglobin as a protein depend upon its tertiary or upon its quaternary structure?

Hemoglobin is a molecule made of four polypeptide chains, each bound to a iron-containing molecular group called a heme group. So the molecule contains four polypeptide chains and four heme groups.

As a protein composed of association of polypeptide chains, the functionality of hemoglobin depends upon the integrity of its quaternary structure.

10. On average what is the life duration of the red blood cells? Where are they destroyed? What is the destination of the heme groups after the destruction of hemoglobin molecules?

On average red blood cells live around 120 days. The spleen is the main organ where old red blood cells are destroyed.

During the red blood cell destruction the heme groups turn into bilirubin and this substance is then captured by the liver and later excreted in the bowels as part of the bile.

11. What are the functions of the spleen? Why is a total splenectomy (surgical removal of the spleen) compatible with life?

The spleen has many functions: it participates in the destruction of old red blood cells; in it specialized leukocytes are matured; it helps the renewal of the hematopoietic tissue of the bone marrow when necessary; it can act as a spongelike organ to retain or liberate blood from or for the circulation.

Total splenectomy is not incompatible with life as none of the functions of the spleen are vital and at the same time exclusive of this organ.

Biology Questions and Answers

12. What is anemia? What are the four main types of anemia?

Anemia is low concentration of hemoglobin in the blood.

The four main types of anemia are the nutrient-deficiency anemia, anemia caused by blood loss, hemolytic anemia and aplastic anemia.

Nutrient-deficiency anemia is caused by dietary deficiency of fundamental nutrients for the production or functioning of the red blood cells, like iron (iron deficiency anemia), vitamin B12 and folic acid.

Anemia caused by blood loss occurs in hemorrhagic conditions or in diseases like peptic ulcerations and hookworm disease.

Hemolytic anemia is caused by excessive destruction of red blood cells, for example, in diseases like malaria or in hypervolemic conditions (excessive water in blood that causes lysis of red blood cells).

Aplastic anemia occurs from deficiencies of the hematopoiesis and it happens when the bone marrow is injured by cancers from other tissues (metastasis), by autoimmune diseases and by intoxication from drugs (like sulfas and anticonvulsants) or by chemical substances (like benzene, insecticides, paints, herbicides and solvents in general). Some genetic diseases also affect the bone marrow causing aplastic anemia.

13. What is the difference between white and red blood cells? What are leukocytes?

Red blood cells are erythrocytes and white blood cells are the leukocytes.

Leukocytes are cells specialized in the defense of the body against strange agents and they are part of the immune system.

14. What are the types of leukocytes and how are they classified into granulocytes and agranulocytes?

The types of leukocytes are lymphocytes, monocytes, neutrophils, eosinophils and basophils. Granulocytes are those in whose cytoplasm there are granules (when viewed under electronic microscopy): neutrophils, eosinophils and basophils are granulocytes. Agranulocytes are the other leukocytes: lymphocytes and monocytes.

15. What is the generic function of leukocytes? What are leukocytosis and leukopenia?

The generic function of leukocytes is to participate in the defense of the body against strange agents that penetrate it or are made inside the body.

Leukocytosis and leukopenia are clinical conditions in which the count of leukocytes in a blood sample is abnormal. When the leukocyte count in

a blood sample is above the normal level for the individual leukocytosis is defined. When the leukocyte count is lower than the expected normal level leukopenia is defined. The multiplication of these defense cells, leukocytosis, generally takes place when the body is suffering infections or in cancers of these cells. The lowering of these defense cells, or leukopenia, occurs when some diseases attack the cells, like in AIDS, or when immunosuppressor drugs are used.

In general the body creates leukocytosis as a defense reaction when it is facing infectious or pathogenic agents. The clinical condition of leukocytosis is thus a sign of infection. Leukopenia occurs when there is a deficiency in the production (for example, in bone marrow diseases) or excessive destruction of leukocytes (for example, in case of HIV infection).

16. What are the mechanisms of hemorrhage contention called?

The physiological mechanisms of hemorrhage contention (one of them is blood clotting) are generically named hemostasis, or hemostatic processes.

17. How are platelets formed? What is the function of platelets? What consequences does the clinical condition known as thrombocytopenia yield?

Platelets, also known as thrombocytes, are fragments of giant cells of the bone marrow called megakaryocytes. With their properties of aggregation and adhesiveness they play a direct role in blood clotting and they also liberate substances that activate other hemostatic processes.

Thrombocytopenia is a clinical condition in which the platelet count of the blood is lower than normal. In this situation the person becomes susceptible to hemorrhages.

18. How does the organism understand that a clotting process must begin?

When there is some tissue wound with injury of blood vessel the platelets and endothelial cells of the wall of the damaged vessel liberate substances (respectively platelet factors and tissue factors) that trigger the clotting process.

19. How can the blood coagulation (clotting) process be described?

Blood clotting encompasses a sequence of chemical reactions whose respective products are enzymes that catalyze the following reactions (that is why the clotting reactions are called cascade reactions). In the plasma thromboplastinogen transforms into thromboplastin, a reaction triggered by tissue and platelet factors liberated after injury of the blood vessel. Thromboplastin then catalyzes along

with calcium ions the transformation of prothrombin into thrombin. Thrombin then catalyzes a reaction that produces fibrin from fibrinogen. Fibrin, as an insoluble substance, precipitates to form a network that traps red blood cells and platelets forming the blood clot and containing the hemorrhage.

20. What are clotting factors?

Clotting factors are substances (enzymes, coenzymes, reagents) necessary for the clotting stages to happen. Besides those triggering factors and reagents already described (tissue and platelet factors, thromplastinogen, prothrombin, fibrinogen, calcium ions), other substances participate in the blood clotting process as clotting factors, like factor VIII, whose deficiency causes hemophilia A, or the factor IX, whose deficiency causes hemophilia B.

21. What is the organ where most of the clotting factors are produced? What is the role of vitamin K in the blood coagulation?

Most of the clotting factors are produced in the liver.

Vitamin K participates in the activation of several clotting factors and it is fundamental for the well-functioning of the blood coagulation.

22. What is factor VIII? What is the genetic disease in which this factor is absent?

Factor VIII has the function of activating factor X that in its turn is necessary for the transformation of prothrombin into thrombin in the clotting cascade. Hemophilia A is the X-linked genetic disease in which the individual does not produce factor VIII and so is more susceptible to severe hemorrhages.

23. How is hemophilia treated? Why is hemophilia rare in females?

Hemophilia is medically treated with administration of factor VIII, in case of hemophilia A, or of factor IX, in case of hemophilia B, by means of blood or fresh frozen plasma transfusions.

Hemophilia, A or B, is an X-linked recessive inheritance and for a girl to be hemophilic it is necessary for both of her X chromosomes to be affected while boys, that have only one X chromosome, are more easily affected. A girl with only one affected chromosome does not present the disease since the normal gene of the unaffected other X chromosome produces the clotting factor.

24. What is the epidemiological association between hemophilia and HIV infection?

Since hemophilic patients need frequent transfusions of clotting factors (VIII or IX) they are more susceptible to contamination by infectious agents present in the blood from which the transfused elements come. In the past the blood banks did not usually perform HIV detection tests and many hemophilic patients have become infected with the virus.

25. What are anticoagulants? What are the practical applications of anticoagulants, like heparin, in Medicine?

Anticoagulants are substances that block the clotting reactions and thus stop the coagulation process. Ordinarily there are anticoagulants circulating in the plasma since under normal conditions the blood must be kept fluid.

In Medicine anticoagulants like heparin are used in surgeries in which tissue injuries made by the surgical act could trigger undesirable systemic blood clotting. They are also used to avoid the formation of thrombus inside blood vessels of patients facing increased thrombotic risk.

26. What is dicoumarol? How does this substance act in the clotting process and what are some examples of its toxicity?

Dicoumarol is an anticoagulant drug. Due to its molecular structure dicoumarol competes with vitamin K for the binding to substrates blocking the formation of clotting factors and interrupting the making of prothrombin. Dicoumarol is found in some vegetables undergoing decomposition, and it can cause severe internal hemorrhages when those vegetables are accidentally ingested. Coumarinic anticoagulants cannot be administered during pregnancy since they pass the placental barrier and can cause fetal hemorrhages.

27. Streptokinase is a substance used in the treatment of acute myocardial infarction. How does this substance act?

Substances known as fibrinolytics, like streptokinase and urokinase, can destroy thrombi (clots formed inside blood vessels, capillaries or within the heart chambers) and are used in the treatment of obstructions of the coronary arteries or other blood vessels.

Streptokinase destroys the fibrin network and so it dissolves the thrombotic clot. Its name comes after the bacteria that produce it, the streptococci.

Biology Questions and Answers

Metabolism and Homeostasis

1. What is metabolism?

Metabolism is the set of physical and chemical processes upon which the life of the cells of a living being depends.

2. What is the difference between anabolism and catabolism?

Metabolism comprises two opposing processes: anabolism and catabolism. Anabolism is a set of synthesis reactions that transform simpler compounds into organic molecules in general with energy spending. Catabolism is a set of reactions that break organic molecules into simpler and less complex substances in general with liberation of energy. The energy liberated in catabolism may be used in vital processes of the organism, including anabolism.

3. What is homeostasis? What are the sensors, controllers and effectors of homeostasis?

Homeostasis comprises the processes by which the organism maintains adequate intra and extracellular conditions to keep possible the normal reactions of the metabolism.

Homeostatic sensors are structures that detect information from the inner and outer environment of the body. These sensors may be nervous receptor cells, cytoplasmic or membrane proteins and other specialized molecules. Controllers are structures responsible for processing and interpreting information received from the sensors. Controllers in general are specialized regions of the central nervous system but on the molecular level there are also some of them, like DNA, a molecule that can get information from proteins to inhibit or stimulate the expression of some genes. Effectors are elements commanded by the controllers that have the function of bringing about actions that in fact regulate and maintain the equilibrium of the organism, like muscles, glands, cellular organelles, etc., and in the molecular level structures that participate in the genetic translation, the produced proteins, etc.

4. How do antagonistic mechanisms manage homeostatic regulation?

The homeostatic maintenance of the body mostly occurs by means of alternating antagonistic compensatory mechanisms. There are regulators that lower the pH and others that increase it, there are effectors whose function is to increase the body temperature and others that lower it, hormones exist that, e.g., reduce the level of glucose in the blood and others that increase the glycemic level. The use of antagonistic mechanisms is a strategy found by evolution to solve the problem of the maintenance of the body equilibrium.

5. What is an example of negative feeback of the homeostatic regulation?

Negative feedback happens when the response to a given action generates an effect that inhibits that action. For example, when the carbon dioxide concentration in blood is high the pulmonary respiration is stimulated for the CO_2 excess to be expelled through expiration. Hyperventilation, however, lowers the carbon dioxide concentration in blood too much generating a negative feedback that commands the reduction of the respiratory frequency.

Negative feedback is the main mechanism of homeostasis and it occurs in a variety of processes, such as in blood pressure control, glycemic control, muscle contraction, etc.

6. What is an example of positive feedback of the homeostatic regulation?

In positive feedback the effect caused by an action stimulates the action even more. This is a rarer mechanism of the homeostatic regulation.

An example of positive feedback is the blood clotting process in which each chemical reaction produces enzymes that catalyze the following reaction until the formation of fibrin. Therefore the products of the antecedent chemical reactions are consumed and the equilibrium of each reaction is dislocated towards the production of more enzymes (a positive feedback).

Biology Questions and Answers

Nutrition and Vitamins

1. What is a nutrient?

A nutrient is every substance used in the metabolism and which is acquired from the diet. For example, vitamins and essential amino acids are nutrients.

2. What is the difference between macro and micronutrients?

The classification criterion of nutrients into macro and micronutrients has no relation to the size of the molecule. Macronutrients are those needed in great amount, for example, proteins and carbohydrates. Micronutrients are those needed in small quantities, like vitamins.

3. According to their functions how can nutrients be classified?

One possible and utile functional classification for nutrients is the one that separates them into energetic, structural and regulatory.

Energetic nutrients are those used as energy source for the metabolism; mainly they are the carbohydrates (but fats and proteins can also be converted into acetyl-CoA and "cycle" the Krebs cycle). Structural nutrients are those used in the support and structure of cells and tissues; they are the amino acids that form structural proteins, like collagen, the membrane proteins, the cytoskeleton proteins, the contractile proteins of the muscle tissue, etc. Regulatory nutrients are those that constitute enzymes and coenzymes of the homeostasis, metabolites of the osmotic and electrolytic equilibrium of cells and hormones; some amino acids, vitamins and mineral salts are part of this group.

4. What are vitamins? What are the main vitamins needed by humans?

Most vitamins are coenzymes (fundamental substances for the enzyme functioning) that are not produced by the organism and must be obtained from the diet.

The main vitamins needed by humans are vitamins A, C, D, E, K, the vitamins of the B complex (including folic acid), biotin and pantothenic acid.

5. What is the difference between water-soluble and fat-soluble vitamins? Why can fat-soluble vitamins cause harm when ingested in excess?

Water-soluble vitamins are those soluble in water. Fat-soluble vitamins are those soluble in oil (lipids, fat).

Vitamin C and the vitamins of the B complex are examples of water-soluble vitamins. Vitamins A, D, E and K are examples of fat-soluble vitamins.

Fat-soluble vitamins, since they are not soluble in water, cannot easily be excreted by the body. So they tend to accumulate in tissues with toxic effect when they are ingested in amounts over what is necessary.

6. What are the main harms caused by vitamin A deficiency? How does this vitamin act in the physiology of vision?

Deficiency of vitamin A (retinol) may cause night blindness, corneal dryness (xerophthalmia) and predisposition to skin injuries.

In the physiology of vision, vitamin A participates in the formation of rhodopsin, a pigment responsible for the visual perception in less illuminated places.

Nutrition Vitamins - Image Diversity: vitamin A deficiency

7. What is folic acid? Why is the anemia caused by deficiency of folic acid known as megaloblastic anemia?

The folic acid (when ionized it is called folate) is a coenzyme that participates in the synthesis and duplication of DNA and for this reason it is fundamental for cell division. If there are not enough folic acid in cells with great turnover, like red blood cells, they have their production reduced.

In folic acid deficiency precursor cells (reticulocytes) that would originate erythrocytes (red blood cells) begin cell division but the process is very slow while the cytoplasm growth is normal. So the cells became abnormally large, a typical feature of this kind of anemia called megaloblastic anemia.

Megaloblastic anemia can be caused also by vitamin B12 (cyanocobalamin) deficiency since this vitamin is important for cell division too. Both types of anemia are nutrient deficiency anemias.

Nutrition Vitamins - Image Diversity: megaloblastic red blood cell

8. What are the vitamins which make up the B complex? Which problems does the lack of these vitamins cause?

Vitamins of the B complex are: thiamin, or vitamin B1; riboflavin, or vitamin B2, and niacin (B3), essential for the constitution of the hydrogen acceptors FAD, NAD and NADP of the energetic metabolism; pyridoxine, or B6; and cyanocobalamin, or vitamin B12.

Deficiency of vitamin B1 causes beriberi, loss of appetite and fatigue. The lack of vitamin B2 causes mucosal injuries in the mouth, tongue and lips. Deficiency of niacin causes nervousness, digestive disturbances, loss of energy and

pellagra. Lack of vitamin B6 causes skin lesions, irritation and convulsions. Vitamin B12 acts together with folic acid and its deficiency causes cell division disruptions leading to pernicious anemia (a type of megaloblastic and nutrient deficiency anemia).

The absorption of vitamin B12 depends on another substance called the intrinsic factor secreted by the gastric mucosa.

9. How does vitamin C act in the body? What is the harm caused by insufficiency of vitamin C? Why was this deficiency also known as "sailors' disease"?

Vitamin C, or ascorbic acid, participates in the metabolism of collagen and it is fundamental for the integrity of blood capillaries.

Scurvy is the disease caused by a lack of vitamin C. It is characterized by tissue lesions in the skin, lips, nose and joints. Scurvy, or scorbutus, was also known as sailors' disease because in maritime voyages of the past it was not common to get on board food that contained vitamin C, like citric fruits. So the sailors became ill with scurvy.

10. Why isn't the cooking of vitamin C-containing foods appropriate for vitamin C supply?

To obtain vitamin C, for example, from an orange dessert, the vitamin-containing food cannot be submitted to high temperatures (cooking) since vitamin C is thermolabile, i.e., it is inactivated by heat.

11. What is the association between vitamin D and sunrays?

Vitamin D, or calciferol, is synthesized in the skin by the action of the ultraviolet range of sunrays upon precursor molecules. Later it is transformed into its active form in the liver and the kidneys.

12. What is the disease caused by vitamin D deficiency? Which tissue does it affect?

The lack of vitamin D causes the disease known as rickets (rachitis), characterized by decalcification of bones and bone deformities. Vitamin D is fundamental for absorption of calcium and thus it is related to the osseous tissue health.

13. What is the function of vitamin E? In which foods can it be found?

Vitamin E, or tocopherol, is a fat-soluble vitamin that participates as coenzyme in the respiratory chain, the final stage of the aerobic cellular respiration. Its deficiency may cause sterility,

spontaneous abortions and muscle dystrophy.

Vitamin E is mainly found in corn oil and peanut oil, wheat germ, milk, eggs and leafy vegetables.

14. Why are some types of hemorrhagic diseases caused by genetic or acquired deficiency of the vitamin K metabolism?

Deficiency of vitamin K predisposes to hemorrhages since this vitamin is fundamental for the formation of prothrombin in the blood clotting process.

15. What are the functions of biotin and pantothenic acid for the body? How are these vitamins obtained?

Biotin (also know as vitamin B8) is a vitamin that acts in the metabolism of amino acids and other acids.
Pantothenic acid (also known as vitamin B5) is important for the aerobic cellular respiration since it acts in the transport of acetyl and acyl radicals.
Biotin is made by bacteria that live in the human digestive tube (under interspecific harmonious ecological interaction) and this supply in general is enough for the body. Biotin and pantothenic acid are found in vegetables, cereals, eggs, fish, milk and lean meat.

16. What are the main mineral salts responsible for the cellular osmotic regulation?

The main ions that act in the regulation of the osmotic pressure in cells and tissues are the chlorine anion, the sodium cation and the potassium cation.

17. What are the main cellular functions of potassium?

Besides being important for the osmotic regulation and for the acid-base equilibrium (pH) potassium is fundamental for the excitatory mechanisms of nerves and in muscle contraction.

18. What are some examples of mineral salts from the diet that act as coenzymes?

Magnesium, zinc and copper are examples of biological coenzymes.

19. What is the disease caused by dietary iodine deficiency?

Iodine deficiency causes hypothyroidism, an abnormally lower production of thyroid hormones that need iodine to be synthesized.

20. What is the importance of iron in diet? What is the disease caused by iron deficiency?

Iron acts as a constituent of the hemoglobin molecule and of enzymes of the digestion and energetic metabolism. Dietary iron deficiency causes iron deficiency anemia, abnormal lowering of hemoglobin concentration in blood due to lack of iron. (In pregnancy there is a high consumption of iron by the fetus and this fact can lead to anemia.)

Biology Questions and Answers

Digestive System

1. What is digestion?

Digestion is the breaking down of larger organic molecules obtained from the diet, e.g. carbohydrates, fats, proteins, into smaller ones, like glucose, fatty acids, glycerol and amino acids.

2. How different are intracellular and extracellular digestion? What is the evolutionary advantage of extracellular digestion?

Intracellular digestion is that in which the breaking down of macromolecules takes place within the cell. Extracellular digestion is that in which macromolecules are broken down in places outside the cell (in the extracellular space, in the surrounds, in the lumen of digestive tubes, etc.)

The advent of extracellular digestion in evolution allowed organisms to benefit from a greater variety of food. The breaking down of larger molecules into smaller ones outside the cell permitted the use of other foods than those that, due the size of their molecules, could not be interiorized by diffusion, phagocytosis or pinocytosis.

3. How is extracellular digestion related to cellular and tissue specialization?

A variety of specialized cells and tissues appeared with extracellular digestion to provide enzymes and special structures for the breaking down of dietary macromolecules.

This phenomenon allowed other cells to be liberated for other tasks and differentiations while benefiting from nutrients distributed through the circulation.

4. What is the difference between a complete digestive system and an incomplete digestive system? How are these types of digestive tubes associated or not to extracellular digestion?

Animals with an incomplete digestive system are those in which the digestive tube has only one opening (cnidarians, platyhelminthes). Animals with a complete digestive system are those in which the digestive tube has two openings, mouth and anus (all other animal phyla, with the exception of poriferans, that do not have any digestive tube).

In animals with incomplete digestive tubes the digestion is mixed, it begins in the extracellular space and finishes in the intracellular space. In animals with complete digestive systems extracellular digestion within the digestive tube predominates.

Biology Questions and Answers

5. What are some evolutionary advantages of animals with complete digestive tube?

The complete digestive tube allows animals to continuously feed themselves without waiting for residuals to be eliminated before beginning the digestion of new foods. In this way the absorption of larger amount of nutrients is possible and therefore bigger and more complex species can develop. Digestive tubes with two openings also make digestion more efficient since they provide different sites with different physical and chemical conditions (mouth, stomach, bowels) for the action of different complementary digestive enzymatic systems.

6. What is mechanical digestion? In molluscs, arthropods, earthworms, birds and vertebrates, in general, which organs respectively participate in this type of digestion?

Mechanical digestion is the fragmentation of food aided by specialized physical structures, such as teeth, previous to extracellullar digestion. The mechanical fragmentation of food helps digestive enzymatic reactions because it provides a larger total area for the contact between enzymes and their substrates.

In some molluscs, the mechanical fragmentation is done by the radula (a teeth-like structure). Some arthropods, like lobsters and dragonflies, have mouthparts that make mechanical digestion of food. In earthworms and birds, the mechanical digestion is made by an internal muscular organ. In mandibulate vertebrates there are mandibles and chewing muscles to triturate food previous to the chemical digestion.

7. Concerning extracellular digestion what is meant by chemical digestion?

Chemical digestion is the series of enzymatic reactions to break macromolecules into smaller ones.

8. Which type of chemical reaction is the breaking of macromolecules into smaller ones that occurs in digestion? What are the enzymes that participate in this process called?

The reactions of the extracellular digestion are hydrolysis reactions, i.e., breaking of molecules with the help of water. The enzymes that participate in digestion are hydrolytic enzymes.

9. Which organs of the body are part of the human digestive system?

The digestive system, also known as "systema digestorium", or gastrointestinal system, is composed of the digestive tube organs plus the

digestive adnexal glands. The digestive tube is composed of mouth, pharynx, esophagus, stomach, small intestine (duodenum, jejunum, ileum), large intestine (caecum, colon, rectum) and anus.

10. What are peristaltic movements? What is their role in human digestion?

Peristalsis is the process of synchronized contractions of the muscular wall of the digestive tube. Peristaltic movements may occur from the esophagus until and including the bowels.

The peristaltic movements are involuntary and they have the function of moving and mixing food along the digestive tube. Peristaltic movement deficiency, for example, in case of injuries of the innervation of the muscular wall of the digestive tube caused by Chagas' disease, can lead to the interruption of the food traffic inside the bowels and to severe clinical consequences like megacolon (abnormal enlargement of the colon) and megaesophagus (enlargement of the esophagus).

11. From the lumen to the external surface what are the tissues that form the digestive tube wall?

From the internal surface to the external surface, the digestive tube wall is made of mucosa (epithelial tissue responsible for the intestinal absorption), submucosa (connective tissue beneath the mucous membrane and where blood and lymphatic vessels and neural fibers are located), muscle layers (smooth muscle tissue, two layers, one interior circular and other exterior longitudinal, structures responsible for the peristaltic movement), serous membrane (associated epithelial and connective tissue forming the external surface of the organ). In the bowels the serous membrane prolongs to form the mesentery, a serosa that encloses blood vessels and supports the bowels within the abdominal cavity.

12. What is the location of the salivary glands in humans?

There are 6 major salivary glands and they are located one in each parotid gland, two beneath the mandibles (submandibular) and two in the base of the tongue (sublingual). More than 700 other minor salivary glands exist dispersed on the lip mucosa, gingiva, palate and pharynx.

13. What is the approximate pH of the salivary secretion? Is it an acid or basic fluid? What are the main functions of saliva?

The saliva pH is approximately 6.8. It is thus a slightly acid pH.

Saliva lubricates the food bolus and initiates the enzymatic extracellular digestion of food. It also works as a

buffer for the mouth pH and it has an important role of having IgA antibodies (also present in tears, colostrum, mother's milk and in the mucosae of the intestine and airways) that protect the organism against pathogens.

14. What is the salivary digestive enzyme? Which type of food does it digest and into which smaller molecules does it transform the food?

The salivary hydrolase is known as salivary amylase, or ptyalin. Ptyalin digests carbohydrates breaking starch and glycogen, glucose polymers, into maltose (a glucose disaccharide) and dextrin.

15. Why doesn't the food enter the trachea instead of going to the esophagus?

When food is swallowed the swallow reflex is activated and the larynx elevates and closes to avoid portions of the food bolus entering the trachea causing aspiration of strange material to the bronchi.

16. Is the esophagus a muscular organ? Why even in a patient lying totally flat on a hospital bed can the swallowed food reach the stomach?

The esophagus is a predominantly muscular organ so the assertion is correct. The esophagus is a muscular tube formed in its superior third of striated muscle tissue, in its middle third of mixed muscle tissue (striated and smooth) and in its lower third of smooth muscle tissue. The peristalsis of the esophagus provides the movement of the food towards the stomach even without gravitational help.

17. What is the route of the ingested food from swallowing until the duodenum?

Until reaching the duodenum the food enters the mouth, passes the pharynx, goes down the esophagus and passes the stomach.

18. what is the valve that separates the stomach from the esophagus called? What is its function?

The valve that separates the stomach from the esophagus is the cardia. It has the function of preventing acid gastric content from entering back into the esophagus. Insufficiency of this valve causes gastroesophageal reflux, a disease in which patients complain of bloating and heartburn (retrosternal burning).

Biology Questions and Answers

19. What is the valve that separates the duodenum from the stomach called? What is its function?

The valve that separates the stomach from the duodenum is the pylorus. It has the function of keeping the food bolus within the gastric cavity for enough time to allow the gastric digestion to take place. It also has the function of preventing the intestinal content from going back into the stomach.

20. What is the pH inside the stomach? Why is there a need to keep that pH level? How is it maintained? Which are the cells that produce that pH?

The normal pH of the gastric juice is around 2. So it is an acid pH.

It is necessary for the gastric pH to be kept acid for the activation of pepsinogen (a proenzyme secreted by the gastric chief cells) into pepsin, the digestive enzyme that acts only under low pH. This pH level is attained by the secretion of hydrochloric acid (HCl) by the parietal cells.

21. Besides being fundamental for the activation of the main gastric digestive enzyme how does HCl also directly participate in digestion?

With its corrosive effect, HCl also helps the rupture of the adhesion between food particles, facilitating the digestive process.

22. How is the gastric mucosa protected from the acid pH of the stomach?

The gastric epithelium is mucus secretory, i.e., it produces mucus. The mucus covers the stomach wall preventing corrosion by the gastric juice.

23. What is the digestive enzyme that acts within the stomach? Which type of food does it digest? What are the cells that produce that enzyme?

The digestive enzyme that acts in the stomach is pepsin. Pepsin has the function of breaking proteins into smaller peptides. The gastric cells that produce pepsinogen (the zymogen precursor of pepsin) are the chief cells.

24. What name does the food bolus that passes from the stomach to the duodenum get?

The partially digested and semifluid food bolus that leaves the stomach and enters the duodenum is called chyme.

Biology Questions and Answers

25. Which are the three parts of the small intestine?

The small intestine is divided into three portions: duodenum, jejunum and ileum.

26. By generally dividing food into carbohydrates, fats and proteins and considering the digestive process until the pylorus (exit of stomach), which of these mentioned types of food have already undergone chemical digestion?

Until the exit of the stomach, carbohydrates, in the mouth, and proteins, in the stomach, have already undergone chemical breaking by digestive enzymes. Carbohydrates have suffered action of the salivary amylase (ptyalin) and proteins have suffered action of the enzyme pepsin of the gastric juice. Fats, until reaching the duodenum, do not undergo chemical digestion.

27. What is the substance produced in the liver that acts in the small intestine during digestion? How does that substance act in the digestive process?

Bile, an emulsifier liquid, is made by the liver and later stored within the gallbladder and released in the duodenum.

Bile is composed of bile salts, cholesterol and bile pigments. Bile salts are detergents, amphiphilic molecules, i.e., molecules with a polar water-soluble portion and a non-polar fat-soluble portion. This feature allows bile salts to enclose fats inside water-soluble micelles in a process called emulsification for them to be in contact with intestinal lipases, enzymes that break fats into simpler fatty acids and glycerol.

28. What is the adnexal organ of the digestive system in which bile is stored? How does this organ react to the ingestion of fat rich food?

Bile is concentrated and stored in the gallbladder.

When fat rich foods are ingested the gallbladder contracts to release bile inside the duodenum. (This is the reason why patients with gallstones must not ingest fatty food, the reactive contraction of the gallbladder may move some of the stones to the point of blocking the duct that drains bile into the duodenum, causing pain and possible severe complications.)

29. What are the digestive functions of the liver?

Besides making bile for release in the duodenum, the liver has other digestive functions.

The venous network that absorbs nutrients from the guts, called mesenteric circulation, drains its blood content almost entirely to the hepatic portal vein. This vein irrigates the liver with absorbed material from the digestion. So the liver has the functions of storing, processing and inactivating nutrients.

Glucose is polymerized into glycogen in the liver; this organ also stores many vitamins and the iron absorbed in the intestine. Some important metabolic molecules, like albumin and clotting factors, are made in the liver from amino acids of the diet. In the liver ingested toxic substances, like alcohol and drugs, are inactivated too.

30. Besides the liver which is the other adnexal gland of the digestive system that releases substances in the duodenum participating in extracellular digestion?

The other adnexal gland of the digestive system is the pancreas. This organ makes digestive enzymes that digest proteins (proteases), lipids (lipases) and carbohydrates (pancreatic amylases). Other digestive enzymes, like gelatinase, elastase, carboxipeptidase, ribonuclease and deoxyribonuclease are also secreted by the pancreas.

31. How does the pancreatic juice participate in the digestion of proteins? What are the involved enzymes?

The pancreas secretes trypsinogen that, undergoing action of the enzyme enterokinase secreted by the duodenum, is transformed into trypsin. Trypsin in its turn catalyzes the activation of pancreatic chymotrypsinogen into chymotrypsin. Trypsin and chymotrypsin are proteases that break proteins into smaller peptides. The smaller peptides are then broken into amino acids by the enzyme carboxipeptidase (also secreted by the pancreas in a zymogen form and activated by trypsin) helped by the enzyme aminopeptidase made in the intestinal mucous membrane.

32. How does the pancreatic juice resume the digestion of carbohydrates? What is the involved enzyme?

Carbohydrate digestion begins with the action of the salivary amylase (ptyalin) in the mouth and it continues in the duodenum by the action of the pancreatic juice. This juice contains the enzyme pancreatic amylase, or amylopsin, that breaks starch (amylum) into maltose (a disaccharide made of two glucose molecules).

33. How does the pancreatic juice help the digestion of lipids? What is the involved enzyme?

The enzyme pancreatic lipase is present in the pancreatic juice. This enzyme breaks triacylglycerol (triglyceride) into fatty acids and glycerol.

34. Besides the pancreatic juice in the intestine there is the releasing of the enteric juice that contains digestive enzymes too. What are these enzymes and which type of molecule do each of these enzymes break?

The enteric juice is secreted by the small intestine mucosa. The enzymes of the enteric juice and their respective functions are described as follows:

Enterokinase: enzyme that activates trypsinogen into trypsin. Saccharase: enzyme that breaks sucrose (saccharose) into glucose and fructose. Maltase: enzyme that breaks maltose into two glucose molecules. Lactase: enzyme that breaks lactose into glucose and galactose. Peptidases: enzymes that break oligopeptides into amino acids. Nucleotidases: Enzymes that break nucleotides into its components (nitrogen-containing bases, phosphates and pentoses).

35. Coming from the acid pH of the stomach which pH level does the chyme find when it enters the duodenum? Why is it necessary to maintain that pH level in the small intestine? What are the organs responsible for that pH level and how is it kept?

Entering the duodenum the chyme meets the pancreatic juice under a pH of approximately 8.5. The neutralization of the chyme acidity is necessary to keep adequate pH level for the functioning of the digestive enzymes that act in the duodenum. Without the neutralization of the chyme acidity the mucous membrane of the intestine would be injured.

When stimulated by the chyme acidity the duodenum makes a hormone called secretin. Secretin stimulates the pancreas to release the pancreatic juice and also the gallbladder to expel bile in the duodenum. The pancreatic secretion, rich in bicarbonate ions, is released in the duodenum and neutralizes the chyme acidity; this acidity is also neutralized by the secretion of bile in the duodenal lumen.

36. What are the five human digestive secretions? Which of them is the only pne that does not contain digestive enzymes?

The human digestive secretions are: saliva, gastric juice, bile, pancreatic juice and enteric juice. Among these

secretions only the bile does not contain digestive enzymes.

37. Why do protease-supplying cells of the stomach and of the pancreas make only precursors of the active proteolytic enzymes?

The stomach and the pancreas make zymogens of the proteases pepsin, chymotrypsin and trypsin and these zymogens are released into the gastric or duodenal lumen for activation. This happens to prevent the digestion of these organs' (stomach and pancreas) own cells and tissues by the active form of the enzymes. So the production of zymogens is a protective strategy against the natural effects of the proteolytic enzymes.

38. After digestion the next step is absorption done by cells of the mucous membrane of the intestine. For this task a large absorption surface is an advantage. How is it possible in the small internal space of the body of a pluricellular organism to present a large intestinal surface?

Evolution tried to solve this problem in two ways. The simplest is the long and tubular shape of the bowels (approximately eight meters in extension), making possible that numerous small intestine loops fold closely. More efficient solutions are the intestinal villi and the microvilli of the mucosal membrane cells.

The intestinal wall is not smooth. The mucous membrane, together with its submucosa, projects inside the gut lumen like glove fingers forming invaginations and villi that multiply the available surface for absorption. In addition the epithelial cells that cover these villi have themselves numerous hairlike projections called microvilli on the external face (lumen face) of their plasma membrane. The absorptive area of the intestines is thus increased hundreds of times with these solutions.

In the jejunum and ileum there are folds that have the function of increasing the absorption surface too.

39. In which part of the digestive tube is water is chiefly absorbed? What about the mineral ions and vitamins?

Most part of water, vitamins and mineral ions are absorbed by the small intestine. The large intestine, however, is responsible for the reabsorption of nearly 10% of the ingested water, an important amount that gives consistency to feces (colon diseases can cause diarrhea).

40. From the intestinal lumen through to the tissues - what is the route of nutrients after digestion?

Monosaccharides, amino acids, mineral salts and water are absorbed by the intestinal epithelium and collected by capillary vessels of the intestinal villi. From the capillaries, nutrients go to the mesenteric circulation, a system of vessels that drains the intestinal loops. The blood of the mesenteric circulation is drained to the portal hepatic vein and some nutrients are processed by the liver. From the liver, nutrients are gathered by the hepatic veins that discharge its blood content into the inferior vena cava. Blood from the inferior vena cava then gains the right chambers of the heart and is pumped to the lungs for oxygenation. From the lungs the blood then returns to the heart where it is pumped to the tissues distributing nutrients and oxygen.

41. What is the special route that lipids follow during digestion? What are chylomicrons?

Triglycerides emulsified by the bile within micelles suffer the action of lipases that break them into fatty acids and glycerol. Fatty acids, glycerol and cholesterol are absorbed by the intestinal mucosa. In the interior of the mucosal cells fatty acids and glycerol form again triglycerides that together with cholesterol and phospholipids are packed in small vesicles covered by proteins and called chylomicrons. The chylomicrons are released in minuscule lymphatic vessels not in blood vessels and they gain the lymphatic circulation. So the lymphatic system plays an important role in the absorption of lipids.

The lymphatic circulation drains its content to the venous blood circulation. In that manner chylomicrons reach the liver where their lipid content is processed and released in the blood under the form of protein-containing complexes called lipoproteins, like HDL, VLDL and LDL.

42. What are the so-called "good" and "bad" cholesterol?

Lipoproteins are complexes made of lipids (triglycerides and cholesterol) and proteins. The lipoproteins present different densities according to the relationship between their protein and lipid quantities since lipids are less dense than proteins. Low-density lipoproteins (LDL) are those with a low protein/lipid relation; high-density lipoproteins (HDL) have a high protein/lipid relation; another group is the very low-density lipoproteins (VLDL) with very low protein/lipid relation.

LDL is known as "bad cholesterol" because it transports cholesterol from the liver to the tissues and so induces the formation of atheroma plaques inside blood vessels, a condition called atherosclerosis (do not confuse with arteriosclerosis) that can lead to severe circulatory obstructions like acute myocardial infarction, cerebrovascular accidents and thrombosis. HDL is known as "good cholesterol" since it transports cholesterol from the tissues to the liver (to be eliminated with the bile) and elevation of the HDL blood level reduces the risk of atherosclerosis. (VLDL transforms into LDL after losing triglycerides in the blood).

Biology Questions and Answers

43. Why does the ingestion of vegetable fibers improve the bowel habit in people that suffer from hard stools?

Some types of plant fibers are not absorbed by the intestine but play an important role in the functioning of the organ. They retain water inside the bowels and thus contribute to the softening of the fecal bolus. A softer fecal bolus is easier to be eliminated during defecation. People that eat less dietary fiber may suffer from hard stools and constipation.

44. What are the main functions of the bacterial flora within the human gut?

Bacteria that live inside the gut have great importance in digestion. Some polysaccharides like cellulose, hemicellulose and pectin are not digested by the digestive enzymes secreted by the body, instead, they are broken by enzymes released by bacteria of the gastrointestinal tract. The intestinal bacterial flora also make vital substances for the functioning of the bowels facilitating or blocking the absorption of nutrients and stimulating or reducing peristalsis. Some gut bacteria are the main source of vitamin K for the body and so they are essential for the blood clotting process.

In the intestinal flora there are utile but also potentially harmful bacteria. It is estimated that more than 100 trillion bacteria live in a human gut. Some bacteria are useful too because they compete with other species preventing excessive proliferation of these bacteria.

45. The releasing of digestive secretions is controlled by hormones. What are the hormones that participate in this regulation?

The hormones that participate in the regulation of digestion are gastrin, secretin, cholecystokin and enterogastrone.

46. How is it produced and what is the function of gastrin in the digestive process?

The presence of food in the stomach stimulates the secretion of gastrin that in its turn triggers the releasing of the gastric juice.

47. Where is it produced and what is the function of secretin in the digestive process?

Secretin is made in the duodenum. The chyme acidity causes the duodenum to release this hormone that in its turn stimulates the secretion of the pancreatic juice.

48. How is it produced and what is the function of cholecystokin in the digestive process?

The fat level of the chyme detected in the duodenum stimulates the secretion of cholecystokin (CCK). CCK acts by stimulating the secretion of the pancreatic juice also, and the releasing of bile by the gallbladder.

49. Where is it produced and what is the function of enterogastrone in the digestive process?

When the chyme is too fatty there is a secretion of enterogastrone by the duodenum. This hormone reduces the peristalsis of the stomach thus slowing the entrance of food into the duodenum (as the digestion of fats takes more time).

50. What are the special structures of the avian digestive tube and their respective functions?

The digestive tube of birds has special structures, in this sequential order: the crop, the proventriculus and the gizzard.

The crop has the function of temporary storage of ingested food and it is a more dilated area of the avian esophagus. The proventriculus is the chemical stomach of the birds where food is mixed with digestive enzymes. The gizzard is a muscular pouch that serves as a mechanical stomach where the food is ground to increase the exposure area of the food particles for the digestive enzymes to act.

51. Compared to mammals do birds absorb more or less water in their digestive system? Why is this phenomenon an adaptation to flight?

Bird feces are more liquid than mammal feces, i.e., less water is absorbed in the avian digestive system. The more frequent elimination of feces in birds due to their less solid feces is an adaptation to flight since their body weight is kept lower.

52. What is meant by "mutualist exploration of cellulose digestion", a phenomenon that occurs in some mammals and insects?

Herbivorous animals eat great amounts of cellulose, a substance not digested by their digestive enzymes. In these animals regions of the digestive tube are colonized by microorganisms that digest cellulose. This mutualist ecological interaction between animals and microorganisms occurs, e.g., in horses, cows, rabbits and in some insects such as termites.

53. Cows swallow their food once and then this food goes back to the mouth to be chewed again. How can this phenomenon be explained?

The food ingested by cows and other ruminant animals passes first within two compartments of the digestive tube called the rumen and the reticulum. Within them the food suffers the action of digestive enzymes released by microorganisms that live there in mutualist ecological interaction. In the reticulum the food is divided in some food bolus too. After passing the reticulum the food (cud) is regurgitated to the mouth to be again chewed and swallowed in a process called rumination. The digesting food then enters the omasum where it is mechanically mixed. After that the food goes to the abomasum, the organ where the chemical digestion takes place. After leaving the abomasum (the true stomach) the food bolus gains the intestine.

Biology Questions and Answers

Respiratory System

1. What is the difference between respiration meaning gas exchange and cellular respiration?

Respiration meaning gas exchange is the process in which an organism absorbs from the environment gases necessary for its cellular metabolism and expels gases that are products of this metabolism. Cellular respiration (aerobic or anaerobic) is the chemical reaction in which organic molecules are degraded to make ATP molecules, the main energy source for the metabolism.

Gas exchange is fundamental for cellular respiration since the supplying of some reagents (oxygen, in aerobic cellular respiration) and the expelling of some products (e.g., carbon dioxide) of this chemical reaction depends on gas exchange.

2. What is the chemical equation of the aerobic cellular respiration?

The chemical equation of the aerobic cellular respiration is the following:

$C_6H_{12}O_6 + 6\ O_2 + 36\ ADP + 36\ P \rightarrow 6\ CO_2 + 6\ H_2O + 36\ ATP$

3. Considering the chemical equation of the aerobic cellular respiration which molecules does the cell need and which molecules does it liberate in the process?

Considering the chemical equation of the aerobic cellular respiration it is observed that glucose and molecular oxygen are needed as reagents and carbon dioxide and water are released. The process also spends ADP and phosphate that turn into ATP.

4. What are the different types of gas exchange that occur in animals?

In beings from the kingdom Animalia the gas exchange may occur either by diffusion, tracheal respiration, cutaneous respiration, branchial respiration or pulmonary respiration.

5. Oxygen comes from the environment and carbon dioxide in the end returns to the environment. How do small animals solve the problem of taking away and bringing these molecules from/to their cells? Why isn't that solution possible for larger animals?

Small animals whose tissues make direct contact or are very close to the

environment, like cnidarians and poriferans, make gas exchange by diffusion.

Larger animals with cells without direct contact with the environment or far from it need special gas transportation systems. In these animals the respiratory and the circulatory systems play this role.

6. Beings from four phyla of the animal kingdom "breath" (do gas exchange) by diffusion. Which are those phyla? How is this type of respiration associated to features present in those animals?

The phyla of the animal kingdom whose beings do gas exchange by diffusion are the poriferans, the cnidarians, the platyelminthes (flatworms) and the nematodes (roundworms). This type of respiration in these beings is possible because their tissues and cells are relatively close to the exterior.

7. Which animals make tracheal respiration? Is there a blood-like fluid that participates in this process?

Insects and arachnids are the arthropod animals that make tracheal respiration. In the body surface of these animals there are many orifices called spiracles that communicate with small tubules, the tracheae, through which air penetrates and carbon dioxide is expelled. The tracheae ramify into tracheoles that reach all tissues of the animal.

In the circulatory system of insects the blood only transports nutrients; gases are independently transported by the tracheal system.

8. What is the difference between respiration by diffusion and cutaneous respiration? Does blood participate in cutaneous respiration?

Cutaneous respiration is not as simple as diffusion. In diffusion the gases diffuse directly between the external environment and the cells. In cutaneous respiration molecular oxygen penetrates through the skin and it is collected by the blood circulation that then distributes the gas to the tissues. Carbon dioxide is also collected from the tissues by the blood and taken to the skin to be eliminated to the environment. So there is important participation of blood in cutaneous respiration.

9. Which animals make cutaneous respiration?

Terrestrial annelids and adult amphibians make cutaneous respiration (in amphibians there is also pulmonary respiration).

The thin skin and the need for living in moist surrounds are typical features of these animals are.

10. What are branchiae? What are examples of animals that "breath" through branchiae?

Branchiae, also known as gills, are small portions of richly vascularized tissues internal or external to the body and in direct contact with the surrounding water. The gills are organs that make gas exchange in aquatic annelids, crustaceans, fishes and amphibian larvae (e.g., tadpoles).

11. What is the difference between gills and lungs?

Gills and lungs are richly vascularized organs that serve for gas exchange between the environment and the circulatory system.

The lungs differentiate from gills in that they are saclike structures always internal to the organism and specialized in gas exchange in terrestrial environment. Branchiae, in their turn, are internal or external laminar structures in direct contact with water and specialized in gas exchange in aquatic environment.

12. Besides vertebrates two invertebrate phyla contain species that make pulmonary respiration. Which are these phyla?

Terrestrial molluscs and the arachnid arthropods are the invertebrates that present pulmonary-like respiration. Some terrestrial molluscs have a mantle cavity filled with air that makes contact with richly vascularized tissues that work as rudimentary lungs. Besides their tracheal respiration some arachnids have book lungs (thin folds resembling leaves of a book) that make gas exchange.

13. What are the three types of respiration in which the circulatory system transports gases?

The circulatory system has an important role in cutaneous respiration, branchial respiration and pulmonary respiration. The respiratory function of the blood is tailored for transportation of gases for exchange between tissues and respiratory surfaces in contact with the exterior (skin, gills, lungs).

14. What are respiratory pigments? What are some respiratory pigments and in which animal groups can each of them be found?

Respiratory pigments are molecules present in the blood that bind to oxygen transporting it to the tissues.

In vertebrates the respiratory pigment is hemoglobin, reddish due to the iron of its composition. In crustacean and arachnid arthropods and in some molluscs the respiratory pigment is hemocyanin, blue due to the copper of its composition. Annelids have hemoglobin, hemerythrin and chlorocruorin as respiratory pigments.

15. What are the organs that form the human respiratory system?

The organs that are part of the human respiratory system can be divided into three groups: lungs, airway and respiratory muscles.

The lungs are the right and the left lungs made of alveoli where gas exchange (entrance of oxygen and exit of carbon dioxide) takes place; the lungs are covered by the pleura (a serous membrane). The airway comprehends the nose, the pharynx, the larynx (including the vocal cords), the trachea, the bronchi and the bronchioles. The muscles upon which the breathing process depends are mainly the diaphragm and the intercostal muscles (muscles between the ribs).

16. What is the anatomical reason for the left bronchus to be more elevated than the right bronchus? Why in most cases of aspiration of foreign material by children is the object found in the right bronchus?

The left bronchus is more elevated than the right bronchus because of the position of the heart in the left side of the chest, anterior and inferior to the left bronchus.

Accidentally aspired objects are frequently found in the right bronchus because the inferior angle between the trachea and this bronchus is lower than the inferior angle between the trachea and the left bronchus since the left bronchus is more horizontalized. Therefore aspired objects tend to fall in the right side (bronchus) and not in the left.

17. How does the body defend itself from microorganisms and other harmful substances that enter the airway during the breathing process?

The epithelium of the airway is a ciliated epithelium and has mucus-secreting specialized cells. The secreted mucus covers the internal wall of the airway retaining organisms and foreign particles that then are swept by the cilia of the epithelium.

In the mucous ciliated epithelium of the airway there is also intense activity of

the immune system with antibodies and leukocytes inactivating and destroying foreign agents.

Other defense mechanisms of the airway are the sneeze and the cough. They help the elimination of solid and semifluid particles like pathologic residuals (sputum) and accidentally aspired objects.

18. Which are the respiratory muscles in mammals?

In mammals the muscles that participate in the breathing process are the diaphragm and the intercostal muscles. In respiratory insufficiency other muscles can help the respiration, the muscles of the shoulders, neck, thorax and abdomen.

19. How are inhalation and expiration carried out?

The diaphragm (exclusive of mammals) and the intercostal muscles can contract or relax varying the volume of the thorax (the compartment where the lungs are located). The changing of the thorax volume forces inhalation or expiration.

When the thorax volume is increased an internal pressure lower than the atmospheric pressure (external) is created and gases naturally enter the lungs. When the thorax volume is lowered the internal pressure rises above the external pressure and the air is expelled from the lungs.

20. What is the difference between arterial and venous blood?

Arterial blood is the oxygen-rich and carbon dioxide-poor blood that irrigates the tissues. Venous blood is the oxygen-poor and carbon dioxide-rich blood collected from the tissues.

21. What is hematosis? In humans where does hematosis occur?

Hematosis is the oxygenation of the blood. Venous blood (oxygen-poor) after hematosis is transformed into arterial blood (oxygen-rich).

In humans hematosis takes place in the lungs.

22. What are the blood vessels that carry venous blood to the heart? What is the blood vessel that collects arterial blood from the heart?

The blood vessels that debouch in the heart carrying venous blood are the inferior and the superior vena cava. The blood vessel that carries arterial blood from the heart is the aorta.

23. What is the gas exchange unit of the mammalian lungs?

The gas exchange units of the mammalian lungs are the alveoli.

24. What is the physical process through which gas exchange is accomplished in the pulmonary alveoli?

The gas exchange (entry of oxygen and exit of carbon dioxide) in the pulmonary alveoli occurs by simple diffusion in favor of the partial pressure gradient.

When the oxygen partial pressure in the inhaled air is higher than the oxygen partial pressure of the capillaries of the alveoli the air diffuses to the circulatory system. If the oxygen partial pressure in the air is lower (a rare situation since the blood that reaches the alveoli is venous blood) the oxygen exits the circulatory system. The same is true for carbon dioxide.

25. What is the structure of the central nervous system that regulates pulmonary respiration?

The pulmonary respiration is controlled by the neural respiratory center located within the medulla (the lower part of the brain continuous to the spinal cord).

26. What is the chemical equation of the formation of bicarbonate from carbon dioxide and water? What is the enzyme that catalyzes this reaction?

The chemical equation of the chemical equilibrium of the formation of bicarbonate having as reagents carbon dioxide and water is as follows:

$CO_2 + H_20 \dashrightarrow H_2CO_3 \dashrightarrow H^+ + HCO_3^-$

The reaction is catalyzed by the enzyme carbonic anhydrase present in red blood cells.

27. What are the consequences of shifting the chemical equilibrium of the formation of bicarbonate from carbon dioxide and water towards the increase of product (bicarbonate) formation?

The increase in product formation in the chemical equilibrium of the formation of bicarbonate from carbon dioxide and water heightens the concentration of hydrogen ions and thus lowers the pH of the solution.

Biology Questions and Answers

28. What are the consequences of shifting the chemical equilibrium of the formation of bicarbonate from carbon dioxide and water towards the consumption of products of the reverse reaction?

The shifting of the chemical equilibrium of the formation of bicarbonate from carbon dioxide and water into the reverse reaction (production of water and carbon dioxide) means spending of hydrogen ions and thus it increases the solution pH.

29. How does the pulmonary ventilation affect the carbon dioxide concentration in blood? What happens to the carbon dioxide concentration and to the blood pH when the respiratory frequency is either lowered or increased?

The pulmonary ventilation frequency (number of inhalations per time unit) rises or lowers the carbon dioxide concentration in blood. If it is intense the gas is more eliminated to the exterior and if it is reduced the gas is retained inside the organism.

Applying the principles of chemical equilibriums to the formation of bicarbonate from carbon dioxide and water one gets the following: if the carbon dioxide concentration is increased the equilibrium shifts towards the formation of bicarbonate and liberation of hydrogen ions and the pH of the solution is lowered; if the carbon dioxide concentration is lowered the equilibrium shifts reversely towards the formation of water and carbon dioxide and also of more hydrogen ions spending and the pH of the solution is raised.

30. What are acidosis and alkalosis?

Acidosis is the condition in which the blood pH is abnormally low. Alkalosis is the condition in which the blood pH is abnormally high. Normal pH levels for the human blood are between 7.35 and 7.45 - slightly alkaline.

31. How does the breathing process correct acidosis?

If the body experiences acidosis the respiratory center located in the medulla gets the information and induces the increase of the respiratory frequency. The increment of the respiratory frequency makes the body eliminate more carbon dioxide and to shift the equilibrium of the formation of bicarbonate towards the spending of more hydrogen ions and thus the blood pH raises.

32. How does the breathing process correct alkalosis?

If the body undergoes alkalosis the respiratory center located in the medulla gets the information and induces the lowering of the respiratory frequency.

The reduction of the respiratory frequency makes the body retain more carbon dioxide and to shift the equilibrium of the formation of bicarbonate towards the production of more hydrogen ions and thus the blood pH lowers.

33. What is the difference between respiratory acidosis and metabolic acidosis and what is the difference between respiratory alkalosis and metabolic alkalosis?

Respiratory acidosis is that in which the blood pH is low due to increased retention of carbon dioxide caused by the lowering of the respiratory frequency or by pulmonary diseases that impair the gas exchange. So the cause of the respiratory acidosis is the pulmonary respiration. Metabolic acidosis is that in which the blood pH is low not due to the pulmonary retention of carbon dioxide but due to metabolic disturbances. Some metabolic disturbances result in liberation in the blood of nonvolatile acids that release hydrogen ions lowering the blood pH (e.g., diabetic ketoacidosis).

Respiratory alkalosis is that in which the pH is high due to increased expelling of carbon dioxide caused by elevated respiratory frequency. Metabolic alkalosis is the alkalosis caused by metabolic disturbances that increase the concentration of bases (alkalis) in the blood.

34. Where are the chemoreceptors that detect the acidity of the blood and trigger the respiratory compensation located?

The chemoreceptors that participate in the ventilation control are structures that collect information about the acidity and alkalinity of the blood. The information is then transmitted by nervous fibers to the respiratory center located within the medulla. The center then commands the respiratory muscles to compensate the abnormal pH.

There are central and peripheral chemoreceptors. Peripheral chemoreceptors of pH, carbon dioxide partial pressure and oxygen partial pressure are located in the walls of the aorta and of the carotid arteries. Central chemoreceptors that get pH information are located within the medulla in the respiratory center. (The pulmonary ventilation is also controlled by receptors that receive pH information from the cerebrospinal fluid.)

Biology Questions and Answers

Circulatory System

1. What is circulation?

Circulation is the movement of substances like nutrients and gases within blood vessels and cavities throughout the organism.

2. Do all animals have a circulatory system?

Not all animals have a circulatory system.

Poriferans, cnidarians, platyhelminthes and nematodes (in these there are the pseudocoelom fluid but no vessels) are avascular animals. Echinoderms do not have true circulatory systems either.

3. What is the alternative means for transport of substances in animals without a circulatory system? Why is blood important for larger animals?

In animals that do not present the circulatory system the transport of substances occurs by cell to cell diffusion.

The blood is a fundamental means of substance transport for larger animals since in these animals there are tissues distant from each other and from the environment thus making diffusion impossible.

4. What are the two types of circulatory systems?

The circulatory systems can be classified into open circulatory system and closed circulatory system.

5. What is an open circulatory system?

Open circulatory system is the one in which blood does not circulate only inside blood vessels but it also falls in cavities that irrigate tissues. In the open circulatory system the blood pressure is low and generally the blood (called hemolymph) has low cellularity.

Arthropods, molluscs (the cephalopods are exception) and protochordates have open circulatory system.

6. What is a closed circulatory system?

A closed circulatory system is one in which blood circulates only inside blood vessels. For this reason the blood pressure is higher in animals with closed circulatory system. The cellularity of the blood is also higher with many specific blood cells.

The closed circulatory system is a feature of annelids, cephalopod molluscs and vertebrates.

Biology Questions and Answers

7. What are the advantages of the closed circulatory system over the open circulatory system?

The closed circulatory system is more efficient. Since blood circulates only inside blood vessels it can do it with more pressure reaching farther distances between the organs where hematosis happens and the peripheral tissues. In addition the circulatory speed also heightens making possible more oxygen supply to great consuming tissues, like the muscle tissues that then can perform faster movements. Animals with an open circulatory system (with the exception of insects that do gas exchange independently from the circulation) are generally slower and have a low metabolic rate.

8. What is the difference between octopuses and mussels regarding their circulatory systems? How does that difference influence the mobility of these animals?

Cephalopod molluscs, like octopuses and squids, have a closed circulatory system with blood pumped under pressure flowing within vessels. Bivalve molluscs, like mussels and oysters, have an open circulatory system (also known as lacunar circulatory system) where blood flows under low pressure since it falls in cavities of the body and does not only circulate within blood vessels. Molluscs with closed circulatory systems are larger, agile and can actively move; molluscs with open circulatory systems are smaller, slow and some are practically sessile.

9. Why, even thoough they have an open circulatory system, can flying insects like flies beat their wings with great speed?

In insects the circulatory system is open but this system does not participate in the gas exchange process and in oxygen supply to the tissues. Gases go in and out through the independent tracheal system that allows direct contact of cells with the ambient air. Therefore an insect can supply the great oxygen demand of its fast-beating wing muscles even having open circulatory system.

10. What are the typical components of a closed circulatory system?

The typical components of the closed circulatory system are the blood vessels within which blood circulates (arteries, veins and capillaries), a pumping organ (heart) and the blood or bloodlike fluid.

11. How does the heart impel the blood?

The heart is a muscular organ that contains chambers (right atrium and right ventricle and left atrium and right ventricle) through which blood passes. The blood enters the heart in the atria,

goes to the ventricles and then leaves the organ.

The blood is pumped out of the heart by the contraction of the muscle fibers that form the ventricular walls. The contraction reduces the ventricle volume thus increasing the internal pressure and the blood then flows to the exit vessels (pulmonary artery for the right ventricle and aorta for the left ventricle). When ventricular muscle fibers distend the ventricles regain their original size and receive new blood flow coming from the atria.

12. What is the difference between systole and diastole

Systole and diastole are the two stages into which the cardiac cycle is divided. Systole is the stage when the contraction of ventricular muscle fibers occurs and the ventricles are emptied. Diastole is the stage of the cardiac cycle when the ventricular muscle fibers distend and the ventricles are filled with blood.

13. What are arterial vessels, arteries and arterioles?

Arterial vessels are every blood vessel that carries blood from the heart to the tissues. Arteries and arterioles are arterial vessels. Arterioles are thin arteries that end in capillaries.
Not all arteries however contain arterial blood (highly oxygenated blood). The pulmonary artery and its ramifications, arteries that carry blood from the right heart ventricle to the lungs, contain venous blood.

14. What are venous vessels, veins and venules?

Venous vessels are every blood vessel that carries blood from the tissues to the heart. Veins and venules are venous vessels. Venules are thin veins that are continuous to capillaries.

In general venous vessels carry venous blood. The pulmonary veins that carry blood from the lungs to the left atrium of the heart however contain arterial blood.

15. What are the capillaries of the vascular system?

Capillaries are small blood vessels that perform exchange of substances between the blood and the body tissues. Capillaries are neither arteries nor are they veins since they have distinct features. In capillaries the wall is made of a single layer of endothelial cells through which substances are exchanged. These vessels receive blood from the arterioles and drain to the venules.

16. What is the part of the vascular system that performs exchange of gases and other substances with the tissues?

Only capillaries perform exchange of gases and other substances with the tissues.

17. Are the arteries or the veins constituted of more muscle tissue? How different are the walls of these two types of blood vessels?

The arterial system has thicker muscle walls since within arteries the blood circulates under higher pressure. The veins are more flaccid than arteries.

From the lumen to the external layer both types of vessels are made of endothelium, muscle tissue and connective tissue. In both the endothelium is a single layer of cells. In arteries the muscle tissue portion is thicker than in veins and in these vessels the external connective tissue is thicker than in arteries.

Arteries are the pulsating blood vessels. The arterial pulse can be felt in a medical examination, for example, by the palpation of the radial artery in the internal and lateral face of the wrist near the base of the thumb.

18. What are the valves of the venous system? What is their function?

The valves of the venous system are structures inside the veins that permit blood to flow only in the normal way (from the tissues to the heart) and forbid it to return in the reverse way in favor of gravity. The valves close when the pressure of the fluid column above (after, regarding normal flux) is higher than the fluid pressure before them. Valves are thus fundamental for the returning of blood to the heart.

19. How do the muscles of the legs and of the feet contribute to the venous return?

The muscles of the legs, mainly the muscles of the calves, contract and compress the deep veins of the legs impelling the blood to the heart.

The plantar portion of the feet retains blood and when it is compressed against the ground it impels its blood volume and aids venous return.

20. What are varices? Why are they more common in the inferior limbs?

Varix means abnormal enlargement of veins. Varices occur when excessive pressure against the normal blood flux creates enlargement of the vein and thus insufficient functioning of its valves (venous insufficiency).

Varices are more common in the veins of the inferior limbs since the fluid column above these vessels is higher. This is the reason why people that spend much time standing (e.g., surgeons) are more susceptible to varices.

In general varices are not the apparent superficial veins that appear in the leg

of varix patients. These apparent vessels are the consequences of internal varices (venous insufficiency) in the deep internal veins of the legs and they appear because the blood flux is diverted to superficial veins. (Popularly however apparent superficial veins are called varices.)

21. What is the lymphatic system?

The lymphatic system is a network of specialized valved vessels that drain interstitial fluid (lymph). The lymphatic system is also responsible for the transport of chylomicrons (vesicles that contain lipids) made after the absorption of fats by the intestinal epithelium.

In the way of the lymphatic vessels there are ganglial-like structures called lymph nodes that contain many cells of the immune system. These cells filter impurities and destroy microorganisms and cellular wastes. The lymphatic vessels drain to two major lymphatic vessels, the thoracic duct and the right lymphatic duct, that in their turns drain into tributary veins of the superior vena cava.

22. Why in inflammatory and infectious conditions may clinical signs related to the lymphatic system occur?

The lymph nodes, or lymph glands, have lymphoid tissue that produces lymphocytes (a type of leukocyte). In inflammatory and infectious conditions the enlargement of lymph nodes of the lymphatic circuits that drain the affected region due to the reactive proliferation of leukocytes is common. This enlargement is known as lymphadenomegaly and sometimes it is accompanied by pain. The search for enlarged or painful lymph nodes is part of the medical examination since these findings may suggest inflammation, infection or other diseases.

23. Which are the heart chambers respectively where the entrance and the exit of blood occur?

The heart chambers through which blood enters the heart are the atria. There are the right atrium and the left atrium.

The heart chambers through which the blood exits the heart are the ventricles. There are the right ventricle and the left ventricle.

24. Concerning the thickness of their walls how different are the heart chambers?

The ventricle walls are thicker than the atrium walls since ventricles are structures responsible for the pumping of the blood to the lungs or tissues. The muscular work of the ventricles is harder and their muscle fibers develop more.

The left ventricle is more muscular than the right ventricle because pumping

blood to the lungs (the right ventricle task) is easier (needs less pressure) than pumping blood to the other tissues of the body (the left ventricle task).

25. What is vena cava? Which type of blood circulates within the vena cava?

The vena cava are either of two large veins that debouch into the right atrium. The superior vena cava drains all blood that comes from the head, the superior limbs, the neck and the superior portion of the trunk. The inferior vena cava carries blood drained from the inferior portion of the trunk and the inferior limbs.

Venous blood circulates within the vena cava.

26. Which is the first (human) heart chamber into which blood enters? Where does the blood go after passing that chamber? What is the name of the valve that separates the compartments? Why is that valve necessary?

The venous blood that comes from the tissues arrives in the right atrium of the heart. From the right atrium the blood goes to the right ventricle. The valve that separates the right ventricle from the right atrium is the tricuspid valve (a valvular system made of three leaflets). The tricuspid valve is necessary to prevent returning of blood to the right atrium during systole (contraction of ventricles).

27. What is the function of the right ventricle? To where does the right ventricle pump the venous blood?

The function of the right ventricle is to get venous blood from the right atrium and pump the blood to be oxygenated in the lungs.

The venous blood is carried from the right ventricle to the lungs by the pulmonary artery and their ramifications.

28. What is the valve that separates the right ventricle from the pulmonary artery? Why is that valve important?

The valve that separates the right ventricle and the base of the pulmonary artery is the pulmonary valve. The pulmonary valve is important to prevent blood from the pulmonary circulation to flow back to the heart during diastole.

29. Do the arteries that carry blood from the heart to the lungs contain arterial or venous blood? What happens to the blood when it passes through the lungs?

Arteries of the pulmonary circulation are arteries that carry venous blood and not arterial blood.

When the blood passes within the alveolar capillaries of the lungs hematosis (oxygenation) occurs and carbon dioxide is released to the exterior.

30. What and how many are the pulmonary veins?

The pulmonary veins are part of the pulmonary circulation. They are vessels that carry oxygen-rich (arterial) blood from the lungs to the heart. There are four pulmonary veins, two that drain blood from the right lung and other two that drain the left lung. The pulmonary veins debouch into the left atrium bringing arterial blood to the heart. Although they are veins they carry arterial blood and not venous blood.

31. To which heart chamber does the blood go after leaving the left atrium? What is the valve that separates these compartments?

The arterial blood that has come from the lungs to the left atrium passes then to the left ventricle.

The valve between the left ventricle and the left atrium is the mitral valve, a bicuspid (two leaflets) valve. The mitral valve is important because it prevents the regurgitation of blood to the left atrium during systole (contraction of the ventricles).

32. What is the function of the left ventricle? Where does the blood go after leaving the left ventricle?

The function of the left ventricle is to get blood from the left atrium and to pump the blood under high pressure to the systemic circulation. After leaving the left ventricle the blood enters the aorta, the largest artery of the body.

33. What is the valve that separates the aorta from the heart? What is the importance of that valve?

The valve between the left ventricle and the aorta is the aortic valve. The aortic valve prevents the retrograde flux of blood to the left ventricle during diastole. Besides, as the aortic valve closes during diastole, part of the retrograde blood flux is impelled through the coronary ostia (openings), orifices located in the aorta wall just after the valvular insertion and contiguous to the coronary circulation responsible for the blood supply of the cardiac tissues.

34. Is the ventricle lumen larger during systole or during diastole?

Systole is the stage of the cardiac cycle on which the ventricles contract. So the lumen of these chambers is reduced and the pressure upon the blood within them is heightened.

During diastole the opposite occurs. The muscle fibers of the ventricles relax and the lumen of these chambers enlarges helping the entrance of blood.

35. What is the stage of the cardiac cycle during which the ventricles are filled?

The filling of the ventricles with blood occurs during diastole.

36. Of which type of tissue is the heart made? How is this tissue oxygenated and nutrified?

The heart is made of striated cardiac muscle tissue. The heart muscle is called the myocardium and it is oxygenated and nutrified by the coronary arteries. The coronary arteries come from the base of the aorta and ramify around the heart penetrating the myocardium.

Diseases of the coronary arteries are severe conditions.

37. Which are the two main metabolic gases transported by the blood?

The main metabolic gases transported by the blood are molecular oxygen (O_2) and carbon dioxide (CO_2).

38. How do respiratory pigments act?

Respiratory pigments are oxygen-carrying molecules present in the blood. When the oxygen concentration is high, for example, in the pulmonary alveoli, the respiratory pigments bind to the gas. In conditions of low oxygen concentration, e.g., in tissues, the respiratory pigments release the molecule.

In the human blood the respiratory pigment is hemoglobin, present within the red blood cells.

39. How different are oxyhemoglobin and hemoglobin? Where is it expected to find a higher concentration of oxyhemoglobin, in peripheral tissues or in the lungs?

Oxygen-bound hemoglobin is called oxyhemoglobin. In the lungs the oxygen concentration is higher and so there is a higher oxyhemoglobin concentration. In the peripheral tissues the situation is the reverse, the concentration of oxygen is lower and there is more free hemoglobin.

Biology Questions and Answers

40. What is hemoglobin F? Why does the fetus need a different hemoglobin?

Hemoglobin F is the hemoglobin found in the mammalian fetus and hemoglobin A is the normal hemoglobin. Hemoglobin F has higher affinity for oxygen.

The fetus needs hemoglobin capable of extracting oxygen from the mother's circulation. Therefore the fetus uses hemoglobin F since it has higher affinity for oxygen than the mother's hemoglobin.

41. In high altitudes is it necessary for the blood to have more or less hemoglobin?

In high altitudes the air is rarefied and oxygen concentration is lower than in low altitudes. In this situation the efficiency of the respiratory system must be greater and thus the organism synthesizes more hemoglobin (and more red blood cells) trying to get more oxygen. This phenomenon is known as compensatory hyperglobulinemia.

The compensatory hyperglobulinemia is the reason why athletes that will compete in high altitudes need to arrive in the place some days before the event so there is time for their body to make more red blood cells and they will be less affected by the effects of the low atmospheric oxygen concentration (fatigue, reduced muscular strength).

42. What is the substance that stimulates the production of red blood cells? Which is the organ that secretes it? Under what conditions does this secretion increase?

The substance that stimulates the production of red blood cells by the bone marrow is erythropoietin. Erythropoietin is a hormone secreted by the kidneys. Its secretion is increased when there is deficient tissue oxygenation (tissue hypoxia) caused either by reduced oxygen availability (as it occurs in high altitudes) or by internal diseases, as in pulmonary diseases.

43. Why is carbon monoxide toxic for humans?

Hemoglobin "likes" carbon monoxide (CO) much more than it likes oxygen. When there is carbon monoxide in the inhaled air it binds to hemoglobin forming carboxyhemoglobin by occupying the binding site where oxygen would bind. Due to the higher hemoglobin affinity for carbon monoxide thus (e.g., in intoxication from car exhausts) there is no oxygen transport and the individual undergoes hypoxia, loses conscience, inhales more carbon monoxide and may even die.

Intoxication by carbon monoxide is an important cause of death in fires and in closed garages.

Biology Questions and Answers

44. What is the stage of cellular respiration during which carbon dioxide is liberated?

In aerobic cellular respiration the release of carbon dioxide happens in the transformation of pyruvic acid into acetyl-CoA (two molecules) and in the Krebs cycle (four molecules). For each glucose molecule, six carbon dioxide molecules are made.

45. How is carbon dioxide released by cellular respiration transported from the tissues to be eliminated through the lungs?

In vertebrates almost 70% of the carbon dioxide is transported by the blood in the form of bicarbonate, 25% bound to hemoglobin and 5% dissolved in the plasma.

46. What is the difference between double closed circulation and simple closed circulation?

Double closed circulation, or closed circulation, is that in which the blood circulates through two associated and parallel vascular systems: one that carries blood to and takes blood from the peripheral tissues (the systemic circulation) and the other that carries blood to and takes blood from the tissues that perform gas exchange with the environment, e.g, the lungs (pulmonary circulation). Double circulation occurs in amphibians, reptiles, birds and mammals.

Simple closed circulation, or simple circulation, is the one in which the tissues that perform gas exchange are associated in series with the systemic circulation, as in fishes.

47. How many chambers does the fish heart have?

The fish heart is a tube made of two consecutive chambers: one atrium and one ventricle.

48. Does the fish heart pump venous or arterial blood?

The venous blood coming from the tissues enters the atrium and passes to the ventricle that then pumps the blood towards the gills. After oxygenation in the gills the arterial blood goes to the tissues. So the fish heart pumps venous blood.

49. Why is the fish circulation classified as a simple and complete circulation?

Complete circulation is that in which there is no mixture of venous blood and arterial blood. Simple circulation is that in which the blood circulates only in one circuit (as opposed to the double circulation that have two circuits, the systemic circulation and the pulmonary

circulation). In fishes the circulatory system is simple and complete.

50. How many heart chambers does the amphibian heart have?

The amphibian heart has three heart chambers: two atria and one ventricle.

51. Why can the amphibian circulation be classified as double and incomplete?

The amphibian circulation is double because it is composed of systemic and pulmonary circulations: respectively, heart-tissues-heart and heart-lungs-heart. Since amphibians have only one ventricle in the heart, venous blood taken from the tissues and arterial blood coming from the lungs are mixed in the ventricle that then pumps the mixture back to the systemic and to the pulmonary circulations. The amphibian circulation is classified as incomplete because venous and arterial blood mix in the circuit.

The blood oxygenation in amphibians occurs also in the systemic circulation since their skin is a gas exchange organ.

52. What is the difference between the amphibian heart and the reptile heart?

The reptiles have double and incomplete circulation too, three heart chambers (two atria and one ventricle). The reptile heart however presents the beginning of a ventricular septation that partially separates a right and left region of the chamber. With the partial ventricular septation the mixture of arterial with venous blood in the reptile heart is less than in amphibians.

53. How many chambers do the bird heart and the mammalian heart have? Concerning temperature maintenance what is the advantage of the double and complete circulation of these animals?

The bird and the mammalian hearts are divided into four chambers: right atrium, right ventricle, left atrium and left ventricle.

Birds and mammals are homeothermic, i.e., they control their body temperature. The four-chambered heart and the double circulation provide the supply of more oxygenated blood to the tissues making possible a higher metabolic rate (mainly cellular respiration rate). Part of the energy produced by the cellular respiration is used to maintain the body temperature.

54. Concerning the mixture of arterial with venous blood what is the difference between the human fetal circulation and the adult circulation?

In the human fetal circulation there are two communications between arterial and venous blood characterizing an incomplete circulation. One of them is the oval foramen, an opening between the right and the left atria of the fetal heart. The other is the arterial duct, a short vessel connecting the pulmonary artery to the aorta. These communications close a few days after birth and so they are not present in the adult heart.

55. How is heart contraction triggered?

Heart contraction is independent from neuronal stimulus (although it can be modulated by the autonomous nervous system). In the heart there are pacemaker cells that trigger by themselves the action potentials that begin the muscle contraction. These cells are concentrated at two special points of the heart: the sinoatrial node (SA node) located in the superior portion of the right atrium and the atrioventricular node (AV node) located near the interatrial septum.

The action potentials generated by depolarization of the SA node cells propagate cell to cell throughout the atria producing the atrial contraction. The atrial depolarization also propagates to the AV node that then transmits the electric impulse to the ventricles through specialized conduction bundles of the interventricular septum (the bundle of His) and then to the Purkinje fibers of the ventricle walls causing ventricular contraction. (The atrial contraction precedes the ventricular contraction for blood to fill the ventricles before the ventricular contraction.)

The repolarization of the SA node makes the atria relax and then the ventricles relax too.

Biology Questions and Answers

Excretory System

1. What is excretion?

Excretion in Physiology is the process of elimination of metabolic wastes and other toxic substances from the body.

2. What are nitrogen wastes?

Nitrogen wastes are residuals derived from the degradation of proteins. They are made from chemical transformation of the amine group of amino acid molecules.

3. What are the three main types of nitrogen wastes excreted by living beings?

The main nitrogen wastes excreted by living beings are ammonia, uric acid and urea. Living beings that secrete ammonia are known as ammoniotelic. Creatures that secrete uric acid are known as uricotelic. Organisms that secrete urea are called ureotelic.

4. Why are most ammoniotelic beings aquatic animals?

Aquatic animals, like crustaceans, bony fishes and amphibian larvae, generally are ammoniotelic since ammonia diffuses more easily through membranes and it is more water-soluble than the other nitrogen wastes. Ammonia is still the most energetically economical nitrogen waste to be synthesized.

5. Why after the passage of animals from the aquatic to the terrestrial habitat does the abandonment of the ammoniotelic excretion occur?

Ammonia is a highly toxic molecule if not diluted and quickly excreted out of the body. For this reason the ammoniotelic excretion was abandoned in terrestrial habitats because the availability of water for dilution is reduced in this medium and wastes cannot be excreted so promptly to the exterior.

6. Comparing toxicity and the need for dilution in water how different are the ureotelic and the uricotelic excretions? What are some examples of animals that present these respective types of excretion?

Urea is more water-soluble than uric acid (an almost insoluble substance). Urea is also more toxic. Both however are less toxic than ammonia.

Some invertebrates, chondrichthian fishes, adult amphibians and mammals are ureotelic. Reptiles, birds and most arthropods are uricotelic.

Biology Questions and Answers

7. What is the nitrogen waste in amphibian larvae and in the adult animal?

Since amphibian larvae are aquatic they excrete ammonia. The terrestrial adult excretes urea.

8. Why is the uricotelic excretion essential for avian and reptile embryos?

In reptiles and birds the excretory system is uricotelic since uric acid is insoluble, less toxic and suitable to be stored within the eggs where their embryos develop.

9. How do embryos of placental mammals excrete nitrogen wastes?

Placental animals, including embryos, excrete urea. In the adult placental mammal urea is excreted through the urine. In embryos the molecule passes to the mother's blood through the placenta and it is excreted in the mother's urine.

10. What is the main nitrogen waste of humans?

Human beings excrete mainly urea eliminated with the urine.

11. How is urea formed in the human body?

Urea is a product of the degradation of amino acids. In the process amino acids lose their amine group which is then transformed into ammonia. In the liver ammonia reacts with carbon dioxide to form urea and water, a process called ureogenesis.

In the intermediary reactions of the ureogenesis a molecule of ornithine is consumed and another is produced. For this reason ureogenesis is also known as the ornithine cycle.

12. Which are the organs of the excretory system?

The excretory system is formed of kidneys (two), ureters (two), bladder and urethra.

13. What are the vessels that carry blood to the kidneys? Is this blood arterial or venous?

The arterial vessels that carry blood to be filtrated by the kidneys are the renal arteries. The renal arteries are ramifications of the aorta and so the blood filtered by the kidneys is arterial (oxygen-rich) blood.

14. Which are the vessels that drain filtered blood from the kidneys?

The venous vessels that collect the blood filtered by the kidneys are the renal veins. The renal veins carry the blood that has been reabsorbed in the nephron tubules.

15. What is the functional unity of the kidneys?

The functional (filtering) unity of the kidneys is the nephron. A nephron is made of afferent arteriole, efferent arteriole, glomerulus, Bowman's capsule, proximal tubule, loop of Henle, distal tubule and collecting duct.

In each kidney there are about one million nephrons.

16. What are the three main renal processes that combined produce urine?

Urine is made by the occurrence of three processes in the nephron: glomerular filtration, tubular resorption and tubular secretion.

In the nephron the blood carried by the afferent arteriole enters the glomerular capillary network where it is filtered. The filtration implies that part of the blood returns to the circulation through the efferent arteriole and the other part, known as the glomerular filtrate, enters the proximal tubule of the nephron. In the nephron tubules (also known as convoluted tubules) substances of the glomerular filtrate like water, ions and small organic molecules are resorbed by the cells of the tubule wall and gain again the circulation. These cells also secrete other substances inside the tubules. The urine is formed of not resorbed filtered substances and of secreted (by the tubules) substances. Urine is drained by the collecting ducts to the ureter of each kidney, then it enters the bladder and later it is discharged through the urethra.

The nephron tubules are surrounded by an extensive capillary network that collects resorbed substances and provides others to be secreted.

17. What is the main transformation presented by the glomerular filtrate in comparison to the blood?

Glomerular filtrate is the name given to the plasma after it has passed the glomerulus and entered the Bowman’s capsule. The glomerular filtrate has a different composition compared to urine since the fluid has not yet undergone tubular resorption and secretion.

The main difference between the blood and the glomerular filtrate is that in the latter the amount of proteins is at a minimum and there are no cells or blood platelets.

18. What is proteinuria? Why is proteinuria a sign of glomerular renal injury?

Proteinuria means losing of proteins through urine. Under normal conditions proteins are too big to be filtered by the glomerulus and they are practically

absent in the urine (the few filtered proteins may also be resorbed in the nephron tubules). Proteinuria is an indication that a more than expected amount of proteins is passing the glomerulus suggesting glomerular disease, e.g., in diabetic nephropathy.

The glomerulus also blocks the passage of blood cells and platelets (hematuria is often a sign of urinary disease although less specific of kidneys since the blood may come from the lower parts of the excretory tract).

19. Where does most of the water resorbed after glomerular filtration go? What are the other substances resorbed by the nephron tubules?

Only 0.5 to 1% of the glomerular filtrate is eliminated as urine. The remaining volume, containing mainly metabolic ions, glucose, amino acids and water, is resorbed through the nephron tubules (by means of active or passive transport) and gains the blood circulation again.

The convolute tubules of the nephron are responsible for the resorption of substances.

20. Why do cells of the nephron tubules present a great amount of mitochondria?

The cells of the tubule wall have high number of mitochondria because many substances are resorbed or secreted through them by means of active transport (a process that spends energy). Therefore many mitochondria are necessary for the energetic supply (ATP supply) of this type of transport.

21. What is tubular secretion? What are some examples of substances secreted through the renal tubules?

Tubular secretion is the passage of substances from the blood capillaries that surround the nephron tubules to the tubular lumen for these substances to be excreted with urine. Ammonia, uric acid, potassium, bicarbonate and hydrogen ions, metabolic acids and bases, various ingested drugs (medicines) and other substances are secreted by the nephron tubules.

22. In which nephron portion does the regulation of acidity and alkalinity of the plasma occur?

The regulation of the acid-basic equilibrium of the body is done by the kidneys and depends upon the tubular resorption and secretion.

Biology Questions and Answers

23. How do kidneys participate in the regulation of the acid-basic equilibrium of the body? How are alkalosis and acidosis respectively corrected by the kidneys?

Kidneys can regulate the acidity or alkalinity of the plasma varying the excretion of hydrogen and bicarbonate ions.

In alkalosis (abnormally high level of the plasma pH) the kidneys excrete more bicarbonate and the equilibrium of formation of bicarbonate from water and carbon dioxide shifts towards formation of more hydrogen ions and bicarbonate and then the plasma pH is lowered. When the body undergoes acidosis (abnormal low level of the plasma pH) the kidneys excrete more hydrogen ions and retain more bicarbonate thus the equilibrium of formation of bicarbonate from water and carbon dioxide shifts towards more hydrogen consumption and the plasma pH is increased.

24. How do kidneys participate in the blood volume control? How is the blood volume of the body related to the arterial pressure?

The kidneys and the hormones that act upon them are the main physiological regulators of the total blood volume of the body. As more water is resorbed in the nephron tubules the more the blood volume increases; as more water is excreted in urine the more the blood volume lowers.

The blood volume in its turn has a direct relation to blood pressure. The blood pressure increases when the blood volume increases and it lowers when the blood volume lowers. That is the reason why one of the main groups of antihypertensive drugs is the diuretics. Doctors often prescribe diuretics for the hypertensive patients to excrete more water and thus lower their blood pressure.

25. Which are the three hormones that participate in the regulation of the renal function?

Antidiuretic hormone (or ADH, or vasopressin), aldosterone and atrial natriuretic factor (or ANF) are hormones that participate in the regulation of the excretory system.

26. What is the function of the antidiuretic hormone? Where is it made and which are the stimuli that increase or reduce its secretion?

The antidiuretic hormone is secreted by the hypophysis (also known as pituitary) and it acts in the nephron tubules increasing the resorption of water. When the body needs to retain water, for example, in cases of blood loss and abrupt blood pressure lowering or in cases of abnormally high blood

osmolarity, there is stimulus for ADH secretion.

When the body has an excess of water, as in cases of excessive ingestion or in abnormally low blood osmolarity, the secretion of ADH is blocked and the diuresis increases. ADH is also known as vasopressin since it increases the blood volume and thus heightens the blood pressure.

27. Why does the ingestion of alcohol increase diuresis?

Alcohol inhibits the secretion of ADH (antidiuretic hormone) by the pituitary. That is why when it is drunk to excess the person urinates too much.

28. How does aldosterone act and where is it produced?

Aldosterone is a hormone that acts upon the nephron tubules stimulating the resorption of sodium. Therefore it contributes to the increase of the blood osmolarity and consequently to the increase of the blood pressure.

Aldosterone is made by the adrenals, glands located over the superior portion of the kidneys.

29. What is an evolutionary explanatory hypothesis for the secretion by the heart of a hormone that regulates the renal function? Which is that hormone?

The renal regulator hormone secreted by the heart is the atrial natriuretic factor (or ANF). The ANF increases the excretion of sodium in the nephron tubules causing less resorption of water, more urinary volume, and thus lowering the blood pressure. The atrial natriuretic factor is secreted when there is an increase of the length of the heart muscle fibers in response to high blood pressure. The ANF is a natural antihypertensive substance. Since the health of the heart depends largely upon the stability of the normal blood pressure the evolution should have preserved the atrial natriuretic factor to allow information from the heart to be an additional mechanism for the renal control of the blood pressure.

30. What is hemodialysis?

Hemodialysis is the artificial blood filtration made by specific machines in substitution of the kidneys. Hemodialysis may be necessary in patients suffering from diseases that cause renal failure, like diabetic renal complications, lupic renal complications and others. During hemodialysis the blood of the patient is deviated to the filtering machine and after the filtration it returns to the body.

Hemodialysis is generally done two, three or more times a week in a process

that takes several hours. Sometimes kidney transplantation is an alternative to hemodialysis.

Biology Questions and Answers

Epithelia

1. What is the function of the skin in humans?

The skin is the external covering of the body. In humans its main functions are protection, perception of information from the environment, control of the body temperature and secretion of substances.

2. What are the tissues that form the skin in vertebrates?

The skin of vertebrates is made of epidermis, an external layer of epithelial tissue, and dermis, a layer of connective tissue under the epidermis. One can cite also the hypodermis, a layer of adipose tissue under the dermis.

Skin annexes may exist in some phyla and classes, like hair, sweat glands and sebaceous glands.

3. Besides the skin what are the other coverings of the body?

Besides the skin there are other covering tissues made of epithelium over other tissue layers. They are the tissues that cover the internal surfaces of hollow organs, like the organs of the digestive tube, the airway, the renal tubules, the ureters, the bladder, the urethra and the blood vessels. The glands and the serous membranes are made of epithelial tissue too.

4. What are some functions of the epithelium?

The epithelial tissues can perform covering, impermeability and protection against the environment, for example, in the skin, resorption, as in the guts and renal tubules, gas exchange, for example, the amphibian skin, thermal regulation, like sweating, secretion of substances, as in the epithelium of glands. In some animals the skin also has the important function of camouflage and mimicry .

5. What is the typical feature of the epithelia? How different is it from the connective tissue?

The typical feature of the epithelium is the absence or almost absence of space between cells. The epithelial cells are compactly positioned side-by-side with the help of specialized structures for cell adhesion like desmosomes and interdigitations. This feature relates to the fact that these tissues are generally exposed to an exterior surround and so they need more resistance and impermeability against the entrance of strange material into the body.

The connective tissue presents opposite features due to its filling function. It has much interstitial material (the matrix) and relatively large space between cells.

6. What are the specialized structures that help the adhesion between cells?

The structures responsible for the union of the epithelial cells are called cell junctions. The main cell junctions are interdigitations, desmosomes, zonula adherens (adherens junction), tight junctions (zonula occludens) and gap junctions.

7. Is the epithelium vascularized? How do nutrients and oxygen reach the epithelium? Why is this feature an important evolutionary acquisition?

Epithelia are not vascularized (capillaries do not directly reach their cells). The epithelium exchanges substances by diffusion with the connective tissue situated under it.

Since the epithelia are not vascularized minuscule skin injuries or scratches that happen all the time do not trigger bleeding and do not expose the blood to contamination from external agents. This is an important protective strategy discovered by evolution.

8. How are the epithelial tissues classified?

The epithelial tissues are classified according to the shape of the cells that form it (epithelial cells may be cuboidal, columnar, or squamous) and according to the number of layers in which those cells are placed in the tissue (into simple or stratified).

The main types of epithelial tissues are simple cuboidal, simple columnar, simple squamous, stratified squamous and pseudostratified columnar (resembling more than one layer but actually having only one). There are also stratified cuboidal and stratified columnar epithelia (rare).

9. How different is the simple cuboidal epithelium from the columnar epithelium? Where can these epithelia be found in the human body?

The simple cuboidal epithelium is made of a single layer of cuboidal epithelial cells. The simple columnar epithelium is made of a single layer of prismatic cells.

The simple cuboidal epithelium can be found, for example, in the renal tubules and in the walls of the thyroid follicles. The simple columnar is the epithelium that covers internally the intestines, the stomach and the gallbladder, for example.

10. How different is the simple squamous epithelium from the stratified squamous epithelium? Where can these epithelia be found in the human body?

The simple squamous epithelium is made of a single layer of flat (squamous) cells. The stratified

squamous epithelium is made of the same type of flat cells placed in several superimposed layers.

The simple squamous epithelium is found in the pulmonary alveoli. The stratified squamous epithelium can be found in the moist mucosae, like the mucosae of the mouth, esophagus and vagina, and it is the epithelium of the skin.

11. What is the function of keratin in the epidermis?

The epidermis is the outer layer of the skin made of epithelial tissue. In the epidermis there are keratin-secreting cells (keratinocytes). Keratin is an insoluble protein that impregnates the surface of the skin providing protection and impermeability. In mammals keratin also forms the hairs.

The keratinized cells of the skin surface form the corneal layer. These cells die and are continuously replaced by others.

12. How different is the fish epidermis from the amphibian epidermis?

The fish epidermis is very thin and contains mucus-secreting cells. The fish skin does not present keratin. The mucus has a protective function and it also helps the sliding of the animal under water. (The fish scales originate from the dermis and not from the epidermis.)

In amphibians there is already a slight keratinization of the skin, probably an additional adaptation to the terrestrial environment. Amphibians have smooth and wet epidermis without scales. These features facilitate their cutaneous respiration.

13. Which are the glands present in the epidermis of mammals, birds and reptiles?

In the epidermis of birds and reptiles there are practically no glands. In mammals there are sweat glands and sebaceous glands.

14. What are melanocytes?

Melanocytes are epithelial cells of the skin specialized in secretion of melanin. Melanin is a pigment that besides coloring the skin, the iris of the eye and the hair, also works as a filter against the ultraviolet radiation of the sun thus protecting the body against the harmful effects of this radiation (mainly burns and carcinogenic mutations).

Melanocytes are the cells affected in one of the more deadly skin cancers: melanoma.

Biology Questions and Answers

Musculoskeletal System

1. Which are the organs that are part of the musculoskeletal system?

The main organs and tissues that are part of the musculoskeletal system in humans are the cartilages, the bones and the muscles.

2. What are the functions of the musculoskeletal system?

The musculoskeletal system has the functions of supporting and protecting organs, maintenance of the body spatial conformation, motion of organs, limbs and bodily portions and nutrient storage (glycogen in muscles, calcium and phosphorus in bones).

3. Which type of tissue are the cartilaginous and the osseous tissue?

The cartilaginous and the osseous tissues are considered connective tissues since they are tissues in which the cells are relatively distant from others with a great amount of extracellular matrix in the interstitial space.

4. What are the cells that form the cartilaginous tissue?

The main cells of the cartilages are the chondrocytes, originated from the chondroblasts that secrete the intersticial matrix. There are also chondroclasts, cells with many lisosomes and responsible for the digestion and remodelation of the cartilaginous matrix.

5. What is the constitution of the cartilaginous matrix?

The cartilaginous matrix is made of collagen fibers, mainly collagen type II, and of proteoglycans, proteins associated to glycosaminoglycans, chiefly hyaluronic acid. The proteoglycans provide the typical rigidity of the cartilages.

6. What are some functions of the cartilages in the human body?

Cartilages are responsible for the structural support of the nose and ears. The trachea and the bronchi are also organs with cartilaginous structures that prevent the closing of these tubes. In joints there are cartilages that cover the bones providing a smooth surface to reduce the friction of the joint movement. In the formation of bones the cartilages act as a mold and they are gradually substituted by the osseous tissue.

Biology Questions and Answers

7. What are the three main cell types that form the osseous tissue? What are their functions?

The three main cell types of the osseous tissue are the osteoblasts, the osteocytes and the osteoclasts.

Osteoblasts are known as bone-forming cells since they are the cells that secrete the proteinaceous part of the bone matrix (collagen, glycoproteins and proteoglycans). The bone matrix is the intercellular space where the mineral substances of the bones are deposited.

Osteocytes are differentiated mature osteoblasts formed after these cells are completely surrounded by the bone matrix. Osteocytes have the function of supporting the tissue.

Osteoclasts are the giant multinucleate cells that remodelate the osseous tissue. They are originated from monocytes and they contain many lisosomes. Osteoblasts secrete enzymes that digest the osseous matrix creating canals throughout the tissue.

8. What is the bone matrix? What are its main components?

Bone matrix is the content that fills the intercellular space of the osseous tissue. The bone matrix is made of mineral substances (about 5%), mainly phosphorus and calcium salts, and organic substances (95%), mainly collagen, glycoproteins and proteoglycans.

9. What are the Haversian canals and the Volkmann's canals of the bones? Is the osseous tissue vascularized?

The Haversian canals are longitudinal canals present in the osseous tissue within which blood vessels and nerves pass. The osseous tissue distributes itself in a concentric manner around these canals. The Volkmann's canals are communications between the Harvesian canals.

The osseous tissue is highly vascularized in its interior.

10. What are the functions of the osseous tissue?

The main functions of the osseous tissue are: to provide structural rigidity to the body and to delineate the spatial positioning of the other tissues and organs; to support the body weight; to serve as a site for mineral storage, mainly of calcium and phosphorus; to form protective structures for important organs like the brain, the spinal cord, the heart and the lungs; to work as a lever and support for the muscles, providing movement; to contain the bone marrow where hematopoiesis occurs.

11. What are the flat bones and the long bones?

The main bones of the body may be classified as flat or long bones (there are bones not classified into these

categories). Examples of flat bones are the skull, the ribs, the hipbones, the scapulae and the sternum. Examples of long bones are the humerus, the radius, the ulna, the femur, the tibia and the fibula.

12. What are the types of muscle tissues? What are the morphological features that differentiate those types?

There are three types of muscle tissue: the skeletal striated muscle tissue, the cardiac striated muscle tissue and the smooth muscle tissue.

The striated muscles present under microscopic view transversal stripes and their fibers (cells) are multinucleate (in the skeletal) or may have more than one nucleus (in the cardiac). The smooth muscle does not present transversal stripes and it has spindle-shaped fibers each with only one nucleus.

13. Which is the type of muscle tissue that moves the bones?

The bones are moved by the skeletal striated muscles. These muscles are voluntary (controlled by volition).

14. Which is the type of muscle tissue that contracts and relaxes the heart chambers?

The myocardium of the heart is made of cardiac striated muscle tissue.

15. Which is the type of muscle tissue that performs the peristaltic movements of the intestines?

The smooth muscle tissue is responsible for the peristaltic movements of the intestines. The smooth muscles are not controlled by volition.

16. Which is the type of muscle tissue that helps to push the food down through the esophagus?

The esophageal wall in its superior portion is made of skeletal striated muscle. The inferior portion is made of smooth muscle. In the intermediate portion there are skeletal striated and smooth muscles. All of these muscles are important to push the food down towards the stomach.

17. How is the striped pattern of the striated muscle cells formed?

The functional units of the muscle fibers are the sarcomeres. Within the

sarcomeres blocks of actin and myosin molecules are posed in organized manner. The sarcomeres align in sequence forming myofibrils that are longitudinally placed in the cytoplasm of the muscle fibers (cells). The grouping of consecutive blocks of actin and myosin in parallel filaments creates the striped pattern of the striated muscle tissue seen under the microscope.

18. What are sarcomeres?

Sarcomeres are the contractile units of the muscle tissue formed of alternating actin blocks (thin filaments) and myosin blocks (thick filaments). Several sarcomeres placed in linear sequence form a myofibril. Therefore one muscle fiber (cell) has many myofibrils made of sacomeres.

The compartments where myofibrils are inserted are delimited by an excitable membrane known as sarcolemma. The sarcolemma is the plasma membrane of the muscle cell.

19. What are the main proteins that constitute the sarcomere? What is the function of those molecules in the muscle cells?

In the sarcomere there are organized actin and myosin blocks. Troponin and tropomyosin also appear associated to actin.

The actin molecules when activated by calcium ions liberated in the proximities of the sarcomere are pulled by myosin molecules. This interaction between actin and myosin shortens the myofibrils originating the phenomenon of muscle contraction.

20. What are the positions of actin and myosin molecules in the sarcomere before and during the muscle contraction?

Schematically actin filaments attached perpendicularly to both sarcomere extremities (longitudinal sides) make contact with myosin filaments positioned in the middle of the sarcomere and in parallel to the actin filaments.

Before the contraction the sarcomeres are extended (relaxed) since the contact between actin and myosin filaments is only made by their extremities. During contraction actin filaments slide along the myosin filaments and the sarcomeres shorten.

21. How do calcium ions participate in muscle contraction? Why do both muscle contraction and muscle relaxation spend energy?

In the muscle cells calcium ions are stored within the sarcoplasmic reticulum. When a motor neuron emits stimulus for the muscle contraction neurotransmitters called acetylcholine are released in the neuromuscular junction and the sarcolemma is excited.

The excitation is conduced to the sarcoplasmic reticulum that then realeases calcium ions into the sarcomeres.

In the sarcomeres the calcium ions bind to troponin molecules associated to actin activating myosin binding sites of actin. The myosin, then able to bind to actin, pulls this protein and the sarcomere shortens. The summation of simultaneous contraction of sarcomeres and myofibrils constitutes the muscle contraction. During muscle relaxation the calcium ions return back to the sarcoplasmic reticulum.

For myosin to bind to actin, and thus for the contraction to occur, hydrolysis of one ATP molecule is necessary. During relaxation the return of calcium ions to the sarcoplasmic reticulum is an active process that spends ATP too. So both muscle contraction and relaxation are energy-spending processes.

22. What is myoglobin? What is the function of this molecule in the muscle tissue?

Myoglobin is a pigment similar to hemoglobin and present in muscle fibers. Myoglobin has a great affinity for oxygen. It keeps oxygen bound and releases the gas under strenuous muscle work. So myoglobin acts as an oxygen reserve for the muscle cell.

23. How does phosphocreatine act in the muscle contraction and relaxation?

Phosphocreatine is the main means of energy storage of the muscle cells.

During relaxed periods ATP molecules made by the aerobic cellular respiration transfer highly energized phosphate groups to creatine forming phosphocreatine. In exercise periods phosphocreatine and ADP resynthesize ATP to dispose energy for the muscle contraction.

24. What happens when the oxygen supply is insufficient to maintain aerobic cellular respiration during muscle exercise?

If oxygen from hemoglobin or myoglobin is not enough for the energy supply of the muscle cell the cell then begins to do lactic fermentation in an attempt to compensate the deficiency.

The lactic fermentation releases lactic acid and this substance causes muscle fatigue and predisposes the muscles to cramps.

25. What is the neurotransmitter of the neuromuscular junction? How does the nervous system trigger muscle contraction?

The nervous cells that trigger the muscle contraction are the motor neurons. The neurotransmitter of the motor neurons is acetylcholine. When a motor neuron is excited the depolarizing current flows along the membrane of its

axon until reaching the synapse at the neuromuscular junction (the neural impulse passage zone between the axon extremity and the sarcolemma). Near the axonal extremity the depolarization allows the entrance of calcium ions into the axon (note that calcium also has a relevant role here). The calcium ions stimulate the neuron to release acetylcholine in the synapse.

Acetylcholine then binds to special receptors in the outer surface of the sarcolemma, the permeability of this membrane is altered and an action potential is created. The depolarization is then conduced along the sarcolemma to the sarcoplasmic reticulum that thus releases calcium ions for the sarcomere contraction.

26. To increase the strength of the muscle work is the muscle contraction intensely increased?

An increase in the strength of the muscle work is not achieved by increase in the intensity of the stimulation of each muscle fiber. The muscle fiber obeys an all-or-nothing rule, i.e., its contraction strength is only one and cannot be increased.

When the body needs to increase the strength of the muscle work a phenomenon known as spatial summation occurs: new muscle fibers are recruited in addition to the fibers already in action. So the strength of the muscle contraction increases only when the number of active muscle cells increases.

27. What is the difference between spatial summation and temporal summation of muscle fibers? What is tetany?

Spatial summation is the recruiting of new muscle fibers to increase the muscle strength. Temporal summation occurs when a muscle fiber is continuously stimulated to contract without being able to conclude relaxation.

The permanence of a muscle fiber under a continuous state of contraction by temporal summation is known as tetany (e.g., the clinical condition of patients contaminated by the toxin of the tetanus bacteria). Tetany ends when all available energy for contraction is spent or when the stimulus ceases.

Biology Questions and Answers

Nervous System

1. What are the physiological systems known as integrative systems? Why is this designation justified?

The integrative systems are the nervous system and the endocrine system. The designation is justified since both systems control and regulate biological functions and act at distance receiving information from organs and tissues and sending effector commands (nervous impulses or hormones) to organs and tissues thus integrating the body.

2. Which are the structures that are part of the nervous system?

The structures that form the nervous system can be divided into the central nervous system (CNS) and the peripheral nervous system (PNS).

The organs of the CNS are the brain (cerebrum, brainstem and cerebellum) and spinal cord. The PNS is made of nerves and neural ganglia. Besides these organs the meninges (dura-mater, arachnoid and pia-mater) are part of the nervous system too since they cover and protect the encephalon and the spinal cord.

3. Which are the main cells of the nervous system?

The main cells of the nervous system are the neurons. Besides the neurons the nervous system is also constituted of glial cells.

4. What are the functional differences between neurons and glial cells?

Glial cells and neurons are the cells that form the nervous system. Neurons are cells that have the function of receiving and transmitting the neural impulses and glial cells (astrocytes, microgliacytes, ependymal cells and oligodendrocytes) are the cells that support, feed and insulate (electrically) the neurons. The Schwann cells that produce the myelin sheath of the peripheral nervous system can also be considered glial cells.

5. What are the three main parts into which a neuron can be divided? What are their respective functions?

The three mains parts into which a neuron can be didactically divided are: dendrites, cell body and axon.

Dendrites are projections of the plasma membrane that receive the neural impulse from other neurons. The cell body is where the nucleus and the main cellular organelles are located. Axon is the long membrane projection that

transmits the neural impulse at distance to other neurons, to muscle cells and to other effector cells.

6. What is the name of the terminal portion of the axon?

The terminal portion of the axon is called presynaptic membrane. Through this membrane neurotransmitters are released into the synaptic junction.

7. What are synapses?

Synapses are the structures that transmit the neural impulse between two neurons.

When the electric impulse arrives the presynaptic membrane of the axon releases neurotransmitters that bind to postsynaptic receptors of the dendrites of the next cell. The activated state of these receptors alters the permeability of the dendritic membrane and the electric depolarization propagates along the neuron plasma membrane to its axon.

8. What is an example of a situation in which the neuron cell body is located in a part of the body and its axonal terminal portion is in another distant part of the body? Why does this happen?

Most of the neurons are situated within the brain and the spinal cord (central nervous system) in places known as neural nuclei. Neural ganglia, or simply ganglia, are structures of the peripheral nervous system located beside the spinal column or near some organs where neuron cell bodies are also located.

Neurons situated at specific points can present distant axonal terminations and they also can receive impulses from axons of distant neurons. The inferior motor neurons situated in the spinal cord are examples since their axons can transmit information to the extremities of the inferior limbs triggering contractions of the foot.

9. According to the function of the transmitted neural impulse which are the types of neurons? How different are the concepts of afference and efference of the neural impulse transmission?

There are three types of neurons: afferent neurons, efferent neurons and interneurons. Afferent neurons are those that only transmit sensory information from the tissues to neural nuclei and ganglia (where they make connection with interneurons or effector neurons). Efferent neurons are those that transmit commands to tasks performed in several parts of the body. Interneurons, also known as association neurons or relay neurons, serve as connection between two other neurons.

Afference is the conduction of sensory impulses and efference is the conduction of effector impulses

(impulses that command some body action).

10. What are nerves?

Axons extend throughout the body inside nerves. Nerves are axon-containing structures presenting many axons and covered by connective tissue. The nerves connect neural nuclei and ganglia with the tissues.

Nerves may contain only sensory axons (sensory nerves), only motor axons (motor neurons) or both types of axons (mixed nerves).

11. What are ganglia?

Ganglia (singular ganglion), or neural ganglia, are structures located outside the central nervous system (for example, beside the spinal column or near viscera) made of concentration of neuron bodies.

Examples of neural ganglia are the ganglia that concentrate cell bodies of sensory neurons in the dorsal roots of the spinal cord and the ganglia of the myenteric plexus responsible for the peristaltic movements of the digestive tube.

In the central nervous system (CNS) the concentrations of neuron bodies are called nuclei and not ganglia.

12. What is meant by the peripheral nervous system (PNS)?

The peripheral nervous system comprehends the nerves and ganglia of the body.

13. What is the function of the myelin sheath? Do all axons present a myelin sheath?

The function of the myelin sheath is to improve the safety and speed of the neural impulse transmission along the axon. The myelin sheath serves as an electrical insulator preventing the dispersion of the impulse to other adjacent structures. Since the myelin sheath has gaps called Ranviers' nodes in its length, the neural impulse "jumps" from one node to another thus increasing the speed of the neural transmission.

Not all neurons have a myelin sheath. There are myelinated axonal fibers and unmyelinated ones.

14. What are the cells that produce the myelin sheath? Of which substance is the myelin sheath formed?

In the central nervous system (CNS) the myelin sheath is made by apposition of oligodendrocyte membranes. Each oligodendrocyte can cover portions of axons of several different neurons. In the peripheral nervous system (PNS) the myelin sheath is made by

consecutive Schwann cell membranes covering segments of a single axon. The Ranviers' nodes appear in the intercellular space between these cells.

The myelin sheath is rich in lipids but it also contains proteins.

15. What are some diseases characterized by progressive loss of the axonal myelin sheath?

Multiple sclerosis is a severe disease caused by progressive destruction of the myelin sheath in the central nervous system. The Guillain-Barré disease is due to destruction of the myelin sheath in the peripheral nervous system caused by autoimmunity (attack by the own immune system). The genetic deficiency in the formation or preservation of the myelin sheath is an X-linked inheritance called adrenoleukodystrophy. The movie "Lorenzo's Oil" featured a boy with this disease and his father's dramatic search for treatment.

16. What are meninges and cerebrospinal fluid?

Meninges are the membranes that enclose and protect the central nervous system (CNS). Cerebrospinal fluid is the fluid that separates the three layers that form the meninges and it has the functions of nutrient transport, defense and mechanical protection for the CNS.

The cerebrospinal fluid fills and protects cavities of the brain and the spinal cord.

17. What is the difference between brain and cerebrum? What are the main parts of these structures?

The concept of brain, or encephalon, comprehends the cerebrum (mostly referred to as the hemispheres, but actually the concept also includes the thalamus and the hypothalamus), the brainstem (midbrain, pons and medulla) and the cerebellum. Brain and spinal cord form the central nervous system (CNS).

18. How is the cerebrum anatomically divided?

The cerebrum is divided into two cerebral hemispheres, the right and the left. Each hemisphere is made of four cerebral lobes: frontal lobe, parietal lobe, temporal lobe and occipital lobe.

Each cerebral lobe contains the gray matter and the white matter. The gray matter is the outer portion and it is made of neuron bodies; the gray matter is also known as the cerebral cortex. The white matter is the inner portion and it is white because it is in the region where axons of the cortical neurons pass.

19. Which is the brain region responsible for the coordination and equilibrium of the body?

In the central nervous system the cerebellum is the main controller of the

motor coordination and equilibrium of the body. (Do not confuse this with muscle command, performed by the cerebral hemispheres).

20. Why is the cerebellum more developed in mammals that jump or fly?

The cerebellum is the main brain structure that coordinates the movement and the equilibrium of the body. For this reason it appears more developed in mammals that jump or fly (like bats). The cerebellum is also very important for the flight of birds.

21. Which is the brain region responsible for the regulation of breathing and blood pressure?

The neural regulation of breathing, blood pressure and other physiological parameters like heartbeat, digestive secretions, peristaltic movements and transpiration is performed by the medulla.

The medulla, together with the pons and the midbrain, is part of the brainstem.

22. Which is the brain region that receives conscious sensory information? Which is the brain region that triggers the voluntary motor activity?

In the brain conscious sensory information is received by the neurons situated in a special region called postcentral gyrus (or sensory gyrus). Gyri are the convolutions of the cerebrum. Each of the two postcentral gyri are located in one of the parietal lobes of the cerebrum.

The voluntary motor activity (voluntary muscle movement) is commanded by neurons situated in the precentral gyrus (or motor gyrus). Each of the two precentral gyri are located in one of the frontal lobes of the cerebrum.

The names post- and pre-central refer to the fact that the motor and sensory gyri are spaced apart in each cerebral hemisphere by the sulcus centralis, a fissure that separates the parietal and frontal lobes.

23. What is the spinal cord? Of which elements is the spinal cord constituted?

The spinal cord is the dorsal neural cord of vertebrates. It is the part of the central nervous system that continues in the trunk to facilitate the nervous integration of the whole body.

The spinal cord is made of groups of neurons situated in its central portion forming the gray matter and of axon fibers in its exterior portion forming the white matter. Neural bundles connect to both lateral sides of the spinal cord segments to form the dorsal and ventral spinal roots that join to form the spinal nerves. The dorsal spinal roots present a ganglion with neurons that receive sensory information; the ventral spinal

roots contain motor fibers. Therefore the dorsal roots are sensory roots and the ventral roots are motor roots.

24. Which are the brain regions associated with memory?

According to researchers some of the main regions of the nervous system associated with the memory phenomenon are the hippocampus, situated in the interior portion of the temporal lobes, and the frontal lobe cortex, both part of the cerebral hemispheres.

25. How is it structurally explained that the motor activity of the left side of the body is controlled by the right cerebral hemisphere and the motor activity of the right side of the body is controlled by the left cerebral hemisphere?

In the cerebral hemispheres there are neurons that centrally command and control muscle movements. These neurons are called superior motor neurons and they are located in a special gyrus of both frontal lobes known as motor gyrus (or precentral gyrus). The superior motor neurons send axons that transmit impulses to the inferior motor neurons of the spinal cord (for neck, trunk and limb movements) and to the motor nuclei of the cranial nerves (for face, eyes and mouth movements).

The fibers cross to the other side in specific areas of those axon paths. About 2/3 of the fibers that go down the spinal cord cross at the medullar level forming a structure known as pyramidal decussation. The other (1/3) of fibers descend in the same side of their original cerebral hemisphere and cross only within the spinal cord at the level where their associated motor spinal root exit. The fibers that command the inferior motor neurons of the cranial nerves cross to the other side just before the connection with the nuclei of these nerves.

The motor fibers that descend from the superior motor neurons to the inferior motor neurons of the spinal cord form the pyramidal tract. Injuries in this tract, for example, caused by spinal sections or by central or spinal tumors may lead to paraplegia and tetraplegia.

26. What is meant by the arch reflex?

In some situations the movement of the skeletal striated muscles does not depend upon commands of the superior motor neurons, i.e., it is not triggered by volition.

Involuntary movements of those muscles may happen when sensory fibers that make direct or indirect connection with inferior motor neurons are unexpectedly stimulated in situations that suggest danger to the body. This happens, for example, in the patellar reflex, or knee jerk reflex, when a sudden percussion on the knee patella (kneecap) triggers an involuntary contraction of the quadriceps (the extension muscle of the thigh). Another

example of the arch reflex occurs when someone steps on a sharp object: one leg retracts and the other, by the arch reflex, distends to maintain the equilibrium of the body.

27. Which are the types of neurons that participate in the spinal arch reflex? Where are their cell bodies situated?

In the arch reflex first a sensory neuron located in the ganglion of a dorsal spinal root collects the stimulus information from the tissues. This sensory neuron makes direct or indirect (through interneurons) connection with inferior motor neurons of the spinal cord. These motor neurons then command the reflex reaction. So sensory neurons, interneurons and inferior motor neurons participate in the arch reflex.

28. What are the respective constituents of the gray matter and of the white matter of the spinal cord?

The gray matter, or gray substance, of the spinal cord contains predominantly neuron bodies (inferior motor neurons, secondary sensory neurons and interneurons). The white matter is mainly made of axons that connect neurons of the brain with spinal neurons.

29. Is the neural impulse generated by the stimulus that triggers the arch reflex restricted within the neurons of this circuit?

The sensory fiber that first conducts the arch reflex connects with neurons of the arch reflex but it also connects with secondary sensory neurons of the spinal cord that transmit information upwards to other neurons of the brain. This is obvious since the person that received the initial stimulus (e.g., the percussion on his/her kneecap) perceives it (meaning that the brain became conscious of the fact).

30. How is it explained that a person with the spinal cord sectioned at the cervical level is still able to perform the patellar reflex?

The arch reflex depends only on the integrity of the fibers at a single spinal level. In the arch reflex the motor response to the stimulus is automatic and involuntary and does not depend upon the passage of information to the brain. So it happens even if the spinal cord is damaged at other levels.

31. How does poliomyelitis affect the neural transmission in the spinal cord?

The poliovirus parasites and destroys spinal motor neurons causing paralysis

of the muscles that depend on these neurons.

32. Concerning volition of the individual how can the reactions of the nervous system be classified?

The efferences (reactions) of the nervous system can be classified into voluntary, when controlled by the will, and involuntary, those not consciously controlled. Examples of reactions triggered by volition are the movements of the limb, tongue and respiratory muscles. Examples of involuntary efferences are those that command the peristaltic movements, the heartbeat and the arterial wall muscles. The skeletal striated muscles are voluntarily contracted; the cardiac striated and the smooth muscles are involuntarily contracted.

33. What are the functional divisions of the nervous system?

Functionally the nervous system can be divided into the somatic nervous system and visceral nervous system.

The somatic nervous system includes the central and peripheral structures that make voluntary control of efferences. Central and peripheral structures that participate in the control of the vegetative (unconscious) functions of the body are included in the concept of visceral nervous system.

The efferent portion of the visceral nervous system is called the autonomic nervous system.

34. What are the two divisions of the autonomic nervous system?

The autonomic nervous system is divided into the sympathetic nervous system and the parasympathetic nervous system.

The sympathetic nervous system comprehends the nerves that come out from the ganglia of the neural chains lateral to the spinal column (near the spinal cord) and thus are distant from the tissues they innervate. The central and peripheral neurons associated to those neurons are also part of the sympathetic.

The parasympathetic nervous system is made of nerves and central or peripheral neurons related to the visceral ganglia, neural ganglia situated near the tissues they innervate.

35. What is the antagonism between the sympathetic and the parasympathetic neural actions?

In general the actions of the sympathetic and the parasympathetic are antagonistic, i.e., while one stimulates something the other inhibits and vice versa. The organs, with few exceptions, get efferences from these two systems and the antagonism

between them serves to modulate their effects. For example, the parasympathetic stimulates salivation while the sympathetic inhibits it; the parasympathetic constricts pupils while the sympathetic dilates it; the parasympathetic contracts the bronchi while the sympathetic relaxes them; the parasympathetic excites the genital organs while the parasympathetic inhibits the excitation.

36. Using examples of invertebrate nervous systems how can the process of evolutionary cephalization be described?

Considering the example of invertebrates it is observed that evolution makes the increasing of the complexity of the organisms to be accompanied by convergence of nervous cells to special structures for controlling and commanding: the ganglia and the brain. In simple invertebrates, like cnidarians, the nervous cells are not concentrated but they are found dispersed in the body. In platyhelminthes a beginning of cephalization with the anterior ganglion concentrating neurons is already verified. In annelids and arthropods the existence of a cerebral ganglion is evident. In cephalopod molluscs the cephalization is even greater and the brain commands the nervous system.

37. What are some main differences of the vertebrate nervous systems comparing to invertebrates?

In vertebrates the nervous system is well-characterized, having the brain and dorsal neural cord protected by rigid skeletal structures. In most invertebrates the nervous system is predominantly ganglial, with ventral neural cords.

38. What are the protective structures of the central nervous system present in vertebrates?

In vertebrates the brain and the spinal cord are protected by membranes, the meninges, and by osseous structures, respectively the skull and the vertebral column. These protections are fundamental for the integrity of those important organs that command the functioning of the body.

39. What is the nature of the stimulus received and transmitted by the neurons?

Neurons receive and transmit chemical stimuli through neurotransmitters released in the synapses. Along the neuron body however the impulse transmission is electrical. So neurons conduct electric and chemical stimuli.

40. What are the two main ions that participate in the electrical impulse transmission in neurons?

The two main ions that participate in the electrical impulse transmission in neurons are the sodium cation (Na+) and the potassium cation (K+).

41. Which is the normal sign of the electric charge between the two sides of the neuron plasma membrane? What is the potential difference (voltage) generated between these two sides? What is that voltage called?

As in most cells the region just outside the surface of the neuron plasma membrane presents a positive electrical charge in relation to the region just inside that thus is negative.

The normal (at rest) potential difference across the neuron membrane is about –70 mV (millivolts). This voltage is called the resting potential of the neuron.

42. How do the sodium and potassium ions maintain the resting potential of the neuron?

The plasma membrane of the neuron when at rest maintains an electric potential difference between its external and internal surfaces. This voltage is called resting potential. The resting potential about –70 mV indicates that the interior is more negative than the exterior (negative polarization). This condition is maintained by transport of sodium and potassium ions across the plasma membrane.

The membrane is permeable to potassium ions but not to sodium ions. At rest the positive potassium ions exit the cell in favor of the concentration gradient since within the cell the potassium concentration is higher than in the extracellular space. The positive sodium ions cannot however go into the cell. As positive potassium ions exit the cell with not enough compensation of positive ions entering the cell, the intracellular space becomes more negative and the cell stays polarized.

43. How is the depolarization of the neuronal plasma membrane generated? How does the cell return to its original rest?

When the neuron receives a stimulus by the binding of neurotransmitters to specific receptors sodium channels open and the permeability of the plasma membrane in the postsynaptic region is altered. Sodium ions then go into the cell causing lowering (less negative) of the membrane potential. If this reduction of the membrane potential reaches a level called the excitation threshold, or threshold potential, about –50 mV, the action potential is generated, i.e., the depolarization intensifies until reaching its maximum level and the depolarization current is transmitted along the remaining length of the neuronal membrane.

If the excitation threshold is reached voltage-dependent sodium channels in the membrane open allowing more sodium ions to enter the cell in favor of the concentration gradient and an approximate –35 mV level of positive

polarization of the membrane is achieved. The voltage-dependent sodium channels then close and more voltage-dependent potassium channels open. Potassium ions then exit the cell in favor of the concentration gradient and the potential difference of the membrane decreases, a process called repolarization.

The action potential triggers the same electrical phenomenon in neighboring regions of the plasma membrane and the impulse is thus transmitted from the dendrites to the terminal region of the axon.

44. What is the excitation threshold of a neuron? How does this threshold relate to the "all-or-nothing" rule of the neural transmission?

The excitation threshold of a neuron is the depolarization level that must be caused by a stimulus to be transmitted as a neural impulse. This value is about −50 mV.

The transmission of the neural impulse along the neuronal membrane obeys an all-or-nothing rule: or it happens with maximum intensity or nothing happens. Always and only when the excitation threshold is reached the depolarization continues and the membrane reaches its maximum possible positive polarization, about +35 mV. If the excitation threshold is not reached nothing happens.

45. How does the depolarization of the neuronal membrane start?

The primary cause of the neuronal depolarization is the binding of neurotransmitters released in the synapse (by the axon of the neuron that sent the signal) to specific receptors in the membrane of the neuron that is receiving the stimulus. The binding of neurotransmitters to those receptors is a reversible phenomenon that alters the membrane permeability of the region since the binding causes sodium channels to open. When positive sodium ions enter the cell in favor of their concentration gradient, the membrane voltage increases, thus lessening the negative polarization. If this depolarization reaches the excitation threshold (about −50 mV) the depolarization continues, the action potential is reached and the impulse is transmitted along the cell membrane.

46. How different are the concepts of action potential, resting potential and excitation threshold concerning neurons?

Action potential is the maximum positive voltage level achieved by the neuron in the process of neuronal activation, around + 35 mV. The action potential triggers the depolarization of the neighboring regions of the plasma membrane and thus the propagation of the impulse along the neuron.

Resting potential is the membrane voltage when the cell is not excited, about –70 mV.

Excitation threshold is the voltage level, about –50 mV, that the initial depolarization must reach for the action potential to be attained.

47. In chemical terms how is the neuronal repolarization achieved?

Repolarization is the return of the membrane potential from the action potential (+35 mV) to the resting potential (-70 mV).

When the membrane reaches its action potential voltage-gated sodium channels close and voltage-gated potassium channels open. So sodium stops entering into the cell and potassium starts to exit. Therefore the repolarization is due to exiting of potassium cations from the cell.

The repolarization causes the potential difference temporarily to increase under –70 mV, below the resting potential, a phenomenon known as hyperpolarization.

48. What is the mechanism by which the neural impulse is transmitted along the axon?

The neural impulse is transmitted along the neuronal membrane through depolarization of consecutive neighboring regions. When a region in the internal surface of the membrane is depolarized it becomes more positive in relation to the neighboring internal region. So positive electrical charges (ions) move towards this more negative region and voltage-gated sodium channels are activated and open. The action potential then linearly propagates along the membrane until near the presynaptic region of the axon.

49. What is the structure through which the neural impulse is transmitted from one cell to another? What are its parts?

The structure through which the neural impulse passes from one cell to another is the synapse. The synapse is composed by the presynaptic membrane in the terminal portion of the axon of the transmitter cell, the synaptic cleft (or synaptic space) and the postsynaptic membrane in the dendrite of the receptor cell.

50. How does synaptic transmission between neurons take place?

The propagation of the action potential along the axon reaches the region immediately anterior to the presynaptic membrane causing its permeability to calcium ions to change and these ions to enter the cell. In the presynaptic area of the axon there are many neurotransmitter-repleted vesicles that by means of exocytosis activated by the calcium influx release the neurotransmitters into the synaptic

cleft. The neurotransmitters then bind to specific receptors of the postsynaptic membrane. (The binding of neurotransmitters to their receptors is reversible, i.e., the neurotransmitters are not consumed after the process.) With the binding of neurotransmitters to the postsynaptic receptors the permeability of the postsynaptic membrane is altered and the depolarization that will lead to the first action potential of the postsynaptic cell begins.

51. What are some important neurotransmitters?

The following are some neurotransmitters: adrenaline (epinephrine), noradrenaline (norepinephrine), acetylcholine, dopamine, serotonin, histamine, gaba (gamma aminobutyric acid), glycine, aspartate, nitric oxide.

52. Since neurotransmitters are not consumed in the synaptic process, what are the mechanisms to reduce their concentrations in the synaptic cleft after they have been used?

Since the binding of neurotransmitters to the postsynaptic receptors is reversible, after these neurochemicals perform their role they must be eliminated from the synaptic cleft. Neurotransmitters can then bind to specific proteins that carry them back to the axon they came from in a process called neurotransmitter re-uptake. They can also be destroyed by specific enzymes, like acetylcholinesterase, an enzyme that destroys acetylcholine. Or they can simply diffuse out of the synaptic cleft.

53. Fluoxetine is an antidepressant drug that presents an action mechanism related to the synaptic transmission. What is that mechanism?

Fluoxetine is a substance that inhibits the re-uptake of serotonin, a neurotransmitter that acts mainly in the central nervous system. By inhibiting the re-uptake of the neurotransmitter the drug increases its availability in the synaptic cleft thus improving the neuronal transmission.

54. What is the neuromuscular synapse?

Neuromuscular synapse is the structure through which the neural impulse passes from the axon of a motor neuron to the muscle cell. This structure is also known as neuromuscular junction, or motor end plate. As in the nervous synapse, the axonal terminal membrane releases the neurotransmitter acetylcholine in the cleft between the two cells. Acetylcholine binds to specific receptors of the muscle membrane, dependent sodium channels then open and the depolarization of the muscle membrane begins. The impulse is then transmitted to the sarcoplasmic

reticulum that releases calcium ions into the sarcomeres of the myofibrils thus triggering contraction.

55. How does the nervous system get information about the external environment, the organs and the tissues?

Information about the conditions of the external and internal environments, like temperature, pressure, touch, spatial position, pH, metabolite levels (oxygen, carbon dioxide, etc.), light, sounds, etc., are collected by specific neural structures (each for each type of information) called sensory receptors. Sensory receptors are distributed throughout the tissues according to their specific roles. The receptors get that information and transmit them through their own axons or through dendrites of neurons that connect to them. The information reaches the central nervous system that interprets and uses it to control and regulate the body.

56. What are sensory receptors?

Sensory receptors are structures specialized in the acquiring of information, like temperature, mechanical pressure, pH, chemical environment and luminosity, transmitting them to the central nervous system. Sensory receptors may be specialized cells, e.g., the photoreceptors of the retina, or specialized interstitial structures, for example the vibration receptors of the skin. In this last case they transmit information to dendrites of sensory neurons connected to them. There are also sensory receptors that are specialized terminations of neuronal dendrites (e.g., the olfactory receptors).

57. According to the stimuli they collect how are the sensory receptors classified?

The sensory receptors are classified according to the stimuli they get: mechanoreceptors are stimulated by pressure (e.g., touch or sound); chemoreceptors respond to chemical stimuli (olfactory, taste, pH, metabolite concentration, etc.); thermoreceptors are sensitive to temperature changes; photoreceptors are stimulated by light; nocireceptors send pain information; proprioceptors are sensitive to the spatial position of muscles and joints (they generate information for the equilibrium of the body).

Biology Questions and Answers

Visual System

1. What is vision? Why is vision important for life on earth?

Vision is the ability of some living beings to perceive, to distinguish and to interpret luminous stimuli.

Vision is important on earth mainly in the terrestrial and in the superficial aquatic habitats because our planet is intensely exposed to sunlight and thus light and colors become distinguishing factors of objects present in the environment, even at distance. This distinction provided new survival strategies for the organisms, new protection mechanisms against external dangers, new ways to find food and to communicate with other individuals, new types of courting and reproduction behaviors, etc. That is, it created new possibilities of interaction with the surrounds and increased capacity to explore new ecological niches.

2. How does photosensitivity in cnidarians, annelids and worms differ from insects, cephalopods and vertebrates?

In the first mentioned group of animals there are photoreceptor cells organized in ocelli or diffusely dispersed in the body. These animals do not form images.

In the animals of the second group the photoreceptor cells are part of more sophisticated structures, the eyes, able to form images and to send them to the nervous system.

3. What are the structures that compose the human vision apparatus?

The organs of the human visual apparatus are the eyes, the optical nerves and the visual areas of the brain (located in the occipital lobes of both hemispheres).

4. What are the main structures of the human eye?

The main structures of the human eye are the cornea, the iris, the pupil, the ciliary muscles, the crystalline lens and the retina (the space between the crystalline lens and the retina within the eyeball is filled with vitreous humor).

5. What is the function of the iris and of the pupil?

The iris works like the diaphragm of a photographic camera since it has muscles that contract or relax varying the pupil diameter. When the luminous intensity heightens the parasympathetic nervous system commands the contraction of the pupil; when there is shortage of light the sympathetic nervous system stimulates the dilation

of the pupils. These movements depend upon the muscles of the iris.

6. Which is the part of the human visual system where the receptors that sense light, i.e., the photoreceptor cells, are located? How do those cells work?

The photoreceptor cells form the retina, a lamina that covers the internal posterior region of the eyeball. The photosensitive cells of the retina are divided into two types: the cone cells and the rod cells. These cells have pigments that sense specific light wave ranges (frequencies) and trigger action potentials conducted by the optical nerves to the visual area of the brain.

7. Since the visual images are projected in an inverted manner on the retina why don't we see things upside down?

Since the crystalline lens is a convex spherical lens it forms inverted images on the retina (every converging lens forms inverted images). The inverted information follows through the optical nerves until the occipital cerebral cortex that contains the visual area of the brain. In the brain the interpretation of the image takes place and the inverted information is reverted.

8. What type of structure is the crystalline lens? What is its function?

The crystalline is a converging spherical lens. This natural lens has the function to project images of objects onto the retina.

9. What is visual accommodation?

Visual accommodation is the phenomenon of varying the curvature of the crystalline lens to make possible the variation of its refractivity to adjust the images of objects exactly onto the retina. The visual accommodation is accomplished by the action of the ciliary muscles.

The nitid vision depends on the visual accommodation since, if the images are not projected onto the retina but in front or behind it, they will appear blurred. The closer an object is more the ciliary muscles must compress the crystalline lens (increasing its curvature); the more distant an object is more the ciliary muscles must relax.

10. What are the near point and the far point of the vision?

The near point is the closest distance between an object and the eye that makes possible the formed image to be focused, i.e., it is the point in which the ciliary muscles are in their maximum contraction. The far point is the most distant point from the eye in which an

object can be placed and its image is still focused, i.e., it is the situation of maximum relaxation of the ciliary muscles. The zone between the near point and the far point is called the accommodation zone.

11. How can the visual deficiencies known as myopia and hypermetropia be optically explained?

Myopia is the visual condition in which the images are formed before (in front of) the retina. Hypermetropia is the visual condition in which the point of image formation is beyond (behind) the retina. Actually myopia is due to an increase in the distance between the retina and the crystalline lens, mainly caused by a slight flattening of the eyeball. In hypermetropia the retina is too close to the crystalline lens due to slight shortening of the eyeball.

In myopia the near point and the far point of vision come closer (the refractivity of the crystalline lens that corresponds to the maximum distension capacity of the ciliary muscles is not enough to provide visual accommodation). In hypermetropia the ciliary muscles are not able to contract more to compensate the inadequate position of the retina, i.e., the near point becomes more distant.

12. What are presbyopia and astigmatism?

Presbyopia is the visual impairment in which there is loss of the cililary muscle strength thus reducing the capability of the crystalline lens to adjust images of near objects onto the retina. In presbyopia the near point of vision becomes more distant. The disease generally occurs in old people.

Astigmatism is caused by irregular shape of the refractive structures, mainly the cornea. In astigmatism a single object-point may produce more than one image onto the retina and so the vision becomes distorted.

Biology Questions and Answers

Hearing System

1. What are the structures that participate in the human auditory sensitivity?

The structures of the human auditory sensitivity are the ears (external, middle and internal), the vestibulocochlear nerves and the auditory areas of the brain (located in the temporal lobes of both hemispheres).

2. What are the main parts of the human ear?

The human ear is divided into three mains parts: the external ear, the middle ear and the internal ear.

3. What are the structures that form the external ear? What is its function?

The internal ear comprises the pinna, or auricle, and the auditory canal. Its function is to conduct the sound waves to the tympanum.

4. What are the elements that form the middle ear? What are the names of the three middle ear ossicles that participate in the phonosensitivity?

The middle ear is formed by the tympanum, the ossicular chain and the oval window. The functional ossicles of the middle ear are the hammer (malleus), the incus and the stapes.

5. What is the tympanum? In which part of the ear is it located and what is its function?

The tympanum (or ear drum) is a membrane located in the middle ear just after the auditory canal and so it separates the middle ear from the external ear. The function of the tympanum is to vibrate with the same frequency of the sound waves that reach it.

6. How is the sound vibration captured by the tympanum transmitted through the ossicular chain of the middle ear?

The acoustic transmission from the external to the middle ear (and to the internal ear too) is entirely mechanical. The vibration of the tympanic membrane triggers the vibration of the hammer that then causes the incus to

vibrate. The incus then causes the stapes to vibrate.

7. What are the elements that constitute the internal ear? What are the functions of those structures?

In the internal ear there are the cochlea and the semicircular canals. The fluid that fills the cochlea receives vibration from the ossicular chain of the middle ear and transmits the pressure to the semicircular canals. Within the semicircular canals the pressure variation of the filling fluid moves cilia of the hair cells of these structures. The hair cells then generate action potentials that are transmitted to the brain through the auditory nerves.

8. Why is there a sense of pressure change inside the ear when someone goes down a mountain?

The pressure inside the middle ear is maintained equal to the external ear (so to the exterior too) due to a communicating duct between the middle ear and the pharynx called the auditory tube, or Eustachian tube. When someone goes down a mountain the air pressure upon the middle ear increases and it is necessary to do some exercises like fake swallowing to force the opening of the pharyngeal orifice of the auditory tube to equalize the pressure again.

9. What is the vestibular system? How does it operate?

The vestibular system is the part of the ear that participates in the control and regulation of the equilibrium of the body (balance).

The semicircular canals of the inner (internal) ear are perpendicularly placed and detect changes in the gravitational position of the head (this is another sensorial function of the inner ear, besides auditory perception). When the head rotates the pressure of the fluid within the canals upon the cilia of specific receptor cells varies and these cells generate action potentials transmitted by the vestibulocochlear nerve. The neural impulse is then interpreted by the brain as information about the gravitational position of the head.

Biology Questions and Answers

Endocrine System

1. What is the difference between the endocrine gland and the exocrine gland?

Endocrine gland is a gland whose secretions (called hormones) are collected by the blood and reach the tissues through the circulation. The hypophysis (pituitary) and the adrenals are examples of endocrine glands. Exocrine gland is a gland whose secretions are released externally through ducts (into the skin, intestinal lumen, mouth, etc.). The sebaceous glands and the salivary glands are examples of exocrine glands.

2. What is the constitution of the endocrine system?

The endocrine system is constituted by the endocrine glands and the hormones they secrete.

3. What is the histological nature of the glands? How are they formed?

The glands are epithelial tissues. They are made of epithelium that during the embryonic development invaginated into other tissues.

In the exocrine glands the invagination has preserved secretion ducts. In the endocrine glands the invagination is complete and there are no secretion ducts.

4. Why is the endocrine system considered one of the integrative systems of the body? What is the other physiological system that also has this function?

The endocrine system is said to have integrative character since the hormones produced by the endocrine glands are substances that act at a distance and many of them act in different organs of the body. So the endocrine glands receive information from some regions of the body and they can produce effects in other regions providing functional integration for the body.

Besides the endocrine system, the other physiological system that also has integrative function is the nervous system. The nervous system integrates the body through a network of nerves connected to central and peripheral neurons. The endocrine system integrates the body through hormones that travel through the circulation and are produced by the endocrine glands.

5. What are hormones?

Hormones are substances secreted by the endocrine glands and collected by the circulation that act to produce effects upon specific organs and tissues.

Hormones are effectors of the endocrine system.

6. What are target organs of the hormones?

Target organs, target tissues and target cells are those specific organs, tissues and cells upon which each hormone acts and produces its effects. Hormones selectively act upon their targets due to specific receptor proteins present in these targets.

7. How does the circulatory system participate in the functioning of the endocrine system?

The circulatory system is fundamental for the functioning of the endocrine system. The blood collects the hormones made by the endocrine glands and through the circulation these hormones reach their targets. Without the circulatory system the 'action at distance' characteristic of the endocrine system would not be possible.

8. Are hormones only proteins?

Some hormones are proteins, like insulin, glucagon and ADH, others are derived from proteins (modified amino acids), like adrenaline and noradrenaline, other are steroids, like the corticosteroids and estrogen.

9. What are the main endocrine glands of the human body?

The main endocrine glands of the human body are the pineal gland (or pineal body), the hypophysis (or pituitary), the thyroid, the parathyroids, the endocrine part of the pancreas, the adrenals and the gonads (testicles or ovaries).

Other organs like the kidneys, the heart and the placenta also have endocrine functions.

10. What is the pineal gland?

The pineal gland, also known as pineal body or epiphysis, is situated centrally in the head. It secretes the hormone melatonin, a hormone produced at night and related to the regulation of the circadian rhythm (or circadian cycle, the wakefulness-sleep cycle). Melatonin possibly regulates many body functions related to the night-day alternation.

11. What is the osseous cavity where the pituitary gland is located?

The pituitary gland, or hypophysis, is located in the sella turcica of the sphenoid bone (one of the bones in the base of the skull). So the gland is situated within the head.

12. What are the main divisions of the hypophysis? What are their functions?

The hypophysis is divided into two portions: the adenohypophysis, or anterior hypophysis, and the neurohypophysis, or posterior hypophysis.

In the adenohypophysis two hormones that act directly, the growth hormone (GH) and the prolactin, and four tropic hormones, i.e., hormones that regulate other endocrine glands, the adrenocorticotropic hormone (ACTH), the thyroid-stimulating hormone (TSH), the luteinizing hormone (LH) and the follicle-stimulating hormone (FSH) are produced.

The neurohypohysis stores and releases two hormones produced in the hypothalamus, oxytocin and the antidiuretic hormone (ADH, or vasopressin).

13. What is the relation between the hypothalamus and the hypophysis?

The hypothalamus is a part of the brain situated just above the hypophysis. The hypothalamus gets peripheral and central neural impulses that trigger response of its neurosecretory cells. The axons of these cells go down to the adenohypophysis to regulate the hipophyseal secretions by means of negative feedback. When the plasma levels of adenohypophyseal hormones are too high the hypothalamus detects this information and commands the interruption of the production of the hormone. When the blood level of an adenohypophyseal hormone is low the hypothalamus stimulates the secretion of the hormone.

The hypothalamic cells produce the hormones released by the neurohypophysis. These hormones are transported by their axons to the hypophysis and then released in the circulation.

14. What are the hormones secreted by the adenohypophysis? What are their respective functions?

The adenohypophisys secretes GH (growth hormone), prolactin, ACTH (adrenocorticotropic hormone), TSH (thyroid-stimulating hormone), FSH (follicle-stimulating hormone) and LH (luteinizing hormone).

GH, also known as somatotropic hormone (STH), acts upon bones, cartilages and muscles promoting the growth of these tissues. Prolactin is the hormone that in women stimulates the production and secretion of milk by the mammary glands. The ACTH is the hormone that stimulates the cortical portion of the adrenal gland to produce and secrete the cortical hormones (glucocorticoids). The TSH is the hormone that stimulates the activity of the thyroid gland increasing the production and secretion of its hormones T3 and T4. The FSH is a gonadotropic hormone, i.e., it stimulates the gonads and in women it acts upon the ovaries inducing the growth of follicles, in men it stimulates spermatogenesis. The LH is also a

gonadotropic hormone that acts upon the ovaries of women to stimulate ovulation and the formation of the corpus luteum (that secretes estrogen) and in men upon the testicles to stimulate the production of testosterone.

15. What is the relation between the thyroid and the hypophysis?

The hypophysis secretes TSH, thyroid-stimulating hormone. This hormone hastens the secretion of thyroid hormones (triiodothyronine and thyroxine, or T3 and T4).

When the plasma concentration of thyroid hormones is high this information is detected by the hypothalamus and by the hypophysis and this gland reduces the TSH secretion. When the thyroid hormone levels are low the TSH secretion increases. It is thus a negative feedback.

Injuries of the hypophysis that cause TSH hyposecretion (for example, in case of tissue destruction) or hypersecretion (in case, e,g., of excessive cell proliferation or cancer) can change the functioning of the thyroid gland completely.

16. What are some diseases caused by abnormal GH secretion by the hypophysis?

In childhood deficient GH secretion may lead to delayed growth and in severe cases to nanism (dwarfism). Excessive production of GH in children may cause exaggerated osseous growth and gigantism. In adults GH excess (for example, in hypophiseal cancer or in people that wrongly ingest GH as a nutritional supplement) may lead to acromegaly, excessive and disproportional growth of the bone extremities, like the skull, the maxillaries, the hands and the feet.

17. What are the target tissues and target organs of each adenohypophyseal hormone?

GH: bones, cartilages and muscles. Prolactin: mammary glands. ACTH: the cortical portion of the adrenals. TSH: thyroid gland. FSH and LH: ovaries and testicles.

18. What are the hormones secreted by the neurohypophysis? What are their respective functions?

The neurohypophysis secretes oxytocin and the antidiuretic hormone (ADH).

Oxytocin is secreted in women during delivery to increase the strength and frequency of the uterine contractions and thus to help the baby's birth. During the lactation period the infant's sucking action on the mother's nipples stimulates the production of oxytocin that then increases the secretion of milk by the mammary glands.

Vasopressin, or ADH, participates in the water regulation of the body and thus in the control of the blood pressure since it allows the resorption of free water through the renal tubules. As water goes back to the circulation the blood volume increases.

19. What is the difference between diabetes mellitus and diabetes insipidus? What are the characteristic signs of diabetes insipidus?

Diabetes mellitus is the disease caused by deficient insulin secretion by the pancreas or by impaired capturing of this hormone by the cells. Diabetes insipidus is the disease caused by deficient ADH secretion by the pituitary (hypophysis) or also by impaired sensitivity of the kidneys to this hormone.

In diabetes insipidus the blood lacks ADH and so tubular resorption of water in the kidneys is reduced and a great volume of urine is produced. The patient urinates a lot and many times a day, a sign also accompanied by polydipsia (increased thirst and exaggerated ingestion of water) and sometimes by dehydration.

20. Why does the urinary volume increase when alcoholic beverages are ingested?

Alcohol inhibits the ADH (antidiuretic hormone) secretion by the hypophysis. Low ADH reduces the tubular resorption of water in the kidneys and thus the urinary volume increases.

21. Which are the target organs and target tissues of the neurohypophysis?

The target organs of oxytocin are the uterus and the mammary glands. The target organs of ADH are the kidneys.

22. Where in the body is the thyroid gland located?

The thyroid is located in the anterior cervical region (frontal neck), in front of the trachea and just below the larynx. It is a bilobated mass below the Adam's apple.

23. What are the hormones secreted by the thyroid gland? What are their functions?

The thyroid secretes the hormones thyroxine (T4), triiodothyronine (T3) and calcitonin.

T3 and T4 are iodinated substances derived from the amino acid tyrosine. They act to increase the cellular metabolic rate of the body (cellular respiration, metabolism of proteins and lipids, etc.). Calcitonin inhibits the release of calcium cations by the bones thus controlling the blood level of calcium.

Biology Questions and Answers

24. Why is the dietary obtainment of iodine so important for thyroid functioning?

The obtainment of iodine from the diet is important for the thyroid because this chemical element is necessary for the synthesis of the thyroid hormones T3 and T4. The iodine supply often comes from the diet.

25. What is a goiter? What is endemic goiter? How is this problem socially solved?

Goiter is the abnormal enlargement of the thyroid gland. The goiter appears as a tumor in the anterior neck and it may be visible or sometimes not visible but palpable. Goiter can occur in hypothyroidism or in hyperthyroidism.

Endemic goiter is the goiter caused by deficient iodine ingestion (deficiency of iodine in the diet). The endemic character of the disease is explained because the iodine content of the diet is often a social or cultural condition affecting many people of some geographical regions. The hypothyroidism caused by deficient iodine ingestion is more frequent in regions far from the sea coast (since sea food is rich in iodine).

Nowadays the problem is often solved by obligatory addition of iodine in table salt. As table salt is a widely used condiment the supply of iodine in diet is almost assured by this method.

26. What happens to the TSH (thyroid-stimulating hormone) blood level in hypothyroidism? Why is there enlargement of the thyroid in the endemic goiter disease?

When there is low T3 and T4 secretion by the thyroid the TSH secretion by the hypophysis is very stimulated and the TSH blood level increases. The increase in the TSH availability promotes the enlargement of the thyroid gland.

The thyroid enlargement is a reaction of a tissue that tries to compensate the functional deficiency by making the gland increase its size.

27. What are some signs and symptoms found in patients with hyperthyroidism?

The hormones made by the thyroid gland stimulate the basal metabolism of the body. In hyperthyroidism there is abnormally high production and secretion of T3 and T4 so the basal metabolic rate is increased. The signs of this condition may be tachycardia (abnormally high heart rate), weight loss, excessive heat sensation, excessive sweating, anxiety, etc. One of the typical signs of hyperthyroidism is exophthalmos (protrusion of the eyeballs). Generally the patient also presents goiter.

Biology Questions and Answers

28. What are some signs and symptoms found in patients with hypothyroidism?

In hypothyroidism the production and secretion of T3 and T4 are impaired. Since these thyroid hormones stimulate the basal metabolism of the body (cellular respiration, fat acid and protein metabolism, etc.) the patient with hypothyroidism may present bradycardia (low heart rate), low respiratory rate, excessive tiredness, depression, cold intolerance and weight gain. Hypothyroidism is normally accompanied by goiter (enlargement of the thyroid in the neck).

29. What is the physiological cause of the syndrome known as cretinism?

Cretinism is caused by chronic deficiency of the thyroid hormones (T3 and T4) during childhood. The chronic hypothyroidism during childhood may cause retardation and low stature due to the low basal metabolic rate in a period of life when growth and development of mind faculties occur.

30. What are the parathyroids? Where are they located and what are the hormones secreted by these glands?

The parathyroids are four small glands embedded two in each posterior face of one thyroid lobe. The parathyroids secrete parathormone, a hormone that together with calcitonin and vitamin D regulates the calcium blood level.

31. What is the relation between secretion of parathormone and the calcium blood level?

The parathormone increases the calcium blood level since it stimulates the resorption (remodelation) of the osseous tissue. When osteoclasts remodel bones calcium is released in the circulation.

Parathormone also acts increasing the calcium absorption in the intestines by vitamin D activation. It acts in the kidneys promoting tubular calcium resorption too.

32. What is a mixed gland? Why is the pancreas considered a mixed gland?

Mixed gland is a gland that produces endocrine and exocrine secretions.

The pancreas is an example of a mixed gland because it secretes hormones in the circulation, like insulin and glucagon, but it also releases an exocrine secretion, the pancreatic juice.

Biology Questions and Answers

33. What are the pancreatic tissues involved respectively in the exocrine and endocrine secretions? What are their respective hormones and enzymes?

The exocrine secretion of the pancreas is produced in the pancreatic acini, aggregates of secretory cells that surround small exocrine ducts. The exocrine pancreas secretes digestive enzymes of the pancreatic juice: amylase, lipase, trypsin, chymotrypsin, carboxypeptidase, ribonuclease, deoxyribonuclease, elastase and gelatinase.

The endocrine secretion of the pancreas is produced and secreted by small groups of cells dispersed throughout the organ called islets of Langerhans. The pancreatic islets make insulin, glucagon and somatostatin.

34. What is the importance of the glucose blood level for human health?

The glucose blood level (glycemia) must be kept normal. If it is abnormally low there is not enough glucose to supply the energetic metabolism of the cells. If it is abnormally and chronically high it causes severe harm to the peripheral nerves, the skin, the retina, the kidneys and other important organs and it may predispose to cardiovascular diseases (acute myocardial infarction, strokes, thrombosis, etc). If it is acutely too high medical emergencies like diabetic ketoacidosis and the hyperglycemic hyperosmolar state may occur.

35. What are the functions of insulin and glucagon for the blood glucose control?

Glucagon increases glycemia and insulin reduces it. They are antagonistic pancreatic hormones. Glucagon acts stimulating glycogenolysis and thus forming glucose from glycogen breaking. Insulin is the hormone responsible for the entrance of glucose from the blood into the cells.

When glycemia is low, for example, during fasting, glucagon is secreted and insulin is inhibited. When glycemia is high, as after meals, there are inhibition of glucagon and more secretion of insulin.

36. What are the target organs upon which insulin and glucagon act?

Glucagon mainly acts upon the liver. Insulin acts in general upon all cells. Both also act upon the adipose tissue respectively stimulating (glucagon) and inhibiting (insulin) the use of fatty acids in the energetic metabolism (an alternate path of the energetic metabolism is activated when there is shortage of glucose).

37. What are the effects of somatostatin for the pancreatic hormonal secretion?

Somatostatin inhibits both insulin and glucagon secretions.

Biology Questions and Answers

38. What is diabetes mellitus?

Diabetes mellitus is the disease caused by deficient production or action of insulin and the consequent low glucose uptake by the cells and high blood glucose level.

39. What are the three main signs of diabetes?

The three main signs of diabetes mellitus are known as the diabetic triad: polyuria, polydipsia and polyphagia.

Polyuria is the excessive elimination of urine; in diabetes it is caused by reduced water resorption in the renal tubules due to increased osmolarity of the glomerular filtrate (caused by excessive glucose). Polydipsia is the exaggerated ingestion of water; the thirst is due to the excessive water loss in the urine. Polyphagia is the exaggerated ingestion of food caused by deficiency in energy generation by glucose-lacking cells.

40. Why do diabetic patients often undergo dietary sugar restriction? What are the main complications of diabetes mellitus?

Diabetic patients are often advised to ingest less carbohydrates since these substances are degraded into glucose and this molecule is absorbed in the intestines. The dietary sugar restriction goal is to control glycemia to maintain it at normal levels.

The main complications of diabetes are tissue injuries that occur in vaious organs caused by the chronic increased blood osmolarity: in the peripheral nerves (diabetic neuropathy), resulting in sensitivity loss, increased wounds (the person does not feel that the tissue is being wounded and the wound expands) and muscle fatigue; in the kidneys (diabetic nephropathy), causing glomerular lesions that may lead to renal failure; in the retina (diabetic retinopathy), leading to vision impairment and blindness; in the skin, as a consequence of the neuropathy. Diabetes mellitus also is one of the major risk factors for cardiovascular diseases like embolism, myocardial infarction and stroke.

41. What is the difference between type I diabetes mellitus and type II diabetes mellitus?

Type I diabetes, also known as juvenile diabetes, or insulin-dependent diabetes (this name is not adequate as type II diabetes may become insulin-dependent), is the impaired production of insulin by the pancreas believed to be caused by destruction of cells of the islets of Langerhans by autoantibodies (autoimmunity).

Type II diabetes occurs in the adult individual and it is often diagnosed in people of more advanced age. In type II diabetes there is normal or low secretion of insulin by the pancreas but the main cause of the high glycemia is the peripheral resistance of the cells to the action of the hormone.

42. In ancient Greece the father of Medicine, Hypocrates, described a method of diagnosing diabetes mellitus by tasting the patient's urine. What is the physiological explanation for this archaic method?

Under normal conditions the glucose filtered by the renal glomeruli is almost entirely resorbed in the nephron tubules and not excreted in urine. With the elevated glucose blood level the renal tubules cannot resorb all the filtered glucose and some amount of the substance appears in the urine. This amount is enough to provide the sweet taste that helped Hypocrates to diagnose diabetes and to differentiate it from other diseases accompanied by polyuria. Nowadays the method is inconceivable due to the danger of contamination of the tester by disease agents possibly present in the patient's urine.

43. What are the main treatments of diabetes mellitus?

The general goal of the diabetes treatment is to maintain normal glycemic levels.

Type I diabetes is treated with parenteral administration of insulin. Insulin must be administered intravenously or intramuscularly because as a protein it would be digested if ingested orally. In type II diabetes treatment is done with oral drugs that regulate the glucose metabolism or in more severe cases with parenteral administration of insulin. The moderation of carbohydrate ingestion is an important aid to diabetes treatment.

The diabetes treatment with the use of hypoglycemic agents, like insulin or oral medicines, must be carefully and medically supervised since if wrongly used these drugs may abruptly decrease the glucose blood level, cause hypoglycemia and even death.

Many other forms of diabetes treatment are under research worldwide.

44. How can bacteria produce human insulin on an industrial scale? What are the other forms of insulin made available by the pharmaceutical industry?

Bacteria do not naturally synthesize insulin. It is possible however to implant human genetic material containing the insulin gene into the bacterial DNA. The mutant bacteria then multiply and produce human insulin. The insulin is isolated and purified for later commercialization. This biotechnology is known as the recombinant DNA technology.

Besides human insulin the pharmaceutical industry also produces insulin to be used by humans made from the pancreas of pigs and cows.

Biology Questions and Answers

45. Where are the adrenal glands located? How many are they and what are their portions?

Each adrenal gland is located on the top of each kidney (forming a hat-like structure for the kidneys), so there are two glands. The adrenal parenchymal structure is divided into two portions: the most peripheral is the cortical portion, or adrenal cortex, and the central is the medullary portion, or adrenal medulla.

46. What are the hormones secreted by the adrenal medulla? What are their respective functions?

The medullary portion of the adrenals secretes hormones of the catecholamine group: adrenaline (also known as epinephrine) and noradrenaline (also known as norepinephrine). Besides their hormonal function, adrenaline and noradrenaline act as neurotransmitters too. The neurons that use them as neurotransmitters are called adrenergic neurons.

Adrenaline increases the glycogen breaking into glucose (glycogenolysis) thus increasing glycemia and the basal metabolic rate of the body. Adrenaline and noradrenaline are released during situations of danger (fightfight or flight response) and they intensify the strength and rate of the heartbeat and selectively modulate the blood irrigation in some tissues by selective vasodilation and selective vasoconstriction. By vasodilation they increase the blood supply to the brain, the muscles and the heart and by vasoconstriction they reduce the blood supply to the kidneys, the skin and the gastrointestinal tract.

Substances like adrenaline and noradrenaline that promote vasodilation or vasoconstriction are called vasoactive substances.

47. What are the hormones secreted by the adrenal cortex? What are their respective functions?

The cortical portion of the adrenals secretes hormones of the corticoid (or corticosteroid) group, derived from cholesterol: glucocorticoid, mineralocorticoids and cortical sex hormones.

The glucocorticoids are cortisol and cortisone. The glucocorticoids stimulate the formation of glucose from the degradation of proteins of the muscle tissue (gluconeogenesis) and so they help to increase glycemia. These hormones play an important immunosuppressant role, i.e., they reduce the action of the immune system and for this reason they are used as medicine to treat inflammatory and autoimmune diseases and rejection of transplanted organs.

The mineralocorticoids aldosterone and deoxycorticosterone regulate the sodium and potassium blood concentration and thus they control the water level of the extracellular space. Aldosterone increases the sodium resorption and thus the water resorption in the renal tubules and it also

stimulates the renal excretion of potassium and hydrogen.

The adrenal cortical sex hormones are androgens, male sex hormones present in men and women. In men their main site of production is the testicle and they promote the appearance of secondary male sex characteristics, like body hair and beard, deep voice, the male pattern of fat distribution and maturation of the genitalia. If abnormally high in women they cause inhibited maturation of the female genitalia and disturbances of the menstrual cycle.

48. Why are glucorticoids used in transplant patients?

Patients with transplanted organs are prone to host versus graft rejection since their own immune system tends to attack the grafted organ because of recognition of the grafted tissue as foreign matter. In the prevention and treatment of this common problem patients are given glucorticoids or other immunosupressants. Glucocorticoids have an immunosuppressant action and so they reduce the aggression of the immune system against the graft.

The immune action however is also very important for the individual. The immune system defends the body against invasion and infection by pathogenic agents (virus, bacteria, toxins) besides being fundamental for the elimination of modified cells that may proliferate and cause cancer. Patients receiving immunosuppressants like glucocorticoids are thus under increased risk of infectious and neoplastic diseases.

49. What are the hormones produced by the testicles and the ovaries?

The testicles make androgenic hormones, the main of them being testosterone. The ovaries produce estrogen and progesterone.

50. What is the endocrine function of the placenta?

The placenta is not a permanent gland of the endocrine system but it also has endocrinal function. The placenta produces estrogen and progesterone. It also secretes human chorionic gonadotropin (HCG, that acts similarly to the hypophyseal LH), human placental lactogen, similar to prolactin and stimulant of the mammary glands, and a series of hormonal peptides similar to the hormones of the hypothalamus-hypophysis axis.

Biology Questions and Answers

Immune System

1. What is the function of the immune system?

The immune system performs specific defense against agents, the antigens, that are foreign or harmful to the body.

Exogenous antigens are often in contact with the skin or entering the airway, the digestive tube and the genital orifices and mucosae. They can also penetrate the circulation directly through wounds.

2. What are the two groups of defense mechanisms of the body against foreign or harmful agents? What is the difference between them?

The body has many defense mechanisms against foreign pathogenic agents. These mechanisms are divided into two groups: the specific mechanisms and the unspecific mechanisms. The specific mechanisms are part of the immune system and comprehend the humoral immune response and the cellular immune response that respectively produce antibodies and defense cells against specific antigens. The unspecific mechanisms fight in a general manner any type of antigen (they do not have specificity) and in them a series of defense means are included, like the skin barrier against foreign agents, the mucous and ciliated epithelium of the airway, inflammation (the inflammatory response) and the action of unspecific proteins and defense cells (e.g., interferons and macrophages).

3. What is inflammation?

Inflammation is the initial response of the unspecific defense system versus aggressions against the body (the aggressions may be caused by infectious parasites, chemical contamination, trauma, physical agents like heat and fire, autoimmunity, etc.). During inflammation a series of unspecific leukocytes present in the circulation are attracted to the injury site in an attempt to destroy harmful agents and to isolate the affected region of the tissue.

4. How does the inflammation mechanism work?

When some tissue injury occurs histamine and other vasoactive substances (called mediators of inflammation) are released, they cause vasodilation and the blood flow to the affected site increases. Granulocyte leukocytes present in the blood are attracted to the site of the injury by substances known as chemotactic factors also released by the injured tissue and by the active granulocytes in the area. The granulocytes exit the capillaries by diapedesis, i.e., using pseudopods. Macrophages present in the region are activated too. These cells flood the extracellular space of the affected area trying to kill or eliminate harmful agents, to prevent tissue

necrosis and to isolate the damaged tissue.

5. What is pus?

Pus is a residual of the inflammatory reaction. It contains a mixture of fragments of dead leukocytes, infectious agents (generally bacteria) and tissues.

6. What is the association between inflammation and fever?

In the tissue region where inflammation occurs bacterial toxins, cytokines, prostaglandins, interleukins and endothelins are released. These substances gain the circulation and reach the central nervous system which then commands the increase of the body temperature.

7. Which type of defense cell do bacteria attract and cause to multiply during the inflammation process? What is the name given to the waste material produced by the inflammation triggered by bacterial infection?

The main leukocytes that generally multiply and participate in the inflammation reaction against bacterial infections are the neutrophils. In this type of inflammation the blood level of these cells are increased, a clinical condition known as neutrophilia.

In the bacterial inflammation fragments of dead bacteria, dead neutrophils and tissues form the pus.

8. Of which type of defense cell do worm infections stimulate the multiplication?

The main leukocytes that generally multiply and participate in the defense against worm infections are the eosinophils. In this type of inflammation the blood level of these cells are increased, a clinical condition known as eosinophilia.

Eosinophils are also increased in allergic conditions.

9. Of which type of defense cell do viral infections stimulate the multiplication?

The main leukocytes that generally multiply and participate in the defense against viral infections are the lymphocytes. In this type of inflammation the blood level of these cells are increased, a clinical condition known as lymphocytosis.

10. What is the defense mechanism that begins to work when inflammation fails to stop an infection?

If the inflammatory attack is not enough to halt the infectious process the body still relies on a specific defense, the immune response proper (humoral and cellular) performed by the lymphocytes.

11. What is the difference between humoral specific immune response and cellular specific immune response?

Humoral specific immune response is the defense system by means of antibodies, defense proteins secreted by lymphocytes that attack foreign agents with high specificity. Cellular specific immune response is the defense system by means of specific lymphocytes (cells) that directly attack other foreign cells and agents.

12. What is an antigen?

Antigen is any substance, particle or infectious agent recognized as foreign to the body. The contact of the antigen with the body promotes a defense reaction against the antigen (unspecific, specific or both).

13. What are the cells responsible for the production of antibodies?

The cells that produce antibodies, i.e., the cells of the humoral immune system, are the B lymphocytes (B cells).

14. What are immunoglobulins?

Immunoglobulin is the alternate name given to antibody. Immunoglobulins are complex proteins containing an invariable portion and a variable portion and made of four polypeptide chains. The variable portion of each immunoglobulin is responsible for the high specificity of the antigen-antibody bond.

15. How do antibodies work to neutralize antigens?

The antibodies, or immunoglobulins, act to facilitate the destruction of antigens: they attract phagocytic leukocytes, they trigger the attack of specific defense molecules (activation of the complement system) and they directly neutralize the toxicity of some antigens.

16. How can an organism that once underwent contact with an antigen be immunized against future infections by the same agent?

This phenomenon is called immune memory. When an antigen makes contact for the first time with cells of the humoral immune system, B lymphocytes that are producers of specific immunoglobulins against that antigen multiply and in days synthesize their antibodies. This is called primary response. Some of these specific B lymphocytes remain in the circulation for a long time, sometimes during the

entire life of the individual, and they become the memory cells of the immune system. When the body is exposed in the future to the same antigen the production of antibodies will be faster and more intense since the immune system is already prepared to react against that antigen. This is called the secondary response.

17. How can the immune memory lead to the efficacy of vaccines and also produce allergies?

Vaccines are controlled inoculations of fragments of infectious agents or of inactive infectious agents to induce the primary immune response, the formation of specific memory B lymphocytes against the antigen. Therefore the organism produces immunoglobulins and becomes prepared to destroy antigens when exposed to new infections by those agents.

In allergies the humoral immune system is sensitized (makes antibodies and specific memory B lymphocytes) against some common environmental substances wrongly recognized as antigens. For example, pollen-derived substances, dust particles, compounds present in foods or in medicines, etc. may be recognized as antigens triggering the primary response and creating an immune memory against them that then become causes of allergy. The more the individual is exposed to those substances the more intense is the immune reaction.

The IgE antibodies that cause allergy bind to receptors of leukocytes called mastocytes whose cytoplasm is full of histamine granules. The antibody-mastocyte bond causes these cells to release a great amount of histamine in the circulation, stimulating inflammation and generating the allergic symptoms and signs. For this reason allergy is treated with antihistamines, drugs that block the histaminic reaction. Exacerbated allergic reactions, for example, in hypersensitivity to some medicines like penicillin and sulfas, may cause anaphylactic shock, a severe clinical condition that sometimes leads to death.

18. How different are the actions of antibodies against bacteria and against virus? Why is the cellular immune response activated in case of chronic viral infection?

The antibodies of the humoral immune system act against extracellular agents, like toxins or bacteria, but they are not active in the intracellular space and they cannot fight virus efficiently.

In case of viral infection (and also of cancerous or precancerous cells) the immune attack is made by the cellular immune system, mediated by T and NK (natural killers) lymphocytes that destroy specific cells and virus.

19. How does the cellular immune response take place?

The lymphocytes that participate in the cellular immune response are the T

lymphocytes. T lymphocytes differentiate into three main types: cytotoxic T lymphocytes (cytotoxic T cell), helper T lymphocytes (helper cell) and suppressor T lymphocytes. The cytotoxic cells are the effectors of the system, i.e., they directly attack other cells recognized as foreign (for example, fungi cells, cells infected by virus, neoplastic cells, graft cells, etc.). The helper cells and the suppressor T lymphocytes act as regulators of the system releasing substances that respectively stimulate and inhibit the immune action of T and B lymphocytes. After the primary immune response memory T lymphocytes also remain in the circulation to provide faster and more effective reaction in case of future infections.

20. What are the antigen-presenting cells of the immune system?

The antigen-presenting cells of the immune system, also known as APC cells, are cells that do phagocytosis and digestion of foreign (to the body) microorganisms and later expose antigens derived from these microorganisms in the outer side of their plasma membrane. These processed antigens are then recognized by lymphocytes that activate the immune response. Several types of cells, like the macrophages, can act as antigen-presenting cells.

21. What are passive and active immunization? According to the duration of the protection how do these types of immunization differ?

Active immunization is that in which an antigen penetrates the body triggering the primary immune response and the production of memory lymphocytes and antibodies that provide faster and more effective immune defense in future infections by the same antigen. Passive immunization is that in which immunoglobulins against an antigen are inoculated in the body to provide protection in case the body becomes infected by the antigen.

Active immunization tends to be longer lasting than passive immunization since in the active type as well as antibodies, specific memory lymphocytes remain in the circulation. In the passive immunization the duration of the protection is that of the duration of the antibodies in the circulation.

22. Why is maternal milk important for the immune protection of the baby?

Besides being nutritionally important, maternal milk participates in the defense of the baby against infectious agents. Soon after delivery the mother produces a more fluid milk called colostrum that is rich in immunoglobulins (antibodies). These antibodies are not absorbed by the baby's circulation but they cover the internal surface of the baby's bowels thus attacking possible antigens and

making more difficult the proliferation of pathogenic bacteria within the organ.

23. How are antivenoms produced? Why are antivenoms an example of passive immunization?

Antivenoms are obtained by the following process: the venom (antigen) is inoculated into other mammals, e.g., in horses; these animals make specific antibodies against the antigen; blood from the animals is collected and purified to get the antibodies; this antibody-containing material is the antivenom. When a human being is infected by the antigen the specific antivenom is given to him/her and the action against the antigen occurs.

Antivenoms may also be administered as a preventive measure and, since it is basically made of specific immunoglobulins against some antigen, the process is an example of passive immunization.

24. What is the difference between homologous and heterologous immunoglobulins?

Homologous immunoglobulin is the human (from the same species) immunoglobulin. In case of inoculation in animals as in veterinary procedures homologous immunoglobulin is that from the blood of animals of the same species of the animal undergoing treatment. Heterologous immunoglobulin is that obtained from animals of different species from the individual into which it will be inoculated.

The homologous immunoglobulin is safer since it is collected from beings of the same species of the individual in which it will be inoculated and thus the risk of the antibodies to be recognized as foreign and to trigger an immune response is lower. Heterologous immunoglobulins are more prone to being destroyed by the own antibodies of the individual.

25. What are natural active immunization and artificial active immunization?

Natural active immunization is that in which a previous natural infection induces the primary immune response, specific memory cells are produced and the individual becomes immune to new infections with the antigen. This is what happens in diseases that affect people only once in life, like mumps and chickenpox.

Artificial active immunization is that in which the primary immune response is caused by the inoculation into an individual of specially prepared antigens. This is the case with vaccines.

26. Why are vaccines made of the own disease agent or of fragments of it?

The goal of vaccines is to artificially induce a specific primary immune

response (and the consequent formation of antibodies and memory cells) concerning a given infection or disease in order to immunize the individual against infections by the pathogenic agent in the future.

Since each antibody does not act against a variety of antigens but instead it acts only against its specific antigen, it is necessary for the immune system to make contact in some way with the antigen against which the immunization is wanted. The reconnaissance of specific molecular portions of each antigen causes the immune system to produce the specific variable portion of the immunoglobulins to attack that antigen. Therefore to induce the active immunization it is necessary to inoculate into the body small parts of the infectious agent or the agent entirely (dead or inactivated).

27. What are the types of antigenic agents that may constitute vaccines?

Vaccines can be constituted of dead agents of disease, of inactivated agents of disease, of inactivated toxins or of fragments of the infectious agent.

Examples of some vaccines and their type of antigenic agents are: BCG, inactivated tuberculosis bacilli; antitetanic vaccine, inactivated toxin; antidiphtheric, inactivated toxin; antipolio Salk, dead poliovirus; antipolio Sabin, attenuated (inactivated) poliovirus.

28. Why doesn't a long lasting vaccine against common cold exist yet?

Viruses that present a high mutation rate like the virus that causes the common cold escape easily from the action of vaccines against them. After a primary immune response (natural or artificially induced) against the virus in the next season of infection new mutant resistant strains appear and the protection obtained with the immune response of the last season is lost. (One could say that the high mutation rate is a form of "immunization" found by these viruses.)

29. Why are vaccines used in the prevention but not in the treatment of infections? Why can antivenom serums be used in prevention and treatment?

Vaccines are not used in the treatment of infections because they depend on the primary immune response that takes about a week to occur and is not so intense and effective. Antivenom serums however are inoculated into the circulation and used as an immediate treatment because they are made of a great amount of immunoglobulin (antibodies) which is potent against their respective specific venom.

30. What is the DNA vaccine?

The DNA vaccine, or DNA vaccination, is a vaccination technology based on

genetic engineering. In DNA vaccination a recombinant plasmid (vector) containing the gene of a specific antigen that is part of a given pathogenic agent is inserted into cells of the individual to be immunized. These cells then begin to produce the antigen that triggers the primary immune response and theoretically the individual becomes immunized against that antigen.

31. What is the name given to conditions in which the own immune system of the individual is the agent of diseases? What are some examples of these conditions?

Diseases caused by the action of the own immune system of the individual are called autoimmune diseases.

The autoimmune diseases appear when the immune system makes antibodies or defense cells that attack cells, tissues and organs of its own body. The attacked cells or tissues are wrongly recognized as antigens by the immune system. Rheumatoid arthritis, lupus, scleroderma, vitiligo, pemphigus, type I diabetes mellitus, Crohn's disease (chronic inflammation of the gut), myasthenia gravis, Graves disease, Hashimoto's disease, etc., are all examples of autoimmune diseases.

Biology Questions and Answers

Gametogenesis

1. What are gametes?

Gametes are cells specialized in sexual reproduction. They contain half of the maximum number of chromosomes of the species and unite with another gamete giving birth to a zygote with double of the number of chromosomes of the gametic cells.

In humans gametes are formed by meiosis; the male gametes are the sperm cells and the female gametes are the egg cells.

2. What is the type of cell division that allows sexual reproduction? What is gametogenesis?

Meiosis is the type of cell division that allows sexual reproduction since it reduces to a half the number of chromosomes of the species making possible the combination of two gametes to form a new individual. (In some beings meiosis creates haploid gametophytes that by means of mitosis generate gametes. Even in this case the function of meiosis is the same: to provide cells with half of the number of chromosomes of the species with separation of the homologous.)

Gametogenesis is the name given to the process of gamete production.

3. What is the name of the cells capable of making gametes? What is the ploidy of these gamete-forming cells?

The cells that form gametes are the germ cells as opposed to the somatic cells. The ploidy (number of chromosomes) of the germ cells is the same as the somatic cells (only during the formation of gametes meiosis occurs and the number of chromosomes is reduced to half).

4. What are gonads? What are the male and the female gonads in humans?

Gonads are the organs that produce gametes. They contain the germ cells that undergo division and generate gametes. In males the gonads are the testicles. In females the gonads are the ovaries.

5. Indicating the name and respective ploidy of each involved cell how can the formation of sperm cells from germ cells be described?

The formation of sperm cells, or spermatogenesis, begins with a germ cell called spermatogonium (2n) that suffers mitosis and gives birth to the spermatocyte I (2n). The spermatocyte I undergoes meiosis I and generates two spermatocyte II (n) that then

undergo meiosis II and produce four spermatids (n). Each spermatid undergoes a maturation process called spermiogenesis and four sperm cells appear.

6. What is the difference between spermatogonium and spermatocyte I?

The male germ cells are the spermatogonia (diploid cells, 2n) situated in the testicles. They mature and by means of mitosis give birth to spermatocytes I (2n) that will undergo meiosis.

7. What is the difference between spermatocyte I and spermatocyte II?

The spermatocyte I (2n) undergoes the first division of meiosis (meiosis I) originating two spermatocyte II (haploid, n).

8. What is the difference between spermatocyte II and spermatid?

The spermatids (n) are the products of the second division of meiosis (meiosis II) in the male gametogenesis. Each spermatocyte II originates two spermatids totaling four spermatids for each spermatocyte I that enter meiosis.

9. What is the difference between spermatids and sperm cells? What is the name of the transformation of spermatids into sperm cells?

Sperm cells (the male gametes) are matured spermatids that have already undergone differentiation (appearance of the flagellum, reduction of the cytoplasm, formation of the acrosome, increase in the number of mitochondria). This differentiation process is called spermiogenesis.

10. What is the acrosome of the sperm cell? How is it formed?

The acrosome is a structure that contains a great number of digestive enzymes, it is located in the anterior end of the sperm cell and it is formed by the union of Golgi apparatus vesicles. The function of the acrosome is to release its enzymes when the sperm cell meets the egg cell to break the external covering of the female gamete thus making fecundation possible.

11. What is the function of the flagellum of the sperm cell? How is it formed?

The flagellum of the sperm cell is made by the centrioles that migrate to the region posterior to the nucleus. Its function is to promote locomotion towards the egg cell.

Biology Questions and Answers

12. Why is the cytoplasm of sperm cells very reduced? Why do mitochondria of sperm cells concentrate in the base of the flagellum?

The reduced cytoplasm of sperm cells decreases the cell weight and provides a more hydrodynamic shape for the locomotion in fluids.

The high concentration of mitochondria at the base of the flagellum of the sperm cell is necessary for the energetic supply of the flagellum (for it to beat and move the sperm cell).

13. Concerning events during the periods of life how different is the gametogenesis in women and in men?

The formation of spermatogonia in men takes place during the embryonic period. The formation of sperm cells however is a continuous process that begins in puberty and goes on until old age and sometimes during all the remaining life of the man.

In women all oogonia are formed before birth. The oogonia turn into oocytes I that enter the first division of meiosis (meiosis I). This division however is interrupted at prophase and continues only in puberty. After the beginning of menses an egg cell is released during each period and, if fecundated, it finishes the meiotic division. The oogenesis stops after menopause (cessation of the menstrual activity) and the climacteric period of life begins.

14. Indicating the name and respective ploidy of each involved cell how can the formation of egg cells from germ cells be described?

The formation of egg cells begins with a germ cell called oogonium (2n) that undergoes mitosis and gives birth to the oocyte I (2n). The oocyte I undergoes meiosis I that however is interrupted at prophase. After puberty during each menstrual cycle an oocyte I finishes the meiosis I and generate one oocyte II (n) and the first polar body (n). With fecundation the oocyte II then undergoes meiosis II and produces the mature egg cell (n) and the second polar body (n).

15. What is the first polar body? How different is it from the oocyte II?

In oogenesis the oogonium differentiates into oocyte I (2n) and this cell enters meiosis. After finishing the first meiotic division (meiosis I) the oocyte I forms two cells: the oocyte II (n) and the first polar body. The oocyte II is bigger because it gets almost all the cytoplasm and the cytoplasmic structures of the oocyte I as a strategy for metabolite and nutrient storage. The oocyte II cell goes then to the second meiotic division. The first polar body is very small and almost lacks cytoplasm; it disintegrates or stays attached to the oocyte II.

Biology Questions and Answers

16. What is the relation between fecundation and the end of the meiotic process during oogenesis?

The oocyte II only completes the second meiotic division (interrupted at metaphase) if fecundation by a male gamete occurs. (One can say therefore that in fact the female gamete is the oocyte II).

17. What is the second polar body?

After termination of the second meiotic division of the oocyte II two cells are generated: the egg cell proper and the second polar body. The second polar body is a very small cell that almost lacks cytoplasm and stays adnexal to the egg cell. The entire cytoplasmic content of the oocyte II passes to the egg cell.

18. What is the relationship between the menstrual cycle and ovulation?

Ovulation is the releasing of the female gamete from the ovary. Ovulation is a periodical event that occurs during each menstrual cycle. Considering as the first day of the menstrual cycle the day when menses begins, the ovulation occurs around the 14th day when the concentrations of the hormones LH and FSH reach high levels.

19. How does the male gamete penetrate the egg cell? How does the female gamete protect itself from the entrance of more gametes after the entrance of the first sperm cell?

The sperm cell that reaches the egg cell triggers the acrosome reaction, a process in which hydrolytic enzymes of the acrosome are released on the external surface of the zona pellucida (the protective layer that surrounds the egg cell). A portion of this layer is digested by the acrosomal enzymes allowing the sperm cell to reach the plasma membrane of the egg cell carrying out fecundation.

At the moment that the sperm cell makes contact with the egg cell membrane a chemical alteration of this membrane occurs. Enzymes secreted by exocytosis (cortical reaction) make the zona pellucida unable to bind to other sperm cells (zonal reaction) and other male gametes cannot enter the egg cell.

20. What are the female pronucleus and the male pronucleus?

The female pronucleus is the proper haploid nucleus of the egg cell. Male pronucleus is the haploid nucleus of the sperm cell that has fecundated the egg cell. After fecundation both pronuclei fuse forming the nucleus of the diploid zygote.

21. Concerning their size and basic morphology how and why do the male and the female gametes differentiate from each other?

The female gametes are big cells full of vitellus (nutritive material). The male gametes are small, mobile and agile flagellate cells.

Those features are related to their respective biological functions. While the female gametes have the basic functions of receiving the sperm cell nucleus and of storing nutrients for the zygote, the male gametes have the function of active movement towards the egg cell.

Biology Questions and Answers

Reproductive System

1. What are the organs that are part of the male genital system?

The organs that comprise the male genital system are the testicles, the epididymides, the vas deferens, the seminal vesicles, the ejaculatory duct, the prostate, the bulbourethral glands, the urethra and the penis.

2. Concerning reproduction what is the function of the testicles?

The testicles are the male gonads, i.e., the organs where the production of gametes takes place. In human beings the gametes are made by meiosis that occur in the testicles.

3. After passing the epididymides through which structures do sperm cells go until exteriorization?

After leaving the epididymis in the testicle sperm cells enter the vas deferens, after that they receive secretions from the seminal vesicles and gather (from right and left sides) in the ejaculatory duct that passes inside the prostate. They also get secretions from the prostate and the bulbourethral glands and then go through the urethra, inside the penis, to the exterior.

4. What is the function of the secretions of the prostate, seminal vesicle and bulbourethral glands in reproduction?

These secretions along with sperm cells from the testicles form the semen. The secretions have the function of nourishing the sperm cells and serving them as a fluid means of propagation. The basic pH of the seminal fluid also neutralizes the acid secretions of the vagina allowing the survival of sperm cells in the vaginal environment after copulation.

5. What are the endocrine glands that regulate sexual activity in males? How does this regulation work and what are the involved hormones?

In males the sexual activity is regulated by the endocrine glands hypophysis (pituitary), adrenals and gonads (testicles).

The FSH (follicle-stimulating hormone) secreted by the adenohypophysis acts upon the testicles stimulating the spermatogenesis. The LH (luteinizing hormone), another adenohypophyseal hormone, stimulates the production of testosterone by the testicles too. Testosterone, whose production

intensifies after the beginning of puberty, acts in several organs of the body and it is responsible for the appearing of the male secondary sex characteristics (beard, body hair, deep voice, increase of the muscle and osseous mass, maturation of genitalia, etc.) Testosterone also stimulates spermatogenesis.

6. What are the organs that are part of the female reproductive system?

The organs that constitute the female reproductive system are the ovaries, the Fallopian tubes (or uterine tubes), the uterus, the vagina and the vulva.

7. In which period of life does the formation of gametes begin in women?

The meiosis that forms female gametes begins in the cells of the ovarian follicles before birth. After the beginning of puberty, under hormonal stimuli, during each menstrual cycle one of the cells is released on the surface of the ovary and meiosis resumes. The meiotic process is only concluded however if fecundation happens.

8. What is the organ that releases the female gamete under formation? How is this release triggered? What is the organ that collects the released gametes?

The organ that liberates the female gamete is the ovary, the female gonad. The releasing of the oocyte is a response to hormonal stimuli. The immature egg cell (still an oocyte) falls into the abdominal cavity and is picked up by the Fallopian tube (uterine tube, or oviduct), a tubular structure that connects the ovary with the uterus.

9. What are the anatomical relationships between the organs of the female reproductive system from the external vulva to the ovaries?

The external female genitalia is called the vulva. The vulva is the external opening of the vaginal canal, or vagina. The vagina is the copulation organ of the females and its posterior extremity communicates with the uterus through the uterine cervix. The uterus is divided into two portions: the cervix and the uterine cavity. The lateral walls of the uterine fundus communicate with the Fallopian tubes. The other extremity of each Fallopian tube ends in fimbria forming fringes in the abdominal cavity. Between the uterine tube and the ovary there is still intra-abdominal space.

Biology Questions and Answers

10. What is the menstrual cycle?

The menstrual cycle is the periodic succession of interactions between hormones and the organs of the female reproductive system that, after the beginning of puberty, regulates the release of the female gametes and prepares the uterus for fecundation and pregnancy.

11. What are the endocrine glands involved in the menstrual cycle? What are the hormones in action?

The endocrine glands that secrete hormones involved in the menstrual cycle are the hypophysis (pituitary) and the ovaries.

The hormones from adenohypophysis are FSH (follicle-stimulating hormone) and LH (luteinizing hormone) and the hormones from the ovaries are estrogen and progesterone.

12. What event marks the beginning of the menstrual cycle? What is the blood concentration of FSH, LH, estrogen and progesterone in this phase of the cycle?

By convention the menstrual cycle begins at the day that menses begins. (Menses is the endometrial hemorrhage excreted through the vaginal canal.) At these days the hormones FSH, LH, estrogens and progesterone are in low concentration.

13. After menses what is the hormone that influences the maturation of the ovarian follicles?

The maturation of the ovarian follicles after menses is stimulated by the action of FSH (follicle-stimulating hormone).

14. What is the hormone secreted by the growing ovarian follicles? What is the action of that hormone upon the uterus?

The follicles that are growing after menses secrete estrogen. These hormones act upon the uterus stimulating the thickening of the endometrium (the internal mucosa of the uterus).

15. What is the relationship between the estrogen level and the LH level in the menstrual cycle? What is the function of LH in the menstrual cycle and when does its blood concentration reach a peak?

The increase in the blood concentration of estrogen with the growing of the ovarian follicle causes the hypophysis to secrete LH. In this phase LH acts

together with FSH promoting the maturation of the follicle that at the 14th day ruptures releasing the female gamete (ovulation). After the release of the ovum LH acts stimulating the formation of the corpus luteum, a structure made from the remaining follicular mass. The LH concentration is at maximum at the 14th day of the cycle.

16. What are the hormones that promote the release of the female gamete from the follicle and at which day of the menstrual cycle does this phenomenon happen? What is this event called?

The hormones that promote the release of the ovum from the follicle are FSH and LH, hormones found in maximum blood concentration around the 14th day of the cycle. The release of the female gamete from the ovary is called ovulation. Ovulation happens at (around) the 14th day of the menstrual cycle.

17. How does the female gamete move from the ovary to the uterus?

The female gamete released from the ovary falls into the surrounding abdominal cavity and is collected by the Fallopian tube. The internal epithelium of the uterine tubes has ciliated cells that move the ovum or the fecundated egg cell towards the uterus.

18. How long after ovulation must fecundation occur to be effective?

If fecundation does not occur approximately 24 hours after ovulation the released ovum often dies.

19. What is the structure into which the follicle is transformed after ovulation? What is the importance of that structure in the menstrual cycle?

The follicle that released the ovum suffers the action of LH and is transformed into the corpus luteum. The corpus luteum is very important because it secretes estrogen and progesterone.

These hormones prepare the uterine mucosa, also known as endometrium, for nidation (implantation of the zygote in the uterine wall) and embryonic development since they stimulate the thickening of the mucous tissue, increase its vascularity and make the appearing of uterine glycogen-producing glands.

20. What is the importance of the uterine glycogen-producing glands?

The uterine glands produce glycogen that can be degraded into glucose to nourish the embryo before the complete development of the placenta.

Biology Questions and Answers

21. How does the hypophysis-corpus luteum negative feedback work? What is the name given to the atrophied corpus luteum after this feedback process?

After ovulation the estrogen and progesterone secretions from the corpus luteum inhibit the hypophyseal FSH and LH secretions (this happens by inhibition of GnRH, gonadotropin-releasing hormone, a hypothalamic hormone). The blood concentration of these adenohypophyseal hormones falls to basal levels again. As LH lowers the corpus luteum (luteum means "yellow") becomes atrophic and turns into the corpus albicans ("white"). With the regression of the corpus luteum the production of estrogen and progesterone ceases.

22. In hormonal terms why does menses occur?

Menses is the endometrial monthly desquamation that occurs as the estrogen and progesterone levels fall after the regression of the corpus luteum because these hormones, mainly progesterone, can no longer support and maintain the thickening of the endometrium.

23. What is the explanation for the bleeding that accompanies menses?

The hemorrhage that accompanies menses occurs because the endometrium is a richly vascularized tissue. The rupture of blood vessels of the uterine mucosa during the menstrual desquamation causes the bleeding.

24. Which are the phases of the menstrual cycle?

The menstrual cycle is divided into two main phases: the follicular (or menstrual) phase and the luteal (or secretory) phase.

The menstrual phase begins at the first day of menses and lasts until ovulation (around the 14th day). The luteal phase begins after ovulation and ends when menses begins (around the 28th day).

25. Including main events and hormonal changes how can the menstrual cycle be described?

One can imagine a cycle like an analog clock at which at 0 o'clock is the beginning and the end of the menstrual cycle and that 6 o'clock corresponds to the 14h day of the cycle.

At 0 o'clock the menses and so the menstrual cycle begins and FSH blood level begins to increase. Around 2 o'clock the maturing follicles under FSH action are already secreting estrogen and the endometrium is thickening. Around 3 o'clock estrogen is intensely stimulating the increase of LH blood level. At 6 o'clock (the 14th day) LH is at its maximum concentration and FSH also at high levels to promote ovulation,

LH then stimulates the formation of the corpus luteum. Around 7 o'clock the corpus luteum is already secreting a great amount of estrogen and progesterone and the endometrium thickens even more, concomitant lowering of FSH and LH occurs with the increasing of the ovarian hormones. Around 11 o'clock the reduced LH and FSH levels make the corpus luteum turn into the corpus albicans, the production of estrogen and progesterone ceases and the endometrium regresses. At 0 o'clock again (28th day) the endometrium desquamates and a new menstrual cycle begins.

26. In general what is the phase of the menstrual cycle when copulation may lead to fecundation?

Although this is not a rule, to be effective fecundation in general must occur within about 24 hours after ovulation (that occurs around the 14th day of the menstrual cycle). Fecundation may occur even if copulation took place up to 3 days before ovulation since the male gametes remain viable for about 72 hours within the female reproductive system.

The fertile period of the women however is considered the period from 7 days before ovulation to 7 days after ovulation.

27. What is the part of the female reproductive system where fecundation occurs?

Fecundation generally occurs in the Fallopian tubes but it can also take place within the uterus. There are cases when fecundation may occur even before the ovum enters the uterine tube, a fact that may lead to a severe medical condition known as abdominal pregnancy.

28. How does the sexual arousal mechanism in women facilitate fecundation?

During sexual arousal in women the vagina secretes substances to neutralize its acidity thus allowing the survival of sperm cells within it. During the female fertile period hormones make the mucus that covers the internal surface of the uterus less viscous to help the passage of sperm cells to the uterine tubes. During copulation the uterine cervix advances inside the vagina to facilitate the entering of male gametes through the cervical canal.

29. What is nidation? In which phase of the menstrual cycle does nidation occur?

Nidation is the implantantion of the embryo in the uterus. Nidation occurs around the 7th day after fecundation, i.e., 7 to 8 days after ovulation (obviously, it occurs only if fecundation also occurs). Since it occurs in the luteal phase the progesterone level is high and

the endometrium is in its best condition to receive the embryo.

30. What is tubal pregnancy?

Many times fecundation takes place in the Fallopian tubes. Generally the newly formed zygote is taken to the uterus where nidation and the embryonic development occur. In some cases however the zygote cannot go down to the uterus and the embryo implants itself in the uterine tube tissue, characterizing the tubal pregnancy. Tubal pregnancy is a severe clinical condition since often the tube ruptures during gestation causing hemorrhage and even death of the woman. The most common treatment for tubal pregnancy has been surgery.

31. How do hormonal tests to detect pregnancy work?

Laboratory tests to detect pregnancy commonly test for human chorionic gonadotropin (HCG) concentration in blood or urine samples. If the level of this hormone is abnormally high, pregnancy is likely.

32. Does the hypophysis-ovaries endocrine axis work in the same way during pregnancy as in non-pregnant women? If pregnancy does not occur how does another menstrual cycle begin?

The functioning of the hypophysis is altered during pregnancy. Since estrogen and progesterone levels remain elevated during the gestational period the production of GnRH (gonadotropin-releasing hormone) from the hypothalamus is inhibited. The lack of GnRH thus inhibits the secretion of FSH and LH from the hypophysis and a new menstrual cycle does not begin.

If pregnancy does not occur the lowering of estrogen and progesterone levels stimulates the production of GnRH by the hypothalamus. This hormone then hastens the adenohypophyseal secretion of FHS and LH that in their turn stimulate the maturation of follicles and the beginning of a new menstrual cycle.

33. What is the endocrine function of the placenta?

The placenta besides being the organ through which the exchange of substances between the mother and the fetus is done also has the function of secreting estrogen and progesterone to keep a high level of these hormones during pregnancy. (The placenta still secretes other hormones like human placental lactogen, that act similarly to the hypophyseal hormones that regulate reproduction, and HCG, human chorionic gonadotropin.)

34. How do contraceptive pills generally work?

Contraceptive pills generally contain the hormones estrogen and progesterone. If

taken daily from the 4th day after menses the abnormal elevation of these hormones acts upon the hypophysis-hypothalamus endocrine axis inhibiting the FSH and LH secretions. Since these hormones then do not reach their normal high levels during the menstrual cycle ovulation does not occur.

(Treatment with contraceptive pills must be initiated under medical supervision.)

35. What are the common contraindications of the contraceptive pills?

There are medical reports associating the use of contraceptive pills with vomiting, nausea, vertigo, headaches, hypertension and other pathological conditions. Some research has attempted to relate the medical ingestion of estrogen and progesterone with increased propensity to cardiovascular diseases (like infarction, strokes and thrombosis) and to malignant neoplasias (cancers). Doctors must always be asked about the risks and benefits of the contraceptive pill prior to use.

36. What are the most common methods of male and female surgical sterilization?

Vasectomy is the most common method of surgical sterilization in men. In vasectomy the vas deferens inside the scrotum are sectioned and closed at a section which will forbid the sperm cells to follow to the ejaculatory duct but still allowing the release of seminal fluid during ejaculation.

Surgical sterilization of women is often done by bilateral tubal ligation. With tubal ligation the ovum does not pass to the uterus so the sperm cells cannot reach it.

37. How does the contraceptive diaphragm work? What are the limitations of this contraceptive method?

The contraceptive diaphragm is an artifact made of latex or plastic that when placed on the vaginal fundus covers the uterine cervix forbidding the passage of sperm cells through the cervical canal. To be more effective the diaphragm needs to be used together with spermicide. This method however does not prevent sexually transmitted diseases (STDs).

38. Why is the use of condoms not just a contraceptive method but also a health protection behavior?

The use of condoms besides being an efficient contraceptive method also helps the prevention of diseases caused by sexually transmitted agents (STDs), like syphilis, gonorrhea, HPV (human papilloma virus that may lead to genital cancers) infestation, HIV infection, etc.

Biology Questions and Answers

39. What is the normal duration of the menstrual cycle? How does the calendar contraceptive method work?

The normal duration of the menstrual cycle is 28 days but it can vary among different women or in different cycles of the same woman.

In the calendar contraceptive method the date n-14 (n minus 14) is taken considering n the number of days of the normal menstrual cycle of the woman (generally n=28). The safety margin +3 or –3 refers to the days around n-14 that intercourse should be avoided to prevent pregnancy. (This method is not exempt from failures. A doctor must always be consulted before relying on any contraceptive method.)

40. How is the ovulation date estimated with the control of the woman's body temperature?

One method to estimate the exact ovulation day is daily control of the body temperature taken always under same conditions. At the ovulation day the body temperature often increases about 0.5 degrees centigrade.

41. What is the contraceptive mechanism of the IUD?

The IUD (intrauterine device) is a piece of plastic coated with copper that is inserted within the uterus by a doctor. Copper is then gradually released (IUD may last 5 to 10 years) and since it has a spermicidal action sperm cells are destroyed before fecundation. Besides this mechanism the movement of the IUD inside the uterus causes slight endometrial inflammation that helps to prevent nidation.

42. Generally how does a male animal realize that the female is receptive to copulation?

In most vertebrate species with internal fecundation the females have reproductive cycles with fertile periods. During this period the female secretes pheromones (odoriferous substances that attract the male of the species) from the skin and mucosae. The presence of the male individual and his pheromones also stimulates the release of pheromones by the female. (Many animals also use pheromones for territorial demarcation and for signal transmission between individuals about the location of dangers and food.)

43. What is parthenogenesis?

Parthenogenesis is the reproduction or formation of a new individual from the egg cell but without fecundation by the male gamete. According to the species, individuals born by parthenogenesis may be male or female, or of any sex.

In bees the drone (the single male bee) is haploid and born by parthenogenesis while the females (queen and workers) are diploid.

Biology Questions and Answers

Biology Questions and Answers

Embryology

Biology Questions and Answers

Biology Questions and Answers

Embryonic Development

1. What is the cell division process directly related to the embryonic growth?

The embryonic growth depends directly on mitosis. Through this type of cell division the zygote divides itself giving birth to a series of cells that by mitosis also compose differentiated tissues and organs until the formation of a complete individual.

2. What is the function of the vitellus in the vertebrate egg? How are these eggs classified according to the amount of vitellus within them?

Vitellus (yolk) is the nutritive material that accumulates in the cytoplasm of the egg (zygote) with the function of nourishing the embryo. According to the amount of vitellus in them, the vertebrate eggs are classified as oligolecithal (little yolk), centrolecithal, or heterolecithal (more yolk diffusely distributed) and telolecithal (more yolk concentrated in one end of the egg).

3. What are the animal pole and the vegetal pole of the vertebrate egg?

The animal pole of a telolecithal egg is the portion of the egg with little vitellus, it is opposite to the vegetal pole which is the region where the yolk is concentrated.

4. What are the four initial stages of the embryonic development?

The four initial stages of the embryonic development are the morula stage, the blastula stage, the gastrula stage and the neurula stage.

5. What is the cell division during the first stage of the embryonic development called? How is this stage characterized?

The cell division in the first stage of the embryonic developments is called cleavage, or segmentation. In this stage several mitoses occur from the zygote forming the new embryo.

6. What are the cells produced in the first stage of the embryonic development called?

The cells that result from the cleavage (the first stage of the embryonic development) are called blastomeres. In this stage the embryo is called morula (similar to a “morus”, mulberry).

Biology Questions and Answers

7. After the morula stage what is the next stage? What is the morphological feature that defines this stage?

After passing the morula stage in which the embryo is a compact mass of cells, the next stage is the blastula stage. In the blastula stage the compactness is lost and an internal cavity filled with fluid appears inside, the blastocele.

8. After the blastula stage what is the following stage of the embryonic development? What is the passage from blastula to the next stage called?

The blastula turns into gastrula in a process known as gastrulation.

9. What is gastrulation? How during gastrulation are the first two germ layers formed? What are these germ layers?

Gastrulation is the process through which a portion of the blastula wall undergoes invagination inside the blastocele, forming a tube called archenteron (primitive intestine). The cells of the inner side of the tube form the endoderm (germ layer) and the cells of the outer side form the ectoderm (another germ layer). It is the beginning of the tissue differentiation in embryonic development.

10. What are the archenteron and the blastopore? What is the stage of the embryonic development in which these structures are formed? What are the destinations of the archenteron and of the blastopore?

Archenteron is the tube formed during gastrulation by means of invagination of the blastula wall inside the blatocele. It is the origin of the gastrointestinal tract. Blastopore is the opening of the archenteron to the exterior. The blastopore gives birth to one of the extremities of the digestive tube: the mouth in protostome beings, or the anus in deuterostome beings.

11. How is the mesoderm (third germ layer) of triploblastic animals formed?

The mesoderm appears from differentiation of endodermal cells that cover the dorsal region of the archenteron.

12. What are the three types of germ layers that form tissues and organs in animals?

The three germ layers are the ectoderm, the mesoderm and the endoderm.

Biology Questions and Answers

13. How are animals classified according to the germ layers present in their embryonic development?

Cnidarians are diploblastic, i.e., they present only endoderm and ectoderm. With the exception of poriferans, all remaining animals are triploblastic. Poriferans do not present differentiated tissue organization and so they do not classify regarding germ layers (although sometimes they are mentioned as diploblastic).

14. How does the embryo turn from gastrula into neurula? How is the neural tube formed? What is the embryonic origin of the nervous system in vertebrates?

The neurula stage is characterized by the appearance of the neural tube along the dorsal region of the embryo. The growth of mesoderm in that region induces the differentiation of ectodermal cells just above. These cells then differentiate forming the neural tube. So the origin of the nervous system is the ectoderm (the same germ layer that gives birth to the skin).

15. What is the notochord? How is this structure formed?

The notochord is a rodlike structure that forms the supporting axis of the embryo and gives birth to the vertebral column in vertebrates. It is formed by differentiation of mesodermal cells.

16. What is the coelom? To which structures do coeloms give birth? Are all animals coelomate?

Coeloms are cavities delimited by mesoderm. Coeloms originate the cavities where the internal organs of the body are located, like the pericardial cavity, the peritoneal cavity and the pleural cavity.

Besides coelomate animals, there are acoelomate animals, like platyhelminthes, and pseudocoelomate animals, like nematodes.

17. What is the germ layer from which the coeloms originate?

The coeloms are originated from mesoderm.

18. What are pleura, pericardium and peritoneum?

Pleura is the membrane that covers the lungs and the inner wall of the chest; pericardium is the membrane that covers the heart; peritoneum is the membrane that covers most organs of the gastrointestinal tract and part of the abdominal cavity. All these membranes delimit coeloms (internal cavities).

Biology Questions and Answers

19. After the neurula stage and from its ventral portion to the dorsal how can the morphology of the embryo be described?

In a schematic longitudinal section of the embryo after the neurula stage, the outermost layer of cells is the ectoderm. In the ventral region comes the archenteron tube formed of endodermal cells. In both sides of the embryo coeloms delimited by mesoderm are present. In the central region above the archenteron and in the middle of the coeloms there is the notochord. In the dorsal region just above the notochord lies the neural tube.

20. What are somites?

Somites are differentiated portions of mesodermal tissue longitudinally distributed along the embryo. The somites originate the muscle tissue and portions of the connective tissues.

21. What are histogenesis and organogenesis?

Histogenesis is the process of tissue formation in the embryonic development. Organogenesis is the process of organ formation. Before histogenesis and organogenesis the primitive embryonic structures have been already formed: germ layers, neural tube, notochord, coeloms, somites.

22. From which germ layer do the epidermis and the nervous system originate? What are other organs and tissues made from that germ layer?

Epidermis and nervous system have the same embryonic origin: the ectoderm. The epidermal appendages (like nails, hair, sweat glands and sebaceous glands), the mammary glands, the adenohypophysis, the cornea, the crystalline lens and the retina are also derived from ectoderm.

23. From which germ layer do blood cells originate? What are other organs and tissues made from that germ layer?

Blood cells have a mesodermal embryonic origin. Other organs made from mesoderm are: covering serous membranes like the pericardium, the peritoneum and the pleura, muscles, cartilages, dermis, adipose tissue, kidneys, ureters, bladder, urethra, gonads, blood and lymph vessels, bones.

24. From which germ layer do the liver and the pancreas originate? What are other organs and tissues made from that germ layer?

The liver and the pancreas are originated from the endoderm. Also from endodermal origin are the epithelia of the airway, the epithelia of the

bladder, of the urethra and of the GI tube (except of the mouth and anus), the alveolar cells of the lungs and the thyroid and parathyroid glands.

25. What are twins? Genetically what are the two types of twins that can be generated?

Twins are simultaneously generated (within the mother's uterus) offspring. Twins classify according to zygosity as monozygotic or as dizygotic twins.

Monozygotic twins, also known as identical twins, are those originated from one single fertilized ovum (therefore from one single zygote); monozygotic twins are genetically identical, i.e., they have identical genotypes and are necessarily of the same sex. Dizygotic twins, also known as fraternal twins, are those generated from two different ova fecundated by two different sperm cells; so they are not genetically identical and they are not necessarily of the same sex.

26. What is polyembryony?

Polyembryony is the phenomenon in which a single embryo in its initial embryonic stage divides itself forming many new individuals of the same sex and genetically identical. This is the way, for example, in which reproduction takes place in armadillos of the genus Dasypus. Polyembryony is an example of natural "cloning".

Extraembryonic Membranes

1. What are extraembryonic membranes?

Extraembryonic membranes are membranous structures that appear in parallel with the embryo and play important roles in the embryonic development. They form from the embryo but do not become part of the individual organism after its birth.

2. What are the extraembryonic membranes present in vertebrates?

The extraembryonic membranes that may be present in vertebrates are the yolk sac, the amnion, the chorion, the allantois and the placenta.

3. Are the extraembryonic membranes the same in all vertebrates?

The presence of each extraembryonic membrane varies according to the vertebrate class.

In fishes and amphibians only the yolk sac is present. In reptiles and birds besides the yolk sac there are also the amnion, the chorion and the allantois.

In placental mammals besides all these membranes the placenta is present too.

4. How is the yolk sac formed? What is the function of the yolk sac?

The yolk sac is formed from the covering of the vitellus by some cells originated from the primitive gut.

The yolk sac stores vitellus, the main nourishment source of non-placental embryos.

5. Which is the extraembryonic membrane whose function is to store nitrogen wastes of the embryo? Is this function present in placental mammalian embryos?

The allantois is the extraembryonic membrane whose function is to store the excreted matter of the embryo.

In placental mammals the allantois is present but it does not exert that function since the embryonic wastes are collected by the mother’s body through the placenta.

Biology Questions and Answers

6. Why can the allantois be considered an adaptation to terrestrial life?

The allantois is an adaptation to dry land because in embryos of oviparous terrestrial beings, like reptiles and birds, the metabolic residuals cannot be immediately excreted to the aquatic surrounds (as fishes and amphibian larvae do). It was necessary then for the appearance of a structure capable of storing the embryonic excretes until hatching.

7. What is the difference between amnion and chorion?

Amnion is the membrane that covers the embryo. Chorion is the membrane that covers the amnion, the yolk sac and the allantois. The space delimited by the chorion and the amnion is called amniotic cavity and it is filled with aminiotic fluid. The amniotic cavity has the functions of preventing desiccation of the embryo and of protecting it against mechanical shocks.

8. Why can the amnion also be considered an adaptation to terrestrial life?

The amnion is also an adaptation to dry land since one of its functions is to prevent desiccation of the embryo.

9. What is the chorioallantois membrane present in the embryonic development of reptiles and birds? How does this membrane participate in the energetic metabolism of the embryo?

The chorioallantois membrane is formed by juxtaposition of some regions of the chorion and the allantois. Since it is porous, the chorioallantois membrane allows the passage of gases between the embryo and the exterior thus making aerobic cellular respiration possible.

10. In which type of animals does the placenta exist? What is its main function?

True placenta is present in placental mammals.

The placenta is formed from the chorion of the embryo and from the mother's endometrium. Its main function is to allow the exchange of substances between the fetus and the mother's body.

11. What are the main substances transferred from the mother to the fetus through the placenta? And from the fetus to the mother?

From the mother to the fetus the main transferred substances through the placenta are water, oxygen, nutrients

and antibodies. From the fetus to the mother, metabolic wastes, including urea (nitrogen waste), and carbon dioxide.

12. Is there a exchange of cells between the mother and the fetus through the placenta?

Under normal conditions, there is no passage of cells across the placenta during gestation. The placenta has a smooth mucosa separating the richly vascularized region in contact with the mother's endometrium from the umbilical cord in contact with the fetal blood. This barrier is known as placental barrier. Although permeable to some substances (selective permeability) the placental barrier forbids the passage of cells.

13. What are the endocrine functions of the placenta?

The placenta has endocrine function since it secretes the hormones progesterone and estrogen that maintain the endometrium (internal covering of the uterus) and prevent menses during pregnancy. The placenta also secretes other important hormones for pregnancy regulation.

14. What is the function of the umbilical cord?

The umbilical cord is a set of blood vessels that connects the fetus with the placenta. In the fetus one extremity of the cord inserts into the center of the abdominal wall (the later scar of this insertion is the umbilicus or navel).

The function of the umbilical cord is to allow the transport of substances, nutrients, gases and residuals, between the fetus and the mother's body.

Biology Questions and Answers

Botany

Biology Questions and Answers

Biology Questions and Answers

Plant Classification

1. What are the main cellular features of the beings of the plant kingdom?

The typical plant cells are eukaryotic (have nucleus), autotrophic (produce their own food) and photosynthetic (use light to make food). Plant cells also have chloroplasts and a cell wall (a structure exterior to the plasma membrane) made of cellulose.

2. How different are animal cells from plant cells?

While plant cells are eukaryotic, autotrophic, photosynthetic and have chloroplasts and cell wall, the animal cells are eukaryotic, heterotroph and do not present chloroplasts nor cell wall.

3. Do plants have tissue organization and specialized organs?

Plants have specialized organs (like reproductive organs, roots, limbs, leaves) and differentiated tissues (vascular tissue in tracheophytes, support tissue, parenchyma, etc.)

4. What are the subkingdoms into which the plant kingdom is divided?

The kingdom Plantae is divided into two big subkingdoms: the bryophytes and the tracheophytes (pteridophytes, gymnosperms and angiosperms). The criterion for the division is the presence or not of conductive (vascular) tissue.

5. What is the difference between bryophytes and tracheophytes?

Bryophytes are nonvascular plants (mosses, liverworts, hornworts), i.e., they do not have a conductive system for transport of sugar, water and nutrients. Tracheophyte plants are vascular plants, they have conductive structures.

6. What are the four main groups into which the study of the plants is divided?

In Botany the plant kingdom is divided into bryophytes, pteridophytes, gymnosperms and angiosperms.

7. What is the difference between cryptogamic and phanerogamic plants?

Cryptogamic (hidden sex organs) plants are those that do not present flowers or

seeds. They comprise the bryophytes and the pteridophytes.

Phanerogamic plants are those having seeds. They comprise the gymnosperms and the angiosperms.

8. What are the two divisions of the angiosperms?

The angiosperms are divided into monocotyledonous and dicotyledonous. (These categories are explained later in this text.)

9. What are the three basic sexual life cycles studied in Biology? Which of them corresponds to metagenesis? Which of them is the human life cycle?

Sexual reproduction may take place through three different types of life cycles: the haplontic (the being is haploid) haplobiontic (a single type of being) cycle; the diplontic (the being is haploid) haplobiontic (a single type of being) cycle; and the diplobiontic cycle (two types of beings, one haploid and the other diploid). The diblobiontic cycle is known as alternation of generations, or metagenesis. In humans the cycle is diplontic haplobiotic (a single diploid being).

10. What respectively are zygotic meiosis, gametic meiosis and sporic meiosis?

Zygotic meiosis is the one that occurs in the haplontic haplobiontic life cycle. Gametes from adult haploid individuals unite forming the diploid zygote. The zygote undergoes meiosis and generates four haploid cells that by mitosis develop into adult individuals. Therefore in the zygotic meiosis the cell that undergoes meiosis is the zygote and the gametes are formed by mitosis.

Gametic meiosis is that in which meiosis produces gametes, i.e., haploid cells that each of which can unite with another gamete forming the zygote. It occurs in the diplontic haplobiontic life cycle (e.g., in humans) in which the individual is diploid and meiosis forms gametes.

Sporic meiosis happens in metagenesis (alternation of generations, or diplobiontic life cycle). In this life cycle cells from the diploid individual (called sporophyte) undergo meiosis producing haploid spores that do not unite with others but instead develop by mitosis into haploid individuals (called gametophytes). In this life cycle the gametes are made by mitosis from cells of the gametophyte.

11. Are gametes always made by meiosis?

In the plant life cycle (diplobiontic life cycle) and in the haplontic haplobiontic life cycle gametes are made by mitosis and not by meiosis. Obviously in some

stage of these sexual life cycles meiosis must occur.

12. Why is the plant life cycle known as alternation of generations?

The plant life cycle is known as alternation of generations because in this cycle there are two different forms of living beings that alternate each other, one haploid and the other diploid. Alternation of generations is also called the diplobiontic cycle, or metagenesis, and it does not occur only in plants, other living beings, like cnidarians, present the cycle.

13. For each of the three types of life cycles what is the respective ploidy of the individual that represents the adult or lasting form?

In the haplontic haplobiontic life cycle the single and lasting form is haploid. In the diplontic haplobiontic life cycle it is diploid. In the diplobiontic life cycle the lasting individual that alternates with the intermediate form may be the haploid gametophyte (as in bryophytes) or the diploid sporophyte (as in pteridophytes).

14. Do plants present only sexual reproduction?

There are asexual forms of reproduction in plants. Some naturally detached pieces of root, limbs or leaves develop into another complete individual. Artificial asexual reproduction of plants can be obtained by means of grafting or cutting.

Biology Questions and Answers

Bryophytes

1. What are the main characteristics of the bryophytes?

Bryophytes are nonvascular plants, i.e., they do not have conductive tissues and they perform transport of water and nutrients by diffusion; they are cryptogamic, i.e., they do not present flowers or seeds; they are small in size; they present water-dependant fecundation; in their life cycle the lasting form is haploid (the gametophyte) and the sporophyte depends on the gametophyte to survive.

2. What are the main bryophyte groups?

The main bryophyte groups are the mosses, the liverworts and the hornworts.

3. How is the transport of substances done across the bryophyte tissues? How is this feature related to the general size of these plants?

In bryophytes there are no water-conducting or nutrient-conducting structures and the transport of these substances is done by cell to cell diffusion. The small size of bryophytes relates to this feature since if there are no conductive vessels it is not viable to have cells too far from each other (the emergence of the conductive tissues in tracheophytes allowed their increase in size).

4. What is the life cycle type of bryophytes?

As in all plants the life cycle of bryophytes is diplobiontic (alternation of generations). In bryophytes the lasting form is the haploid one.

5. In general where is the sporophyte positioned in relation to the gametophyte in bryophytes? How does the sporophyte obtain nutrients?

The bryophyte sporophyte in general is a tiny long stem that grows on the top of the gametophyte. The sporophyte depends totally upon the gametophyte to obtain nutrients.

6. Why can the bryophytes be considered the "amphibians of the plant world"?

Like adult amphibians, the bryophytes live in the terrestrial environment but they depend on water to reproduce. For this reason the nickname is justified.

Biology Questions and Answers

Pteridophytes

1. What are the main representatives of the pteridophytes? Is this plant group cryptogamic or phanerogamic?

The better known pteridophytes are the ferns and the maidenhairs, from the filicinae (filicopsida) group, and the selaginellas, mosslike plants from the lycopodineae group (lycopsida). Pteridophytes are cryptogamic plants, i.e., they are flowerless and seedless.

2. How different are pteridophytes from bryophytes regarding substance transport?

Pteridophytes are tracheophyte (vascular) plants, i.e., they have tissues specialized in conduction of water and nutrients. Bryophytes are nonvascular plants. In pteridophytes therefore the substance transport is done through vessels and in bryophytes that transport occurs by diffusion.

3. Why are pteridophytes better adapted to dry land than bryophytes? Were pteridophytes always less abundant than phanerogamic plants?

Although bryophytes and pteridophytes have water-dependant gametes for fecundation the emergence of conductive vessels in this last group facilitated life in a terrestrial environment. The conductive vessels of the pteridophytes collect water from the moist soil and distribute it to the cells. Bryophytes do not have this option and they depend entirely on the water that reaches the aerial part of the plant and so they need to live in humid or rainy places.

Before the ascension of the phanerogamic plants (plants that present seeds) the pteridophytes were the plants that predominated in the terrestrial environment. The large pteridophyte forests of the Carboniferous period (named after the pteridophytes) are responsible for the formation of coal deposits, mainly in Europe, Asia and North America; the Carboniferous period occurred between 290 and 360 million years ago and is part of the Paleozoic era.

4. What is the evolutionary importance of pteridophytes?

As the first tracheophytes, pteridophytes were also the first plants to extensively colonize the terrestrial environment forming forests. They also

constituted an important source of food for terrestrial animals. By presenting conductive vessels they could be larger, a feature inherited from them by phanerogamic plants.

5. What are the main parts of ferns?

Ferns are constituted by small roots that come downwards from the rhizome (stem, often horizontalized). The fronds also arise from the rhizome. On the back side of each leaf of the plant there are small dustlike dots called sori (singular, "sorus", also known as "seeds").

6. What is the type of life cycle present in pteridophytes?

Like all plants pteridophytes present diplobiontic (alternation of generations, or metagenesis) life cycle.

7. Why are pteridophytes more common in humid places?

Pteridophytes are more common in humid places because they depend on water for their gametes to fecundate one another. In humid environments their reproduction is more intense and they proliferate.

8. What is the structure of the adult fern within which cells undergoing meiosis can be found?

In these plants meiosis takes place within structures called sorus (plural, sori), small dustlike brown dots lining the underside of fern leaves. The sori contain sporangia where reproductive cells undergo meiosis and where spores are produced.

9. What is the prothallus of pteridophytes?

Prothallus is the pteridophyte gametophyte (the haploid individual that forms gametes). The gametophyte develops by mitosis from a spore.

10. How are gametes formed in the pteridophyte life cycle, by mitosis or meiosis? What is the type of meiosis that occurs in pteridophytes?

In pteridophytes gametes are made by mitosis from special cells of the gametophyte. As in all plants, in pteridophytes, meiosis is sporic, i.e., cells of the sporophyte undergo meiosis and generate spores that then by mitosis develop into the gametophyte.

11. What is the lasting form in pteridophytes, the gametophyte or the sporophyte? How can it be compared to bryophytes?

The lasting form in pteridophytes is the diploid (2n) sporophyte (the fern itself, for example). In bryophytes the lasting form is the gametophyte (n).

12. What is xaxim?

Most pteridophytes have subterraneous stems parallel to the substrate called rhizomes. Xaxim is a type of pteridophyte with an aerial stem generally perpendicular to the soil and from which hundreds of roots arise to absorb water from the environment. The xaxim stem is used to make flower pots and other plant supports for gardening (also popularly known as xaxim).

Biology Questions and Answers

Gymnosperms

1. What are the main divisions and representing species of the gymnosperms?

This group of plants can be divided into conifers (pine, sequoia, cypress), that have flowers known as strobiles (cones), cycads (very ancient gymnosperms, like the cycads used in garden architecture, that also form strobiles), gnetaceae (gnetum) and ginkgos (the known species is Ginkgo biloba).

2. How different are gymnosperms from bryophytes and pteridophytes?

Gymnosperms are not cryptogamic as bryophytes and pteridophytes are. They are phanerogamic and so they form flowers and seeds.

3. What is the evolutionary importance of the emergence of seeds in the plant kingdom?

The evolutionary importance of the seed is related to the plant capability of distant colonization and to the protection of the embryo. Embryo-containing seeds can be carried by water, wind and animals and germinate in different environments. This fact contributes to the exploration of a variety of ecological niches and for the diversity of plant species.

Seeds in addition protect the plant embryo against external aggressions and they also provide germination under more adequate conditions (inside the seed). These features contribute to the evolutionary success of the phanerogam.

4. In which areas of the globe is gymnosperm abundance noteworthy?

These plants are the typical vegetation of cold regions like the taiga, or boreal forest, of the northern hemisphere, or the araucaria forests of the southern hemisphere.

5. What is the life cycle of the gymnosperms?

As all plants they present a diplobiontic life cycle, i.e., alternation of generations with diploid and haploid stages. The lasting (final) stage is the diploid one.

6. What is pollen?

Pollen grains are the male gametophytes of the phanerogamic (flowering) plants. Therefore within the pollen grains the male gametes of these plants are formed by mitosis.

Biology Questions and Answers

7. How are the male gametes of gymnosperms formed? What is the relationship between the pollen grains and the concept of alternation of generations?

In the male strobiles (cones) there are microsporophylls (fertile leaves of the strobile) that contain microsporangia. Within the microsporagium spore mother cells undergo meiosis and generate haploid microspores. The microspore wall develops into winglike projections (to facilitate its aerial propagation) and mitosis occurs producing two cells, the generative cell and the tube cell. The final structure containing these elements is the pollen grain.

The pollen grain relates to the alternation of generations since it is the male gametophyte (the haploid stage of the life cycle).

8. How are the female gametes of gymnosperms formed? What is the relationship between this process and the concept of alternation of generations?

In the female strobiles (cones) there are megasporophylls (fertile leaves of the strobile) that contain megasporangia. In the megasporangium the spore mother cell undergoes meiosis generating four haploid cells of which three regress and one gives birth to the functional megaspore. The functional megaspore by several mitosis forms the female gametophyte that contains the oospheres (female gametes) of the plant. The female gametophyte is located within the megasporangium that has a small opening, the micropyle, through which the pollen tube enters.

The process is related to the diplobiontic life cycle (alternation of generations) since the functional megaspore generates the haploid stage of the plant (the female gametophyte).

9. How do fecundation and zygote formation occur in these plants? Do these processes depend on water?

The microsporangia in the male strobile rupture at the right period of the year releasing thousands of pollen grains. Since their pollen grains are “winged” they can be transported by the wind over distances. When the pollen grains fall into the female strobiles they pass the micropyle and enter the pollen chamber. This process is called pollination.

Within the pollen chamber the generative cell nucleus divides forming two gametic nuclei and the tube cell elongates forming the pollen tube. The pollen tube penetrates the female gametophyte and the gametic nuclei (also known as sperm nuclei) pass through the tube; one of them unites with an oosphere (the female gamete) and forms the zygote (2n). Generally fecundation occurs one year after pollination and during this time interval the maturation of the male and of the female gametes takes place.

The fecundation in these plants is independent from water. The gametophytes however are entirely dependent on the sporophyte (the adult plant) for nutrition and hydration.

10. How are the gymnosperm seeds formed? What are the ploidies of the structures that compose the seeds?

Their seeds are formed from differentiation of the megasporangia in the female strobiles (cones). After an oosphere is fecundated the female gametophyte originates the haploid (n) primary endosperm (nutritive tissue that covers the embryo) and the covering of the megasporangium turns into the diploid (2n) seed shell.

Biology Questions and Answers

Angiosperms

1. What are angiosperms, the flowering plants? What is the main feature that distinguishes them from the gymnosperms?

Flowering plants have flowers and seeds (phanerogamic plants). They differ from gymnosperms by having their seeds within fruits.

2. What are the two main groups into which flowering plants are divided?

Angiosperm plants are divided into monocotyledonous (monocots) and dicotyledonous (dicots).

3. What are the main morphological differences between monocot plants and dicot plants?

The main differentiation criteria between monocots and dicots are: number of cotyledons (seed leaf) in seeds, one in monocots and two in dicots; pattern of leaf veins, parallel in monocots, reticulated in dicots; multiplicity of petal number, multiples of three in monocots, multiples of four or five in dicots; position of vascular bundles in the stem, scattered in monocots, concentrically ringed in dicots.
Grasses, banana tree, sugar cane, orchids are examples of monocots.
Sunflowers, oaks and waterlilies are examples of dicots.

4. What are the androecium and the gynoecium? What are the other structures of flowers?

Androecium is the set of male reproductive structures of flowers. It comprehends the stamens formed of filament and anther; one flower has one androecium that may have one or several stamens. Gynoecium is the set of female reproductive structures of flowers. It generally is composed of a single pistil that includes the stigma, the style and the ovary. The androecium usually surrounds the central gynoecium.

Besides the androecium and the gynoecium typical flowers are also made of peduncle, sepals and petals.

5. What is pollination? What are the main forms of pollination?

The process in which pollen grains (the male gametophytes of phanerogamic plants) reach the female gametophyte is called pollination.

The main forms of pollination are: anemophily, in which pollen is carried by wind. Hydrophily, pollination helped

by water; entomophily, pollen carried by insects; ornitophily, pollination by birds; chiropterophily, pollen dissemination by bats.

Characteristics of the flowers of each plant species relate to the type of pollination used by the plant. Colored flowers are specialized in bird and insect attraction; nocturnal flowers generally are white and perfumed, many specialized in pollination by bats; the nectar is also a specialization to attract pollinator animals; flowers that produce an exaggerated amount of pollen often use the wind as pollinator; the position of anthers more external or internal next to the nectar is a way to facilitate the pollen dissemination respectively by the wind or by animals.

6. How are the male gametophytes and the male gametes formed in angiosperms?

In the anthers of each stamen there are pollen sacs. Within the pollen sacs there are microspore mother cells, or microsporocytes. These cells undergo meiosis forming microspores. Each microspore by mitosis forms a pollen grain containing one generative cell and one tube cell. The pollen grain is the male gametophyte.

When pollination occurs and the pollen grain makes contact with the stigma (the apex of the pistil) the tube cell elongates its cytoplasm forming the pollen tube that grows towards the ovary. The generative cell divides forming two sperm nuclei (male gametes) that migrate through the pollen tube.

7. How many cellular nuclei does the pollen tube of angiosperms have? What is the ploidy of each of these nuclei?

The pollen tube that is the mature male gametophyte of angiosperms has three cellular nuclei: two sperm nuclei and one tube cell nucleus.

All those nuclei are part of the male gametophyte of the plant and thus each of them is haploid (n).

8. How is the female gametophyte formed in angiosperms?

In the flower ovary there are megasporangia enclosed by a tegument having a small opening, the micropyle. Within the megasporangium there is a megasporocyte, or megaspore mother cell, that undergoes meiosis forming four megaspores of which three regress and only one is functional. The functional megaspore undergoes (three) mitosis generating eight cells that as a whole form the embryonic sac.

Biology Questions and Answers

9. What is the embryonic sac? Which are the cells that form the embryonic sac? What are their ploidies?

The embryonic sac is the female gametophyte of angiosperms.

The embryonic sac is composed of three cells that remain next to the micropyle, two lateral synergids and the central oosphere (egg); one binucleated cell, the polar nuclei, is placed in the central region; three antipodal cells stay in the opposite side to the micropyle.

Since all these cells come by mitosis from the functional megaspore they are haploid (n).

10. After pollination how does fecundation occur in angiosperms? In these plants is fecundation dependent on water?

After pollination one of the sperm nuclei from the pollen tube unites with the oosphere of the embryonic sac forming the diploid (2n) zygote. The other sperm nucleus fuses with the polar nuclei of the embryonic sac originating a triploid (3n) cell that by mitosis will turn into the secondary endosperm of the seed. The synergids and the antipodal cells degenerate after the fecundation process.

Fecundation in these plants is independent from water.

11. What is the difference between self pollination and cross pollination? Which of these two modes of pollination contributes more to the plant diversity?

Self pollination occurs when pollen grains from a flowering plant fall into the pistils of the same plant and thus gametes from the same individual unite to form a zygote. Cross pollination occurs when pollinators carry pollen grains from a plant to reach other individual plants of the same species thus gametes of different individuals form the zygote.

Since it promotes formation of zygotes containing genes from different individuals (new gene combinations) cross pollination contributes more to biological diversity.

12. What is dichogamy?

Dichogamy is the phenomenon of the maturation of female reproductive structures of the plant in a different period to the maturation of the male reproductive structures. Dichogamy prevents self pollination and makes cross pollination almost obligatory so assisting in an evolutionary strategy to promote genetic recombination.

13. What are the typical structures of the seed? What is endosperm?

A typical seed is composed of the embryo, endosperm and shell. Within seeds of angiosperms there are one or two cotyledons (seed leaf, one in monocots, two in dicots).

The endosperm is the tissue within the seed that has the function of nourishing the embryo.

14. How different are the endosperm of gymnosperms and the endosperm of angiosperms?

In gymnosperms the endosperm is haploid (n), it is called primary endosperm. In angiosperm the endosperm is triploid (3n), it is called secondary endosperm.

15. What are cotyledons?

Cotyledons, or seed leaves, are structures formed by the embryo of angiosperms to absorb nutrients from the endosperm and to store and transfer these nutrients to the embryo. (Cotyledons are auxiliary embryonic structures).

Seeds of monocots have a single cotyledon. Seeds of dicots have two cotyledons.

16. What are the main functions of fruits?

The main functions of fruits are the protection and spreading of seeds.

17. From which floral structure do fruits come?

Fruits are modified ovaries of the flowers.

18. How are fruits formed?

The fecundation in angiosperms triggers the release of hormones that act upon the ovaries. The ovary wall then develops into a fruit that contains the seeds.

19. Are fruits always the flesh part of the "fruits"? Is the edible part of the onion a fruit?

In some so-called fruits the actual fruit is not the flesh part. For example, the flesh part of the strawberry is not the fruit. The fruits are the small hard dots on the surface of the strawberry. Another example: the flesh part of the cashew is not the fruit. The fruit is the nut.

The edible part of the onion is the stem of the plant and not the fruit.

20. Why are there plants having single-seeded fruits and plants having fruits with more than one seed?

Plants that produce single-seeded fruits, for example, mango and avocado, often

have ovaries with only one egg inside. Fruits with more than one seed are originated from plants whose ovaries have more than one egg.

21. What are infructescences, pseudofruits and parthenocarpic fruits?

Infructescences are aggregated fruits formed from inflorescences, aggregated flowers. Grape clusters are examples of infructescences. Pseudofruits are "fruits" not made in the ovaries and in general their true fruits lack development and are found within the flesh, like in apples and pears. Parthenocarpic fruits are those made without fecundation, by means of hormonal stimuli, like bananas.

22. What is the evolutionary importance of the fruits for the angiosperms?

The fruits contain seeds and they can detach from the plant falling on the ground or can serve as food for animals. Therefore with the emergence of fruits the seeds of angiosperms could be transported across long distances contributing to the propagation of the species.

23. What are the trends of the gametophyte in the evolution of plants?

A tendency of the gametophyte evolution in plants has been towards the formation of gametes that are independent from water. In bryophytes and in pteridophytes the fecundation is totally dependent on water. In phanerogamic plants such dependency does not exist.

Another tendency is the reduction in the size and duration of the gametophyte. In bryophytes the gametophyte is indeed the lasting stage. In pteridophytes, gymnosperms and angiosperms it became the temporary stage and its relative size was successively reduced.

A third evolutionary trend relates to the interdependency between gametophytes and sporophytes. In bryophytes the sporophyte is entirely dependent on the gametophyte to survive. In the remaining plants the sporophyte is the independent stage and the once autotrophic gametophyte in bryophytes and pteridophytes became dependent upon the sporophyte in the phanerogamic plants.

Biology Questions and Answers

Plant Tissues

1. How are the plant tissues classified according to their functions?

Plant tissues are divided into growth (embryonic) tissues, supporting, filling and photosynthetic tissues (ground tissues), conductive (vascular) tissues and covering (dermal) tissues.

Embryonic tissues: primary meristems; secondary meristems. Supporting tissues: collenchyma; sclerenchyma. Filling and photosynthetic tissues: photosynthetic parenchyma; storage parenchyma. Conductive tissues: xylem; phloem. Covering tissues: epidermis; periderm.

2. Which are the growth tissues of plants? How do they classify and where can they be found?

The growth tissues of the plants are the meristems. Meristems are the tissues that produce the plant growth giving birth to all other tissues; they are formed of undifferentiated cells having intense cell division rate. Meristems classify as primary meristems and as secondary meristems.

Primary meristems are found in the apex of the stem, in the lateral buds of the stem, in the basis and tips of the shoots and within the root cap. Primary meristems are responsible for the primary growth (lengthening) of the plant.

Secondary meristems are those that make the plant grow in thickness (secondary growth) and they are formed by tissues that thicken the stem: cambium and phellogen (cork cambium).

3. What is the difference between the lateral and the apical buds of the plants?

Lateral buds are portions of meristematic tissue located in the base of the shoots. Apical buds are portions of meristematic tissue situated in the tip of the stem and shoots.

4. What are apical meristems? Which type of plant growth does this meristem promote?

Apical meristems are those primary meristems found in the apex of the stem and in the tips of shoots and roots.

The apical meristems are responsible for the primary growth of the plants.

5. What are lateral meristems? Where can they be found and which type of plant growth do they promote?

Lateral, or secondary, meristems, are the cambium and the phellogen (also known as cork cambium), tissues from the stem, branches and roots that by mitosis generate other tissues. These tissues participate in the secondary growth of plant, i.e., in the thickening of the stem, branches and roots.

6. What are the main features of the meristematic cells? Why do these cells need to have a high mitotic rate?

Meristematic cells have very thin cell walls, small vacuoles, a well-centralized nucleus and they are constantly undergoing mitosis. Meristematic cells need a high mitotic rate because they are responsible for the plant growth.

7. What is the best identification hypothesis for a plant tissue seen under the microscope having most cells undergoing cell division?

The best hypothesis is that the tissue is a sample of meristematic tissue. Meristematic tissues seen under the microscope have many cells undergoing mitosis.

8. Which are the plant tissues responsible for the supporting of the plant?

The plant supporting tissues are the collenchyma and the sclerenchyma.

The collenchyma is made of living and elongated cells that accumulate cellulose and pectin in some regions of the cell wall making them unequally thick and thus providing flexibility.

The sclerenchyma is made mostly of dead cells killed by lignin deposition (lignin is an impermeable biopolymer) forming elongated, rigid and impermeable fibers. The sclerenchyma is a plant tissue widely used in the textile industry.

9. Which is the plant tissue responsible for the filling of the space between other tissues?

The plant-filling tissue is generically called parenchyma. The plant parenchyma can be divided into photosynthetic parenchyma, a tissue that has cells with many chloroplasts and a high photosynthesis rate found mainly in leaves, and storage parenchyma, specialized in the storage of water (e.g., in cactus), starch or air (e.g., in aquatic plants).

10. Where in the leaves is the photosynthetic tissue often located?

The main photosynthetic tissue is the photosynthetic parenchyma (also known as chlorenchyma, do not confuse with collenchyma) often located between the

superior and the inferior epidermis of the leaves.

11. How are water, mineral salts and food (sugar) transported throughout the plant?

Water, mineral salts and sugar are transported throughout the plant through conductive vessels formed by specialized tissues.

12. Which are the specialized conductive tissues of the plants?

The vascular tissues of the plants are the xylem and the phloem. Xylem is the plant tissue that forms the vessels that conduct water and mineral salts absorbed from the soil to the plant cells. Phloem is the plant tissue that forms the vessels that conduct dissolved sugar from the leaves (where they are produced by photosynthesis) to other plant cells.

13. What are the cell types that form the xylem? What are the main features of those cells?

The main cells of the xylem are the tracheids and the vessel elements (these only in angiosperms). The tracheids and the vessel elements are dead cells that have lost their cytoplasm and only their cell wall impregnated with lignin (an impermeable biopolymer) remained. The tracheids form tubes that communicate with neighboring tubes through pores; the vessel elements do not present pores but instead they communicate with the successive vessel element through perforations in their extremities.

14. What are the cell types that form the phloem? What are the main features of those cells?

The main cells that form the phloem are the sieve elements and the companion cells. The sieve elements form the vessel walls; they are living enucleated cells positioned in series forming the sieve tubes. Between successive vessel elements there are communicating pores. The companion cells are located outside and alongside the sieve tubes and they help in the absorption of the material to be transported.

15. What is the vascular cambium? What is its function?

Vascular cambium is the secondary meristematic tissue that in roots and in the stem forms the vascular tissues (xylem and phloem) of the plant. Usually the outer side of the vascular cambium produces a layer of phloem and the inner (more central) side of the tissue produces a layer of xylem.

16. What are vascular bundles? How does the configuration of the vascular bundles within the stem differentiate monocots from dicots?

Vascular bundles are segments of xylem and associated phloem that run longitudinally within the stem. In dicots the vascular bundles are organized side-by-side forming concentric rings. In monocots the vascular bundles are scattered and do not form rings.

17. What are the main plant tissues that form the rings observed on stem sections of some trees?

The rings observed on a stem cross section of dicot trees are made of conductive tissues: xylem and phloem.

18. How can the age of a tree be estimated from the analysis of the rings present on a cross section of its stem?

For the growth of the tree it is necessary to have formation of new vessels within the stem, a task performed by the vascular cambium. The vascular cambium is more active in hot seasons (summer and spring) generating a lighter band made of large calibered vessels. During winter and fall the vascular cambium produces the opposite, so small calibered vessels and a darker band appears outside the previous lighter band. Therefore two ring bands are made yearly, one lighter and the other darker. By a direct count of these band pairs one can estimate the age of the tree.

19. What are the plant tissues that constitute the functional structures of the leaf veins?

Leaf veins are made of vascular tissues. They are constituted by xylem and phloem that respectively conduct water and mineral nutrients (xylem) and sugar (phloem).

20. Which are the plant tissues specialized in covering?

The covering tissues, or dermal tissues, of the plants are the epidermis (that covers the leaves and the young stems and shoots) and the periderm (a tissue that substitutes the epidermis in stems, shoots and roots). The periderm is made of phelloderm, phellogen and suber (cork).

21. Which are the plant tissues that cover the stem and the leaves?

The stem may be covered by epidermis (having stomata, cuticle and photosynthetic cells) as in monocots or, alternatively, the epidermis is substituted by the periderm

(phelloderm, phellogen and cork) as in dicots and gymnosperms.

The leaves are covered by epidermis.

22. What is phellogen? What is its function?

Phellogen, also known as cork cambium, is the meristematic plant tissue responsible for the formation of the periderm (the covering of the stem, shoots and roots). The inner side of the phellogen layer forms the phelloderm and its outer side forms the cork (suber). The suber secretes suberin, an impermeable substance that impregnates the tissue.

23. Which type of plant tissue is cork?

Cork, the material, for example, used to cap wine bottles, is extracted from the suber of a special oak called cork oak.

24. What are the plant root hairs? Where can they be found and what is their function?

The root hairs are external elongated projections of the root epidermis. Their role is to increase the absorption of water by the root.

25. Why does bark often die and break naturally?

The bark is the mature periderm of the stem, branches and roots. It dies and breaks when these structures grow and thus the peridermal suber formed of already dead cells ruptures.

26. What is the leaf cuticle?

The leaf cuticle is a thin waxy layer made of cutin and waxes on the outer surface of the leaf epidermis. Its function is to control the cellular transpiration.

27. Which are the plant tissues that form the plant roots?

The roots have a central portion called medulla made of vascular tissue (inner xylem and outer phloem). The medulla is surrounded by the medullary parenchyma and delimited by pericycle, a meristem that originates the secondary roots (ramifications). Externally to the medulla lies the cortical portion formed of endodermis (that surrounds the pericycle) and cortical parenchyma. The covering of the roots is epidermis (with root hairs) later substituted by suberized (corky) periderm.

28. What is the root cap?

The root cap is a protective structure located in the tip of the growing root. It protects the meristematic tissue of the root forming a cap that surrounds the tip. The cover is necessary since during

the growth of the root the meristem otherwise would be injured by the friction with the soil.

29. What are secondary roots? In origin how secondary roots differentiate from shoots?

Secondary roots are ramifications of the primary (main) root. The secondary roots emerge from the pericycle, inner tissue of the root. The shoots originate from the lateral buds of the stem. Therefore the origin of the secondary roots is endogenous and the origin of the shoots is exogenous.

30. Why do roots of many swamp plants have a special morphology?

Swamp and marsh plants generally present supporting roots that ramify from portions of the stem above the ground helping the plant to fixate down the muddy and sandy soil. They may also have respiratory roots (pneumatophores), structures that emerge from buried roots to catch oxygen.

Biology Questions and Answers

Plant Physiology

1. Why do plants need to exchange gases with the environment?

Plants need to do gas exchange because they create aerobic cellular respiration (like animals) and they need to get molecular oxygen and to release carbon dioxide. Besides aerobic cellular respiration plants still need to get carbon dioxide to make photosynthesis and to release the molecular oxygen that is the product of this reaction.

2. What are the main gas exchange organs of the plants? How is the process accomplished?

In the covering of the leaves and of the primary structure of the stem gas exchange is made through the cuticle and pores of the epidermis. In the covering of the secondary structure of the stem of woody plants gas exchange is made through the lenticels of the periderm (small breaches of the cork). The gas exchange in plants is accomplished by simple diffusion.

3. What is plant transpiration? What are the two main types of plant transpiration process? Which of them is more significant in volume?

Transpiration is the loss of water from the plant to the atmosphere in the form of vapor.

Transpiration occurs through the cuticle of the epidermis (cuticular transpiration) or through the ostioles of the stomata (stomatal transpiration). The most important is stomatal transpiration since it is more intense and physiologically regulated.

4. What are stomata? How do these structures participate in the plant transpiration?

Stomata (singular, stoma) are small specialized passages for water and gases present in the epidermis of the plants. As the plant needs more or less to lose water and heat the stomata respectively close or open preventing or allowing the passage of gases by diffusion.

5. What are the elements that constitute the stomata?

The stoma is made of a central opening, the ostiole, or slit, delimited by two guard cells responsible for its closing or opening. A substomatal chamber is located under the ostiole.

Biology Questions and Answers

6. How do plants control the opening and the closing of the stomata?

The opening and the closing of the stomata depend upon the necessity of the plant to lose water and heat through transpiration (exit of water vapor means elimination of heat). When the plant has excessive water the guard cells become turgid and the ostiole opens. When little water is available the guard cells become flaccid and the ostiole closes.

Water enters and goes out the stomata by osmosis.

Other factors like light intensity and carbon dioxide concentration in the leaves influence the opening and the closing of the stomata. When luminosity is high the photosynthesis rate increases and the stomata open to absorb more carbon dioxide from the environment and release heat; when luminosity is low the stomata tend to close. When the carbon dioxide concentration in the photosynthetic parenchyma is low the stomata open to absorb more of the gas and make photosynthesis possible; when such concentration is high the stomata tend to close.

7. Do plants placed under an environment drier than the habitat where they are used to living have an increase or a reduction in the time during which their stomata remain open?

If plants from a moister region were transferred to a drier region probably their stomata would remain closed for a longer time, i.e., the time during which stomata are open will be reduced to lower the loss of water by transpiration.

8. Why do some plants adapted to a dry environment open their stomata only at night?

During the day in dry habitats the guard cells become flaccid and the stomata close; concurrently carbon dioxide is disallowed to pass to participate in diurnal photosynthesis. Some plants from dry regions solve this problem through the method of nocturnal carbon dioxide fixation. At night, when water loss by transpiration is lower, the stomata open, carbon dioxide enters and it is stored within the parenchymal tissues. During the day the stored gas is mobilized to be used in photosynthesis.

9. How has the position of the stomata changed in some plants to prevent excessive water loss by transpiration?

In some plants that have leaves that receive too much sunlight the stomata concentrate in the inferior epidermis, so their heating is lower and less water is lost by stomatal transpiration. In other plants of dry environments the stomata group in some regions of the leaf; over the surface of these areas the water concentration of the air is higher comparing to the environment and the

loss of water by transpiration is thus reduced. Some plants of dry climates also have stomata within cavities.

10. Is transpiration the only way through which leaves lose water?

Plants do not only lose water as vapor, as by transpiration. The leaves also lose liquid water by a phenomenon known as gutation. Gutation takes place through structures called hydathodes similar to stomata. Gutation mainly occurs when transpiration is difficult due to high air humidity or when the plant is placed in a watery soil.

11. When air humidity is high does the plant transpiration increase or lower?

When air humidity is high transpiration diminishes. Since transpiration is a simple diffusion process it depends upon the concentration gradient of water between the plant and the environment. If the atmosphere has too much water vapor the gradient becomes lower or even reversed.

12. How do the water absorption volume and the water transpiration volume comparatively vary in plants in a day? What is the final comparative balance of these processes?

During the day the transpired volume of water is higher than the volume absorbed by the roots. At night the situation reverses and the roots absorb more water than the transpired volume.

It is observed that the transpired and the absorbed volumes practically equal in a day.

13. How do plants solve the problem of transporting substances throughout their tissues?

In bryophytes the substance transport is done by diffusion. In tracheophytes (pteridophytes, gymnosperms and angiosperms) there are specialized conductive vessels, the xylem that carries water and mineral salts and the phloem that conducts organic material (sugar).

14. Is transportation of gases in tracheophytes made through the vascular tissues?

Carbon dioxide and oxygen are not transported through the xylem or phloem. These gases reach the cells and exit the plant by diffusion through intercellular spaces or between neighboring cells.

15. Are the xylem and the phloem made of living cells?

The cells that constitute the xylem ducts are dead cells killed by lignin deposition. The cells of the phloem are living cells.

16. What is the importance of lignin for the xylem formation?

Lignin is important because it is deposited on the cell wall of the xylem cells providing impermeability and rigidity to the xylem vessels.

17. What is root pressure?

Root pressure is the pressure that forces water from the soil to be absorbed by the xylem of the root. It is due to the osmotic gradient between the interior of the root and the soil.

18. What is capillarity? How is this phenomenon chemically explained? What is the relevance of capillarity for water transport in plants?

Capillarity is the phenomenon through which water moves inside extremely thin tubes (capillaries) aided by the attraction between water molecules and the capillary wall. The capillarity phenomenon is possible because water is a polar molecule and forms intermolecular hydrogen bonds. Therefore there is electrical attraction (adhesion force) between the capillary wall and the water molecules that then pull each other (cohesion force) since they are bound. Not just water but other liquids may move inside capillaries by capillarity.

Capillarity is not too relevant for the transport of water in plants. It contributes only to a few centimeters of ascension.

19. What are the forces that make water to flow within the xylem from the roots to the leaves?

Water enters the roots due to the root pressure and a water column is maintained within the xylem from the roots to the leaves. The most important factor that makes water ascend is transpiration, mainly in the leaves. As leaves lose water by transpiration their cells tend to attract more water creating suction inside the xylem. The cohesion property of water that keeps its molecules bound (one pulls the other) by hydrogen bonds helps the process.

20. What is tree girdling? What happens to a plant when that girdle is removed from the stem (below the branches)?

Malpighi's girdling, or tree girdling, is the removal from a stem of a complete external girdle containing the phloem

(that is more external) but preserving the xylem (that is more internal).

When a girdle like that is removed below the branches the plant dies because organic food (sugar) is disallowed to pass to the region below the girdle and thus roots die from the lack of nutrients. Since roots die the plant does not get water and mineral salts and dies too.

21. What are plant hormones?

Plant hormones, also called phytohormones, are substances that control the embryonic development and the growth of the adult plant.

22. What are the main natural plant hormones and what are their respective effects?

The main natural plant hormones and their respective functions are the following:

Auxins (the best known natural auxin is IAA, indoleacetic acid): their function is to promote plant growth, distension and cellular differentiation. Gibberellins: have action similar to auxins (growth and distension), stimulate flowering and fruit formation and activate seed germination. Cytokinins: increase cellular division rate and together with auxins help growth and tissue differentiation, slow the plant aging. Ethylene (ethene): a gas released by plants that participates in the growth process and has noteworthy role in fruit ripening and in leaf abscission.

23. What is the plant coleoptile? Why does the removal of the coleoptile extremity disallow plant growth?

Coleoptile is the first (one or more) aerial structure of the sprouting plant that emerges from the seed. It encloses the young stem and the first leaves, protecting them.

The top of the coleoptile generally is the region where auxins are made. If this region is removed, plant growth stops since auxins are necessary to promote growth and tissue differentiation.

24. What is indolacetic acid (IAA)?

Indolacetic acid (indolyl-3-acetic acid), or IAA, is the main natural auxin made by plants. It promotes plant growth and cellular differentiation.

25. What are synthetic auxins and what are their uses?

Synthetic auxins, like indolebutyric acid (IBA) and naphthalenic acid (NAA) are substances similar to IAA (a natural auxin) but artificially made. Some are used to accelerate methods of asexual reproduction (like grafting or budding) and others are even used as herbicides since they selectively kill some plants (mainly dicots).

Biology Questions and Answers

26. Where in plants is a large amount of IAA found?

Auxins are produced and found in large amount in the apical buds of the stem and shoots and in the young leaves.

27. How do phytohormones help the development of parthenocarpic fruits?

Parthenocarpic fruits are those produced without fecundation. Some plants naturally make parthenocarpic fruits, like the banana tree, stimulated by their own hormones.

Angiosperms that do not naturally produce parthenocarpic fruits may do it if auxins are applied to flowers before fecundation. Therefore even without fecundation the ovaries grow and fruits are formed although seedless.

28. How do auxins act helping the lateral (secondary) growth of the stem?

Auxins stimulate the formation of conductive vessels, xylem and phloem, promoting the thickening of the stem.

29. What happens when the auxin concentration in some structures of the plant is over the action range of the hormone?

In some parts of the plant (stem, roots, lateral buds) there are auxin concentration ranges in which the hormonal action is positive (stimulate growth). It is observed that concentrations over the superior limit of those ranges have the opposite effect (inhibition of growth).

30. What is the phenomenon of apical dominance in plants? How can it be artificially eliminated?

Apical dominance is the phenomenon through which high (over the positive range limit) auxin concentrations due to auxins from the apical bud moving downward the stem inhibit the growth of the lateral buds of the plant. At the beginning of the stem development the apical dominance causes the plant growth to be longitudinal (upwards) since the growth of the lateral buds remains inhibited. As the lateral buds become more distant from the apex the auxin concentration in these buds lowers and shoots grow more easily.

The growth of tree branches can be stimulated preventing the apical dominance through the removal of the apical bud.

31. What are gibberellins? Where are they produced?

Gibberellins are plant hormones that stimulate plant growth, flowering and fruit formation (also parthenocarpy) and the germination of seeds. There are more than 70 known types of

gibberellins. Gibberellins are made in the apical buds and in young leaves.

32. What are cytokinins? Where are they made?

Cytokinins are phytohormones active in the promotion of cellular division, they slow down the aging of tissues and act together with auxins stimulating plant growth. Cytokinins are produced by the root meristem and distributed through the xylem.

33. What is the plant hormone remarkable for stimulating flowering and fruit ripening? What are the uses and practical inconveniences of that hormone?

The plant hormone notable for stimulating and accelerating fruit ripening is the gas ethylene (ethene). By being a gas, ethylene acts not only in the plant that produces it but also in neighboring ones.

Some fruit processing industries use ethylene to accelerate fruit ripening. On the other hand, if the intensification or acceleration of fruit ripening is not desirable care must be taken to prevent the mixture of ripe fruits that release ethylene with the others.

34. Are the development and growth of plants only influenced by plant hormones?

Physical and chemical environmental factors, like intensity and position of light in relation to the plant, gravitational force, temperature, mechanical pressures and chemical composition of the soil and of the atmosphere, can also influence the growth and development of plants.

35. What are plant tropisms?

Tropisms are movements caused by external stimulus. In Botany the studied plant tropisms are: phototropism (tropism in response to light), geotropism (tropism in response to the earth gravity) and thigmotropism (tropism in response to mechanical stimulus).

36. To which direction does the growth of one side of a stem, branch or root induce the structure to curve?

Whenever one side of a stem, branch or root grows more than the other side the structure curves towards the side that grows less. (This is an important concept for plant tropism problems.)

37. What is phototropism?

Phototropism is the movement of plant structures in response to light. Phototropism may be positive or

negative. Positive phototropism is that in which the plant movement (or growth) is towards the light source and negative phototropism is that in which the movement (or growth) is inverse, away from the light source.

Phototropism relates to auxins since the exposition of one side of the plant to light makes these hormones concentrate in the darker side. This fact makes the auxin action upon the stem to be positive, i.e., the growth of the darker side is more intense and the plant arcs towards the lighter side. In the root (when submitted to light, in general experimentally) the auxin action is negative (over the positive range), the growth of the darker side is inhibited and the root curves towards this side.

38. What are the types of plant geotropisms? Why do the stem and the root present opposite geotropisms?

The types of geotropisms are the positive geotropism, that in which the plant grows in favor of the gravitational force, as for example in roots, and the negative geotropism, that against the gravitational force, for example, in the stem.

Root geotropism and stem geotropism are opposed due to different sensitivities to auxin concentration in these structures. The following experiment can demonstrate the phenomenon: Stem and root are placed in a horizontal position (parallel to the ground) and naturally auxins concentrate along their bottom part. Under this condition it is observed that the stem grows upwards and the root grows downwards. This happens because in the stem the high auxin concentration in the bottom makes this side grow (longitudinally) more and the structures arcs upwards. In the root the high auxin concentration in the bottom inhibits the growth of this side and the upper side grows more making the root to curve downwards.

39. What is thigmotropism?

Thigmotropism is the movement or growth of the plant in response to mechanical stimuli (touch or physical contact), as when a plant grows around a supporting rod. It occurs for example in grape and passionfruit vines, etc.

40. What is photoperiod?

Photoperiod is the daily time period of light exposure of a living being. The photoperiod may vary according to the period of the year.

41. What is photoperiodism?

Photoperiodism is the biological response presented by some living beings to their daily time of light exposure (photoperiod).

Biology Questions and Answers

42. What are the plant organs responsible for the perception of light variation? What is the pigment responsible for this perception?

Leaves are mainly responsible for perception of light intensity in plants. The pigment that performs this perception and commands photoperiodism is called phytochrome.

43. How does the photoperiodism affect the flowering of some plants?

Flowering is a typical and easy to observe example of photoperiodism. Most flowering plants flower only during specific periods of the year or when placed under some conditions of daily illumination. This occurs because their blossoming depends on the duration of the photoperiod that in its turn varies with the season of the year. Flowering is also affected by exposition to certain temperatures.

44. What is the critical photoperiod? How can the critical photoperiod relate to flowering be experimentally determined?

The critical photoperiod is the limit of the photoperiod duration for the occurrence of some biological response. This limit can be a maximum or a minimum, according to the characteristics of the biological response and to the studied plant.

To determine the critical photoperiod relating to flowering, 24 groups of plants of the same species can be taken and the following experiment can be done: Each group is submitted to a different photoperiod, the first group to 1 hour of daily exposure to light, the second to 2 hours, the third to 3 hours, and so on, until the last group is exposed to 24 hours. It is observed later that beyond a specific duration of light exposure plants present or do not present flowering and the remaining submitted to a shorter photoperiod present opposite behavior. The duration of the light exposure that separates these two groups is the critical photoperiod.

45. How do plants classify according to their photoperiodism-based flowering?

According to their photoperiodism-based flowering plants classify as long-day plants, those that depend on longer photoperiods than the critical photoperiod to flower, as short-day plants, those that depend on shorter photoperiods than the critical photoperiod to flower, and as indifferent plants, whose flowering does not depend on the photoperiod.

Biology Questions and Answers

46. Why do most plants present opposite phyllotaxis?

Phyllotaxis is the way leaves are arranged on shoots. Most plants have opposite phyllotaxis (alternating in sequence, one in one side of the shoot, the following in the opposite side) as a solution to prevent self shading of the leaves thus improving the efficiency of photosynthesis.

Biology Questions and Answers

Biology Questions and Answers

Genetics

Biology Questions and Answers

Biology Questions and Answers

Genetic Concepts

1. What is a gene?

A gene is a sequence of DNA nucleotides that codifies the production of a protein.

2. Is a gene a triplet of consecutive DNA nucleotides?

A gene is not a triplet of DNA nucleotides with their respective nitrogen-containing bases, like AAG or CGT. The nucleotide triplets may be pieces of genes but not genes.

A gene is a portion of a DNA molecule that codifies a specific protein. Thus it is formed by several DNA nucleotide triplets.

3. How is the concept of chromosome related to the concept of the gene?

A chromosome is a DNA molecule. A chromosome may contain several different genes and also DNA portions that are not genes.

4. What is meant by "gene locus"?

Gene locus (locus means place) is the location of a gene in a chromosome, i.e., the position of the gene in a DNA molecule.

5. What are alleles of a gene?

Diploid individuals have paired chromosomes. For example in humans there are 23 pairs of chromosomes totaling 46 chromosomes. Each pair comprehends homologous chromosomes, one chromosome from the father and another from the mother, both of them containing information related to the production of the same proteins (with the exception of the sex chromosomes, which are partially heterologous). So in the diploid individual it is said that each gene has two alleles, one in each chromosome of the homologous pair.

6. Are the alleles of a gene necessarily originated one from the father and the other from the mother? Are there exceptions?

It is natural that alleles have come one from the father and the other from the mother but it is not obligatory. In a "clone" generated by nucleus transplantation technology, for example, the alleles come from a single individual. In polysomies (as in trisomy 21) each gene of the affected chromosome has three alleles, in trisomies, or four, in tetrasomies.

Biology Questions and Answers

7. What is a phenotype?

A phenotype is every observable characteristic of a living being conditioned by its genes. Some phenotypes may be altered by nongenetic factors (for example, artificial hair coloring). Specific phenotypes are also called phenotypical traits.

8. What is a genotype? What is the difference between genotype and phenotype?

Genotype is the genes, DNA nucleotide sequences contained in the chromosomes of an individual, that condition the phenotype. Phenotypes then are a biological manifestation of genotypes.

For example, the altered hemoglobin chain of sickle cell disease and the manifestation of the disease itself are the phenotype. The altered DNA nucleotide sequence in the gene that codifies the production of that abnormal hemoglobin chain is the genotype.

9. Does the environment exert an influence on the phenotype?

A phenotype may be altered (compared to the original situation conditioned by its genotype) by nongenetic means. Examples: some hormones may cease to be secreted due to diseases but the genes that determine their secretion remain intact; a person can go to a hairdresser and change the color of his/her hair; plastic surgery can be performed to alter facial features of an individual; colored contact lenses may be worn; a plant can grow beyond its genetically conditioned size by application of phytohormones.

Revealing cases of environmental influence on phenotypes are observed in monozygotic twins that have grown in different places. Generally these twins present very distinct phenotypical features due to the environmental and cultural differences of the places where they lived and to their different individual experiences in life.

(Biologically programmed phenotypical changes, like nonpathological changes of the skin color caused by sunlight exposure, tanning, or the variation of the color of some flowers according to the pH of the soil cannot be considered independent from the genotype. Actually these changes are planned by the genotype as natural adaptations to environmental changes.)

10. Are environmental phenotypical changes transmitted to the offspring?

Changes caused on phenotypes by the environment are not transmitted to the offspring (unless their primary cause is genotypical change in germ cells or in gametic cells). If a person changes the color of the hair or undergoes aesthetic plastic surgery the resulting features are not transmitted to his/her offspring.

11. What are the situations in which the environment can alter the genotype of an individual? What is the condition for this type of change to be transmitted to the offspring?

The environment can only alter genotypes when its action causes alterations in the genetic material (mutations) of the individual, i.e., deletion, addition or substitution of entire chromosomes or of nucleotides that form the DNA molecules.

Mutations are only transmitted to the offspring when affecting the germ cells that produce gametes or the gametes themselves.

12. What are some examples of phenotypical characteristics that present two or more varieties and of phenotypical features that do not vary? In relation to the genes correspondent to those characteristics that vary among individuals what can be expected about their alleles?

Color of the eyes, color of the hair, color of the skin, height, blood type are examples of phenotypical features that present two or more varieties. Other examples are the color of flowers and seeds in some plants, the sex of the individual in dioecius species, etc. Examples of phenotypical characteristics that do not present variation among individuals of the same species are: in general the number of limbs, the anatomical position of the organs, the general constitution of tissues and cells, etc.

Phenotype possibility of presenting natural variations (in beings of the same species) are necessarily determined by two or more different alleles of the correspondent gene. These different alleles combine and form different genotypes that condition the different phenotypes (variations).

13. Considering a pair of homologous chromosomes containing a gene having two different alleles how many different genotypes can the individual present?

If a gene of a diploid species has different alleles, for example, A and A', the possible genotypes are: A'A', AA, and AA'. So any of these three different genotypes may be the genotype of an individual.

14. For an individual having a genotype formed of two different alleles that condition different varieties of the same phenotypical trait, upon what will the phenotypical feature actually manifested depend?

If an individual presents a gene having different alleles (common situation), for

example, A and A', three types of genotypes may be formed: AA, A'A' and AA'. The question refers to an individual bearing a genotype made of two different alleles, so it is the AA' genotype (the heterozygous individual).

This AA' individual may manifest the phenotype conditioned by the allele A or the phenotype conditioned by the allele A' or still a mixed phenotype of those two forms. If the allele A is dominant over the allele A' the form conditioned by A will manifest. If A' is the dominant allele, the form determined by A' will manifest. This phenomenon is known as dominance and occurs because the recessive (nondominant) allele manifests only when present in double in the genotype (in homozygosity), while the dominant allele manifests even when in heterozygosity. If none of the alleles dominate a mixture of the two varieties conditioned by both alleles appears or instead a third form may come out.

15. What is the difference between dominant allele and recessive allele?

Dominant allele is the allele that determines phenotypical features that manifest in homozygous or heterozygous genotypes.

In Genetics the dominant allele is represented in uppercase, e.g., "A", and its recessive allele is written in lowercase, "a".

In molecular terms generally the recessive allele has a nucleotide sequence previously identical to the corresponding sequence in the dominant allele but that during evolution was inactivated by mutation. This fact explains the expression of the dominant phenotype in heterozygosity (since one functional allele is still present).

16. Whenever a pair of alleles has different alleles is there dominance between them?

Not in all cases of a gene having two different alleles is the dominance complete. There are genes in which heterozygosity occurs with incomplete dominance (manifestation of an intermediate phenotype in relation to the homozygous, like in the color of roses, between white and red) and other genes that present codominance (expression of a third different feature, as in the MN blood group system).

17. What is the difference between homozygosity and heterozygosity?

Homozygosity occurs when an individual has two identical alleles of a gene, for example, AA or aa. Heterozygosity occurs when an individual has two different alleles of the same gene, in the example, Aa.

18. Why can it be said that a recessive allele can remain hidden in the phenotype of an individual and revealed only when manifested in homozygosity in the offspring?

A recessive allele can remain hidden because it does not manifest in heterozygous individual, i.e., it may be present in the genotype but not expressed in the phenotype. When this allele is transmitted to the offspring and forms homozygous genotype with another recessive allele from other chromosomal lineage the phenotypical characteristics that come out reveal its existence.

Biology Questions and Answers

Mendel's Laws

1. Who was Gregor Mendel?

Mendel is considered the father of Genetics. He was a monk, biologist and botanist born in Austria in 1822 and who died in 1884. During the years 1853 to 1863 he cultivated pea plants in the gardens of his monastery to be used in his research. His experiments consisted of crossing pea plants of distinct characteristics (size, color of the seeds, etc.), cataloging the results and interpreting them. The experiments led him to enunciate his laws, results published in 1886 with no scientific repercussion at that time. Only at the beginning of the 20th century, in 1902, 18 years after his death, were his merits broadly recognized.

2. What in Genetics is hybridization?

Hybridization in Genetics is the crossing of individuals from "pure" and different lineages in relation to a given trait, i.e., the crossing of different homozygous for the studied trait.

In Mendel's experiments with peas, for example, a plant from a green pea lineage obtained from self fecundation of its ascendants through several generations was crossed (cross fecundation) with another plant from a yellow lineage also obtained by self fecundation of ascendants. (The self fecundation through several generations of ascendants and the exclusive obtainment of individuals with the desired characteristics ensured that the individuals of the parental generation were "pure", i.e., homozygous for that characteristic.)

3. What is monohybridism?

Monohybridism is the study of only one characteristic in the crossing of two pure individuals (hybridization) for that characteristic.

4. Considering hybridization in a trait like the color of the flowers of a given plant species (red dominant/ yellow recessive) conditioned by a pair of different alleles, what are the phenotypical results of the first generation (F1) and the phenotypical results of the second generation (F2, formed by crossing among F1 genotypes)? What are the phenotypical proportions in F1 and F2?

In relation to genotypes and phenotypes the hybridization comprises of: parental generation (P): RR (read), yy (yellow). F1 generation (RR x yy): Ry (red). F2 generation (Ry x Ry): RR (red), Ry (red), Ry (red) and yy (yellow).

In the F1 generation the proportion of red flowers is 100%. In the F2

generation, the phenotypical proportion is three red (75%) to one yellow (25%).

5. Considering hybridization in a trait like the color of the flowers of a given plant species (red/yellow) conditioned by a pair of different alleles in relation to complete dominance (red dominant/ yellow recessive), why in the F1 generation is one of the colors missing?

In this monohybridism one of the colors does not appear in the F1 generation because their parental generators are pure, i.e., homozygous, and in F1 all descendants are heterozygous (each parental individual forms only one type of gamete). Since only heterozygous genotypes appear and red is dominant over yellow the individuals of the F1 generation will present only red flowers.

6. Considering hybridization in a given trait like the color of the hair of a mammalian species (white/black) conditioned by a pair of different alleles under complete dominance (black dominant, B/ white recessive, w), how can the phenotypical proportion obtained in the F2 generation be explained? What is this proportion?

In the monohybridism conditioned by two different alleles the F1 generation presents only heterozygous individuals (Bw). In F2 there is one individual BB, two individuals Bw and one individual ww. In relation to the phenotype there are in F2 two black individuals and one white individual, since black is the dominant color. So the proportion is 3:1, three black-haired to one white-haired.

7. What is meant by saying that in relation to a given trait conditioned by a gene with two different alleles the gametes are always "pure"?

To say that gametes are pure means that they always carry only one allele of the referred trait. Gametes are always "pure" because in them the chromosomes are not homologous, they contain only one chromosome of each type.

8. What is the Mendel's first law?

The Mendel's first law postulates that a characteristic (trait) of an individual is always determined by two factors, one inherited from the father and the other from the mother and the direct offspring of the individual receives from it only one of these factors (aleatory). In other words, each trait is determined by two factors that segregate during gamete formation.

The Mendel's first law is also known as the law of purity of gametes. Mendel deduced the way genes and alleles were transmitted and traits were conditioned without even knowing of the existence of these elements.

9. Which is the type of gamete (for a given trait) produced by a dominant homozygous individual? What is the genotypical proportion of these gametes? What about a recessive homozygous individual?

If an individual is dominant homozygous, for example, AA, it will produce only gametes having the allele A. The proportion thus is 100% of AA gametes.

If an individual is recessive homozygous, for example, aa, it will produce only gametes having the allele a, also in a 100% proportion.

10. Which is the type of gamete produced by a heterozygous individual? What is the genotypical proportion of these gametes?

Heterozygous individuals, for example, AA, produce two different types of gametes: one containing the allele A and another type containing the allele a. The proportion is 1:1.

11. In the F2 generation of a hybridization for a given trait conditioned by a pair of alleles T and t, according to Mendel's first law what are the genotypes of each phenotypical form? How many respectively are the genotypical and phenotypical forms?

In the mentioned hybridization the genotypical forms in F2 will be TT, tt and Tt. Therefore there will be three different genotypical forms and two different phenotypical forms (considering T dominant over t).

12. Why can the crossing of an individual that manifests dominant phenotype with another that manifests recessive phenotype (for the same trait) determine whether the dominant individual is homozygous or heterozygous?

From the crossing of an individual having recessive phenotype with another having dominant phenotype (for the same trait) it is possible to determine whether the dominant individual is homozygous or heterozygous. This is true because the genotype of the recessive individual is obligatorily homozygous, for example, aa. If the other individual is also homozygous, AA, the F1 offspring will be only heterozygous (aa x AA = only Aa). If the other individual is

heterozygous there will be two different genotypical forms, Aa and aa in the 1:1 proportion. So if a recessive phenotype appears in the direct offspring the parental individual that manifests dominant phenotype is certainly heterozygous.

13. What is a genetic family tree?

Genetic family tree is a schematic family tree that shows the biological inheritance of some trait through successive generations.

Genetic family trees are useful because it is practically impossible and ethically unacceptable to make experimental crossings for genetic testing between human beings. With the help of family tress the study is made by analysis of marriages (and crossings) that have already occurred in the past. From the analysis of family trees, for example, information on probabilities of the emergence of some phenotype and genotypes (including genetic diseases) in the offspring of a couple can be obtained.

14. What are the main conventional symbols and signs used in genetic family trees?

In genetic family trees the male sex is usually represented by a square and the female by a circle. Crossings are indicated by horizontal lines that connect squares to circles and their direct offspring are listed below and connected to that line. The presence of the studied phenotypical form is indicated by a complete hachure (shading) of the circle or the square correspondent to the affected individual. It is useful to enumerate the individuals from left to right and from top to bottom for easy reference.

15. What are the three main steps for a good study of a genetic family tree?

Step 1: to determine whether the studied phenotypical form has a dominant or recessive pattern. Step 2: to identify recessive homozygous individuals. Step 3: to identify the remaining genotypes.

16. What is Mendel's second law?

Mendel's second law postulates that two or more different traits are also conditioned by two or more pair of different factors and that each inherited pair separates independently from the others. In other words, gametes are formed always with an aleatory representative of each pair of the factors that determine phenotypical characteristics.

Mendel's second law is also known as the law of independent segregation of factors, or law of independent assortment.

Biology Questions and Answers

17. What is the condition for Mendel's second law to be valid?

Mendel's second law is only valid for genes located in different chromosomes. For genes situated in the same chromosome, i.e., linked genes (genes in linkage) the law is not valid since the segregation of these genes is not independent.

18. According to Mendel's second law, in the crossing between homozygous individuals concerning two pairs of nonlinked alleles, AABB x aaBB, what are the genotypical and phenotypical proportions in F1 and F2?

Parental genotypes: AABB, aaBB. Gametes from the parental generation: Ab and aB. Thus F1 will present 100% AaBb gametes (and the phenotypical correspondent form).

As F1 are AaBb individuals the gametes from their crossing can be: AB, Ab, aB and ab. The casual combination of these gametes forms the following genotypical forms: one AABB, two AABb, two AaBb, four AaBB, one Aabb, one Aabb, one aaBB, two aaBb and two aabb. The phenotypical proportion then would be: nine A_B_ (double dominant); three A_bb (dominant for the first pair, recessive for the second); three aaB_ (recessive for the first pair, dominant for the second); one aabb (double recessive).

19. Considering independent segregation of all factors, how many types of gametes does a VvXXWwYyzz individual produce? What is the formula to determinate such number?

The mentioned individual will produce eight different types of gametes (attention, gametes and not zygotes). To determine the number of different gametes produced by a given multiple genotype the number of heterezygous pairs is counted (in the mentioned case, three) and the result is placed as an exponent of two (in the example, 2^3 = 8).

20. How is it possible to obtain the probability of emergence of a given genotype formed of more than one pair of different alleles with independent segregation from the knowledge of the parental genotypes?

Taking as example the crossing of AaBbCc with aaBBCc, for each considered pair of allele it is possible to verify which genotypes it can form (as in an independent analysis) and in which proportion. AA x aa: Aa, aa (1:1). Bb x BB: BB, Bb (1:1). Cc x Cc: CC, Cc, cc (1:2:1). The genotype to which the probability is to be determined is for example aaBbcc. For each pair of this genotype the formation probability is determined: to aa, 0.5; to Bb, 0.5; to cc, 0.25. The final result is obtained by multiplication of these partial probabilities, 0.5 x 0.5 x, 0.5, resulting 0.0625.

Biology Questions and Answers

Non-mendelian Inheritance

1. According to Mendel's law phenotypical characteristics would be determined by pair of factors (alleles) that separate independently in gametes. What are the main types of inheritances that are exceptions to Mendel's rules?

There are many types of inheritance that do not follow the mendelian pattern. Notable among them are: multiple alleles, gene interactions (complementary genes, epistasis and quantitative, or polygenic, inheritance), linkage with or without crossing over and sex-linked inheritance.

Pleiotropy, lacking of dominance and lethal genes do not fit as variations of inheritance since genes can have these behaviors and at the same time obey mendelian laws.

Mutations and aneuploidies are abnormalities that also alter the mendelian pattern of inheritance as well as mitochondrial inheritance (passage of mitochondrial DNA from the mother through the cytoplasm of the egg cell to the offspring).

2. What is the genetic condition in which the heterozygous individual has different phenotype from the homozygous individual?

This condition is called lack of dominance and it can happen in two ways: incomplete dominance or codominance.

In incomplete dominance the heterozygous presents an intermediate phenotype between the two types of homozygous, as in sickle cell anemia in which the heterozygous produces some sick red blood cells and some normal red blood cells. Codominance occurs, for example, in the genetic determination of the MN blood group system, in which the heterozygous has a phenotype totally different from the homozygous, not being an intermediate form.

3. What is pleiotropy?

Pleiotropy (or pliotropy) is the phenomenon in which a single gene conditions several different phenotypical traits.

Some phenotypical traits may be sensitive to pleiotropic effects (for example, inhibition) of other genes, even when conditioned by a pair of alleles in simple dominance. In these cases a mixture of pleiotropy and gene interaction is characterized.

Biology Questions and Answers

4. What are lethal genes?

Lethal genes are genes having at least one allele that, when present in the genotype of an individual, causes death. There are recessive lethal alleles and dominant lethal alleles. (There are also genes having alleles that are dominant when in heterozygosity but lethal when in homozygosity, i.e., the dominance related to the phenotype does not correspond to the dominance related to lethality.)

5. What are multiple alleles? Is there dominance in multiple alleles?

Multiple alleles is the phenomenon in which the same gene has more than two different alleles (in normal mendelian inheritance the gene has only two alleles). Obviously these alleles combine in pairs to form the genotypes.

In multiple alleles relative dominance among the alleles may exist. A typical example of multiple alleles is the inheritance of the ABO blood group system, in which there are three alleles (A, B or O, or IA, IB and i). IA is dominant over i, which is recessive in relation to the other IB allele. IA and IB lack dominance between themselves.

Another example is the color of rabbit fur, conditioned by four different alleles (C, Cch, Ch and c). In this case the dominance relations are C > Cch > Ch > c (the symbol > means "dominates over").

6. What are gene interactions? What are the three main types of gene interactions?

Gene interaction is the phenomenon in which a given phenotypical trait is conditioned by two or more genes (do not confuse with multiple alleles in which there is a single gene having three or more alleles).

The three main types of gene interaction are: complementary genes, epistasis and polygenic inheritance (or quantitative inheritance).

7. What are complementary genes? Does this inheritance pattern obey Mendel's second law?

Complementary genes are different genes that act together to determine a given phenotypical trait.

For example, consider a phenotypical trait conditioned by 2 complementary genes whose alleles are respectively X, x, Y and y. Performing hybridization in F2 4 different phenotypical forms are obtained: X_Y_ (double dominant), X_yy (dominant for the first pair, recessive for the second), xxY_ (recessive for the first pair, dominant for the second) and xxyy (double recessive). This is what happens, for example, regarding the color of budgerigar feathers, in which the double dominant interaction results in green feathers, the dominant for the first pair, recessive for the second interaction results in yellow feathers, the recessive for the first pair, dominant for the

second interaction leads to blue feathers and the double recessive interaction leads to white feathers.

Each complementary gene segregates independently from the others since they are located in different chromosomes. Therefore the pattern follows Mendel's second law (although it does not obey Mendel's first law).

8. What is epistasis? What is the difference between dominant epistasis and recessive epistasis?

Epistasis is the gene interaction in which a gene (the epistatic gene) can disallow the phenotypical manifestation of another gene (the hypostatic gene). In dominant epistasis the inhibitor allele is the dominant allele (for example, I) of the epistatic gene so inhibition occurs in dominant homozygosity (II) or in heterozygosity (Ii). In recessive epistasis the inhibitor allele is the recessive allele of the epistatic gene (i) so inhibition occurs only in recessive homozygosity (ii).

9. In the hybridization of 2 genes (4 different alleles, 2 of each pair) how does epistasis affect the proportion of phenotypical forms in the F2 generation?

In dihybridism without epistasis double heterozygous parental individuals cross and in F2 4 phenotypical forms appear. The proportion is 9 double dominant to 3 dominant for the first pair, recessive for the second to 3 recessive for the first pair, dominant for the second to 1 double recessive (9:3:3:1).

Considering that the epistatic gene is the second pair and that the recessive genotype of the hypostatic gene means lacking of the characteristic, in the F2 generation of the dominant epistasis the following phenotypical forms would emerge: 13 dominant for the second pair or recessive for the first, i.e., the characteristic does not manifest, 3 dominant for the first pair, recessive for the second, i.e., the characteristic manifests. The phenotypical proportion would be 13:3. In the recessive epistasis in F2 the phenotypical forms that would emerge are: 9 double dominant (the characteristic manifests), 7 recessive for the first pair or recessive for the second, i.e., the characteristic does not manifest. So the phenotypical proportion would be 9:7.

These examples show how epistasis changes phenotypical forms and proportions, from the normal 9:3:3:1 in F2 to 13:3 in dominant epistasis or to 9:7 in recessive epistasis (note that some forms have even disappeared).

(If the recessive genotype of the hypostatic gene is active, not simply meaning that the dominant allele does not manifest, the number of phenotypical forms in F2 changes.)

Biology Questions and Answers

10. What is polygenic inheritance? How does it work?

Polygenic inheritance, also known as quantitative inheritance, is the gene interaction in which a given trait is conditioned by several different genes having alleles that may or may not contribute to increase the phenotype intensity. The alleles may be contributing or noncontributing and there is no dominance among them. Polygenic inheritance is the type of inheritance, for example, of skin color and of stature in humans.

Considering a given species of animal in which the length of the individual is conditioned by polygenic inheritance of three genes, for the genotype having only noncontributing alleles (aabbcc) a basal phenotype, for example, 30 cm, would emerge. Considering also that for each contributing allele a 5 cm increase in the length of the animal is added, so in the genotype having only contributing alleles (AABBCC) the animal would present the basal phenotype (30 cm) plus 30 cm more added by each contributing allele, i.e., its length would be 60 cm. In the case of triple heterozygosity, for example, the length of the animal would be 45 cm. That is the way polygenic inheritance works.

11. What is the most probable inheritance pattern of a trait with gaussian proportional distribution of phenotypical forms?

If a trait statistically has a normal (gaussian, bell-shaped curve) distribution of its phenotypical forms it is probable that it is conditioned by polygenic inheritance (quantitative inheritance).

In quantitative inheritance the effects of several genes add to others making it possible to represent the trait variation of a given population in a gaussian curve with the heterozygous genotypes in the center, i.e., appearing in larger number, and the homozygous in the extremities.

12. How to find the number of pair of alleles involved in polygenic inheritance using the number of phenotypical forms of the trait they condition?

Considering “p” the number of phenotypical forms and “a” the number of involved alleles of the polygenic inheritance. The formula $p = 2a + 1$ is then applied.

(Many times it is not possible to determine precisely the number of phenotypical forms, p, due to the multigenic feature of the inheritance, since often the observed variation of phenotypes seems to be on a continuum or the trait suffers environmental influence.)

13. Why is sex-linked inheritance an example of nonmendelian inheritance?

Sex-linked inheritance is a type of nonmendelian inheritance because it opposes Mendel's first law, which postulates that each trait is always conditioned by two factors (alleles). In nonhomologous regions of the sex chromosomes the genotypes of the genes contain only one allele (even in the case of the XX karyotype, i.e., in women, one of the X chromosomes is inactive).

14. What is mitochondrial inheritance?

Mitochondrial inheritance is the passage of mitochondrial DNA molecules (mtDNA) to the offspring. All stock of mtDNA an individual has have come from the mother, the maternal grandmother, the maternal great grandmother and so on, since mitochondria are inherited from the cytoplasm of the egg cell (that later constitutes the cytoplasm of the zygote).

There are several genetic diseases caused by mitochondrial inheritance, like Leber's hereditary optic neuropathy, that leads to loss of the central vision of both eyes, and the Kearns-Sayre syndrome, a neuromuscular disease that causes ophthalmoplegia and muscle fatigue.

Mitochondrial inheritance is an excellent means of genetic analysis of the maternal lineage (just like the Y chromosome is an excellent means of study of the paternal lineage).

Biology Questions and Answers

Linkage and Crossing Over

1. Why is not Mendel's second law always valid for two or more phenotypical traits of an individual?

Mendel's second law, or the law of the independent assortment, is valid for genes located in different chromosomes. These genes during meiosis segregate independently.

Mendel's second law however is not valid for phenotypical features conditioned by genes located in the same chromosome (genes under linkage), since these genes, known as linked genes, do not separate in meiosis (except for the phenomenon of crossing over).

2. Why is drosophila a convenient animal for the study of linked genes?

The fruit fly drosophila is suitable for the study of Genetics because it presents many distinct traits but only four chromosomes (one sex chromosome and three autosomes).

3. What is linkage?

Two genes are said to be under linkage, or linked, when they reside in the same chromosome.

For example, the research of the human genome discovered that the factor III of clotting gene and the factor V of clotting gene are located in the same chromosome (the human chromosome 1). The factor VII gene however is not linked to those genes since it is located in the chromosome 13.

4. What is crossing over? How is meiosis related to this phenomenon?

Linked alleles, for example, A-b and a-B, form the gametes A-b and a-B that maintain the linkage of the alleles. This type of linkage is called complete linkage. In the first division of meiosis (meiosis I) however the crossing over phenomenon may occur. Chromosomes from a pair of homologous may exchange extremities and some once linked alleles, for example, A-b and a-B, recombine to form different gametes, in the case, A-B and a-b.

Crossing over may happen when the arms of the chromatids of each homologous are paired during meiosis. Matching portions of the extremities of two nonsister chromatids (one from one homologous of the pair) break and the pieces are exchanged, each of them becoming part of the arm of the other chromatid. For example, if the allele A is situated in a side of the arm relating to the point of breaking and the allele b is

located in the other side, they will be separated and gametes A-B and a-b will be formed, instead of A-b and a-B.

(The percentage of recombinant gametes relating to normal gametes depends upon the crossing over rate that in its turn depends upon how far distant the given alleles are in the chromosome.)

5. In genetic recombination by crossing over what is the difference between parental gametes and recombinant gametes?

Parental gametes are those gametes that maintain the original linkage of genes (alleles) in the chromosome. Recombinant gametes are those in which the original linkage is undone due to exchange of chromosomal pieces by crossing over during meiosis.

6. What is recombination frequency?

Recombination frequency, or crossing over rate, is the percentage of recombinant gametes made by crossing over (in relation to the number of parental gametes made). It always refers to two genes located in the same chromosome.

7. Why does the recombination frequency of genes vary with the distance between them in the chromosome?

The farther the distance between the loci of two genes in a chromosome the higher the recombination frequency between these genes. This is true because once alleles are nearer in the chromosome it is more probable that they are kept united when chromosomal extremities are exchanged by crossing over. On the other hand, if they are farther apart it will be easier for them to separate by crossing over.

8. What is a centimorgan?

Centimorgan, or recombination unit, by convention is a distance between two linked genes that corresponds to 1% of recombination frequency of these genes.

9. How can the concept of recombination frequency be used in genetic mapping?

Genetic mapping is the determination of the location of the genes in a chromosome.

By determining the recombination frequency between several different linked genes it is possible to estimate the distance between them in the chromosome. For example, if a gene A has a recombination frequency of 20% with the gene B, this gene B has

recombination frequency of 5% with the gene C and this gene C has recombination frequency of 15% with the gene A, it is possible to assert that the gene A is 20 centimorgans distant from the gene B and that between them lies the gene C at 15 centimorgans of distance from the gene A.

10. Is crossing over important for the diversity of biological evolution?

Sexual reproduction and recombination of linked genes (crossing over) are, along with mutations, the main instruments of biological variability. Sexual reproduction allows many combinations between genes situated in different chromosomes. Crossing over, however, is the only means to provide recombination of alleles located in a same chromosome. Crossing over probably emerged and has been maintained by the evolution because of its importance to biological diversity.

Biology Questions and Answers

Sex Determination and Sex-Linked Inheritance

1. How is the genetic determination of sex established in humans?

In the diploid genome of human beings there are 46 chromosomes, 44 of them are autosomes and two are sex chromosomes. The individual inherits one of these chromosomes from each parent.

The human sex chromosomes are called X chromosome and Y chromosome. Individuals having two X chromosomes (44 + XX) are female. Individuals having one X chromosome and one Y chromosome (44 + XY) are male. (Individuals 44 + YY do not exist since the chromosome Y is exclusively from paternal lineage.)

2. What are the homologous and the heterologous portions of the human sex chromosomes?

Homologous portion is that in which there are genes having alleles in both Y and X sex chromosomes. The homologous portions are situated more in the central part of the sex chromosomes, near the centromere.

Heterologous portion is that whose genes do not have correspondent alleles in the other sex chromosome. These genes are located more in the peripheral regions of the arms of the Y and X chromosomes.

3. Concerning the sex chromosomes of the XY system which type of gamete do the male and the female individuals respectively produce?

The individual of the male sex is XY so he forms gametes containing either the X chromosome or the Y chromosome in a 1:1 proportion. The individual of the female sex is XX and thus she forms only gametes containing an X chromosome.

4. Is it possible that an X chromosome of a woman can have come from her father?

It is not only possible that an X chromosome of a woman is from her father, it is certain. Every woman has an X chromosome from her father and the other X chromosome from her mother.

In men however the X chromosome comes always from his mother and the Y chromosome is always from his father.

Biology Questions and Answers

5. Is it more indicated for a geneticist desiring to map the X chromosome of the mother of a given family (the researcher does not have access to her DNA, only access to the genetic material of the offspring) to analyze the chromosomes of her daughters or of her sons?

To analyze the X DNA of a mother (assuming no access to her own material) it is more indicated to study the genetic material of her sons since all X chromosomes of males come from the mother while the daughters have X chromosomes from the mother and from the father. By researching the material of the sons it is ensured that the studied X chromosome is from the mother.

6. Do the genes of the X and Y chromosomes determine only sex characteristics?

Besides sex genes the sex chromosomes have also autosomal genes, genes that codify several proteins related to nonsexual traits.

7. What are the main diseases caused by errors of the number of sex chromosomes in the cells of an individual?

Diseases caused by abnormal number of sex chromosomes are called sex aneuploidies.

The main sex aneuploidies are: 44 + XXX, or trisomy X (women whose cells have an additional X chromosome); 44 + XXY, or Klinefelter's syndrome (men whose cells have an extra X chromosome); 44 + XYY, or double Y syndrome (men whose cells have an additional Y chromosome); 44 + X, Turner’s syndrome (women whose cells lack an X chromosome).

8. What is the inactivation of the X chromosome? What is a Barr body?

Inactivation of the X chromosome is a phenomenon that occurs in women. Since women have two X chromosomes only one of them remains active and functional mixed to the chromatin while the other remains condensed and inactive.

In the same woman in some cell lineages the functional X chromosome is the one from the father and in other cell lineages the functional chromosome is the X from the mother characterizing a condition known as mosaicism (related to the X chromosome).

Under the microscope the inactive X chromosome is seen as a granule generally in the periphery of the nucleus. This granule is called the Barr body.

Biology Questions and Answers

9. Besides the XY system are there other sex determination systems?

Some animals have a sex determination system different from the XY system.

The X0 system is the sex determination system of many insects; in this system the females are XX and the males have only one X chromosome (a conditioned represented by X0).

In birds, in some fishes and in lepidopterae (butterflies) insects the sex determination is made by the ZW system; in this system females are ZW and males are ZZ.

In another system, the haploid-diploid sex determination system, one of the sexes is represented by the fertilized diploid individual and the individual of the opposite sex is formed by parthenogenesis, being haploid (it occurs in bees and other insects).

10. What are X-linked traits?

X-linked traits are phenotypical traits conditioned by genes located in the nonhomologous (heterologous) portions of the X chromosome.

11. How many alleles of genes that condition X-linked traits do female and male individuals respectively present?

For each correspondent gene to an X-linked trait women present always two alleles since they have two X chromosomes. Men present only one allele of genes related to X-linked traits since they have one X chromosome.

12. What is the clinical deficiency presented by hemophilic people? What is the genetic cause of that deficiency?

Hemophilia is a disease characterized by impaired blood clotting and the affected person is more prone to internal and external hemorrhages.

Patients with hemophilia A have alteration in the gene that codifies the factor VIII of blood clotting, a gene located in the non-homologous portion of the X chromosome. Patients with hemophilia B present a defect of the gene that codifies the factor IX of clotting, a gene also located in the non-homologous region of the X chromosome. Thus both diseases are X-linked diseases.

13. What are all possibilities of genotypes and phenotypes formed in the combination of alleles responsible for the production of factor VIII?

Considering the alleles Xh and X, where Xh represents the allele that conditions hemophilia A, in women the possible genotypes are XX, XXh and XhXh. In men the possible genotypes are XY and

XhY. Concerning the phenotypes, factor VIII is produced in every individual with at least one nonaffected X chromosome. So the women XX and X Xh and the men XY are normal. Only women XhXh and men XhY have the disease.

14. Why is it rare to find hemophilic women?

There are more hemophilic men than hemophilic women because women need to have two X chromosomes affected to develop the disease while in men the disease manifests when the single X chromosome is affected.

15. Is it possible for any son of a couple formed by a hemophilic man (XhY) and a nonhemophilic noncarrier (XX) woman to be hemophilic?

If mothers are not affected by the disease and noncarriers of the gene (do not have an Xh allele) it is impossible for their sons to be hemophilic since the X chromosome of males always comes from the mother. Hemophilic sons are only possible when the mother is hemophilic (homozygous for the hemophilic gene, a very rare situation) or carriers of an affected X chromosome (XXh).

16. What is the clinical manifestation of the disease known as daltonism?

The X-linked daltonism is a disease in which the affected individual sees the red color as green or confounds these two colours.

17. What is the type of genetic inheritance of daltonism? Is daltonism more frequent in men or in women? What is the physiological explanation for the daltonism?

Daltonism is a recessive X-linked inheritance (gene situated in the nonhomologous portion of the X chromosome).

Daltonism is more frequent in men since in them only the single X chromosome needs to be affected for the disease to manifest. In women it is necessary for both X chromosomes to be affected for the disease to come out.

The disease appears due to a defect in the gene that codifies a retinal pigment sensitive to red.

18. Are sex-linked diseases associated only to genes of the X chromosome?

There are many X-linked diseases, like hemophilia A, hemophilia B and adrenoleukodystrophy, but known Y-linked diseases are few and very rare.

19. What are holandric genes?

Holandric genes are genes situated in the nonhomologous region of the Y chromosome. Holandric genes condition phenotypes that emerge only in men since individuals of the female sex do not present in their X chromosomes genes from the nonhomologous portion of the Y chromosome (existent only in men). A widely known holandric gene is the one that conditions hypertrichosis pinnae (hair in the ears), a phenotype inherited from fathers to sons through the Y chromosome.

20. What is sex-influenced dominance?

Sex-influenced dominance is the phenomenon in which the manifestation of a phenotype of a gene in heterozygosity depends on the sex of the individual. For example, hereditary baldness is a dominant phenotypical form if the individual is male and it is a recessive form if the individual is female.

Biology Questions and Answers

Blood Types

1. What are the main human blood group systems?

In humans the main blood group systems are the ABO system, the Rh system and the MN system.

2. Why is the determination of the blood types of the donor and of the recipient important in transfusions?

Red blood cells have different antigens in the outer surface of their plasma membrane; for example, the antigens A and B of the ABO system are glycoproteins of the membrane. If a donor has red blood cells with antigens not present in the red blood cells of the recipient (lacking of transfusion compatibility) the immune system of the recipient recognizes these molecules as actual antigens (i.e., foreign substances) and triggers a defense response producing specific antibodies against those antigens. The transfused red blood cells then are destroyed by these antibodies and the recipient individual may even die.

3. What are the antigens and the respective antibodies of the ABO blood group system?

The ABO blood system includes the erythrocytic antigens A and B that can be attacked by the antibodies anti-A and anti-B.

The antigens A and B are agglutinogens and the antibodies anti-A and anti-B are agglutinins.

4. What are the blood types of the ABO blood system?

The blood types of the ABO blood system are the type A, the type B, the type AB and the type O.

5. What are the antigens and antibodies of each blood type of the ABO blood system?

Type A: antigen A, antibody anti-B.
Type B: antigen B, antibody anti-A.
Type AB: antigens A and B, does not produce antibody A neither antibody B.
Type O: does not have antigen A neither antigen B, has antibodies anti-A and anti-B.

(Obviously antibodies are made by B lymphocytes not by red blood cells.)

6. What is the logic of the transfusional compatibility concerning the ABO blood group system?

The transfusional compatibility for the ABO system takes into account the

antigens present in the red blood cells of the donor and the antibodies that the recipient can produce. Whenever the recipient is not able to produce antibodies against antigens of the red blood cells of the donor the transfusion is compatible.

So regarding ABO compatibility type A can donate to type A and to type AB. Type B can donate to type B and to type AB. Type AB can donate only to type AB. Type O can donate to all ABO types.

(Blood transfusion must be studied, planned and supervised by doctors.)

7. What are universal donors and universal recipients concerning the ABO blood system?

Universals donors of the ABO blood type system are the individuals of the type O. Type O blood does not have antigen A neither antigen B in its red blood cells and can be donated to individuals of any ABO type.

Universal recipients of the ABO blood type system are the individuals of the type AB. Type AB blood does not contain antibody anti-A neither antibody anti-B and people of this group can receive blood from any of the ABO types.

8. What is the type of genetic inheritance that determines the ABO blood group system? What are the relations of dominance among the involved alleles?

The inheritance of the ABO blood system is a multiple alleles inheritance. There are three involved alleles, I_A, I_B and i that combine in pairs to form the genotypes.

Concerning dominance, the allele i is recessive in relation to the alleles I_A and I_B. Between I_A and I_B however lack of dominance is established with the heterozygous (I_AI_B) manifesting distinct phenotype.

9. What are the genotypes and respective blood types of the ABO system?

Since the alleles are I_A, I_B and i the possible genotypes are I_AI_A (blood type A), I_AI_B (blood type AB), I_BI_B (blood type B) and ii (blood type O).

10. Is it possible to perform investigation of natural paternity, maternity or brotherhood and sisterhood using the ABO blood typing?

By using the ABO blood typing it is possible only to exclude paternity, maternity or brotherhood/sisterhood but it is not possible to conclude positively about these relationships.

For example, if an individual has type O blood, ii genotype, he or she cannot have biological parents of the type AB (I_AI_B genotype) since necessarily one of his/her alleles has come from the father and the other from the mother. Another example: a couple of individuals of the type O (ii) in their turn can only generate direct offspring of the type O blood, since they do not have alleles that condition antigen A neither antigen B.

11. Is ABO blood compatibility enough for the safety of blood transfusion?

Besides ABO blood compatibility the compatibility concerning the Rh blood system must also be checked. In addition it is of fundamental importance for the safety of blood transfusion performing tests to detect agents of main blood transmitted infectious diseases, like HIV (AIDS), hepatitis B and C, syphilis, Chagas disease, etc.

(Any transfusion must be studied, planned and supervised by doctors.)

12. What is the Rh factor?

RH factor is a protein of the red blood cell plasma membrane that behaves as antigen in blood transfusions triggering a humoral (antibody-based) immune response. Most people present the protein in their red blood cells and are part of the Rh+ group. People that do not have the protein classify as Rh-.

The origin of the name Rh factor is related to the first researches that discovered this blood antigen was in rhesus monkeys ("Macaca mulatta").

13. How are the antibodies against the Rh factor formed?

Anti-Rh antibodies are made by humoral immune response. When an Rh- individual makes contact with the Rh factor this is recognized as foreign (antigen), the primary immune response begins and small amounts of anti-Rh antibodies and memory B lymphocytes are made. In future contact with the antigen there will already be circulating antibodies and memory immune cells prepared to create an intense and effective attack against the Rh factor.

14. What is blood typing?

Blood typing is the determination, by means of tests, of the classification of a blood sample concerning blood group systems (specially the ABO system and the Rh system).

15. How is the blood typing concerning the ABO system and the Rh usually done?

In the blood typing for the ABO system and the Rh system a blood sample is collected from the person and three small volumes of the sample are separated and dispersed on glass laminae (slides). On the first lamina

serum containing anti-A antibody is dripped; on the second lamina serum containing anti-B antibody is dripped; on the third lamina serum with anti-RH antibody is dripped. If no agglutination reaction takes place in all of the laminae the blood is of type O- (universal donor); if agglutination occurs only in the first lamina the blood is type A-; and so on.

There are other methods of blood typing. Blood typing must be performed by qualified technicians.

16. What are the inheritance and dominance patterns of the Rh blood system?

The inheritance pattern of the Rh blood system is autosomal dominant, i.e., the heterozygous manifests as Rh+. The dominance is complete (R is dominant over r). The possible genotypes are RR, Rr (both Rh+) and rr (Rh-).

Curiosity: the Rh factor is codified by a gene containing 2790 DNA nucleotides situated in the human chromosome 1.

17. What is the logic of the transfusional compatibility concerning the Rh blood group system?

An Rh+ donor can only donate blood to an Rh+ recipient. A person that lacks the Rh factor (Rh-) can donate to individuals of the Rh+ and Rh- groups.

18. What is the Rh typing of the mother and of the fetus in the hemolytic disease of the newborn?

In the hemolytic disease of the newborn the mother is Rh- and the fetus Rh+. In this disease antibodies produced by the mother attack the fetal red blood cells.

The hemolytic disease of the new born is also known as erythroblastosis fetalis.

19. How does the immune process that causes the hemolytic disease of the newborn take place?

In the hemolytic disease of the newborn the mother has Rh- blood. This mother when generating her first Rh+ child makes contact, possibly during delivery, with Rh+ red blood cells of the child and her immune system triggers the primary immune response against the Rh factor. In the next gestation in which the fetus is Rh+ the mother will already have much more anti-Rh antibodies in her circulation; these antibodies cross the placental barrier and gain the fetal circulation causing fetal hemolysis (destruction of the red blood cells of the fetus).

20. How can the hemolytic disease of the newborn be prevented?

Erythroblastosis fetalis can be prevented if in the first delivery of a Rh+ child from a Rh- mother serum containing

anti-Rh antibodies is given to the mother in the first 72 hours (after the delivery). Therefore the administered anti-Rh antibodies destroy the fetal red blood cells that entered the mother's circulation before the triggering of her primary immune response.

21. What is the MN blood system? What is the pattern of genetic inheritance of the MN blood system?

The MN blood system is a third (in addition to the ABO and the Rh) system of blood antigens also related to proteins of the red blood cell plasma membrane.

The inheritance pattern of the MN blood system is autosomal with codominance, a type of lack of dominance in which the heterozygous manifests a phenotype totally distinct from the homozygous. The possible phenotypical forms are three blood types: type M blood, type N blood and type MN blood.

Biology Questions and Answers

Karyotype and Genetic Diseases

1. What is karyotype?

The name karyotype is given to the set of chromosomes of an individual, usually when visualized and identified under the microscope. The visualization generally is made with the cells in the initial phases of cell division for the chromosomes to be seen already replicated and condensed.

2. Which type of genetic disease can be identified from the visual analysis of the number of chromosomes present in a karyotype?

The counting and identification of chromosomes in the karyotype of an individual can diagnose the aneuploidies, diseases caused by alteration in the number of chromosomes in relation to the normal number of the species.

3. Why in the preparation of a karyotype analysis is the use of a substance like colchicine interesting?

Colchicine is a substance that disallows the formation of microtubules and thus of the spindle fibers in cell division. Under the action of this drug the cells interrupt division at metaphase and the anaphase does not occur. Therefore the use of colchicine in the study of karyotypes is interesting because chromosomes will be seen replicated and condensed.

4. What is the karyotype found in Down syndrome?

Down syndrome is an aneuploidy, i.e., a numeric alteration of chromosomes within the cells compared to the normal number of chromosomes of the species. Affected individuals have in their cells an additional chromosome 21 instead of only one pair. For this reason the condition is also called trisomy 21. The affected person has karyotype with 47 chromosomes: 45 + XY or 45 + XX.

5. What is aneuploidy? What are the conditions caused by the aneuploidies?

Aneuploidy is an abnormal number of chromosomes in the cells of an individual.

The main aneuploidies of the human species and their respective conditions are: the nullisomies (absence of any chromosome pair of the species, often incompatible with life); the monosomies (absence of a chromosome from a pair, for example, Turner's syndrome, 44 + X); the trisomies (an extra chromosome, for example, the triple X syndrome, 44 + XXX, or the Edwards

syndrome, trisomy 18, 45 + XY or 45 + XX).

6. In general what is the cause of the aneuploidies?

Generally the aneuploidies are caused by impaired assortment of chromosomes during meiosis. For example, when the homologous chromosomes of the pair 21 do not separate gametes with two chromosomes 21 and gametes without chromosomes 21 form. If a gamete with two chromosomes 21 fecundates a normal gamete of the opposite sex the zygote will present trisomy (three chromosomes 21). If a gamete without chromosomes 21 fecundates a normal gamete of the opposite sex there will be a zygote with monosomy (with only one chromosome 21).

The defects in the separation of chromosomes during cell division are called chromosomal nondisjunctions. During meiosis nondisjunctions may occur in the anaphase I (nondisjunction of homologous) as well in anaphase II (nondisjunction of sister chromatids).

7. Do all genetic diseases result from alteration in the number of chromosomes of the cells?

Besides aneuploidies there are other genetic diseases, other chromosomal abnormalities and also the genetic mutations.

8. How are genetic diseases classified?

Genetic diseases classify into chromosomal abnormalities and genetic mutations.

Among chromosomal abnormalities there are the aneuploidies, diseases caused by alterations of the normal (euploidy) number of chromosomes of the species. An example of aneuploidy is Down syndrome, or trisomy 21, in which there are three chromosomes 21 instead of the normal pair. In the group of chromosomal abnormalities there are also the deletions (absence of part of a chromosome), the inversions (in which a chromosome breaks and its pieces reconnect in inverse manner) and the translocations (pieces of a chromosome that exchange positions).

In the genetic mutation group there are the deletions (one or more DNA nucleotide absent), the substitutions and the insertions.

9. What are genetic mutations?

Genetic mutations are alterations of the genetic material (compared to the normal condition of the species) involving modifications in the normal nucleotide sequence of a gene but without structural or numeric chromosomal changes.

These modifications may be deletions (loss of nucleotides), substitutions (exchange of nucleotides by other different nucleotides) or insertions

(placement of additional nucleotides in the DNA molecule).

10. Does every gene mutation cause alteration in the protein the gene normally codifies?

Not every gene mutation causes alteration in the composition of the protein the gene codifies. Since the genetic code is degenerated, i.e., there are amino acids codified by more than one different DNA nucleotide triplet, if by chance the mutation substitutes one or more nucleotides of a codifier triplet and the newly formed triplet still codifies the same amino acid codified by the original triplet there will be no modification in the protein made from the gene.

11. How do genetic mutations influence biological diversity?

Too extensive or too frequent genetic mutations generally are deleterious for individuals and species. These mutations often cause important phenotypical changes or defects incompatible with the survival of the body and the continuity of the species.

However small genetic mutations that do not cause the appearing of lethal changes are continuously accumulated in the genetic patrimony of the species. These mutations gradually add to each other giving birth to small phenotypical changes in individuals. These small changes are exposed to the selective criticism of the environment (natural selection) and the more favorable for survival and reproduction are preserved (the remaider are eliminated as their carriers have difficulty in surviving and reproducing). In this manner the combined processes of accumulation of small mutations and of natural selection incorporate new features in the species and they may even lead to speciation (formation of new species) and promotion of biological diversity.

(Obviously only genetic mutations transmitted by cells that originate new individuals, in sexual or asexual reproduction, have evolutionary effect.)

12. What are mutagenic agents?

Mutagenic agents, or mutagens, are physical, chemical or biological factors that can cause alteration in DNA molecules.

Examples of well-known or believed to be mutagenic agents are: X, alpha, beta and gamma rays, ultraviolet radiation, nitrous acid, many dyes, some sweeteners, some herbicides, many substances of tobacco, some viruses, like HPV, etc. Small DNA fragments known as transposons can also act as mutagens when incorporated into other DNA molecules.

Biology Questions and Answers

13. How are mutagenic agents related to cancer incidence in a population? Is cancer a disease transmitted to the individual offspring?

The exposition of a population to mutagenic agents (for example, the people living in the surrounds of the Chernobyl nuclear power plant and exposed to the radiation from the nuclear accident in 1986) increases the cancer incidence in that population. This occurs because the mutagenic agents increase the rate of mutation and the probability of mutant cells to proliferate in pathological manner (cancer).

Cancer itself is not a hereditarily transmissible disease. Genetic predispositions for the development of cancer, however, can be inherited.

14. How do the repairing enzymes of the genetic system act?

There are enzymes within the cells that detect errors or alterations in DNA molecules and begin a repair of those errors. First, enzymes known as restriction endonucleases, specialized in cutting DNA molecules (also used in genetic engineering), cut the affected piece of DNA. Then polymerase enzymes build correct sequences of nucleotides correspondent to the affected piece taking as template the DNA chain complementary to the affected chain. Finally the new correct sequence is bound in the DNA under repair by specific enzymes.

15. What are some diseases or genetic abnormalities caused by recessive genes?

Examples of recessive genetic diseases are: cystic fibrosis, albinism, phenylketonuria, galactosemia, Tay-Sachs disease.

16. What are some diseases or genetic abnormalities caused by dominant genes? Why are severe dominant genetic diseases rarer than recessive ones?

Examples of dominant genetic diseases are: Huntington's disease (or Huntington’s chorea), neurofibromatosis, hypercholesterolemia, polycystic kidney disease.

Severe and early autosomal dominant diseases are rarer than recessive autosomal diseases because in this last group the affected allele may be hidden in the heterozygous individuals and transmitted to the offspring until undergoing homozygosity (actual manifestation of the disease). In severe dominant diseases the heterozygous manifests the condition and often dies without having offspring. (Some genetic diseases are of later manifestation, like Huntington disease; in these cases the incidence is higher because many individuals have children before knowing that they are carriers of the dominant gene).

17. What is consanguineal marriage? Why is the appearing of genetic disease more probable in the offspring of a consanguineal marriage?

Consanguineal marriage is the marriage between relatives, i.e., people having common near ancestors.

The consanguineal marriage increases the probability of recessive genetic disease in the offspring since it is common for people from the same genetic lineage to be heterozygous carriers of alleles that condition recessive genetic diseases.

18. How is the early diagnosis of genetic diseases usually done?

Genetic disease may be diagnosed in the prenatal period by karyotype analysis, in case of aneuploidies, or by DNA analysis, in case of other diseases.

The test is performed by removal of material containing cells of the embryo by amniocentesis (extraction of amniotic fluid) or cordocentesis (puncture of the umbilical cord) or even by chorionic villus biopsy (that can be done earlier in gestation).

Ultrasonography is a diagnostic procedure for some genetic diseases that produce morphological variations during the embryonic development. The study of genetic family trees is also an important auxiliary method in the early diagnosis of many genetic diseases.

The Hardy-Weinberg Principle

1. What is allele frequency?

Allele frequency is the percentage of appearances of an allele in the genotypes of a given population (compared to the other alleles of the studied gene).

For example, in the ABO blood system there are three alleles (I_A, I_B and i). Considering a group of three persons, one with genotype I_Ai, other I_AI_B and other ii, the frequency of the allele I_A in this "population" is 2/6, the frequency of the allele I_B is 1/6 and the frequency of the allele i is 3/6.

2. What is genetic equilibrium?

Genetic equilibrium is the result of the Hardy-Weinberg law, a principle that affirms that under specific conditions the frequencies of the alleles of a gene in a given population remain constant.

(The Hardy-Weinberg principle is not valid in the following conditions: for populations too small, in the occurrence of noncasual (driven) crossings, for populations with many infertile members and in case of action of evolutionary factors, like natural selection, mutations and migrations.)

Biology Questions and Answers

3. What is the mathematical expression of the genetic equilibrium for genes with two alleles? Is this statistical distribution the same as the statistical distribution of the respective phenotypes?

Considering p the frequency of one of the alleles and q the frequency of the other allele of a given gene in a population, in this population individuals produce p gametes with the first allele for each q gamete containing the second allele. Therefore the probabilities of formation of homozygous genotype for the first allele is p^2, of homozygous genotype for the second allele is q^2 and of the heterozygous genotype is p.q + q.p, i.e., 2p.q.

Since the sum of those probabilities necessarily is 1, the resulting mathematical expression is: $p^2 + 2p.q + q^2 = 1$.

In general the number of genotypical forms is not identical to the number of phenotypical forms since there are dominance and other interactions between genes that affect the manifestation of the phenotype.

4. An hypothesis for the extinction of the dinosaurs is that the earth had been hit by a gigantic meteor that caused the death of those big reptiles. In that case the entire genetic pool of those animals has been destroyed, invalidating the Hardy-Weinberg equilibrium. In Genetics what is this type of gene frequency change called?

The phenomenon in which a large number of genes is destroyed or introduced in a population is called genetic drift.

When a genetic drift occurs the Hardy Weinberg principle is not applicable.

5. What are the penetrance and the expressivity of a gene?

Individuals that carry a same genotype do not always manifest in an identical manner the correspondent phenotype. These manifestations may differ in intensity, from one individual to another, or even the phenotype may not manifest in some percentage of carriers.

Gene penetrance is the percentage of phenotypical manifestation of a gene in a given population of carrier individuals (same genotype). Gene expressivity is the degree (intensity) of the phenotypical manifestation of a gene in each individual or group of individuals that carry the gene (same genotype). The gene penetrance and the gene

expressiveness may be influenced by the environment.

6. Why is a balanced frequency of different alleles of a gene in a population more useful for the survival of that population facing environmental changes?

For a trait conditioned by two alleles, for example, A and a, a balanced frequency between the alleles A and b is more advantageous for survival. For example, in an environmental situation in which the aa homozygous phenotype becomes incompatible with life the presence of a good number of individuals AA and Aa will result in better survival chance for the species. Another example: an environmental situation in which the dominant phenotype becomes incompatible with life; in this case the existence of heterozygous and recessive homozygous individuals in enough number may be fundamental for the survival of the species.

Biology Questions and Answers

Genetic Engineering

1. What is biotechnology?

Biotechnology is the application of biological knowledge to obtain new techniques, materials and compounds of pharmaceutical, medical, agrarian, industrial and scientific use, i.e., of practical use.

The pioneer fields of biotechnology were agriculture and the food industry but nowadays many other practical fields use its techniques.

2. What is genetic engineering?

Genetic engineering is the use of genetic knowledge to artificially manipulate genes: It is one of the fields of biotechnology.

3. At the present level of the biotechnology what are the main techniques of genetic engineering?

The main techniques of genetic engineering today are: the recombinant DNA technology (also called genetic engineering itself) in which pieces of genes from an organism are inserted into the genetic material of another organism producing recombinant beings; the nucleus transplantation technology, popularly known as "cloning", in which a nucleus of a cell is grafted into a enucleated egg cell of the same species to create a genetic copy of the donor (of the nucleus) individual; the technology of DNA amplification, or PCR (polymerase chain reaction), that allows millions replications of chosen fragments of a DNA molecule.

The recombinant DNA technology is used to create transgenic organisms, like mutant insulin-producing bacteria. The nucleus transplantation technology is in its initial development but it is the basis, for example, of the creation of "Dolly" the sheep. PCR has numerous practical uses, as in medical tests to detect microorganisms present in blood and tissues, DNA fingerprint and obtainment of DNA samples for research.

4. What are restriction enzymes? How do these enzymes participate in the recombinant DNA technology?

Restriction enzymes, or restriction endonucleases, are enzymes specialized in the cutting of DNA fragments each acting upon specific sites of the DNA molecule. Restriction enzymes are used in the recombinant DNA technology to obtain with precision pieces of DNA molecules to be later inserted into other DNA molecules cut by the same enzymes.

Biology Questions and Answers

5. What are DNA ligases? How do these enzymes participate in the recombinant DNA technology?

DNA ligases are enzymes specialized in tying the complementary DNA chains that form the DNA double helix. These enzymes are used in the recombinant DNA technology to insert pieces of DNA cut by restriction enzymes into other DNA molecules submitted to the action of the same endonucleases.

6. What are plasmids?

Plasmids are circular DNA molecules present in the genetic material of some bacteria. They may contain genes responsible for bacterial resistance to some antibiotics and for proteins that cause virulence (pathogenic hostility).

7. How is genetic engineering used to create bacteria capable of producing human insulin?

In the production of human insulin by bacteria the human insulin gene is incorporated into the genetic material of these microorganisms. The mutant bacteria multiply forming lineages of insulin-producing bacteria.

In bacteria there are circular strands of DNA called plasmids, minichromosomes which act as an accessory to the main DNA. To create a mutant bacteria capable of producing insulin a plasmid is submitted to the action of restriction enzymes (restriction endonucleases) specialized in cutting DNA fragments. The once circular plasmid is open by the restriction enzyme. The same enzyme is used to cut a human DNA molecule containing the insulin gene. The piece of human DNA containing the insulin gene then has its extremities bound to the plasmid with the help of DNA ligases. The recombinant plasmid containing the human insulin gene is then inserted into the bacteria.

Another human hormone already produced by recombinant bacteria is GH (somatotropin, or growth hormone).

The insertion of DNA molecules into cells of an individual is also the method of the gene therapy, a promising treatment for genetic diseases. In gene therapy cells from an organism deficient in the production of a given protein receive (by means of vectors, e.g., virus) pieces of DNA containing the protein gene and they then begin to synthesize the protein.

8. What is cloning?

Cloning is the making of an organism genetically identical to another by means of genetic engineering.

The basis of cloning is the nucleus transplantation technology. A nucleus from a cell is extracted, generally from an embryonic (not differentiated) cell and this nucleus is inserted into a previously enucleated reproductive cell (in general an egg cell); the egg is then implanted in the organ where the embryonic development will take place. If embryonic development occurs the new organism will have identical genetic

patrimony to the organism owner of the cell whose nucleus was used in the transplantation.

9. What is PCR? How does PCR works?

PCR, polymerase chain reaction, is a method to synthesize many copies of specific regions of a DNA molecule known as target-regions. Its inventor, Kary Mullis, won the Nobel prize for Chemistry in 1993.

First, the DNA to be tested is heated to cause the double helix to rupture and the polynucleotide chains to be exposed. Then small synthetic sequences of DNA known as primers and containing nucleotide sequences similar to the sequences of the extremities of the region to be studied (for example, a region containing a known gene exclusive of a given organism) are added. The primers paired with the original DNA in the extremities of the gene to be amplified. Enzymes known as polymerases, that catalyze DNA replication, and nucleotide supply are added. The primers then are completed and the chosen region is replicated. In the presence of more primers and more nucleotides millions of copies of that specific region are generated. (PCR is very sensitive even using a minimal amount of DNA).

10. What is the fact of Molecular Biology on which DNA fingerprint is based?

DNA fingerprint, the method of individual identification using DNA, is based on the fact that the DNA of every individual (with exception of identical twins and individual clones) contains nucleotide sequences exclusive to each individual.

Although normal individuals of the same species have the same genes in their chromosomes, each individual has different alleles and even in the inactive portions of the chromosomes (heterochromatin) there are differences in nucleotide sequences among individuals.

11. Why are the recombinant DNA technology and the nucleus transplantation technology still dangerous?

The recombinant DNA technology and the nucleus transplantation technology (cloning) are extremely dangerous since they are able to modify, in a very short time, the ecological balance that evolution has taken millions of years to create on the planet. During the evolutionary process, under the slow and gradual action of mutations, genetic recombinations and of natural selection species emerged and were modified and genetic patrimonies were formed. With genetic engineering however humans can mix and modify genes, making changes of unpredictable long term consequences, risking creating new plant or animal diseases, new types of cancers and new disease outbreaks. It is a field as potentially dangerous as the manipulation of nuclear energy.

12. What is the main moral problem about the cloning of human individuals?

Besides biological perils, a very serious moral problem involves the nucleus transplantation technology concerning humans: an individual right of a human being is offended when a man or woman is made as a copy of another.

Since it is impossible to first ask if the person to be generated wants or not to be a genetic copy of another person, certainly the most important human right is being offended, one's individual freedom, when a human being is obliged to be a genetic copy of another. It is indeed a danger to democracy, whose most basic principle must be nonviolation of individual freedom.

Biology Questions and Answers

Biology Questions and Answers

Evolution

Biology Questions and Answers

Biology Questions and Answers

Origin of Life

1. How old is the earth?

It is believed that the earth is approximately 4.5 billion years old.

2. How old is the universe?

From analysis of data collected by the Hubble telescope the age of the universe is estimated to be about 12 billion years.

3. When did life appear on earth?

It is estimated that life on earth emerged about 3.5 billion years ago, thus 1 billion years after the formation of the planet.

4. Historically how has the origin of life on earth been explained?

The most recurrent explanation for the phenomenon of life on earth is the mythological. People from various parts of the world developed explanatory myths about the origin of animals and human beings. Some of those myths were incorporated into religions and almost all religions have metaphorical or transcendental explanations about the origin of life on the planet.
With the development of science new explanatory attempts have emerged. Notable among them are the spontaneous generation hypothesis, or abiogenesis, that asserted that living beings were created from nonliving material, the cosmic panspermia hypothesis, theory that life on earth is a result of seeding from the outer space, the autotrophic hypothesis, according to which the first living beings were autotrophs, and the heterotrophic hypothesis, the most accepted nowadays, that affirms that life emerged from heterotrophic cells.

At the end of the 1980s decade a new hypothesis known as the RNA world hypothesis was presented. This hypothesis asserts that primitive life had only RNA as genetic material and as structural molecules that later turned into DNA and proteins. The RNA world hypothesis is strengthened by the fact that RNA can play a catalytic role, like enzymes, and by the finding that some bacteria have ribosomes made only of RNA without associated proteins.

5. What is the spontaneous generation hypothesis?

The spontaneous generation hypothesys, or abiogenesis, asserts that life on earth has come from nonliving material. For example, the fact that with time rats appeared around waste was considered in the past a confirmation of this hypothesis. Some supporters of spontaneous generation associated it with the existence of an active principle

(the vital elan) that would be the source of life, a theory known as vitalism.

6. How did the experiments of Redi and Pasteur refute the hypothesis of spontaneous generation?

To refute the spontaneous generation hypothesis many experiments were performed. Francisco Redi, in 1668, verified that maggots appeared on meat only when there was exposition to the environment; within closed environments, they did not appear. In 1862, Louis Pasteur working with swan-neck flasks refuted the abiogenesis hypothesis definitively. In this experiment Pasteur demonstrated that boiled (to kill microorganisms) nutritive soups put in swan-neck flasks (with a curved down mouth so microorganisms could not enter easily) did not contaminate with microorganisms while the same soups within flasks with open upwards mouths were contaminated in a few days. The fact that both flasks were open refuted the argument of the vitalists that the vital elan could not enter the flasks. Pasteur broke the swan-necks of the flasks to demonstrate that proliferation of microorganism could happen if these beings were able to reach the broth.

7. What is panspermia?

Panspermia is a hypothesis that describes life on earth as not originated from the planet. The idea is that the first living beings that colonized the earth came from outer space, from other planets or even from other galaxies by traveling in meteorites, comets, etc. According to this hypothesis even the type of life now existent on earth could have also been seeded intentionally by extraterrestrial beings in other stellar and planetary systems.

8. What is the autotrophic hypothesis on the origin of life?

The autotrophic hypothesis on the origin of life asserts that the first living beings on earth were producers of their own food, just like plants and chemosynthetic microorganisms.

9. What is the heterotrophic hypothesis on the origin of life?

According to the heterotrophic hypothesis the first living beings were very simple heterotrophic organisms, i.e., not producers of their own food, which emerged from the gradual association of organic molecules into small organized structures (the coacervates). The first organic molecules in their turn would have appeared from substances of the earth's primitive atmosphere submitted to strong electrical discharges, to solar radiation and to high temperatures.

Biology Questions and Answers

10. What is the most accepted hypothesis about the origin of life on earth? How does it compare to the other main hypotheses?

The heterotrophic hypothesis is the strongest and most accepted hypothesis about the origin of life.

The spontaneous generation hypothesis has been excluded by the experiments of Pasteur. The panspermia hypothesis is not yet completely refuted but it is not well-accepted since it would be necessary to explain how living beings could survive long space journeys under conditions of extreme temperatures as well as to clarify the manner by which they would resist the high temperatures faced when entering the earth's atmosphere. The autotrophic hypothesis is weakened if one takes into account that the production of organic material from inorganic substances is a highly complex process requiring diversified enzymatic systems and that the existence of complex metabolic reactions on the primitive earth were not probable.

11. Before the emergence of life of what gases was the earth's primitive atmosphere constituted?

The earth's primitive atmosphere was basically formed of methane, hydrogen, ammonia and water vapor.

12. What are the main constituents of the earth's atmosphere in our time?

The present atmosphere of the earth is constituted mainly of molecular nitrogen (N_2) and molecular oxygen (O_2). Nitrogen is the most abundant gas, approximately 80% of the total volume. Oxygen makes up about 20%. Other gases exist in the atmosphere in a low percentage. (Of great concern is the increase in the amount of carbon dioxide due to human activity, the cause of the threatening global warming.)

13. Was there molecular oxygen in the earth's primitive atmosphere? How has that molecule become abundant?

The presence of molecular oxygen in the primitive atmosphere was probably at a minimum and extremely rare. Oxygen became abundant with the emergence of photosynthetic beings, approximately, 1.5 billion years after the appearance of life on the planet.

14. Which physical elements contributed to the great amount of available energy on the primitive earth at the time of the origin of life?

3.5 billion years ago the water cycle was faster than today, resulting in hard storms with intense electrical discharges. There was also no chemical protection from the ozone layer against

ultraviolet radiation. The temperatures in the atmosphere and on the planet surface were very high. Electricity, radiation and heat constituted large available energy sources.

15. What was the experiment of Stanley Miller (1953) on the origin of life?

In 1953 Stanley Miller arranged an experimental apparatus that simulated the atmospheric conditions of the primitive earth. The experiment contained a mixture of methane, ammonia, hydrogen and circulating water that when heated was transformed into vapor. He submitted the mixture to continuous bombardment of electrical discharge and after days obtained a liquid residual within which he discovered organic molecules and among them surprisingly the amino acids glycine and alanine, the most abundant constituents of proteins. Other researchers reproduced the Miller experiment and noted also the formation of other organic molecules such as lipids, carbohydrates and nucleotides.

16. What are coacervates?

Coarcervates are small structures made of the aggregation of organic molecules under water solution. By electrical attraction the molecules join into bigger and more organized particles distinct from the fluid environment forming a membrane-like structure that separates an internal region of the coacervate from the exterior. The coacervates might divide themselves and also absorb and excrete substances. It is believed that these structures may have been the precursors of cells.

17. How can coacervates be formed of phospholipids or polypeptides?

Phospholipids are amphipathic molecules, i.e., they present a polar portion and a nonpolar portion. In contact with water these molecules tend to spontaneously unite and organize themselves forming membranes that create a closed interior space separated from the exterior environment. Polypeptide chains in their turn can attract water (by electrical attraction) forming a surrounding water layer and also creating an organized structure with delimited interior space.

18. How could coacervates have facilitated the emergence of life on earth?

Coacervates probably provided a nitid separation between an internal and an external environment and thus the organic material within was not lost to the ocean. The enzymatic action inside that internal environment could develop in different manners increasing the speed of specific chemical reactions. Coacervates also allowed the molecular flux across its membrane to be selective. Since containing different molecules and differently organized from each other, coacervates could have promoted a competition for

molecules from the environment setting out an evolutionary selection.

19. What is the evolutionary origin of the internal membranous organelles of the cell?

It is accepted that the internal membranous organelles of the eukaryotic, like the Golgi apparatus and the endoplasmic reticulum, appeared from invaginations of the external membrane of primitive cells.

20. How have prokaryotic cells given origin to aerobic eukaryotic cells and to photosynthetic aerobic eukaryotic cells?

According to the most accepted hypothesis aerobic eukaryotic cells emerged from the association of aerobic prokaryotes engulfed by primitive anaerobic eukaryotic cells. This would have been the origin of mitochondria that thus would have primitively been aerobic bacteria engulfed by eukaryotic anaerobes. This hypothesis is called the endosymbiotic hypothesis on the origin of mitochondria.

Chloroplasts would also have appeared by endosymbiosis from the entry of photosynthetic prokaryotes into aerobic eukaryotes, both establishing a mutualist ecological interaction.

21. What evidence strengthens the hypothesis that chloroplasts could have been photosynthetic prokaryotes and mitochondria could have been aerobic prokaryotes?

The fact that chloroplasts are the organelles responsible for photosynthesis in plants leads to the supposition that before symbiosis they were autotrophic prokaryotes. For the reason that mitochondria are the center of the aerobic cellular respiration, the powerhouse of the eukaryotic cell, it is supposed that they were once aerobic prokaryotes.

The endosymbiotic hypothesis to explain the emergence of aerobic and autotrophic eukaryotic beings is strengthened further by the following evidence: chloroplasts as well as mitochondria have their own DNA, similar to bacterial DNA; chloroplasts and mitochondria reproduce asexually by binary division, like bacteria do; both organelles have ribosomes and synthesize proteins.

22. How did the first fermenting autotrophs appeared? What about the first aerobic beings?

The heterotrophic hypothesis asserts that the first living beings were the fermenting heterotrophs. Fermentation released carbon dioxide (CO_2) and then the atmosphere became enriched by this gas. By mutation and natural selection organisms capable of using

carbon dioxide and light to synthesize organic material appeared. These would have been the first photosynthetic beings (that were also fermenting beings since there was no abundance of oxygen).

Since photosynthesis is a reaction that releases molecular oxygen, with the emergence of fermenting autotrophs this gas became available. Some organisms then developed aerobic respiration using O_2, a highly efficient method to produce energy.

23. Why is it more probable that the photosynthetic prokaryotes appeared before the aerobic eukaryotes?

It is more probable that photosynthetic prokaryotes appeared before the aerobic eukaryotes because without photosynthesis the earth's atmosphere would not be enriched with molecular oxygen, and without oxygen the existence of aerobic beings would not be possible.

24. What is an argument that shows that the emergence of photosynthetic beings was crucial for life to reach the marine surface and later the dry land?

Ultraviolet radiation from the sun was not disallowed to reach the surface of the primitive earth. Therefore the development of life on dry land or even near the aquatic surface was impracticable. Probably the first living beings lived submerged in deep water to avoid destruction by solar radiation. Only after the appearance of photosynthetic beings and the later filling of the atmosphere with oxygen released by them the formation of the atmospheric ozone layer that filters ultraviolet radiation was possible.

Biology Questions and Answers

Theory of Evolution

1. What is the problem that the theory of evolution and its rival theories try to solve?

The problem that the theory of evolution, or simply evolution, and its rival theories try to solve is to explain how the different living beings that live on earth have appeared.

2. What is the main theory opposed to evolution?

The main theory that opposes the evolution theory on the explanation of how species emerged (phylogenesis) is fixism.

3. What is fixism?

Fixism is the theory about the diversity of life on earth that affirms that the current existent species were identical to species of the past and came out already adapted to the environment without undergoing changes.

Fixism opposes evolutionism since evolutionism is the idea that current species emerged from gradual transformations suffered by ancestral and extinct species.

The religious version of fixism is called creationism. Many different forms of creationism are found in the mythology of various religions. Modernized religious interpreters teach creationism as a metaphorical wisdom and not as opposed to evolutionism.

Furthermore it is possible to make evolution compatible with creationism by considering that God in His perfection would not create a world so full of imperfections and sufferings like our world. One can maintain the creationist belief thinking that the world God created is another much better world or at least not the one that we see while admitting the imperfection of life that we see has emerged by evolution.

4. In the scientific competition against fixism what are the main arguments that favor evolutionism?

The main arguments in favor of evolutionism are: paleontological, from the study of similarities among fossils of different periods; of compared anatomy, the existence of structures with same origin and function and of residual organs, like the human appendix, that reveal relationships among species; of compared embryology, similarities of structures and developmental processes among embryos of related species; of molecular biology, larger percentage of similar nucleotide sequences in the DNA of species having common ancestors.

Biology Questions and Answers

5. What are fossils?

Fossils are petrified vestiges of beings that lived in the past conserved by chemical and geological processes and found within rocks and sedimentary strata of the terrestrial crust.

6. How does the study of fossils strengthen the theory of evolution?

The study of fossils reveals ancient and extinct species having many similar structures to others of the present and of the past. Fossils still allow radioactive dating to estimate the periods during which species lived and to establish a chronological relationship between them. Those evidences strengthen the hypothesis of relationship and common origin among species and that their features have modified gradually until the formation of the current species.

7. Historically what were the two main evolutionary theories?

The two main evolutionary theories were lamarckism and darwinism.

8. What is meant by the law of use and disuse and by the law of the transmission of acquired characteristics?

According to the law of use and disuse the characteristics of a body vary as it is more or less used. This rule is valid for example for features like the muscular mass and the size of the bones.

The law of the transmission of acquired characteristics in its turn established that parents could transmit to their offspring characteristics acquired by the law of use and disuse.

9. What is lamarckism?

Lamarckism is the theory that unites the law of use and disuse with the law of the transmission of acquired characteristics, i.e., that asserted that acquired characteristics, for example, the muscular mass, could be transmitted from a parent to its offspring.

The theory was proposed by the French naturalist Lamarck in the beginning of the 19th century. At that time the idea was not so absurd since nobody knew how the transmission of hereditary characteristics occurred. (Lamarck had great merit in introducing an evolutionary theory based in natural law at a time dominated by fixism.)

10. Who was Charles Darwin?

Charles Darwin was an English naturalist born in 1809 and considered the father of the theory of evolution. At the end of the year 1831, before turning 23 years of age, Darwin embarked as volunteer scientist on the ship the Beagle for a five year expedition to the

South American coast and the Pacific. During the voyage, whose most famous passage was the stop in the Galapagos Islands, Darwin collected data that he used to write his masterpiece "The Origin of Species" (1859). In this book the principles of the common ancestry of all living beings and of natural selection as the force that drives the diversity of species were described. Darwin died in 1882.

(The original name of the most famous book written by Darwin was "On the Origin of Species by Means of Natural Selection".)

11. What is the mechanism described by Darwin that eliminates species less adapted to environmental conditions?

The mentioned mechanism is the natural selection.

12. How did Darwin reach the principle of natural selection from the observation of differences among individuals of the same species?

Darwin recognized that in a same species there were individuals with different characteristics. He also realized that those differences could lead to different survival and reproduction chances for each individual. Therefore he discovered the importance of the environment acting upon organisms and preserving those having more advantageous characteristics for survival and more able to generate offspring and so he described the basis of the principle of natural selection.

13. How did the industrial revolution in England offer an example of natural selection?

One of the classic examples of natural selection is regarding the moths of industrial zones of England in the end of the 19th century and the beginning of the 20th century. As the industrial revolution advanced the bark of the trees that moths landed on became darker due to the soot released from factories. The population of light moths then decreased and was substituted by a population of dark moths since the mimicry of the dark moths in the new environment protected them from predators, i.e., they had an adaptive advantage in that new environment. Light moths in their turn suffered the negative effect of natural selection for becoming more visible to predators and were almost eliminated. In the open forest far from factories however it was experimentally verified that light moths maintained their adaptive advantage and the dark moths continued to be more easily found by predators.

14. What are the fundamental similarities and differences between lamarckism and darwinism?

Both lamarckism and darwinism are evolutionary theories as opposed to

fixism, both admit the existence of processes that caused changes in the characteristics of the living beings in the past.

They have however different explanations for those changes. Lamarckism combines the law of use and disuse with the law of the transmission of acquired characteristics to explain the changes. Darwinism defends the action of the natural selection.

15. In the time of Darwin the results of Mendel's research on biological inheritance had not been published, Genetics was not yet developed, neither DNA nor the concept of genetic mutation were known. What is the modern darwinist theory that incorporates these bodies of knowledge?

The modern darwinist theory that incorporates knowledge from Genetics and Molecular Biology is called neodarwinism, or synthetic theory of evolution.

16. How does the synthetic theory of evolution incorporate knowledge from Genetics and Molecular Biology into the darwinism?

Today it is known that variation of inherited characteristics is created by alterations in the genetic material of the individuals, more precisely by modifications or recombinations of DNA molecules. Small changes in the genetic material accumulate and new phenotypical characteristics emerge. The carriers of these characteristics then are submitted to natural selection. From modern Biology its recognized that natural selection generates in a given population an increase in the frequency of alleles and genes more favorable to survival and reproduction; less advantageous genes and alleles tend to be eliminated.

17. Using the concepts of variability, environmental pressure and natural selection how does the synthetic theory explain the darwinian natural selection?

Genetic variability occurs from recombination of chromosomes during sexual reproduction and from DNA mutations in germ cells and gametes. Such variability creates individuals who are carriers of some new phenotypical characteristics compared to their ancestors. These individuals are submitted to environmental pressure and can be more or less well-succeeded concerning survival or reproduction. Those better succeeded transmit their genetic patrimony to a larger number of descendants increasing the frequency of their genes in the population; those less well-succeeded tend to transmit their genes to a small number of descendants decreasing the frequency of their genes in the population or even becoming extinct. This process is called natural selection (preservation of organisms

that present more adapted phenotypes for the environmental pressure they face).

18. In hospitals where many tuberculosis patients are treated the population of the tuberculosis mycobacteria may be constituted of multiresistant (to antibiotics) strains. How does the synthetic theory of evolution explain this fact?

The appearance of multiresistant strains of pathogenic parasites in hospitals, for example, of multiresistant tuberculosis bacteria, can be explained by the synthetic theory of evolution.

As in any environment, TB bacteria in hospitals undergo changes in their genetic material. In the hospital environment however they suffer continuous exposition to antibiotics. Many of them die by the antibiotic action but carriers of mutations that provide resistance to those antibiotics proliferate freely. These resistant microorganisms when submitted to other antibiotics again undergo natural selection and those which became resistant to these other drugs are preserved and proliferate. Thus strains of multiresistant (nontreatable) mutant bacteria emerge in hospitals.

The use of antibiotics is a factor that promotes natural selection and the emergence of multiresistant bacteria. This is the reason why hospitals often have committees that control the use of antibiotics.

19. What is reproductive isolation?

Living beings are considered under reproductive isolation when they cannot cross among themselves or if they can cross but cannot generate fertile offspring.

20. What is the relationship between the concept of reproductive isolation and the concept of species?

Reproductive isolation is an important concept because it defines the concept of species: only living beings that can cross among themselves and generate fertile offspring, i.e., that are not under reproductive isolation, belong to the same species. For example, humans and chimps are under reproductive isolation and are not of the same species.

21. What is speciation?

Speciation is the process by which different species emerge from a common ancestor species. Speciation generally begins when populations of the same species become geographically isolated, i.e., when they are separated by some physical barrier that disallows crossing between individuals from one population and individuals of another population.

Groups that for a long time are kept under geographical isolation tend to accumulate different phenotypical

characteristics from each other by means of genetic variability (mutations and recombination) and natural selection. When those differences reach a point that makes the crossing of individuals of one group with individuals of the other group impossible or the generation of fertile offspring no longer happens it is said that speciation has occurred.

22. Why does geographical isolation lead to speciation?

Geographical isolation between groups of the same species leads to formation of a new species since it disallows crossing among isolated individuals. Distinct characteristics from the other groups are incorporated by genetic variability and natural selection into the isolated groups until the emergence of a new species. So the geographical isolation creates the reproductive isolation.

23. How can the fact that fishes and dolphins have similar organs and similar general shape be explained?

Fishes and dolphins have similar organs and shape because although they have phylogenetically distant ancestors they face similar environmental pressures since they share the same habitat (water). So by undergoing genetic variability and natural selection some similar features, for example, the hydrodynamic body and the presence of fins, were incorporated into these animals.

24. What is adaptive convergence?

Adaptive convergence is the phenomenon by which living beings facing the same environmental pressure (problems) and undergoing genetic variability and natural selection incorporate similar (analogous) organs and structures (solutions) into their bodies during evolution. For example, the fins and the hydrodynamic body of fishes and dolphins, phylogenetically distant animals.

25. What is adaptive radiation?

Adaptive radiation is the appearance of several other species from one common ancestral species that have spread to various regions or environments. The different characteristics among the species correspond to the adaptive necessities of the ecological niches each one occupies, i.e., to different environmental pressures.

26. What is the difference between analogous and homologous organs?

Characteristics of different species are said to be analogous when having the same biological function, for example, the wings of bats and the wings of insects.

Characteristics of different species are said to be homologous when having the

same biological origin, i.e., when they are products of differentiation of a same characteristic from a common ancestor, like cat paws and human feet. (Characteristics of different species may be analogous and homologous.)

Biology Questions and Answers

Biology Questions and Answers

Ecology

Biology Questions and Answers

Biology Questions and Answers

Concepts of Ecology

1. What is Ecology?

Ecology is the field of Biology that studies the relationship between living beings and between living beings and the environment.

2. What is a species?

A species is a set of living beings able to cross among themselves generating fertile offspring.

This concept however does not apply to individuals of exclusive asexual reproduction and so other definitions have been proposed. For example, "a species is a set of living beings that evolve in a common manner all of them considered ancestors of the same type in relation to common descendants".

3. What is a population?

A population is a set of individuals of the same species found in a given place in a given time.

4. What is a community? What is the difference between the concepts of community and population?

A community is a set of populations of living beings that live in the same region and interact with each other.

In Ecology a population is a set whose members (living in a given place in a given time) are part of the same species. A community is a set of populations of different species (living in a given place in a given time).

5. What is the difference between an ecological niche and a habitat?

An ecological niche is a set of peculiar activities, resources and strategies that a species explores to survive and reproduce.

An habitat is the place where the species lives to explore its ecological niche.

In other words it can be said that the habitat is the "address" of the species and the ecological niche is the "profession" of the species.

6. What are biotic factors?

Biotic factors are living beings (plants, animals and microorganisms) that are part of a given environment.

7. What are abiotic factors?

Abiotic factors are the nonliving elements that constitute a given environment, like light, temperature, minerals, water, gases, atmospheric pressure, etc.

8. What is an ecosystem?

An ecosystem is a system composed of biotic and abiotic factors in interaction.

9. What is a biosphere?

A biosphere is a set of all of the ecosystems of the planet.

10. What are autotrophic beings? What are heterotrophic beings?

Autotrophic beings are those that can produce their own food, i.e., that make organic material from inorganic compounds. Heterotrophic beings are those that need to incorporate organic material to nourish themselves. Therefore heterotrophs depend on the production of the autotrophs.

11. What are the processes that autotrophic beings use to produce organic material from inorganic substances?

Autotrophic beings make organic material by photosynthesis or by chemosynthesis. There are photosynthetic autotrophs, like plants, and chemosynthetic autotrophs, like some bacteria.

Biology Questions and Answers

Earth's Biomes

1. What is a biome?

A biome is a prevailing ecosystem constituted by similar biotic and abiotic factors present in one or more regions of the planet.

2. What are the major terrestrial biomes?

The major terrestrial biomes are: tundra, taigas (or boreal forest), temperate forests, tropical forests, grasslands and deserts.

3. What are the typical vegetation and the typical fauna of the tundra?

Tundra has vegetation formed mainly by mosses and lichens. In the fauna the densely furred animals, like caribous, musk oxen and polar bears, and also migratory birds are found.

4. What are the typical vegetation and the typical fauna of the taigas?

Taiga, or the boreal forest, is characterized by coniferous trees, pine forests. There are also mosses, lichens, small bushes and angiosperms. In the taiga many mammals, like moose, wolves, foxes and rodents, migratory birds and a great diversity of insects are found.

5. What are the typical vegetation and the typical fauna of the temperate forests?

In the temperate forest deciduous trees predominate. Mammals are found in great number, like bears and deer.

6. What are deciduous trees?

Deciduous trees are plants that lose their leaves in a period of the year. In the case of the deciduous trees of the temperate forest the fall of the leaves occurs in the autumn (fall). The loss of leaves is a preparation to face the cold months of the winter: roots, stem and branches are more resistant to low temperature and snow than the leaves; without leaves the metabolic rate of the plant is reduced; the decaying fallen leaves help to nourish the soil.

7. What is the typical localization of the tropical forests regarding latitude?

Tropical rain forests, like the Amazon forest and the Congo forest, are typically located in low latitude, i.e., in the equatorial and tropical zones.

Biology Questions and Answers

8. What are the typical vegetation and the typical fauna of the tropical forests?

In the vegetation of the tropical forests broadleaf evergreen trees predominate. On the top of the trees epiphytes and lianas grow. Many varieties of pteridophytes can be found in these forests. Regarding the fauna, the abundance and diversity is also great: there are monkeys, rodents, bats, insectivores, felines, reptiles, birds, amphibians and invertebrates, mainly insects.

9. How can the abundance and diversity of living beings in the tropical forests be explained?

The biodiversity of these ecosystems can be explained by the great availability of the main abiotic factors for photosynthesis. Since these factors are abundant plants can perform maximum photosynthetic activity, living and reproducing easily. With a great amount and diversity of producers (autotrophs), the consumers (heterotrophic animals and microorganisms) also have abundant food and a complex food web emerges creating many different ecological niches to be explored. So the appearance of varied living beings as well as the existence of large populations is possible.

10. Why are the tropical forests also known as stratified forests?

In tropical forests tall trees of several species have their crowns forming a superior layer under which diverse other trees and plants develop forming other inferior layers. From the upper layer to the inferior layers the penetration of light lowers gradually and the exposition to wind and rain, the moisture and the temperature also vary. Different compositions of abiotic factors condition the prevailing of different vegetation in each layer.

11. What is the typical vegetation of the grasslands?

Grasslands are mainly formed of herbaceous (nonwoody) vegetation: grass, bushes and small trees.

12. What are the grasslands of North America and of South America respectively called?

The steppe grasslands of North America are called prairies. The grasslands of South America are known as “pampas” (the steppe grassland) and “cerrado” (the savannah grassland).

13. How are grasslands classified?

Grasslands may be classified into steppes and savannahs. In the steppes the prevailing vegetation is grass, as in the pampas of South America and in the prairies of North America. The fauna is mainly formed by herbivores, like rodents and ungulates. The savannahs present small trees, for example in the Brazilian cerrado or the African savannahs. The fauna is diverse; in the Brazilian cerrado there are animals like ostriches, lizards, armadillos, jaguars, etc., and many types of insects; the African savannahs are the home of large herbivores and carnivores, like zebras, giraffes, antelopes, lions and leopards.

14. What are the typical vegetation and the typical fauna of the deserts?

The predominant fauna of desert ecosystems is formed by reptiles, like lizards and snakes, terrestrial arthropods and small rodents. In these areas plants very adapted to a dry climate may be found, like the cactus, which are plants that do not have real leaves and thus lose less water, along with grasses and bushes near places where water is available.

15. Which terrestrial vertebrate group is extremely rare in deserts?

Amphibians are terrestrial vertebrates extremely rare in desert environments (although there are a few species adapted to this type of ecosystem). Amphibians are rare in deserts because they do not have a permeable skin and so they easily lose water by evaporation and desiccate. They also need an aquatic environment to reproduce, since their fecundation is external and their larva is water-dependent.

16. What are plankton, nekton and benthos?

Plankton, nekton and benthos are the three groups into which aquatic living beings may be divided.

The plankton is formed by the algae and small animals that float near the water surface carried by the stream. The nekton is composed of animals that actively swim and dive in water, like fishes, turtles, whales, sharks, etc. The benthos comprises the animals ecologically linked to the bottom, including many echinoderms, benthonic fishes, crustaceans, molluscs, poriferans and annelids.

17. What are the phytoplankton and the zooplankton?

Phytoplankton and zooplankton are divisions of the plankton. The phytoplankton comprises the autotrophic floating beings: algae and cyanobacteria. The zooplankton is formed by the heterotrophic planktonic beings: protozoans, small crustaceans, cnidarians, larvae, etc.

18. What is the group of aquatic beings composed of a large number of photosynthetic beings?

A large number of photosynthetic beings is found in the plankton, i.e., in the surface of aquatic ecosystems. This is because light is abundant on the surface.

Biology Questions and Answers

Food Chains and Trophic Pyramids

1. What is the primary energy source for life on earth?

The primary energy source for life on earth is the sun. The sun plays the important role of keeping the planet warmed and it is the source of the luminous energy used in photosynthesis. This energy is converted into organic material by the photosynthetic autotrophic beings and consumed by the other living beings.

2. What is the main means by which autotrophic beings obtain energy?

The main means by which autotrophs obtain energy is photosynthesis. (There are also chemosynthetic autotrophs.)

3. Which is the autotrophic group responsible for the production of most part of the molecular oxygen of earth?

Algae and cyanobacteria of the phytoplankton are the organisms that contribute most to the production of molecular oxygen.

4. In the ecological study of food interactions, what are the autotrophic beings called?

In Ecology autotrophic beings are called producers because they synthesize the organic material consumed by the other living beings of an ecosystem.

An ecosystem cannot exist without producers.

5. How are the heterotrophic beings divided in the ecological study of food interactions?

Heterotrophs are divided into consumers and decomposers. An ecosystem can exist without consumers but it cannot be sustained without decomposers. Without the decomposers the organic material would accumulate causing environmental degradation and later death of the living beings.

6. What is a food chain?

The food chain is the linear not branched sequence in which a living being serves as food for another, starting with the producers and going up to the decomposers.

Biology Questions and Answers

7. How is energy transferred along a food chain?

The energy flux along a food chain is always unidirectional, from the producers to the decomposers.

8. What are trophic levels? How many trophic levels can a food chain have?

Trophic levels correspond to positions on a food chain. Therefore producers always belong to the first trophic level and decomposers to the last trophic level, consumers that directly eat the producers belong to the second trophic level and so on.

There is no limit regarding the number of trophic levels on a chain, since many orders of consumers can exist.

9. What are primary consumers? Can a food chain present quaternary consumers without having secondary or tertiary consumers? Can a tertiary consumer of one chain be a primary or secondary consumer of another chain?

Primary consumers are living beings that eat autotrophic beings, i.e., they eat the producers. Primary consumers always belong to the second trophic level of a chain.

A food chain cannot have consumers of superior orders without having the consumer of the inferior orders. A consumer however can participate in several different chains not always belonging to the same consumer order in each of them.

10. What is the difference between the concepts of food chain and food web?

The chain concept is a theoretical model to study the energy flux in ecosystems. Actually in an ecosystem the organisms are part of several interconnected food chains, forming a food web. Therefore the chain is a theoretical linear sequence and the web is a more realistic representation of nature in which the food chains interconnect forming a web.

11. What are the three main types of trophic pyramids studied in Ecology?

The three types of trophic pyramids studied in Ecology are the numeric pyramid, the biomass pyramid and the energy pyramid.

Generally the variable dimension of the pyramid is the width, and the height is always the same for each represented strata of living beings. The width therefore represents the number of individuals, or the total mass of these individuals or the available energy in each trophic level.

Biology Questions and Answers

12. What do numeric pyramids represent?

Numeric pyramids represent the number of individuals in each trophic level of a food chain.

13. In a numeric pyramid to which trophic level does the base always refer? What about the top level?

In a numeric pyramid the base corresponds to the first trophic level, i.e., to the producers. The top level of the pyramid corresponds generally to the last consumer order of the food chain (since the number of individual decomposers, most of them microorganisms, is too large to be represented).

14. In a numeric pyramid is it possible for the base to be smaller than the other levels?

Since the numeric pyramid represents the quantity of individuals in each trophic level of the food chain, inferior trophic levels with less individuals than the superior trophic levels may exist. For example, a single tree can serve as food to millions of insects.

15. In the short term what will happen to the levels above and below a population of secondary consumers of a numeric pyramid if a large number of individuals from this population dies?

If an intermediate level of a numeric pyramid has its variable dimension decreased, i.e., if the number of individuals of that level is reduced, the number of individuals of the level below will increase and the number of individuals of the level above will be reduced. That happens because the individuals of the level below will face less predators and the individuals of the level above will have less available food.

16. What do biomass pyramids represent?

Biomass pyramids represent the sum of the masses of the individuals that participate in each trophic level of a food chain.

17. What is dry mass?

When biomasses are compared often the concept of dry mass is used. The dry mass is the total mass less the water mass of an individual. The total mass is also called fresh mass. To use dry mass instead of fresh mass is useful because among living beings there are differences related to the proportion of water within their body and such differences can distort the quantitative

analysis of incorporated organic material.

18. What do energy pyramids represent?

Energy pyramids represent the amount of available energy in each trophic level of the food chain.

19. Into which type of energy is the light used in photosynthesis transformed?

The luminous energy used in photosynthesis is transformed into chemical energy.

20. Can the amount of available energy in a given trophic level be larger than the available energy in inferior trophic levels? What does that condition means to the conformation of the energy pyramids?

A superior trophic level always has less available energy than inferior trophic levels. This is because in each trophic level only a fraction of the organic material of the level below is incorporated into the consumers (into their bodies). The other part is eliminated as waste or is used in the metabolism as energy source. Therefore it is never possible to have energy pyramids with inverted conformation, i.e., with the tip to the bottom and the base to the top. It is also not possible to have superior trophic levels with a variable dimension larger than inferior ones. In every energy pyramid, from the base to the top, the size of the variable dimension decreases.

21. What is the gross primary production of an ecosystem? How does GPP relate to photosynthesis?

Gross primary production of an ecosystem, or GPP, is the quantity of organic material found in a given area in a given period.

Since only autotrophs produce organic material and photosynthesis is the main production process, GPP is a result of the photosynthesis.

22. What are the factors that for influencing photosynthesis also interfere with the gross primary productivity?

Mainly water and light, but also mineral salts, temperature and carbon dioxide are factors that interfere with the gross primary productivity.

23. What are the destinations of the organic material fabricated by the producers?

Part of the organic material synthesized by the producers is consumed as energy source for the metabolism of the own producer individual. The other part is incorporated (into the body) and becomes available to heterotrophic beings of the ecosystem. In each following trophic level part of the organic material is used in the metabolism of the individuals of the level, the other part is eliminated as waste and only a fraction is incorporated and becomes available as food for the following level.

24. What is the formula of the net primary production (NPP)? How does NPP relate to the energy pyramids?

Net primary production is the gross primary productivity less the organic material consumed as energy source in the metabolism of the producers: NPP = GPP – (organic material spent in aerobic respiration). It represents the organic material available in the first trophic level.

The base of the energy pyramids must represent the NPP and not the GPP since the idea of these pyramids is to show the available energy in each trophic level of the food chain.

Biology Questions and Answers

Biogeochemical Cycles

1. What are biogeochemical cycles?

Biogeochemical cycles are representations of the circulation and recycling of matter in nature.

The main biogeochemical cycles studied in Ecology are the water cycle, the carbon cycle and the nitrogen cycle.

2. What is the respective importance of water, carbon and nitrogen for living beings?

Water is the main solvent of living beings and it is necessary practically for all biochemical reactions, including as reagent of photosynthesis. Many properties of water are very important for life.

Carbon is the main chemical element of organic molecules; carbon dioxide is also reagent of photosynthesis and product of the energetic metabolism of living beings.

Nitrogen is a fundamental chemical element of amino acids, the building blocks of proteins that in their turn are the main functional molecules of living beings; nitrogen is also part of the nucleic acid molecules, the basis of reproduction, heredity and protein synthesis.

3. What is the water cycle?

The water cycle represents the circulation and recycling of water in nature.

Liquid water on the planet surface is heated by the sun and turns into water vapor that gains the atmosphere. In the atmosphere large volumes of water vapor form clouds that when cooled precipitate liquid water as rain. Therefore water comes back to the planet surface and the cycle is completed. As possible steps of the cycle, water may still be stored in subterranean reserves or in the form of ice in mountains and oceans and it may also be used in the metabolism of living beings, incorporated into the body of the individuals or excreted through urine, feces and transpiration.

4. Why is the sun the "motor" of the water cycle?

The sun can be considered the motor of the water cycle because upon its energy the transformation of liquid water into water vapor depends. So the sun is the energy source that causes water to circulate in nature.

5. What is the carbon cycle?

The carbon cycle represents the circulation and recycling of the chemical element carbon in nature as a result of the action of living beings.

Photosynthetic beings absorb carbon as carbon dioxide available in the atmosphere and the carbon atoms become part of glucose molecules. During the cellular respiration of these beings part of this organic material is consumed to generate ATP and in this process carbon dioxide is returned to the atmosphere. The other part is incorporated by the photosynthetic organisms into the molecules that compose their structure. The carbon atoms incorporated into the producers are transferred to the next trophic level and again part is liberated by the cellular respiration of the consumers, part becomes a constituent of the consumer body and part is excreted as uric acid or urea (excretes later recycled by decomposer bacteria). Therefore carbon absorbed by the producers in photosynthesis returns to the atmosphere through cellular respiration along the food chain until the decomposers that also liberate carbon dioxide in their energetic metabolism. Under special conditions in a process that takes millions of years carbon incorporated into organisms may also constitute fossil fuels stored in deposits under the surface of the planet; as fossil fuels burn the carbon atoms return to the atmosphere as carbon dioxide or carbon monoxide. The burning of vegetable fuels, like wood, also returns carbon to the atmosphere.

6. What is the main biological process that consumes carbon dioxide?

The main biological process that consumes carbon dioxide is photosynthesis.

7. How is carbon dioxide made by producers and consumers?

Carbon dioxide is made by producers and consumers through cellular respiration.

8. What are fossil fuels?

Fossil fuels, like oil, gas and coal, form when organic material is preserved from the complete action of decomposers, generally buried deep and under pressure over millions of years. Under such conditions the organic material transforms into hydrocarbon fuels.

Fossil fuels are a natural reservoir of carbon. When oxygen is present these fuels can be burned and carbon dioxide and carbon monoxide are released into the atmosphere.

9. What is the most abundant form under which nitrogen is found in nature?

The most abundant nitrogen-containing molecule found in nature is molecular nitrogen (N_2). The air is 80% constituted of molecular nitrogen.

10. Under which form is nitrogen fixed by living beings?

Most living beings cannot use molecular nitrogen to obtain nitrogen atoms.

Producers fix nitrogen mainly from nitrate (NO_3^-). Some plants also fix nitrogen from ammonia. Consumers and decomposers acquire nitrogen through digestion of mainly proteins and nucleic acids from the body of other living beings.

11. What is the nitrogen cycle?

The nitrogen cycle represents the circulation and recycling of the chemical element nitrogen in nature.

The nitrogen cycle basically depends on the action of some specialized bacteria. Bacteria of the soil called nitrogen-fixing bacteria present in plant roots absorb molecular nitrogen from the air and liberate nitrogen in the form of ammonia. The decomposition of organic material also produces ammonia. In the soil and roots (mainly of leguminous plants), a first group of chemosynthetic bacteria called nitrifying bacteria, the nitrosomonas, produces energy consuming ammonia and releasing nitrite (NO_2). The second group of nitrifying bacteria, the nitrobacteria, uses nitrite in chemosynthesis releasing nitrate (NO_3). In the form of nitrate, nitrogen is then incorporated by plants to be used as constituent of proteins and nucleic acids and the element then follows along the food chain. Nitrogen returns to the atmosphere by the action of denitrifying bacteria that use nitrogen-containing compounds from the soil and release nitrogen gas (molecular nitrogen).

12. Why is a leguminous crop rotation used in agriculture?

Leguminous crop rotation and other crop rotations are used in agriculture because in these plants many bacteria important for the nitrogen cycle live. The leguminous crop rotation (or cojointly with the main crop) helps the soil to become rich in nitrates that are then absorbed by the plants.

Green manure, the covering of the soil with grass and leguminous plants, is also a way to improve the fixation of nitrogen and it is an option in avoiding chemical fertilizers.

Biology Questions and Answers

Biodiversity

1. What is biodiversity?

Biological diversity is the variety of species of living beings of an ecosystem. In ecosystems which are more biodiverse, like tropical forests, a great variety of plants, microorganisms and animals live; in ecosystems less biodiverse, like deserts, there are less variety of living beings.

2. How does biological diversity relate to the characteristics of the abiotic factors of an ecosystem?

The availability of abiotic factors like light, moisture, mineral salts, heat and carbon dioxide, more or less conditions the biodiversity of an ecosystem. Photosynthesis depends on water and light, and plants also need mineral salts, carbon dioxide and adequate temperature for their cells to work. In environments where these factors are not restrictive the synthesis of organic material (by photosynthesis) is at a maximum, plants and algae can reproduce easier, the population of these beings increase, potential ecological niches multiply and new species emerge. The large mass of producers makes viable the appearing of a diversity of consumers of several orders. In environments with restrictive abiotic factors, like deserts, the producers exist in small numbers and less diversity, a feature that thus extends to consumers and conditions fewer ecological niches to be explored.

3. How does the vegetal stratification of an ecosystem influence the biological diversity?

The vegetal stratification of an ecosystem, like the strata of the Amazon Rainforest, creates vertical layers with peculiar abiotic and biotic factors, dividing the ecosystem into several different environments. Therefore in the superior layer near the crowns of big trees the exposition to light, rain and wind is greater but moisture is lower compared to the inferior layers. As one goes down the strata the penetration of light diminishes and moisture increases. Regarding the biotic factors, communities of each stratum present ing differcomposition and features, food habits, reproduction strategies, etc. Such variations in the abiotic and biotic factors make the selective pressure upon living beings to be also diversified, there are more ecological niches to be explored and more varied beings emerge during the evolutionary process.

4. Despite having a great biodiversity why is the Amazon Rainforest under risk of desertification?

The natural soil of the Amazon Rainforest is not very fertile but it is

enriched by the vegetal covering made of leaves and branches that fall from the trees. Deforestation reduces this enrichment. In deforestation zones the rain falls directly on the ground causing erosion, "washing" large areas (leaching) and contributing to make the soil even less fertile. Besides that, the deforestation disallows the recycling of essential nutrients for plants, like nitrogen. In this manner those regions and their neighboring regions undergo desertification.

5. How can a great biological diversity protect an ecosystem from environmental damage? Why are less biodiverse ecosystems at risk of suffering deep biological harm if submitted to even small changes?

In ecosystems with more biodiversity the food webs and ecological interactions among living beings are more complex and diverse. In these ecosystems environmental changes can be more easily compensated by the multiplicity of available resources, foods and survival options.

In ecosystems with less biodiversity the individuals are more dependent on some beings that serve them as food and they interact with a small number of different species. In these ecosystems generally abiotic factors are restrictive and the species are more specialized to such conditions and more sensitive to environmental changes. So even small environmental harm can cause big disturbances in the equilibrium of the ecosystem.

6. Is monoculture a system that contributes to great biological diversity of an ecosystem?

Monoculture means that in a large area a single crop (only one species of plant) is cultivated. Therefore monoculture does not contribute to the formation of a community with great variety of species in the area. Since there is only a single type of producer the types of consumers that can live in the area are also restricted.

7. What are some economic applications that can be generated by very biodiverse ecosystems?

Very biodiverse areas present enormous economic potential. They can be a source of raw material for the research and production of medicines, cosmetics, chemical products and food. They are depositories of genetic wealth that can be explored by biotechnology. They are sources of species for agriculture. They can also be explored by 'ecological tourism'.

8. What are the main causes of the loss of biological diversity nowadays?

The biggest dangers to biological diversity today are the action of humans. The main of them is the destruction of habitats caused by the growth of the cities, deforestation, pollution and fires. The second is the invasion of ecosystems by nonnative species introduced by humans; these species change the equilibrium of ecosystems causing harm. Other big dangers are predatory hunting and fishing and global warming.

Biology Questions and Answers

Ecological Interactions

1. What is inharmonious ecological interaction?

Inharmonious, or negative, ecological interaction is that in which at least one of the participating beings is harmed.

2. How are ecological interactions classified?

Ecological interactions are classified as intraspecific or interspecific interactions and as harmonious or inharmonious interactions.

3. What are intraspecific and interspecific ecological interactions?

Intraspecific ecological interactions are those between individuals of the same species. Interspecific ecological interactions are ecological interactions between individuals of different species.

4. What is inharmonious ecological interaction?

Inharmonious, or negative, ecological interaction is that in which at least one of the participating beings is harmed.

5. What is harmonious ecological interaction?

Harmonious, or positive, ecological interaction is that in which none of the participating beings is harmed.

6. What are the main intraspecific ecological interactions?

The main harmonious intraspecific ecological interactions are colonies and societies. The main inharmonious intraspecific ecological interactions are intraspecific competition and cannibalism.

7. What are colonies and societies?

Colonies are functional integrated aggregates formed by individuals of the same species. Colonies are often confused with a single individual. Examples are the coral reefs, by-the-wind sailors and filamentous algae.

Societies are interactions for labor division and collaboration among individuals of the same species. Human societies are examples of ecological societies; other species, like bees, ants, termites, wolves and dolphins, also form societies.

Biology Questions and Answers

8. What is competition? Which type of ecological interaction is competition?

Competition is the ecological interaction in which the individuals explore the same ecological niche or their ecological niches partially coincide and therefore competition for the same environmental resources takes place.

Competition is harmful for all participating beings and thus it is classified as an inharmonious (negative) ecological interaction.

9. What is an example of intraspecific competition?

Intraspecific competition occurs in practically all species, for example, the competition of humans for a job.

10. Why is cannibalism an inharmonious intraspecific ecological interaction?

In cannibalism an individual eats other of the same species (occurs in some insects and arachnids). Since it is an interaction between beings of the same species and at least one of them is harmed (the other is benefited) the classification as inharmonious intraspecific ecological interaction is justified.

11. What are the main interspecific ecological interactions?

The main harmonious interspecific ecological interactions are: protocooperation, mutualism and commensalism. The main inharmonious interspecific ecological interactions are: interspecific competition, parasitism, predatism and ammensalism.

12. What is protocooperation?

Protocooperation is the ecological interaction in which both participants benefit but which is not obligatory for their survival. Protocooperation is a harmonious (positive) interspecific ecological interaction. Examples of protocooperation are: the action of the spur-winged plover that using its beak eats residuals from crocodile teeth; the removal of ectoparasites from the back of bovines by some birds that eat the parasites; the hermit crab that live inside shells over which sea anemones live (these offer protection to the crab and gain mobility to obtain food).

13. What is mutualism?

Mutualism is the ecological interaction in which both participants benefit and that is obligatory for their survival. Mutualism is a harmonious (positive) ecological interaction. Mutualism is also known as symbiosis. Examples of mutualism are: the association between microorganisms that digest cellulose and the ruminants or insects within which they live; the lichens, formed by

algae or cyanobacteria that make organic material for the fungi and absorb water with their help; nitrifying bacteria of the genus Rhizobium that associated to leguminous plants offer nitrogen to these plants.

14. What is commensalism?

Commensalism is the ecological interaction in which one individual benefits while the other is neither benefited nor harmed. Commensalism is a harmonious (positive) ecological interaction, since none of the participants is harmed. An example of commensalism is the numerous bacteria that live in the skin and in the digestive tube of humans without being pathogenic or beneficial. They are innocuous bacteria living in commensalism with humans.

15. What benefits can commensalism offer to a species?

Commensalism may involve obtainment of food (for example, the innocuous bacteria of the human gut), shelter or support (epiphytes on trees) and transportation (pollen carried by insects or birds). The commensalism that involves obtainment of shelter is also called inquilinism.

16. What are some examples of interspecific competition?

Examples of interspecific competition are: the dispute among vultures, worms, flies and microorganisms for carrion and the competition between snakes and eagles for rodents.

17. What is parasitism?

Parasitism is the ecological interaction in which a being lives at the expense of another. The parasite often does not cause immediate death of the host since it needs the host alive to survive.

Parasitism is an inharmonious (negative) interspecific ecological interaction, since although one participant benefit the other is harmed.

18. What are some examples of parasitism?

Classical examples are the parasites of humans (host), like the trypanosome that causes Chagas' disease, the HIV virus (AIDS), the bacteria that causes tuberculosis, the schistosome that causes schistosomiasis, the hookworms, etc. Other examples are: tree (host) and parasitic helminths (parasite), dog (host) and lice (parasite), cattle (host) and tick (parasite), etc.

19. What is predatism?

Predatism is the ecological interaction in which one individual mutilates or kills another to get food. Predatism is an

inharmonious (negative) ecological interaction since one participant is harmed.

20. Is herbivorism a form of predatism?

Herbivorism is a form of predatism in which first order consumers feed from producers (plants or algae). For example, birds and fruits, humans and edible vegetables, etc. (There are proposals to consider the herbivorism of leaves a form of parasitism and the herbivorism of entire plants and seeds a form of predatism).

21. What is ammensalim?

Ammensalism is the ecological interaction in which an individual harms another without obtaining benefit. Ammensalism is an inharmonious (negative) ecological interaction since one participant is harmed.

(Sometimes it is wrongly said that ammensalism is a form of ecological interaction in which an organism releases in the environment substances that harm another species; this situation is indeed an example of ammensalim but the concept is not restricted to it.)

One of the best examples of ammensalism is the one established between humans and other species under extinction due to human actions like habitat devastation by fires, ecological accidents, leisure hunting, etc. Anther example is the red tide, proliferation of algae that by intoxication can lead to death of fishes and other animals.

Biology Questions and Answers

Ecological Succession

1. What is ecological succession?

Ecological succession is the changing sequence of communities that live in an ecosystem during a given time period.

2. What are pioneer species? What is the role of the pioneer species?

Pioneer species are those first species that colonize places where previously there were no living beings, like, for example, algae that colonize bare rocks. In general, pioneer species are autotrophs or those that maintain harmonious ecological interaction with autotrophic beings (like autotrophic bacteria, herbaceous plants, lichens).

The pioneer community is formed of species able to survive under hostile environments. The presence of these species modifies the microenvironment generating changes in abiotic and biotic factors of the ecosystem undergoing formation. Therefore they open the way to other species to establish in the place by the creation of new potential ecological niches.

3. What is the difference between primary ecological succession and secondary ecological succession?

Primary ecological succession is the changing sequence of communities from the first biological occupation of a place where previously there were no living beings. For example, the colonization and the following succession of communities on a bare rock.

Secondary ecological succession is the changing sequence of communities from the substitution of a community by a new one in a given place. For example, the ecological succession of the invasion of plants and animals in an abandoned crop or land.

4. What is the climax stage of an ecological succession?

The climax stage is the stage of the ecological succession in which the community of an ecosystem becomes stable and does not undergo significant changes. In the climax community practically all ecological niches are explored and greater biodiversity is possible. In this stage the biomass, the photosynthesis rate and the cellular respiration reach their maximum levels and thus the net primary production (NPP = organic material made by the producers – organic material consumed in the cellular respiration of the producers) tends to zero. At the climax the amount of oxygen released by photosynthesis is practically equal to the oxygen consumed by respiration. (This is one more reason why it is

wrong to say that the Amazon Rainforest, an ecosystem at climax stage, is "the lung" of the earth. Other reasons are: lungs are not producers of oxygen; the algae and cyanobacteria of the phytoplankton are the main producers of the molecular oxygen of the planet.)

5. How do biodiversity, the total number of living beings and the biomass respectively vary during the ecological succession?

Biodiversity, the number of living beings and the biomass of an ecosystem tend to increase as the succession progresses and they stabilize when the climax stage is reached.

At the initial stage of the succession the use of carbon dioxide and the fixation of carbon into the biomass are high, since the total number of living beings in the ecosystem is increasing. At the climax stage the use of carbon dioxide by photosynthesis equals the production by cellular respiration and the fixation of carbon into the biomass tends to zero.

Biology Questions and Answers

Population Ecology

1. What is a population?

In Biology a population is a set of individuals of the same species living in a given place and in a given time.

2. What is population density?

Population density is the relation between the number of individuals of a population and the area or volume they occupy. For example, in 2001 the human population density of the United States (according to the World Bank) was 29.71 inhabitants per square kilometer and China had a population density of 135.41 humans per square kilometer.

3. What is population growth rate?

Population growth rate (PGR) is the percent variation between the number of individuals in a population at two different times. Therefore the population growth rate can be positive or negative.

4. How different are the concepts of migration, emigration and immigration?

Migration is the moving of individuals of a species from one place to another. Emigration is the migration seen as an exit of individuals from one region (to another where they will settle permanently or temporarily). Immigration is the migration seen as the settling in one region (permanently or temporarily) of individuals coming from another region. Therefore individuals emigrate "from" and immigrate "to".

5. What are the main factors that affect the growth of a population?

The main factors that make populations grow are births and immigration. The main factors that make populations decrease are deaths and emigration.

6. What are some examples of migratory animals?

Examples of migratory animals are: southern right whales from Antarctica, that procreate on the Brazilian coast; migratory salmons that are born in the river, go to the sea and return to the river to reproduce and die; migratory birds from cold regions that spend the winter in tropical regions, etc.

Biology Questions and Answers

7. What is biotic potential?

Biotic potential is the capability of growth of a given population under hypothetical optimum conditions, i.e., in an environment without limiting factors to such growth. Under such conditions the population tends to grow indefinitely.

8. What is the typical shape of a population growth curve? How can the biotic potential be represented in the same way graphically?

A typical population growth curve (number of individuals x time, linear scale) has a sigmoidal shape. There is a short and slow initial growth followed by a fast and longer growth and again a decrease in growth preceding the stabilization or equilibrium stage.

The population growth according to the biotic potential curve however is not sigmoidal, it is only crescent-shaped and points up to the infinite value of the scale (there is neither a decreasing stage nor equilibrium).

9. What is environmental resistance?

Environmental resistance is the action of limiting abiotic and biotic factors that disallow the growth of a population as it would grow according to its biotic potential. Actually each ecosystem is able to sustain a limited number of individuals of a given species.

The environmental resistance is an important concept of population ecology.

10. What are the main limiting factors for the growth of a population?

The factors that limit the growth of a population can be divided into biotic factors and abiotic factors. The main abiotic limiting factors are: availability of water and light, availability of shelter. The main limiting biotic factors are: population density and inharmonious (negative) ecological interactions (competition, predatism, parasitism, ammensalism).

11. How do the availability of water and light and the climate affect the growth of a population?

The availability of water and light and the climate are abiotic factors that limit the growth of a population. Since the producers are responsible for the synthesis of organic material transferred along the food chains of an ecosystem, water and light affect the availability of food and a population cannot grow beyond the number of individuals the environment is able to feed. For example, in the desert, the biomass is relatively small and populations that live in this ecosystem are smaller (compared to the same species in environments with large available biomass). The climate, including the temperature, affects the population growth because

excessive change in this factor, as the occurrence of droughts or floods, may cause significant population decline; small climatic changes can also alter the photosynthesis rate and reduce the availability of food in the ecosystem.

12. How do populations of predators and prey vary in predatism?

Whenever a predator population increases at the first moment the prey population tends to decrease. At a second moment the decrease of the prey population and the bigger population density of predators cause the predator population to decrease. The prey population then reverts the tendency to decrease and begins to grow.

If variations in the size of populations occur in an unexpected intensity (different from the usual intensity of the ecological interaction) for example, due to ecological accidents killing many prey, the prey-predator equilibrium is disturbed and both species can be harmed. The existence of the predator sometimes is fundamental for the survival of the prey population, since the absence of predatism favors the proliferation of the prey and, in some cases, when the excessive proliferation creates a population size over the sustenance capacity of the ecosystem, environmental degradation occurs and the entire prey population is destroyed.

13. What is the relationship between environmental resistance and the population growth according to the biotic potential curve and the real population growth curve?

The difference between the real population growth curve (number of individuals x time) and the population growth according to the biotic potential curve of a given population is a result of environmental resistance.

14. How different is the growth according to the biotic potential of a viral population from the growth according to the biotic potential of a bacterial population?

The growth curve according to the biotic potential of virus and bacteria both present a positive exponential pattern. The difference between them is that in each time period bacteria double their population while the viral population multiplies dozens or hundreds of times. The viral population growth curve thus has more intense growth. This happens because bacteria reproduce by binary division, each cell generating two daughter cells, while each virus replicates generating dozens or even hundreds of new viruses.

15. What are age pyramids?

Age pyramids are graphical representations in form of superposed

rectangles each representing the number of individuals included in age ranges into which a population is divided. Generally the lower age ranges are represented more to the bottom of the pyramid, always below higher ranges, and the variable dimension that represents the number of individuals is the width (there are age pyramids however in which the variable dimension is the height).

16. What are the analyses provided by the study of human age pyramids?

The study of human age pyramids can provide the following analyses: proportion of individuals at an economically active age; proportion of elderly (indicating the quality of the pension and health systems); proportion of children and youth (indicating need for job generation and educational services); reproductive profile (shows the population growth tendency); postnatal survival rate (indicates quality of the health system, hygiene conditions, nutrition and poverty); longevity profile; etc.

It is possible to predict whether a population belongs to a rich and industrialized society or to a poor country since the patterns of the age pyramids differ according to these conditions.

17. What are the main characteristics of the age pyramids of developed countries?

In a stabilized human population the age pyramid has a narrower base since the reproduction rate is not so high. The adult age ranges are generally wider than the infantile ranges showing that in practice there is no population growth. There is a proportionally high number of older individuals meaning that the life quality is elevated and the population has access to health services and good nutrition. These are features of the age pyramids of developed countries.

18. What is the typical conformation of the age pyramids of underdeveloped countries?

The age pyramids of peripheral countries or underdeveloped countries have characteristics related to the poverty of such populations, with a wider base and narrow apex. The base age range, if much wider than the other levels, indicates a high birth rate. The levels just above the base may present an impressive reduction in poorer populations due to infant mortality. Ranges that represent the youth are also wide showing future pressure on job and habitation needs. The widths of the rectangles diminish as age increases to the apex that represents the elderly, demonstrating difficult life conditions, precarious health services and low life expectancy.

Biology Questions and Answers

Environmental Issues

1. What is pollution?

Pollution is the contamination of an ecosystem by factors that are harmful for the equilibrium of its biotic or abiotic constituents.

2. Is pollution always caused by humans?

In most cases pollution is caused by human activity. Other species and some abiotic factors however can also pollute an ecosystem. For example, the red tide is created by proliferation of some algae and volcanic dust is a consequence of the internal activity of the planet.

3. Why is waste considered one of the major environmental issues?

The environmental problem concerning waste worsens with industrial development and the global growth of consumption societies in the 20th and 21st centuries, factors that cause the immense volume of residuals produced by mankind in the last decades. The increased waste generation raises the issue about what to do with waste since nature is not able to degrade and resorb with adequate speed and efficiency most of the residuals. Therefore the various kinds of waste accumulate, polluting the environment and creating danger to humans and nature. (The present destination of waste has been public waste depositories where the waste volume is compressed and buried underground, an environmentally risky method. Another method has been incineration, with the grave consequence of causing air pollution.)

4. What are the main types of waste?

The waste can be classified into many types, each of them carrying its own different environmental problem: organic waste, recyclable waste, non recyclable waste, toxic waste, nuclear toxic waste and space waste.

The organic waste is more easily resorbed by nature, but the speed and the geographical concentration of its production due to urbanization generate pollution of rivers, lakes, proliferation of disease vectors and environmental degradation of towns. The recyclable waste is composed of residuals that can be reprocessed, used again by humans, like plastics and metals; the problem regarding recyclable waste is that the separation of such material is not culturally diffused and there is not enough social organization to use them; so the recyclable waste is mixed to other wastes increasing the volume of waste depositories even more. The non recyclable waste is formed of residuals that technology cannot yet recycle, like ceramics, photographic paper, mirrors, cigarettes, plasticized papers, etc; this kind of waste in the future may become recyclable waste and should be

separated. The toxic waste includes industrial chemical residuals that are harmful for life and the environment, like contaminated medical waste and the domestic waste containing insecticides and medicines; the toxic waste is one of the major environmental problems since it puts the life of humans and other living beings in danger. The nuclear toxic waste is made of materials that release invisible dangerous radiation for many years; nuclear toxic waste is produced in the extraction of nuclear minerals (like uranium), by nuclear reactors and nuclear plants, in hospitals where Nuclear Medicine is performed and in research centers; although the nuclear waste is often put into armored receptacles the risk of accidents is permanent. Space waste is the waste produced by the activity of humans in space from the second half of the 20th century; it consists of non operating satellites, rocket piece and other equipments that remain orbiting the earth or other celestial bodies or even travelling across space.

Environmental Issues: organic waste recyclable waste non recyclable waste toxic waste nuclear toxic waste

5. What is selective waste collection?

Recyclable waste is waste that can be reprocessed and used again. Waste recycling depends on the separation of the recyclable residuals from non recyclable ones and on the classification of the recyclable into plastics, metals, papers, etc. The function of the selective waste collection is to simplify that separation for the waste to be sorted at the point of origin. Selective collection also helps the creation of an environmental conscience in the people that produce the waste.

6. What is the cost-benefit relationship regarding sewage treatment as a strategy to fight water pollution?

To treat sewage is much cheaper for society. The non treated sewage pollutes rivers, lakes and the sea, being a cause of diseases transmitted through water. For the society the costs of these diseases are much higher than the cost of the sewage treatment.

One of the most economical systems to treat sewage is the aerobic treatment system, reservoirs kept very oxygenated for aerobic bacteria to decompose organic material.

7. What is eutrophication?

Eutrophication is the process of excessive increasing of nutrients, like phosphate and nitrate, in water due to direct deposit of non treated sewage. The nutrients act as fertilizers leading to abnormal proliferation of aquatic algae. With the exaggerated growth of the alga population the number of aerobic bacteria that cause decomposition of organic material also increases. The proliferation of these bacteria depletes the dissolved oxygen killing fishes and other animals. Besides, the lack of oxygen causes the decomposition to be assumed by anaerobic bacteria. Anaerobes multiply and release

hydrogen sulfide that makes water improper to other living beings and creates a putrid smell.

8. What is a biodigester?

A biodigester is equipment that produces carbon dioxide, hydrogen sulfide and fuel gases (biogases) like methane from organic material under decomposition (dung, food waste, sugar cane waste, etc.). The biogas is used in heating, as energy for motors and machines and it even has industrial uses. Biodigesters are widely used in public waste depositories and in rural areas. Besides producing biogas the organic waste can be turned into good quality fertilizer.

9. What are the environmental harms caused by mercury pollution? What are the main sources of mercury pollution?

Mercury is a metal that when present in the water of rivers, lakes and seas contaminates fishes, crustaceans, molluscs and other living beings. The mercury accumulates along the food chain and in each following trophic level the amount of the metal within the individuals is higher. When humans eat contaminated animals they also become contaminated and severe nervous system injuries may emerge. The main sources of mercury pollution are gold mining and the use of derived substances in industry and agriculture.

10. Besides mercury which other heavy metals cause toxic pollution?

Examples of other heavy metals that cause toxic pollution are lead, cadmium and chromium.

11. What are persistent organic pollutants (POPs?

POPs, or persistent organic pollutants, are toxic substances formed from organic compounds. POPs are made in several industrial processes, like the production of PVC, paper whitened by chlorine, herbicides, insecticides and fungicides, and also in the incineration of waste. Examples of POPs are dioxins, furanes, chlordane, DDT, dieldrin, heptachloride, toxaphen and hexachlorbenzene.

POPs are toxic and highly harmful since, like the heavy metals, they are bioaccumulative, i.e., they are not degraded by the body and accumulate even more in each following trophic level of the food chains. In humans POPs can cause cancer and nervous, immune and reproductive impairments.

12. Is the upward move of warm air good or bad for the dispersion of pollutants?

The upward movement of warm air is a natural method of dispersion of pollutants. The air near the ground is hotter because the sun heats the soil and the soil heats the air nearby. Since

it is less dense, the warm air tends to move towards higher and colder strata of the atmosphere. Such movement helps the dispersion of pollutants.

13. Does thermal inversion occur in the winter or in the summer?

Pollutant low altitude thermal inversion occurs in the winter. In this period of the year the sun heats the soil less and the natural upward move of warm air decreases. Therefore the pollutants form a low altitude layer between the cold air layer near the ground and another layer of warmer air above. The pollutant layer over industrial areas or big urban concentrations reduces the penetration of the sun's energy and the air bellow takes an even longer time to warm.

14. Why does thermal inversion increases air pollution? What harm can thermal inversion cause to humans?

Thermal inversion confines at low altitude a layer of pollutants that would have been dispersed by the natural upward move of warm air. The solid particles present in the atmosphere cause health problems, like the exacerbation of asthma and other pulmonary diseases, cough, respiratory unease and ocular discharges; later the pollution can also trigger the appearance of cardiovascular and neoplastic diseases.

15. What is the role of the ozone layer for living beings?

Ozone, O3, is a gas of the atmosphere that filters ultraviolet radiation from the sun disallowing most of that radiation from reaching the surface of the planet. Ultraviolet radiation is harmful for living beings because it is a mutagen and can cause cancer (mainly skin cancer), other DNA mutations and even burns.

16. What are the main chemical compounds that destroy the ozone layer?

The mains chemical compounds that destroy the ozone layer are the CFCs, chlorofluorocarbons, or freons, substances used in the past in refrigerators, airconditioners and spray cans.

Chlorofluorocarbons react with ozone in the high atmosphere releasing molecular oxygen and therefore the amount of ozone in the atmosphere is reduced.

Another substance that destroys the ozone layer is methyl bromide, used in agricultural insecticides.

17. What is nuclear pollution?

Nuclear pollution consists of radiations emitted from atomic nuclei, these radiations are highly injurious to living beings. They can be originated from the extraction of radioactive minerals, nuclear plant reactors, nuclear research

centers, hospitals and medical centers that use radioisotopes, nuclear bomb explosions or accidents with transportation, handling or storage of nuclear material. Nuclear materials remain dangerous for many years, contaminating the environment with radiation that can cause cancer, immune impairment, congenital deficiencies, burns and even death. The damage is proportional to the intensity of the exposition to the radiation.

Its persistent feature and high aggression power make nuclear pollution one of the major environmental problems of our time.

18. What is plutonium reprocessing? Why is it a big environmental issue?

Plutonium is the highly radioactive chemical element produced from uranium by nuclear plants. Plutonium can be reprocessed to be used again in nuclear plants or in other destinations, like the making of nuclear bombs. Plutonium reprocessing nowadays, however, is done only in some countries like France, Russia and Britain. The countries that have nuclear plants, like Japan, Australia, etc., send their atomic waste by ship to those plutonium reprocessing centers. Besides the inherent risks of the storage of nuclear waste, plutonium reprocessing brings the risks of the transport of radioactive material across the oceans. The "nuclear ships" often travel near the coast of many countries posing danger to their populations.

19. What is transgenic food?

Transgenic beings are animals, microorganisms and plants that contain recombinant DNA, i.e., genes from other plants, microorganisms or animals artificially inserted into their genetic material. Transgenic beings are made for scientific and economic purposes, in this last case with the intention of improving their commercial features. For example, bacteria that produce human insulin are transgenic beings made by biotechnology. The main targets of the transgenic technology are edible vegetables, like soy, corn, potato and tomato.

20. Why are transgenics considered a threat to the environmental safety?

Transgenics can be dangerous to the entire biosphere since the transfer of genes between species may have immediate and long term unpredictable consequences. The creation of new species by nature is a slow process, dependent on causal mutations and natural selection, a relatively safe process for the ecological equilibrium. It is impossible to know how the fast and artificial introduction of transgenic beings in nature affects ecosystems. Pathogenic agents may be involuntarily created in laboratories, spreading unknown diseases; transgenic species may uncontrollably proliferate destroying ecological interactions that have taken thousands of years to be established; the ingestion of transgenic food also has unpredictable effects.

Biology Questions and Answers

21. What is biological control?

Biological control is a natural method to control the size of animal, microorganism or plant populations. Biological control is based on the knowledge of inharmonious (negative) ecological interactions between species. Using such knowledge a parasite, competitor or predator species is introduced in an ecosystem in order to attain reduction of the population of another species with which it has inharmonious ecological interaction. The biological control presents the advantage of substituting the use of pesticides and other toxic chemical products in the control of plagues and diseases. It however should be employed with caution under serious previous study to avoid harmful ecological disequilibrium.

A kind of biological control of some species can be done by the introduction of previously sterilized males, that do not generate offspring.

22. What is bioremediation?

Bioremediation is the use of microorganisms, like bacteria, protists and fungi, to degrade noxious substances turning them into non toxic or less toxic substances. Bioremediation employs microorganisms whose metabolism uses contaminants as reagents.

Bioremediation is used, for example, in the decontamination of environments polluted by oil spills. In this process bacteria that use hydrocarbons as substrate for their cellular respiration are employed.

23. What is global warming?

Global warming is the increase in the temperature of the planet due to accumulation of some gases in the atmosphere, especially gases that retain the solar energy reflected by the planet surface. The main gas that causes the global warming is carbon dioxide, CO_2, but other gases act as "warming gases" too, like methane, CH_4, and nitrous oxide, N_2O. The exaggerated increase of carbon dioxide in the atmosphere has been caused by the burning of fossil fuels (mainly oil and coal) in industrial and urban societies and by forest fires. (It is important to note that the natural warming provided by gases of the atmosphere is fundamental for the maintenance of the planet temperature.)

Predictions of studies sponsored by the United Nations stated that the global warming may cause life-threatening transformations to the planet in the near future. Countries that are the biggest emitters of carbon dioxide, like the United States and China, however, systematically ignore the warnings and continue to largely contribute to the danger.

Global warming is one of the most polemic environmental issues today.

Biology Questions and Answers

Diseases

Biology Questions and Answers

Biology Questions and Answers

Concepts of Parasitism

1. What is parasitism?

Parasitism is an inharmonious interspecific ecological interaction in which individuals of a species (the parasites) explore organs, tissues or cells of individuals of another species (the hosts) causing harm to these.

2. What is the difference between ectoparasite and endoparasite?

Ectoparasites are parasites that explore the external surface of the host (like, for example, mites that parasite the skin). Endoparasites are parasites that live within the body of the host (like the taenias).

3. Concerning the number of hosts how are parasites classified?

Parasites that require only one host are called monoxenous parasites. Parasites that need more than one host for their life cycle are called heteroxenous parasites.

4. What is the criterion used to classify hosts as intermediate hosts or as definitive hosts?

The criterion used to classify hosts as intermediate hosts or as definitive hosts is the kind of reproduction of the parasite, sexual or asexual, within the host. The host within which the sexual reproduction stage of the parasite occurs is the definitive host. The host within which the asexual reproduction stage of the parasite occurs is the intermediate host.

5. What are vectors of parasites?

Vectors of a parasite are organisms able to transport the parasite during stages of its life cycle mediating the infection of other hosts. For example, the mosquito Aedes aegypti is the vector of the dengue virus; triatomine bugs are vectors of the Trypanosoma cruzi, protozoan that causes Chagas' disease; mice are vectors of leptospira, bacteria that cause leptospirosis.

6. What is an etiological agent of disease?

An etiological agent of disease is the agent that causes the disease. It may be a living being, substance or environmental fact.

7. What is the difference between the concepts of epidemic disease and endemic disease?

Endemic diseases are those that often affect people of a given place, many or few individuals. Epidemic diseases are those of rapid spread and elevated number of new cases. An endemic disease can turn into an epidemic disease.

Biology Questions and Answers

Bacterial Infections

1. What are some human diseases caused by bacteria and what are their respective modes of transmission?

The main human bacterial infections transmitted by respiratory secretions (sneezes, cough) and saliva drops are: bacterial pneumonias, tuberculosis, whooping cough (pertussis), diphtheria, bacterial meningitis. Main bacterial diseases transmitted by blood or sexual contact are: gonorrhea, syphilis. Main bacterial diseases transmitted by animal vectors are: bubonic plague, endemic typhus, leptospirosis. Some bacterial diseases transmitted through fecal-oral route and contaminated food are: cholera, typhoid fever. Other important bacterial infections: Hansen's disease, possibly transmitted by saliva drops and contact with injured skin and mucosae; trachoma, eye disease transmitted by ocular secretions; tetanus, transmitted when the etiological agent enters the body through skin wounds.

2. What is tuberculosis? How is the disease transmitted? Is there treatment for tuberculosis?

Tuberculosis is a disease caused by the Mycobacterium tuberculosis, bacteria which attack other organs of the body but mainly the lungs leading to respiratory insufficiency. Before 1940, tuberculosis had already been one of the main causes of death in the USA and Europe. The disease can remain latent, without manifestation for several years and even throughout the life.

Tuberculosis is highly contagious, transmitted by air route through sneezes and coughs from a person with the active disease. Transmission is common between members of the same family or even in work environments. The disease today has treatment with efficient antibiotics. Generally, the patient receives three different drugs for several months until healing is complete. There are however some strains of multiresistant TB bacteria that emerged by mutation and natural selection due to the intense use of antibiotic drugs mainly in hospitals and treatment facilities; in these cases the treatment is more difficult.

3. Is there vaccine against tuberculosis?

The vaccine against tuberculosis is called BCG (bacillus Calmette-Guérin). BCG is not used in some countries where tuberculosis is not so prevalent because it can distort later diagnostic studies of the disease; in other countries, like Brazil, it is obligatory for children. The vaccine is made of attenuated TB bacteria.

Biology Questions and Answers

4. Are all pneumonias caused by bacteria?

Pneumonia is the generic name of inflammation of the lungs. Besides bacterial pneumonias, there are pneumonias caused by virus, fungi, toxic pneumonias, etc.

5. What is Hansen's disease (etiological agent, mode of transmission, clinical manifestations and prevention)?

The etiological agent of Hansen's disease is bacteria called Mycobacterium leprae. The mode of transmission is not yet totally known but it is believed that respiratory secretions and saliva drops can spread the disease. Hansen's disease is a chronic disease (slow progression) that generally attacks the skin and the peripheral nerves although other areas of the body can be affected. In the skin nodules, reddish spots, thickening of the dermis and lack of sensitivity appear; the mucosae, especially the nasal mucosa, may be injured and also the viscera may be affected. The main form of prevention is information, since there is available treatment; infected people should, as soon as possible, look for health services for evaluation and treatment of the disease.

In the past Hansen's disease was called leprosy.

6. What is the etiological agent and the main manifestations of cholera?

Cholera is a bacterial disease caused by the Vibrio cholerae. The disease is transmitted by fecal-oral route and the main mode of transmission is ingestion of contaminated water or food. It is most prevalent in places that lack adequate sanitary conditions.

Inside the human gut the cholera vibrion releases toxins called enterotoxins. The infection can cause intense diarrhea, vomiting, dehydration and even death in more severe cases.

7. What is meningitis?

Meningitis is the generic name given to inflammation of the meninges, membranes that cover the central nervous system. Meningitis can have several causes (infectious, toxic, traumatic, neoplastic infestation, autoimmune). Bacterial infections caused by meningococcus, haemophilus, pneumococcus or by tuberculosis bacteria are severe and contagious.

The main symptoms of bacterial meningitis are high fever, nuchal rigidity, intense headache, vomiting and sometimes convulsions. The disease should be treated with antibiotics.

8. What is syphilis?

Syphilis, also known as lues, is a disease caused by the bacteria Treponema pallidum. Before the

discovery of penicillin, syphilis was a fatal disease. Today the use of antibiotics can cure the disease completely. Patients with primary syphilis present a single and painless wound in the skin, sometimes called chancre, in the region where the treponema has penetrated; the chancre is highly infective. Syphilis is one of the main STDs, sexually transmitted diseases. Generally the chancre develops in the penis, vagina, anus, hands or mouth, and the bacteria is often transmitted by sexual contact. Later syphilis develops into systemic diseases, secondary and tertiary syphilis.

Syphilis can also be transmitted by blood transfusions, accidents with contaminated objects and vertically from the mother to the child (congenital syphilis). It is very important for patients with the disease to seek treatment as soon as possible and to undergo tests to look for other STDs, like HPV and HIV infections.

9. What is an antibiogram?

Antibiogram is a laboratory test intended to guide the choice of adequate antibiotic to treat a given bacterial infection. In the antibiogram cultures of bacteria obtained from tissues contaminated by the infection under study are submitted to the action of different antibiotics. After some time it is verified which of the antibiotics were successful in interrupting the bacterial growth or in killing the bacterial population.

The antibiogram is very important to avoid exaggerated and inefficient use of antibiotics and the emergence of multiresistant bacteria.

Biology Questions and Answers

Protozoan Diseases

1. Which is the kingdom of the parasites that cause malaria and Chagas' disease?

Those diseases are caused by the protozoans, beings of the kingdom Protista.

2. What is the scientific name of the etiological agent of Chagas' disease?

The etiological agent of Chagas' disease is the Trypanosoma cruzi. The name "cruzi" was given in honor of the Brazilian doctor Oswaldo Cruz. The disease was named after the Brazilian doctor Carlos Chagas.

3. Under which forms is the Trypanosoma cruzi found in its hosts?

In the definitive hosts as well as in triatomine bugs (intermediate hosts) the protozoan that causes Chagas' disease alternates mastigote (flagellate) and amastigote forms and also intermediate forms between these forms.

4. What is the vector of Chagas' disease? How is the disease transmitted?

The vector of Chagas' disease is its intermediate host, a triatomine bug. The main species is Triatoma infestans.

Hemipteran insects, like triatiomines, have sucking mouthparts that can be used to suck blood from animals or organic fluids from plants. The vectors of Chagas' disease are hematophagous hemipterans that have nocturnal habits. The blood-sucking bugs become infected when they bite a contaminated person. The parasites then multiply within the bug gut and are eliminated with its feces. When a contaminated triatomine bites another person it defecates near the bite site and the released protozoans can penetrate into the definitive host through mucosae or through the bite wound. Wild and domestic mammals can also be vessels for the disease.

5. What is the life cycle of Trypanosoma cruzi?

Trypanosoma cruzi is a heteroxenous parasite, i.e., it has an intermediate host, the triatomine bug, and a definitive host, the human. The triatomine bug becomes infected by sucking the blood of a contaminated person. Within the bug gut the protozoan reproduces itself. When the triatomine bites another person it defecates near the bite site. Generally the bitten person itches the area of the bite and the parasite gains the circulation of the definitive host. Within

humans the Trypanosoma cruzi multiply as amastigote form in the cardiac muscle tissue or in the nervous tissue forming pseudocysts. These pseudocysts break releasing flagellate parasites into the circulation and the cycle is repeated.

6. What is the incubation period of an infection?

Incubation period is the time interval between the infection by an agent that causes disease and the first signs or symptoms of the disease.

7. What is the average incubation period of Chagas' disease? What are some signs and symptoms of the acute phase of Chagas' disease?

Chagas' disease may or may not present an acute phase. When it is present, the incubation period is about 5 to 14 days. The chronic phase, however, can manifest in more than 10 years after the infection.

At the site where the trypanosoma has penetrated the skin or the mucosa becomes swelled: This sign is known as chagoma. Another sign that may appear in up to 20% of cases after the infection is the Romana's sign, a swelling of one of the eyelids when infection took place through the ocular route. In the acute Chagas' disease fever, malaise, inflammation and enlargement of lymph nodes may occur. In more severe cases fatal inflammation of the cardiac muscle or of the meninges may happen.

8. In the long term which are the organs affected by chronic Chagas' disease?

In the chronic phase of Chagas' disease, that manifests years after the infection, the trypanosoma infests the muscles of the heart causing insufficient blood pumping, pulmonary edema and increase in the size of the organ (cardiomegaly). This is the cardiac manifestation of Chagas' disease. The main symptoms that appear are dyspnea, cough and cardiac arrhythmias.

In the digestive form of manifestation of the disease the parasite destroys cells of the autonomic nervous system responsible for the peristaltism of the digestive tube. Since the motility of the esophagus and intestines is reduced the transit of materials inside these organs is impaired and they increase in size (width), conditions respectively known as megaesophagus and megacolon. The main symptoms are dysphagia (impaired swallowing), constipation, flatulence and formation of fecaloma (accumulation of feces inside the bowels).

9. What is prophylaxis?

Prophylaxis are measures taken to prevent diseases. For example, the use of condoms in sexual relations is a prophylaxis against contamination by

agents that cause STDs (sexually transmitted diseases).

10. What are the etiological agents of malaria?

The etiological agents of malaria are protozoans of the genus Plasmodium. There are four different types of plasmodia that cause malaria: Plasmodium malariae, Plasmodium vivax, Plasmodium falciparum and Plasmodium ovale.

11. What are the human tissues affected by malaria? What are the main clinical manifestations of the disease?

The plasmodium infects the human blood causing destruction of red blood cells and it also affects the liver. Malaria characterizes by periodical episodes of fever, chills and sweating that can be accompanied by headache, nausea, vomiting and jaundice. The destruction of red blood cells may lead to anemia and hypoxemia.

The infection by Plasmodium falciparum if not treated can cause other complications and even death.

12. What is the vector of malaria? How different is its behavior from the behavior of the vector of dengue fever?

The vector of malaria is a mosquito of the genus Anopheles, also called anopheline. In opposition to the mosquito vector of the dengue fever, the anopheline has nocturnal habits.

13. What are the intermediate and the definitive hosts of the plasmodium?

In the life cycle of the plasmodium humans are the intermediate hosts (where asexual reproduction takes place) and the vector mosquito is the definitive host (where sexual reproduction occurs).

14. What is the life cycle of Plasmodium vivax?

The vector mosquito bites a contaminated person and ingests female and male gametocytes of the parasite. Within the insect gut the gametocytes differentiate into gametes and fecundation occurs, forming zygotes. Each plasmodium zygote by mitosis (sporogony) generates numerous infective sporozoites that migrate to the salivary glands of the mosquito. When the mosquito bites a person the sporozoites enter the human circulation and when in the liver they undergo the first asexual reproduction (tissue schizogony), releasing several merozoites into the blood. The

merozoites infect red blood cells where the second asexual reproduction of the cycle (erythrocytic schizogony) and the production of many other parasites occur; some of these parasites differentiate into gametocytes. The red blood cells then break (hemolysis), the parasites are released in the blood and the cycle can restart.

15. To which phase of the plasmodium life cycle do the typical chills and fever of malaria correspond?

The typical chills and fever episodes of malaria correspond to the phase when red blood cells are destroyed after the erythrocytic schizogony of the plasmodium life cycle.

16. What are the main prophylactic measures against malaria?

The main preventive measures against malaria are the elimination of the vector mosquito, treatment of infected people, avoidance of the mosquito bite, information for travelers to endemic areas and the use of preventive medicines.

17. What are other important human diseases caused by protozoans?

Some other important protozoan infections are amebiasis, giardiasis, trichomoniasis, leishmaniasis, toxoplasmosis and meningoencephalitis by free-living amoebas.

18. What is the etiological agent of amebiasis? How is it transmitted and what are the typical manifestations of the disease?

Amebiasis is caused by the protozoan Entamoeba histolytica, or simply amoeba.

The transmission of the disease is oral-fecal, through contaminated water and food or by insects like cockroaches and flies. The amoeba parasites the intestine of humans generally in an asymptomatic manner, but it can sometimes cause enteritis with diarrhea and severe dysentery, abdominal pain, weight loss and anemia. In rare cases extra-intestinal invasion may occur affecting the liver, skin, genital organs and other organs.

19. What is the parasite that causes giardiasis? How is it transmitted and what are the typical manifestations of the disease?

Giardiasis is a protozoal infection caused by Giardia lamblia, or simply giardia, a flagellate protozoan.

The transmission is fecal-oral, through contaminated water and food or carried by insects like cockroaches and flies. Giardiasis manifests like amebiasis, as

an enteritis with diarrhea, abdominal pain, weight loss and anemia.

20. What is trichomoniasis? Why is it classified as an STD?

Trichomoniasis is an extra-intestinal protozoan infection caused by Trichomonas vaginalis, a flagellate protozoan. The parasite infects the urinary tract of males and females. In females it causes discharge, pain and itching.

Trichomoniasis is an STD because its main mode of transmission is sexual contact.

21. What are the main manifestations of leishmaniasis?

There are two main forms of leishmaniasis: cutaneous leishmaniasis and visceral leishmaniasis (also known as kala-azar). The form is determined by the species of infective leishmania and by the immune response of the host.

22. What is the etiological agent of cutaneous leishmaniasis? How is the disease transmitted and what are its typical manifestations?

The etiological agent of cutaneous leishmaniasis is the protozoan Leishmania braziliensis.

The transmission, like in the visceral form of the disease, is by the bite of the sand fly Lutzomya (named after the Brazilian scientist Adolfo Lutz), the vector host. Cutaneous leshmaniasis develops in the bite site where the parasite establishes itself. The skin wound has a volcanic crater shape, a reddish injury with elevated borders. From the primary lesions the parasites can spread through the blood to affect other areas, mainly the mucosae of the nose, mouth and pharynx, causing facial deformations.

23. What is the etiological agent of visceral leishmaniasis? How is the disease transmitted and what are its typical manifestations?

Visceral leishmaniasis is caused by the protozoan Leishmania donovani.

The transmission is similar to the cutaneous leishmaniasis, by the bite of sand flies. The affected organs generally are the liver, the spleen and the bone marrow. The patient often has fever, weight loss, splenomegaly (hypertrophy of the spleen), anemia and decreased counts of leukocytes and platelets. The disease may cause death.

24. What is the parasite that causes toxoplasmosis? How is the disease transmitted and what are its typical manifestations?

Toxoplasmosis is caused by the protozoan Toxoplasma gondii, a sporozoan.

Toxoplasmosis is a disease transmitted by cats, which are the definitive hosts of the parasite. Cats eliminate toxoplasma oocysts in feces; the oocysts are extremely resistant and remain viable for months in the environment. Human beings are infected when ingesting water or food contaminated by oocysts or when making contact with contaminated objects. Humans can also become infected by eating meat of animals like pork, cow and sheep, which can be intermediate hosts too. Vertical transmission, from mother to offspring, may also occur.

In toxoplasmosis the cystic form of the parasite invades tissues of the body, including the brain and the retina. The infestation is potentially fatal. In congenital toxoplasmosis the child may present blindness and mental retardation. The disease is especially severe when occurring as an opportunistic disease in AIDS patients.

Biology Questions and Answers

Fungal Infections

1. What are the main human diseases caused by fungi?

The main human diseases caused by fungi in immunocompetent patients are coccidioidomycosis, histoplasmosis, blastomycosis, paracoccidioidomycosis, or South American blastomycosis, sporotrichosis and onychomycosis (nail mycosis).

In immuno-deficient patients, besides the diseases mentioned above, other fungal diseases like systemic candidiasis, aspergillosis, cryptococcosis and other opportunistic diseases can occur.

2. Moniliasis is one of the most common opportunistic diseases in AIDS. What is the etiological agent of moniliasis and what is the other name of the disease? Why is monilia also common in healthy newborns?

The etiological agent of moniliasis is Candida albicans, a fungus. Moniliasis is also known as mucocutaneous candidiasis. In AIDS moniliasis can complicate and turn into systemic candidiasis, affecting many organs.

Newborns do not yet have their immune system working with complete efficiency and thus they are more susceptible to candidiasis that generally appears in mouth and in the genital mucosae and disappears naturally.

3. What are some fungal diseases transmitted by animal feces?

Bat and pigeon feces can carry Histoplasma capsulatum, the fungus agent of histoplasmosis. The infection is transmitted through inhalation of contaminated dust in places visited by these animals (caves, tunnels, squares, roofs, etc.). Cryptococcosis is another fungal disease transmitted by pigeon excrement.

4. What are some antibiotics used against fungi?

The topical or systemic azoles (like itraconazole, fluconazole and others), amphotericin B, the echinocandins (caspofungin, micafungin), terbinafine and griseofulvin are examples of antifungal drugs.

Biology Questions and Answers

Viral Infections

1. What are some human diseases caused by virus and what are their respective modes of transmission?

The main viral diseases transmitted by respiratory secretions (sneezes, cough) and by saliva drops are flu, mumps, smallpox (variola, already considered eradicated), rubella, measles, SARS. Main viral diseases transmitted through blood or sexual contact are AIDS, hepatitis B, hepatitis C, HPV, ebola hemorrhagic fever. Main viral diseases transmitted by animal vectors are rabies, dengue fever, yellow fever. Some viral diseases transmitted by fecal-oral route, including contaminated food, are hepatitis A, poliomyelitis (disease almost eradicated in many parts of the world).

2. What is the virus that causes flu? Why doesn't the body produce permanent immunity against that virus? How does the vaccine against flu work?

Flu is a disease caused by the influenza virus, a highly mutant DNA virus. Due to the high mutation rate of the virus, that forms many different strains, flu always presents epidemic features in affected populations and people may have several flu episodes during life (the immune response made from previous infections is not efficient in future infections).

The vaccine against flu is a vaccine made of attenuated virus of three different strains. Each year the WHO (World Health Organization) researches and determines which are the strains that should compose the vaccine. This is a strategy to face the high mutation rate of the virus.

3. Why is rubella during gestation a threat to the fetus?

If occurring during gestation rubella is a dangerous disease because the virus crosses the placenta and contaminates the fetus. The fetus then develops congenital rubella, a teratogenic (cause of malformations) disease.

Congenital rubella may be prevented by vaccination. Doctor must always be consulted before vaccination.

4. What are the main available vaccines against poliomyelitis?

The vaccines used against poliomyelitis are the Sabin vaccine and the Salk vaccine. The Sabin vaccine contains attenuated virus and is taken through oral drops. The Salk vaccine is made of dead virus and is administered by injection.

Biology Questions and Answers

5. Is rabies caused by virus or by bacteria? How is it transmitted? Which organs and tissues are affected by the disease? How is it prevented and treated?

Rabies, also known as hydrophobia, is a viral disease. It is found in dogs, cats, bats and other wild mammals. The transmission to humans occurs through the saliva of contaminated animals, mainly through bites.

The rabies virus is neurotropic and attacks the central nervous system in a fast and lethal fashion. The prevention of the disease is done by prophylactic vaccination of animals and humans. The treatment is done by anti-rabies serum containing specific antibodies against the virus.

6. What is the difference between smallpox (variola) and measles?

Smallpox is a viral infection like measles. Smallpox is transmitted by respiratory secretions, saliva and objects in contact with contaminated patients. The disease is characterized by the appearance of numerous vesicles on the skin of the face, trunk and limbs, that can suppurate and form crusts; smallpox complications can lead to death. Measles is transmitted by saliva drops and respiratory secretions too. It is characterized by exanthems (red spots on the skin), fever, malaise and lymphadenomegaly (enlarged lymphnodes). If not treated measles complications can cause death.

Smallpox killed thousands of people around the world in the end of the 19th century and the beginning of the 20th century but today it is almost eradicated by vaccination. Nowadays however a great fear is the possibility of use of smallpox virus in biological weapons and by bioterrorists. Measles is not eradicated and affects millions of people each year. Both diseases can be prevented by vaccination.

7. What are the three main types of viral hepatitis?

There are many types of viral hepatitis. The most important epidemiologically are hepatitis A, hepatitis B and hepatitis C.

8. What are the modes of transmission, main signs and symptoms and treatments of hepatitis A?

Hepatitis A is an acute disease of low mortality caused by the hepatitis A virus (an RNA virus). It is transmitted by fecal-oral route often through contamination of foods like vegetables and sea-food. The virus attacks the liver and its incubation period varies between 15 and 45 days. After incubation the symptoms are fever, headache, abdominal pain, malaise, nausea and vomiting and the main signs are jaundice, hepatomegaly (enlargement of the liver) and darkened urine (due to excessive bile in blood). Blood tests show increased levels of hepatic enzymes caused by injuries to liver

cells. Hepatitis A often heals naturally after 4 to 6 weeks.

9. What are the modes of transmission, main signs and symptoms and treatments of hepatitis B?

Hepatitis B is a disease caused by a DNA virus. The transmission is by blood (wounds, sexual relations, transfusions, accidents with contaminated material, etc.). The most common form of the disease is chronic, the infected patient carries the virus for life and the liver gradually suffers injuries that can lead to cirrhosis or even to hepatic cancer. Another form of the disease is acute, sometimes fulminating, with symptoms similar to those of hepatitis A but more severe and sometimes lethal. There are persons that are asymptomatic carriers of the virus. The level of hepatic injury is assessed by blood tests of hepatic enzymes and by hepatic biopsy (extraction of small samples of tissue to be examined under the microscope). Viral replication can be estimated through PCR (polymerase chain reaction).

10. What are the modes of transmission, main signs and symptoms and treatments of hepatitis C?

Hepatitis C is caused by an RNA virus and transmitted through blood (like hepatitis B, through wounds, sexual relations, transfusions, accidents with contaminated material, etc.). The usual manifestation is chronic and many people that have the virus are asymptomatic. The liver gradually undergoes injuries and some patients evolve to cirrhosis, hepatic cancer and death. Today interferon use is an attempt to control replication of the hepatitis C virus. The assessment of the disease is made periodically by hepatic biopsy and by blood tests of hepatic enzymes. Viral replication can be estimated through PCR (polymerase chain reaction).

11. Are there non viral hepatitides?

Hepatitis is a generic name for inflammation of the liver. There are bacterial hepatitides, for example, in lepstopirosis, and toxic hepatitides, for example by alcohol, medicines or inhaled chemical products.

12. What are the main human viral diseases transmitted by mosquitoes?

The main human viral infections transmitted by mosquitoes are dengue fever and yellow fever.

13. What is dengue?

Dengue, or dengue fever, is an epidemic disease in some countries (for example, in Brazil), and its most dangerous form is hemorrhagic dengue. It is caused by four different but related viruses, the reason that it is difficult for an already

infected person to become immunized against the disease. Dengue is prevalent in tropical and subtropical regions of Asia, Africa and South America and it is transmitted by the bite of the Aedes aegypti mosquito, a diurnal mosquito. The viral infection causes varied symptoms similar to flu, like fever, malaise, myalgia (muscle pain); in hemorrhagic dengue high fever, with or without convulsions, and hemorrhages may occur leading to circulatory failure and death. There is no vaccine against dengue since there are four agent viruses and it is supposed that the severity of the disease is greater when the patient is already protected against one type of virus and is infected by another. The best prophylactic method is to eliminate the vector mosquito.

14. What is yellow fever?

Yellow fever is a viral infection that occurs mainly in Central Africa and in the Amazon region of South America. It is prevented through vaccination and transmitted by many species of mosquitoes of the Aedes genus, including Aedes aegypti e Haemogogus. The infection causes clinical manifestations that range from asymptomatic cases to lethal fulminating cases. Generally the disease begins with fever, chills, malaise, headache, nausea and evolves to jaundice (increase of bilirubin in blood, after which the disease is named), mucosal and internal hemorrhages, hemorrhagic vomiting and renal failure.

Prevention is done by regular mass vaccination and vaccination of travelers to endemic areas. The combat against the vector mosquito is also an important prophylactic measure.

15. Why is it difficult to produce efficient vaccines against a viral infection like dengue and AIDS?

It is difficult to make vaccines against dengue because there are four different types of viruses that cause the disease (DEN1, DEN2, DEN3 and DEN4) and it is supposed that the protection against one of them aggravates the clinical manifestation when the person is later infected by the another dengue virus.

In the case of HIV, the production of a vaccine is difficult because the virus is highly mutant and evades the antibody action.

16. Is a viral infection treated with the same kind of drug that treats bacterial infections?

Antibacterial drugs, potent against a great variety of bacteria, are not effective against viruses, which are intracellular parasites. A viral infection is difficult to treat since anti-viral drugs are too specific and have limited efficiency. In general the anti-viral drugs reduce the viral load (number of virus) relieving symptoms. The anti-virals (and anti-retrovirals, drugs that act against RNA virals) often inhibit the action of specific enzymes that participate in the virus life cycle.

Biology Questions and Answers

AIDS

1. How is HIV transmitted? What is the disease caused by this virus?

HIV (human immunodeficiency virus) is supposed to be transmitted through blood, semen, vaginal secretions and maternal milk.

HIV is the virus that causes AIDS (acquired immune deficiency syndrome), a disease characterized by destruction of cells of the immune system making the body susceptible to many opportunistic and severe diseases.

2. Which type of virus is the HIV? What is the enzyme reverse transcriptase present in HIV?

HIV is a retrovirus, i.e., an RNA viral (its genetic material is RNA and not DNA).

Reverse transcriptase is a specific enzyme of the retrovirus responsible for the transcription of the viral RNA into DNA within the infected (host) cell. This DNA then commands the production of viral proteins and the viral replication.

3. What are CD4 lymphocytes? What is the relationship between these cells and HIV? How does HIV replicate?

CD4 lymphocytes are T helper lymphocytes that present in their plasma membrane receptor proteins called CD4.

CD4 lymphocytes are the cells that HIV infects and within which the virus replicates. HIV has proteins in its capsule that bind to the CD4 receptors of lymphocytes. Through that bond the virus fuses with the cell membrane and its content (RNA, reverse transcriptase, protease, etc.) penetrates into the cytoplasm and the viral replication process begins.

HIV RNA is then converted into DNA by the reverse transcriptase. The new DNA is inserted into the genetic material of the lymphocyte with the aid of enzymes called integrases. By transcription and translation this DNA commands the synthesis of proteins necessary for the assemblage of new viruses. Long polypeptides are thus produced and then fragmented into proteins and viral enzymes by the enzyme protease. So new HIV viruses are assembled and break the cell membrane to gain the circulation.

4. Why is AIDS difficult to prevent by vaccination?

It is difficult to produce a vaccine against AIDS because the HIV is a highly mutant virus. In almost every replication the produced viruses have different proteins in their surface

making difficult their recognition by the immune system.

5. What is the cause of the immunodeficiency presented by AIDS patients?

The cause of the immunodeficiency presented by AIDS patients is the destruction of CD4 T helper lymphocytes by the HIV. With this destruction the immune system becomes impaired and the body cannot defend itself against many diseases that normally do not develop in immunocompetent people.

6. What is the difference between carriers of HIV and AIDS patients?

A person can be a carrier of the HIV without necessarily being affected by the immunodeficiency syndrome at that time since the virus can remain in the body for many years without producing clinical manifestations. The AIDS condition is characterized when the patient actually becomes immunodeficient and begins to show signs and symptoms of opportunistic diseases.

7. How does the CD4 counting act to monitor the HIV infection? What is another laboratory method to follow up the disease?

The CD4 counting test is done from a blood sample of a person infected by the HIV. In this test the number of CD4 cells is counted. If that number (concentration) is abnormally low it means immunodeficiency and the patient usually must be treated with antiretroviral drugs. The other test used to follow up the infection is the viral load test. In this test the number of HIV virus is estimated from a blood sample indicating whether the treatment (control) of the disease has been successful or not.

8. What are the main opportunistic diseases that can affect AIDS patients?

Among the opportunistic diseases that affect HIV infected people during the AIDS stage some are: mucocutaneous and systemic candidiasis, Kaposi's sarcoma (blood vessel tumors that result in darkened spots on the skin and internal organs), tuberculosis, cytomegalovirus infection, pneumonia by the fungus P. Carinii (pneumocystis pneumonia), toxoplamosis, herpes, etc. Some other opportunistic diseases are: salmonellosis, histoplasmosis, aspergillosis, cryptococcosis, isosporiasis, lymphomas.

9. How long is the incubation period of the HIV? What is meant by acute AIDS?

The incubation period of the HIV (the time interval between the infection and the beginning of the immunodeficiency

symptoms) ranges in average from 10 to 15 years.

Acute AIDS is the clinical situation characterized by signs and symptoms that may appear in 5 to 30 days after the infection by the HIV, due to the high replication rate of the virus on this period. Acute AIDS does not always happen and many times it is mistaken for common diseases like the common cold. The patient can present fever, malaise, myalgia (muscle pain) and arthralgia (joint pain), lymphadenomegaly (enlargement of lymphnodes), sweating and diarrhea. The manifestation often lasts from 3 to 15 days.

10. What are the three phases into which the HIV infection is often divided?

The HIV infection is often divided into three phases: the acute phase, from the infection to 1 until 9 weeks after the infection, a phase in which the virus replicates and the number of CD4 lymphocytes is reduced; the asymptomatic phase, lasting from 9 weeks to often more than 10 years, in which the viral load remains stable and the CD4 count is not abnormally low; the AIDS stage, when the viral load is high, CD4 count is abnormally low and opportunistic diseases manifest.

11. How do antibody-based tests detect how HIV infection works?

After the infection by the HIV the immune system begins the production of antibodies (primary immune response) against the virus. The tests ELISA (enzyme-linked immunosorbent assay) and Western-blot search for the presence of specific antibodies against HIV antigens in blood samples. Since only one positive ELISA is not conclusive, as false positive tests may happen, the Western-blot test is often used after the positive ELISA.

12. What is the window phase of an infection? How is this concept important for the test of HIV infection in blood banks?

The primary immune response of the body facing any infection is not immediate. The window phase is the period from the infection until the formation of detectable specific antibodies against the infective agent. In this period, immunochemical tests that indirectly search infections, like the ELISA and the Western-blot for HIV, give a negative result even if the person is actually infected by the agent. In the case of HIV, the window phase can last about 2 weeks to 3 months.

The window phase is a big problem for blood banks that perform only immunochemical tests on the donated blood. This is the reason why in some countries the blood donors are submitted to a series of questions regarding their prior behavior, mainly sexual and drug use related, in the months preceding the donation and also to voluntary confidential self exclusion, in which they declare whether their blood may be used or should be excluded. Instead of facing this dangerous problem, modern blood

banks nowadays use the PCR (polymerase chain reaction) for HIV, a test that is not distorted by the window phase since it is not antibody-based. Using specific primers, the PCR detects the presence of DNA generated by reverse transcription of the HIV RNA.

13. What are some strategies of the anti-retroviral drugs used in the AIDS treatment?

Anti-retroviral drugs used in AIDS treatment try to approach any of the several steps of the HIV life cycle. There are three main groups of drugs: the reverse transcriptase inhibitors, that attempt to disallow the formation of DNA from the viral RNA (zidovudine, or AZT, ddI, d4T, 3TC, nevirapine, efavirenz, etc.); the protease inhibitors, that block the enzyme protease necessary for the assemblage of new virus (saquinavir, ritonavir, nelfinavir, indinavir); and the group of entry inhibitors (includes fusion inhibitors), that try to block the entry of HIV into the host cell (enfuvirtide, a fusion inhibitor).

14. Why is the AIDS treatment often done with a drug cocktail?

The treatment of acquired immune deficiency syndrome is often done with one or more anti-retroviral drugs of different groups, for example, a protease inhibitor plus a reverse transcriptase inhibitor in an attempt to approach in one single time two or more stages of the HIV life cycle. Besides that, the high mutation rate of the virus may make the treatment ineffective and for this reason the use of the drug cocktail allows physicians to choose other different drug combinations to escape the viral resistance.

15. What are some prophylactic measures against HIV infection?

The main prophylactic measures against HIV infection are: the use of condoms in sexual relations, not to share syringes and needles, careful handling of contaminated medical and nosocomial material, up-to-date information about the virus and its mode of transmission.

Biology Questions and Answers

Worm Diseases

1. What are worm infections?

Worm infections are human diseases caused by platyhelminthes (flatworms) or nematodes (roundworms).

2. What are the most important worm infections?

The most important human worm infections are schistosomiasis, taeniasis, cysticercosis, ascariasis and ancylostomiasis (hookworm infection).

Other important worm infections caused by platyhelminthes are: fascioliasis, caused by Fasciola hepatica, which attacks the liver and the bile ducts; hydatid disease, also known as echinococcosis, caused by a taenia-like parasite and transmitted by feces of dogs in contact with sheep, with a clinical picture similar to cysticercosis. Other important infections caused by roundworms are: strongyloidiasis, agent Strongyloides stercoralis, a common opportunistic disease in AIDS; filariasis, also known as elephantiasis, transmitted by mosquitoes of the Culex genus, caused by Wuchereria bancrofti and other thread-like worms and manifested by obstruction and fibrosis of lymphatic vessels that cause swelling (lymphedema) of limbs; enterobiasis (pinworm infection), caused by Enterobius vermicularis, a worm that parasites the colon and the human perianal region; cutaneous larva migrans, an ancylostomiasis of the skin caused by Ancylostoma braziliensis.

3. What is schistosomiasis?

Schistosomiasis is a worm infection caused by schistosomes, a species of flatworms (platyhelminthes). The disease is prevalent in Latin America and in the Far East. The main species of schistosome found in Latin America is Schistosoma mansoni.

4. How do schistosomes differentiate regarding sex separation?

Schistosomes are dioecious, i.e., the species has separated sexes, male and female individuals.

5. What is the intermediate host of Schistosoma mansoni? Where does that host live?

The intermediate host of the schistosome is a gastropod mollusc, a snail of the Planorbidae family and Biomphalaria genus. The snail vector of schistosomiasis lives in freshwater, as in lagoons and creeks.

6. What is the life cycle of the schistosome?

Male and female adult schistosomes live within blood vessels of the human intestines. The females release eggs that trespass the vessel walls and enter the intestinal lumen being eliminated with the human feces. When in water the egg releases a larva called miracidium that then swims to reach the snail that is the intermediate host. Within the snail miracidia transform into cercariae, another kind of schistosome larva. The cercariae leave the snail and swim until penetrating through the human skin. In humans the cercaria gains the circulation infecting mainly the blood vessels of the intestines, liver or lungs and develops into the adult form of the parasite.

7. What are the main phases and clinical manifestations of schistosomiasis?

Schistosomiasis has acute and chronic phases. Days after the infection the cercarial dermatitis appears at the site where the worm penetrated the skin. In one or two months the acute phase begins and fever, cough, muscle pain and nausea occur but soon disappear; in some people this phase may not manifest. In the chronic phase of the disease the worm infestation can affect the bowels, causing diarrhea, bloody feces, tiredness and hepatosplenomegaly (enlargement of the liver and spleen). The excessive pressure upon the hepatic portal vein produces varix (collateral circulation) in the esophagus and the patient may have hemorrhages and bloody vomiting that may even cause death.

8. What are the main prophylactic measures against schistosomiasis?

The main measures to prevent schistosomiasis are: information for infected individuals to look for treatment and to not disseminate the disease; chemical and biological combat against the vector snail; basic sanitary conditions to avoid contamination of lakes, rivers and other water streams by infected feces; to avoid contact with fresh water suspected of contamination.

9. What are taenias? What are the diseases caused by them?

Taenias, also know as tapeworms, are platyhelminth animals (flatworms). The main diseases caused by taenias are taeniasis and cysticercosis.

10. How do taenias classify according to the division of sexes?

Taenias are monoecious (hermaphrodite), the same individual has female and male reproductive organs and undergoes self fecundation.

Biology Questions and Answers

11. What are the two main species of taenias that cause human diseases?

The two mains species of taenias that cause disease in humans are Taenia solium, or the pork tapeworm, and Taenia saginata, or the beef tapeworm.

Besides these species there are still the fish tapeworm, or Diphyllobothrium latum, and a tapeworm, Echinococcus granulosus, which lives in dogs and cause in humans the severe disease known as hydatid disease, or echinococcosis.

12. How do taenias obtain food and make gas exchange?

Tapeworms have hooks and sucking structures on their heads (scolex) that fixate the parasite in the gut wall; these structures often do not injure the host tissue. The parasite obtains food and makes gas exchange through absorption and diffusion across its skin; since it is a platyhelminth it does not have a digestive system or a circulatory system.

13. What are the segments that form the body of the tapeworm called? What is their function?

The body of the tapeworm is made of segments called proglottids. The proglottids are reproductive structures of the taenia and contain the organs that produce male and female gametes. As the proglottids become distant from the scolex (head) they mature. Mature proglottids can fecundate themselves or neighboring ones and the eggs formed are stored inside them. Proglottids called pregnant proglottids, full of eggs, detach from the body of the worm and are eliminated with the human feces.

14. Concerning their respective intermediate hosts how different are Taenia solium and Taenia saginata?

The intermediate hosts of Taenia solium are pigs and the intermediate hosts of Taenia saginata are cattle.

15. What is the life cycle of a tapeworm?

Pregnant proglottids with taenia eggs are released together with human feces. If ingested by the intermediate hosts, swine or bovine, the eggs break inside their intestines and the larva trespass the mucosa and gains the circulation to settle on muscles, heart, brain and other organs of these animals and then differentiate into cystic larvae called cysticerci. Humans become infected when eating raw or badly cooked swine or bovine meat contaminated by cysticerci. In the human intestines the cysticerci develop into adult worms and the cycle goes on.

16. What is the difference between taeniasis and cysticercosis?

Taeniasis is the parasitic disease caused by the adult tapeworm installed within the human intestine.

Cysticercosis occurs when humans ingest eggs or pregnant proglottids of taenias, for example, through badly washed food or self infection. In cysticercosis humans assume the role of intermediate hosts of the parasite and the cysticerci develop within human organs like muscles, brain, eyes and subcutaneous tissue. The brain infestation by cysticerci, a condition known as neurocysticercosis, is extremely severe and may lead to death.

In the normal life cycle of taenias the humans are the definitive hosts and develop taeniasis, a less serious disease, and not cysticercosis.

17. If a person eats raw or badly cooked meat infected by Taenia solium or Taenia saginata will this person develop taeniasis or cysticercosis?

If a person eats raw or badly cooked meat infected by Taenia solium or Taenia saginata he or she will develop the disease taeniasis. The ingestion of contaminated raw or badly cooked infected meat means that cysticerci are being ingested. The human then will be affected by taeniases since in his or her gut the cysticerci may develop into an adult tapeworm.

18. How does self infection by tapeworms occur?

Taeniasis patients may develop the most severe form of the worm infection, cysticercosis, because their feces contain eggs and pregnant proglottids of the taenia and there is risk of self infection due to bad hygienic habits, like not washing the hands after defecation. If these individuals ingest the eggs of the parasite they can develop cysticercosis too.

19. What are some prophylactic measures for tapeworm infections?

The main prophylactic measures against taeniasis and cysticercosis are: not to ingest raw or badly cooked swine or bovine meat; sanitary education of the people; appropriate destination of feces; adequate treatment of infected people.

20. What is ascaris? What is the disease caused by this worm?

Ascaris, or Ascaris lumbricoides, is an animal of the nematode phylum, i.e., a roundworm. Ascaris causes ascariasis, a common worm infection of the intestine.

Biology Questions and Answers

21. How do ascaris obtain food?

The ascaris live within the human gut and feed from the food ingested by the infected person.

22. Does Ascaris lumbricoides present an intermediate host?

Ascaris is a monoxenous parasite, its life cycle is dependent only on one host and so it does not have intermediate host.

23. What is the life cycle of ascaris?

Adult ascaris that live within the human intestine can release up to 200 thousand eggs a day. The eggs are eliminated with human feces and mature in the environment under some heat and moisture conditions. Humans may ingest mature eggs through food contaminated by human feces or through bad hygienic habits. The eggs again inside the human intestine release larvae that cross the enteric mucosa and gain the circulation reaching the lungs. In the lungs the larva mature and go to the airway and to the pharynx when they are then swallowed. Within the gut the larvae develop into adult worms.

24. What are the main symptoms of the pulmonary and of the intestinal phases of the ascaris infestation?

In the pulmonary phase the ascaris infestation causes cough, hemoptysis, dyspnea, fever, fatigue and may cause a special kind of pneumonia called eosinophilic pneumonia. In the intestinal phase the symptoms are due to spoliation of nutrients of the host and thus hunger and weight loss may appear. Masses of ascaris inside the bowels can cause severe intestinal obstruction.

25. What are some prophylactic measures against ascariasis?

The main prophylactic measures against ascariasis are: efficient washing of vegetables and other foods; basic sanitary conditions and appropriate destination of feces; hygiene education for people; combat against insects that can carry the eggs of the parasite, like flies and cockroaches.

26. What is ancylostomiasis?

Ancylostomiasis is a disease caused by Ancylostoma duodenale or Necator americanus, both hookworms belonging to the nematode phylum (roundworms). Ancylostomiasis caused by these worms is also called hookworm disease.

Since the parasites nourish themselves on human blood the infection causes

anemia, hypoproteinemia and the patient often seems pale.

27. Which is the typical feature of the hookworms related to the way they obtain food and explore the host?

Both Ancylostoma duodenale and Necator americanus have mouthparts with hooks or "teeth" that help the fixation of the parasite in the human intestine wall and facilitate the tissue injury necessary to drain blood from the host. The structures are evolutionary adaptations for the parasitic way of life of these animals.

28. Are hookworms monoxenous or heteroxenous?

Hookworms are monoxenous, i.e., their life cycle depends only on one host.

29. What is the life cycle of the hookworms?

Adult hookworms within the human intestine release eggs that are eliminated with the human feces. Under adequate conditions of moisture and temperature the eggs mature in the soil and generate larvae. The larvae differentiate into thread-like infective larvae that can penetrate the human skin, generally through the feet. The larvae them gain the human circulation and reach the lungs from where they go to the airway and the pharynx. When the larvae are swallowed they enter the small intestine and develop into adult worms and the cycle restarts.

30. What are the main prophylactic measures against hookworm disease?

The main prophylactic measures against hookworm disease are: to avoid walking barefoot on soils suspected of contamination; basic sanitary conditions and appropriate destination of feces; treatment of infected people.

Prion Diseases

1. What is a prion?

A prion is an infectious (transmissible) protein able to replicate by transforming other proteins into a copy of the prion. The mechanism of copying is not yet understood by science.

The hypothesis come out from research about a nervous system disease known as Creutzfeldt-Jacob disease, epidemiologically associated to a bovine disease called bovine spongiform encephalitis (the mad cow disease). Research discovered that the infectious agent that causes those diseases, suprisingly, was a protein capable of copying itself and of being transmitted by ingestion (the reason why meat from contaminated animals cannot be consumed), inoculation and even heredity.

2. What are the main human diseases caused by prions?

The main known human diseases of such type are the Creutzfeldt-Jacob disease (CJD), the kuru and the Gerstmann-Sträussle-Scheinken disease (GSS). The hypothesis that many other diseases of unknown etiological agents are actually caused by self-replicating infectious proteins is strong.

Biology Questions and Answers

Degenerative Diseases

1. What are degenerative diseases?

Degenerative diseases are non infectious prevalent diseases whose incidences increase with aging.

2. What are risk factors for diseases?

Risk factors for a disease are everything that contributes to increase the risk of the disease to appear. For example, for most cardiovascular diseases, tobacco smoking and diabetes mellitus are both important risk factors; for some cancers having a genetic component a positive family history is a risk factor, etc.

3. What are the main human degenerative diseases?

The main human degenerative diseases are divided into three groups: cardiovascular diseases, neoplastic diseases and degenerative diseases of the nervous system. The main cardiovascular diseases are hypertension, the cardiopathies, including coronary disease and myocardial infarction, and the cerebrovascular accidents (CVAs, or strokes). Neoplasias are benign tumors and cancers. The main degenerative diseases of the nervous system are Alzheimer's disease and Parkinson's disease.

4. What is hypertension?

Hypertension is a disease in which the arterial blood pressure, during systole or during diastole, is abnormally high.

Hypertension, or high blood pressure, is a condition that must be diagnosed and treated since it produces irreversible injuries in arteries and, later, it causes other severe diseases in organs like the heart, brain, kidneys, retina, etc.

5. What are the main risk factors for hypertension?

The main risks factors for hypertension are tobacco smoking, stress, obesity, sedentary lifestyle and alcoholism.

6. What is the relation between the maximum and the minimum blood pressure with the phenomena of systole and diastole?

The maximum blood pressure is the pressure on the wall of the systemic arteries during systole, i.e., when the heart is pumping blood to arterial vessels. The minimum blood pressure is the pressure on the wall of the systemic arteries during diastole, i.e., when the heart ventricles are relaxing and getting blood.

Biology Questions and Answers

7. What are the main degenerative diseases of the heart?

The main degenerative diseases of the heart are heart failure, arrhythmias, valvular heart diseases, coronary insufficiency and myocardial infarction.

8. What is coronary disease?

Coronary disease, or coronary insufficiency, is a disease in which there is total or partial obstruction of one or more of the arteries that irrigate the heart musculature, i.e., obstruction of the coronary arteries. The disease is formed by slow and gradual formation of atheroma plaques inside the coronaries. The fatty plaques grow and block the flow of blood, a process known as atherosclerosis (do not confuse with arteriosclerosis which is the hardening of the arteries generally cause by chronic high blood pressure).

The main risk factors for coronary disease are tobacco smoking, diabetes mellitus, hypertension, hypercholesterolemia (high level of bad cholesterol and low level of good cholesterol), stress, alcoholism and sedentary lifestyle.

Coronary disease may present in two manners, as angina pectoris or as myocardial infarction. If the arterial obstruction is not complete and extensive the patient often feels chest pain (angina pectoris), mainly when performing physical exercise or in any situation when the heart needs more oxygen. If the obstruction of one or more coronaries is complete or blood cannot irrigate some regions of the heart muscle (myocardium) the infarction occurs and the muscle cells of the affected area die.

9. What is myocardial infarction?

Myocardial infarction is the condition in which an area of this tissue or the entire heart muscle dies by hypoxia due to lack of blood irrigation. Myocardial infarction is a severe disease since on the dependence of its extension the heart can fail, i.e., it can no longer pump blood to the lungs or to the body or it can even stop beating (causing death).

The main cause of myocardial infarction is coronary obstruction, blocking of the arteries that carry arterial blood to the heart muscle. Other events like hemodynamic shock (circulation stoppage due to large hemorrhages, for example) can also cause myocardial infarction.

10. What is coronary bypass graft?

Coronary artery bypass graft is a kind of surgical myocardial revascularization, i.e., a way to provide blood to a myocardium whose blood supply is impaired or blocked due to coronary disease. In this surgical treatment of coronary disease one or more blood vessel grafts taken from other parts of the body are used to join the obstructed artery (in a region after the obstruction) with the aorta or other healthy coronary

artery thus reestablishing the blood flow to the myocardium. Often the blood vessel grafts are part of the saphenous vein from the leg or of the mammary artery from the chest or even of the radial artery from the forearm.

11. What are cerebrovascular accidents?

Cerebrovascular accident (CVA), also known as stroke, is the generic name given to infarction (tissue and cellular death by hypoxia) of areas of the brain due to vascular obstruction or hemorrhages. CVAs are divided into ischemic and hemorrhagic. In the ischemic CVA blocking of arteries that carry blood to the brain occurs; its cause is generally atherosclerosis (atheroma formation) of these vessels. In the hemorrhagic CVA there is rupture of one or more blood vessels of the brain with blood leakage, increasing intracranial pressure and thus interruption of blood flow in some areas of the brain. The severity of the stroke depends on the function performed by the affected area of the brain, for example, motor function, visual function, vegetative function, etc., and on the size of the involved area.

The main risk factors for cerebrovascular accidents are hypertension, hypercholesterolemia, tobacco smoking and old age.

12. What are neoplasias?

Neoplasia is any abnormal and uncontrolled proliferation of cells of an organism. Neoplasias can be benign or malign. Benign neoplasias are those in which the cell proliferation is limited to a given site of the body and so neoplastic cells do not spread to other close regions or at distance through the circulation. Malign neoplasias are those in which the neoplastic cells disseminate at distance to other sites and organs of the body, a process called metastasis, where they continue to proliferate. Malign neoplasias injure tissues and if not eradicated they are fatal. Benign neoplasia can also be deadly when it forms a tumor that grows and compresses vital organs.

13. How different are the concepts of neoplasia, tumor and cancer?

Not every tumor is neoplastic and not every neoplasia creates tumor. Tumor is the generic name given to the abnormal increase in mass or volume of any area of the body (for example, the enlarged tonsils during throat infection are a kind of tumor, any inflammation creating a swelled area characterize a tumor, etc.). Neoplasias can form tumors, some of them very large, by aggregation of neoplastic cells in the region where the neoplasia began or in distant implantations. Cancer is a synonym for malign neoplasia.

14. What is cancer?

Cancers are malign neoplasias, i.e., abnormal and uncontrolled proliferation of cells that can disseminate to other sites of the body. Cancer dissemination

at distance usually occurs through blood or lymphatic vessels.

15. How do malign neoplasias appear?

Neoplasias appear due to DNA mutations in genes that regulate the cellular proliferation thus making the cell lose its capacity to control and limit its division by mitosis. The cell then divides continuously and uncontrollably and this defect is transmitted to its daughter cells.

16. What are carcinogens?

Carcinogens are factors capable of producing neoplasias. Any mutagen, a substance that can induce DNA mutation, is a potential carcinogen. Examples of carcinogens are radiation, nitrous acid, many substances inhaled through tobacco smoking and the human papilloma virus (HPV).

17. How do cells of neoplastic tumors obtain oxygen and nutrients and release wastes?

In neoplastic tumors a phenomenon called angiogenesis occurs. Angiogenesis is the formation of new blood vessels. Neoplastic cells induce the formation of new blood vessels to irrigate and drain the neoplastic tissue. Angiogenesis is important because the tumor growth depends on it. A lot of research on cancer has tried to discover natural and synthetic substances to inhibit angiogenesis.

18. What are the main types of cancer that affect humans?

Excluding skin cancer, that are the more easily detected and so cases are registered in larger number, the main types of cancer in men are prostate cancer, lung cancer, stomach cancer; in women, breast cancer, colon and rectal cancer and lung cancer are of great incidence. Other common cancers are ovarian cancer, pancreatic cancer, liver cancer, esophageal cancer, brain cancer and the leukemias and lymphomas (blood cancers).

Epithelial cancers, of the skin as well as of the internal organs, are more common because epithelial tissues are more exposed to carcinogens.

The proportional incidence of the many types of cancers varies according to the considered population.

19. What is the main risk factor for lung cancer?

The main risk factor for lung cancer is tobacco smoking. The large number of cases of this type of cancer is due to the increased number of smokers worldwide.

20. What is the main risk factor for skin cancer?

The main risk factor for skin cancer is solar exposition of the skin without protection against ultraviolet radiation (a potential carcinogen).

The most lethal skin cancer is melanoma.

21. How is cancer usually treated?

If the cancer is in its initial stage treatment is often done by surgical removal of the neoplastic tissue. Cancers already disseminated are often treated with radiation (radiotherapy) and anti-mitotic drugs (chemotherapy).

22. What are the main degenerative diseases of the nervous system?

The main degenerative diseases of the nervous system are Alzheimer's disease and Parkinson's disease.

Degenerative diseases of the nervous system are caused by progressive tissue degradation or loss of neurons in some regions of the nervous system.

23. What is Alzheimer's disease?

Alzheimer's disease is a degenerative disease of the central nervous system in which the patient has progressive dementia and alteration of mental functions.

The disease generally appears after 40 years of age and it is more frequent in the elderly. Image studies of the brain show broad loss of brain tissue. (The Alzheimer's disease should not be confused with other mental deteriorations common in the elderly.)

24. What is Parkinson's disease?

Parkinson's disease is a degenerative disease of the nervous system in which the main manifestations are progressive motor disturbances, like tremors of feet, hands and mandibles (jaws) and walking and balance impairments. Parkinson's disease is due to the degeneration of dopaminergic motor neurons, i.e., motor neurons that use dopamine as a neurotransmitter, located in a specific region of the brain, the mesencephalon. Such degeneration creates deficiency of dopamine in the nervous system. (Parkinson's disease should not be confused with other causes of tremors, like the use of some medicines.)