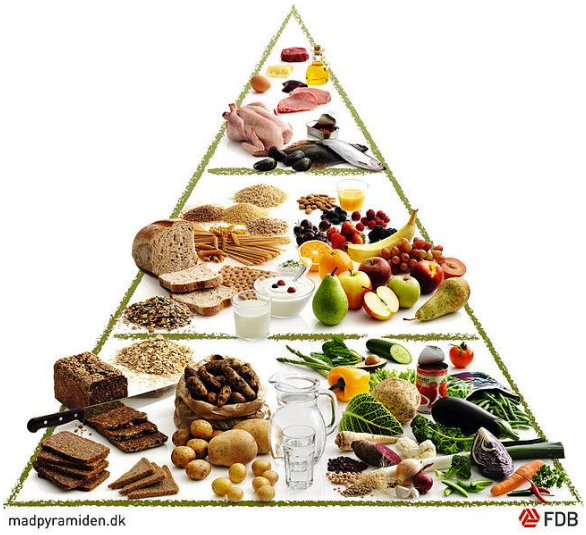
NATIONAL SCIENCE OLYMPIAD 2013: LIFE SCIENCES

Study the following picture of a food pyramid and answer questions (1), (2), (3), (4), (5), (6), (7), (8), (9) and (10).



(1) Which of the following foods are the richest sources of potassium?

(A) Potatoes, bananas and white beans
(B) Whole wheat bread, yoghurt and fish
(C) Carrots, pasta and eggs
(D) Broccoli, cucumbers and olive oil.

ANSWER: (A)

Potassium (K) ions are necessary for the function of all living cells. Potassium ion diffusion is a key mechanism in nerve transmission, and potassium depletion in animals, including humans, results in various cardiac dysfunctions. Potassium accumulates in plant cells, and thus fresh fruits and vegetables are a good dietary source of it. Heavy crop production rapidly depletes soils of potassium, and agricultural fertilizers consume 95% of global potassium chemical production. A potassium intake sufficient to support life can in general be guaranteed by eating a variety of foods. Foods rich in potassium include parsley, dried apricots, dried milk, chocolate, nuts (especially almonds), potatoes, bananas, avocados and soybeans.

(2) Which foods are the richest sources of a vitamin that prevents scurvy?

(A) Spinach
(B) Yoghurt
(C) Carrots
(D) Chicken.

ANSWER: A

Vitamin C is a cofactor in at least eight enzymatic reactions including several collagen synthesis reactions that, when dysfunctional, cause the most severe symptoms of scurvy In animals, these reactions are especially important in wound-healing and in preventing bleeding from capillaries. Spinach (*Spinacia oleracea*) has a high nutritional value and is a rich source of vitamin A (and especially high in lutein), vitamin C, vitamin E, vitamin K, magnesium, manganese, folic acid, iron, calcium, potassium, zinc and selenium.

(3) Although consumption of leafy green vegetables is important, caution must be exercised since some of them contain oxalic acid. Why is the presence of oxalic acid in these vegetables a problem?

(A) Oxalic acid causes liver cancer
(B) Oxalic acid is poisonous and leads to the formation of kidney stones.
(C) Oxalic acid leads to atherosclerosis
(D) None of the options (A) to (C)

ANSWER: B

The toxicity of oxalic acid is due to kidney failure, which arises because it causes precipitation of solid calcium oxalate, the main component of kidney stones. Oxalic acid can also cause joint pain due to the formation of similar precipitates in the joints. Members of the spinach family of plants (Amaranthaceae) contain high levels of oxalates.

(4) *"An apple a day keeps the doctor away."* What is this statement intended to mean?

(A) That apples contain the highest content of sugars, vitamins, fiber and minerals than any fruit and thus good for health.
(B) That in addition to sugars, fiber and vitamins, apples also contain high levels of immune boosting compounds that keep us healthy.
(C) The statement is not supposed to be taken literally but is meant to promote consumption of fresh fruits in general.
(D) None of the options (A) to (C)

ANSWER: C

Compared to many other fruits and vegetables, apples contain relatively low amounts of vitamin C, but are a rich source of other antioxidants Apples' antioxidant property prevents the damage to cells and tissues. The fiber content, while less than in most other fruits, helps regulate bowel movements and may thus reduce the risk of colon cancer. The fiber contained in apples reduces cholesterol by preventing reabsorption, and (like most fruits and vegetables) they are bulky for their caloric content.

(5) Although wine, when taken in moderation, has been proven to confer certain health benefits, it is not included in the food pyramid. A reason for this could be that

(A) The same benefits can be obtained from eating the grapes themselves and not their fermented juice.
(B) The pyramid was probably drawn by religiously biased scientists who want to discourage alcohol consumption.
(C) Wine contains sulfites added as preservatives, which nullify any health benefits the wine could offer.
(D) Wine contains yeast extracts and bacteria used in fermentation, some of which can cause liver cirrhosis.

ANSWER: A

Alcohol is a toxin and damages cells. The best-known health effect of alcohol is a small increase in HDL cholesterol. However, regular physical activity is another effective way to raise HDL cholesterol, and niacin can be prescribed to raise it to a greater degree. Alcohol may also prevent platelets in the blood from sticking together. That may reduce clot formation and reduce the risk of heart attack or stroke. (Aspirin may help reduce blood clotting in a similar way).

Wine, especially red wine, contains many other chemicals which may have health benefits, but the compound resveratrol has been studied the most. Structurally, resveratrol is a polyphenol. Polyphenols play a key role in the health benefits of wine by acting as antioxidants that prevent cell damage. Resveratrol is found in widely varying amounts among grape varieties. Fresh grape skin contains about 50 to 100 micrograms of resveratrol per gram.

The American Heart Association does not recommend drinking wine or any other form of alcohol to gain these potential benefits. The AHA recommends controlling your weight, getting enough physical activity and following a healthy diet. There is no scientific proof that drinking wine or any other alcoholic beverage can replace these conventional measures.

(6) Which of the following foods are, in the strict scientific sense, NOT fruits?

(A) Tomatoes, pumpkins and olives.
(B) Apples, apricots and avocado pears.
(C) Peanuts, chestnuts and hazel nuts.
(D) None of the options (A) to (C)

ANSWER: D

In its strict botanical sense, a fruit is the fleshy or dry ripened ovary of a plant, enclosing the seed or seeds. Thus, apricots, bananas, and grapes, as well as bean pods, corn grains, tomatoes, cucumbers, and (in their shells) acorns and almonds, are all, technically, fruits. Popularly, however, the term is restricted to the ripened ovaries that are sweet and either succulent or pulpy.

(7) Which of the following correctly lists foods that contain high levels of cholesterol?

(A) Red meat, chicken and olive oil.
(B) Olive oil, sunflower seeds and pecan nuts.
(C) Avocado pears, whole cereal grains and chicken.
(D) None of the options (A) to (C)

ANSWER: D

Cholesterol is an essential structural component of mammalian cell membranes and is required to establish proper membrane permeability and fluidity. In addition to its importance within cells, cholesterol also serves as a precursor for the biosynthesis of steroid hormones, bile acids and vitamin D. Animal fats are complex mixtures of triglycerides, with lesser amounts of phospholipids and cholesterol. As a consequence, all foods containing animal fat contain cholesterol to varying amounts Major dietary sources of cholesterol include cheese, egg yolks, beef, pork, poultry, fish and shrimp. From a dietary perspective, cholesterol is not found in significant amounts in plant sources.

(8) Herbs and spices, while they offer some benefits and improve the flavor of food, are not shown in the pyramid. A possible reason could be:

(A) They make the food taste too good, leading to people eating too much and becoming obese.

(B) Some spices are actually toxic so excluding herbs and spices altogether was the best decision.

(C) The pyramid only shows what constitutes a healthy diet and the methods of food preparation are left to the individual.

(D) The herbs and spices trade is a multi-billion dollar business and including them in the pyramid would have led to rejection of the pyramid by companies whose products are not shown.

ANSWER: C

Spices and herbs are parts of various plants cultivated for their aromatic, pungent, or otherwise desirable substances. Spices and herbs consist of rhizomes, bulbs, barks, flower buds, stigmas, fruits, seeds, and leaves. They are commonly divided into the categories of spices, spice seeds, and herbs. Spice seeds are the tiny aromatic fruits and oil-bearing seeds of herbaceous plants such as anise, caraway, cumin, fennel, poppy and sesame. Herbs are the fresh or dried aromatic leaves of such plants as marjoram, mint, rosemary and thyme. Spices, spice seeds, and herbs are employed as adjuncts to impart flavor and aroma or piquancy to foods. In the small quantities used to prepare culinary dishes, they have little nutritional value, but they stimulate the appetite, add zest to food, and enhance flavors. Many spices have antimicrobial properties. This may explain why spices are more commonly used in warmer climates, which have more infectious diseases, and why the use of spices is especially prominent in meat, which is particularly susceptible to spoiling.

(9) The organic way of producing food means?

(A) Using cultivation methods and business practices that are fair and empowering to farm laborers.

(B) Growing food without the use of artificial fertilizers, pesticides and herbicides.

(C) Having sales contracts with retailers to make sure that produce from farms reaches the consumer within hours after harvest (i.e., very fresh).

(D) Using antibiotics and not toxic herbicides and pesticides in farms to prevent plant and animal diseases.

ANSWER: B

Organic farming, also called organic gardening, is a system of crop cultivation employing biological methods of fertilization and pest control as substitutes for chemical fertilizers and pesticides; the latter products are regarded by proponents of organic methods as injurious to health and the environment and unnecessary for successful cultivation. Organic farming as a conscious rejection of modern agri-chemical techniques had its origin in the 1930s, when Sir Albert Howard, a British agricultural scientist, introduced a system of holistic and natural animal and plant husbandry in which town wastes were returned to the soil for utilization as nutrient material.

(10) Which of the following foods are best avoided by those who suffer from phenylketonuria?

(A) Nuts
(B) Meat
(C) Dairy products
(D) ALL of the above

ANSWER: D

Phenylketonuria (PKU), also called phenylpyruvic oligophrenia, is hereditary inability of the body to metabolize the amino acid phenylalanine (Phe). Phenylalanine is normally converted in the human body to tyrosine, another amino acid, by the enzyme called phenylalanine hydroxylase. This enzyme is not active in individuals who have phenylketonuria. As a result of this metabolic block, abnormally high levels of phenylalanine accumulate in the blood, cerebrospinal fluid, and urine. Abnormal products of phenylalanine breakdown, such as highly reactive ketone compounds, can also be detected in the urine.

Phenylalanine is a large, neutral amino acid (LNAA). LNAAs compete for transport across the blood-brain barrier (BBB) via the large neutral amino acid transporter (LNAAT). If phenylalanine is in excess in the blood, it will saturate the transporter. Excessive levels of phenylalanine tend to decrease the levels of other LNAAs in the brain. However, as these amino acids are necessary for protein and neurotransmitter synthesis, Phe build-up hinders the development of the brain, causing mental retardation. All PKU patients must adhere to a special diet low in Phe for optimal brain development. The diet requires severely restricting or eliminating foods high in Phe, such as meat, sea food, eggs, nuts, legumes and dairy products. Infants may still be breastfed to provide all of the benefits of breast milk, but the quantity must also be monitored and supplementation for missing nutrients will be required. The sweetener aspartame, present in many diet foods and soft drinks, must also be avoided, as aspartame contains two amino acids: phenylalanine and aspartic acid.

The central dogma of Biology is: DNA is copied (replication), transcribed into RNA, then translated to proteins which are then modified, depending on their cellular functions.

On the basis of this statement, please answer questions (11), (12), (13), (14), (15), (16), (17), (18), (19) and (20).

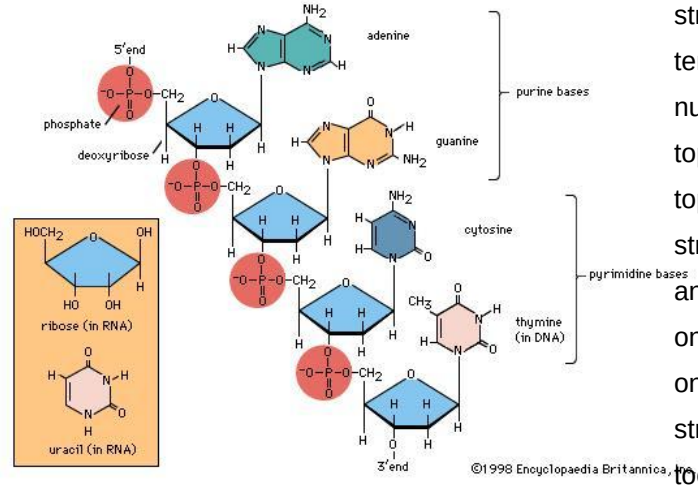
(11) What is the structure of DNA?

(A) A double helix containing an alternating deoxyribose and nitrogenous base backbone from which phosphate groups protrude, leading to hydrogen bonding with the complementary strand and coiling.
(B) A double helix containing an alternating deoxyribose and phosphate backbone and nitrogenous bases attached to the sugar and interacting complementarily with bases on another strand.
(C) A double helix with an alternating nitrogenous base and phosphate backbone from which sugars protrude and allow complementary paining with another strand.
(D) None of the above.

ANSWER: B

The following diagram, from Encyclopedia Britannica, shows the structure of one strand of DNA. The inset shows the corresponding

pentose sugar and pyrimidine base in ribonucleic acid (RNA). Two sugar-phosphate chains are paired through hydrogen bonds between A and T and between G and C, thus forming the twin-stranded double helix of the DNA molecule. The chemical DNA was first discovered in 1869, but its role in genetic inheritance was not demonstrated until 1943. In 1953, James Watson and Francis Crick determined that the structure of DNA is a double-helix polymer, a spiral consisting of two DNA strands wound around each other. These two scientists were awarded the 1962 Nobel Prize for Physiology or Medicine for this achievement.



(12) In Eukaryotes, DNA is compactly packaged into chromosomes in the nucleus and requires uncoiling before replication, and transcription can occur. How is this achieved?

(A) Through the activities of enzymes called helicases and topoisomerases.

(B) Through the activities of enzymes called topoisomerases, peptidases and chromosome hydrolases.

(C) A cell that will need to divide in the future normally has all the DNA, RNA and proteins it will ever need to pass to daughter cells and simply repackages them and passes them on.

(D) None of the above.

ANSWER: A

Before replication can occur, the two strands of the double helix first must be unwound from each other. A class of enzymes called DNA topoisomerases removes helical twists by cutting a DNA strand and then resealing the cut. Enzymes called helicases then separate the two strands of the double helix, exposing two template surfaces for the alignment of free nucleotides. There are two classes of topoisomerases; topoisomerase I and topoisomerase II. Topoisomerase I cuts one strand of a DNA double helix, relaxation occurs, and then the cut strand is reannealed. Cutting one strand allows the part of the molecule on one side of the cut to rotate around the uncut strand, thereby reducing stress from too much or too little twist in the helix. Topoisomerase II cuts both strands of one DNA double helix, passes another unbroken DNA helix through it, and then reanneals the cut strands.

(13) Three consecutive nitrogenous bases on a DNA strand (codon) encode one amino acid, hence the term genetic triplet code. How it this accurately maintained throughout the cell's life?

(A) The enzymes that are responsible for replication and transcription (DNA and RNA polymerases) have proof-reading

activities and can excise erroneously inserted nitrogenous bases and replace them with correct ones.

(B) An error in one nitrogenous base is not a problem; nature has chosen to use three to encode one amino acid in mitigation of the effects of such errors.

(C) An error will eventually lead to a non functional protein and the accumulation thereof will prompt the cell to go back and correct the mistake through negative feedback mechanism.

(D) None of the above.

ANSWER: A

DNA polymerase can add free nucleotides only to the 3' end of the newly forming strand. This results in elongation of the newly forming strand in a 5'-3- direction. No known DNA polymerase is able to begin a new chain (*de novo*). DNA polymerase can add a nucleotide only on to a pre-existing 3'-OH, and, therefore, needs a primer at which it can add the first nucleotide. Primers consist of RNA and/or DNA bases. In DNA replication, the first two bases are always RNA, and are synthesized by another enzyme called primase. An enzyme known as a helicase is required to unwind DNA from a double-strand structure to a single-strand structure to facilitate replication of each strand. It is important to note that the directionality of the newly forming strand (the daughter strand) is opposite to the direction in which DNA polymerase moves along the template strand. DNA polymerase moves along the template strand in a 3'-5' direction, and the daughter strand is formed in a 5'-3' direction. This difference enables the resultant double-stranded DNA formed to be composed of two DNA strands which are antiparallel to each other.

Error correction is a property of some, but not all, DNA polymerases. This process corrects mistakes in newly synthesized DNA. When an incorrect base pair is recognized, DNA polymerase moves backwards by one base pair of DNA. The 3'-5' exonuclease activity of the enzyme allows the incorrect base pair to be excised (this activity is known as proofreading). Following base excision, the polymerase can re-insert the correct base and replication can continue forwards.

(14) Proteins are post-translationally modified to equip them with their requisite functional capabilities. Which of the following is not an example of post-translational modification of proteins?

(A) Phosphorylation

(B) Conjugation to lipids

(C) Glycosylation

(D) Peroxidation

ANSWER: D

Posttranslational modification (PTM) is the chemical modification of a protein after its synthesis during translation. It is one of the later steps in protein biosynthesis, and thus gene expression, for many proteins. After translation, the posttranslational modification of amino acids extends the range of functions of the protein by attaching it to other biochemical functional groups (such as phosphate, various lipids and carbohydrates, changing the chemical nature of an amino acid (e.g. deimination of arginine into

citrulline), or making structural changes (e.g. formation of disulfide bridges).

Peroxidation refers to the oxidative degradation of organic molecules, which in the body, affects mainly lipids. It is the process in which free radicals remove electrons from the lipids in cell membranes, resulting in cell damage. This process proceeds by a free radical chain reaction mechanism. It most often affects polyunsaturated fatty acids, because they contain multiple double bonds in between which lie -CH_2- groups that possess especially reactive hydrogens. As with any radical reaction, the reaction consists of three major steps: initiation, propagation, and termination.

(15) Misreading of the genetic code during transcription and translation can lead to mutations of two types: point mutations or frame shift mutations. Which of these following statements are TRUE about these mutations?

(i) A point mutation is the insertion of a wrong nucleotide during replication, which could lead to the use/insertion of a wrong amino acid during translation.

(ii) A frameshift mutation is caused by insertions or deletions of a number of nucleotides that is not evenly divisible by three from a DNA sequence.

(iii) Point mutations do not necessarily always lead to non-functional proteins because of the degeneracy of the triplet code.

(A) (i) only

(B) (ii) and (iii) only

(C) (i) and (iii) only

(D) (i), (ii) and (iii)

ANSWER: D

All the statements are true. During the process of DNA replication, errors occasionally occur in the polymerization of the second strand. These errors, called mutations, can have an impact on the phenotype of an organism, especially if they occur within the protein coding sequence of a gene. Error rates are usually very low—1 error in every 10–100 million bases, ue to the "proofreading" ability of DNA polymerases.

Point mutations can cause genetic diseases such as sickle cell disease and thalassemia. Frame shift mutations result in a completely different translation from the original, and are also very likely to cause a stop codon to be read, which truncates the creation of the protein. These mutations may impair the function of the resulting protein. One reason inheritance of frameshift mutations is rare is that, if the protein being translated is essential for growth under the selective pressures the organism faces, absence of a functional protein may cause death before the organism reaches reproductive age. Frameshift mutations may result in severe genetic diseases such as Tay-Sachs disease. Although most mutations that change protein sequences are harmful or neutral, some mutations have a positive effect on an organism.

Degeneracy is the redundancy of the genetic code. The genetic code has redundancy but no ambiguity For example, although codons GAA and GAG both specify glutamic acid (redundancy), neither of them specifies any other amino acid (no ambiguity). The codons encoding one amino acid may differ in any of

their three positions. For example the amino acid glutamic acid is specified by GAA and GAG codons (difference in the third position), the amino acid leucine is specified by UUA, UUG, CUU, CUC, CUA, CUG codons (difference in the first or third position), while the amino acid serine is specified by UCA, UCG, UCC, UCU, AGU, AGC (difference in the first, second, or third position).

Degeneracy results because there are more codons than encodable amino acids. For example, if there were two bases per codon, then only 16 amino acids could be coded for (4^2=16). Because at least 21 codes are required (20 amino acids plus stop) and the next largest number of bases is three, then 4^3 gives 64 possible codons, meaning that some degeneracy must exist. Degeneracy makes the genetic code more fault-tolerant for point mutations.

(16) Three types of RNA are involved in the translation of the genetic code to proteins; mRNA, tRNA and rRNA. Which of the following are the TRUE about the functions of these RNA molecules?

(i) mRNA genetic information is encoded in the sequence of nucleotides, which are arranged into codons consisting of three bases each.

(ii) because the genetic code contains multiple codons that specify the same amino acid, there are many tRNA molecules bearing different anticodons which also carry the same amino acid)

(iii) ribosomal RNA catalyzes the formation of a peptide bond between the 2 amino acids that are contained in the rRNA.

(A) (i) only
(B) (ii) and (iii) only
(C) (i) and (iii) only
(D) (i), (ii) and (iii)

ANSWER: D

All the statements are true. Each protein-coding gene is transcribed into a molecule of the related RNA polymer. In prokaryotes, this RNA functions as mRNA; in eukaryotes, the transcript needs to be processed to produce a mature mRNA. The mRNA is, in turn, translated on a ribosome into a chain of amino acids otherwise known as a polypeptide. The process of translation requires transfer RNAs which are covalently attached to a specific amino acid, guanosine triphosphate as an energy source, and a number of translation factors. tRNAs have anticodons complementary to the codons in an mRNA and can be covalently "charged" with specific amino acids at their 3' terminal ends by enzymes known as aminoacyl tRNA synthetases, which have high specificity for both their cognate amino acid and tRNA. The high specificity of these enzymes is a major reason why the fidelity of protein translation is maintained.

(17) Retroviruses such as HIV seem to operate contrary to the central dogma of biology. How is this so?

(A) Their genetic material is RNA from which proteins are made directly, eliminating the need for transcription.

(B) Retroviruses' genetic material is proteins from which RNA and DNA are made, a complete reversal of the central dogma.

(C) Their genetic material is RNA from which DNA is made and the rest of their life cycles then proceed in line with the central dogma.

(D) None of the above.

ANSWER: C

A retrovirus is an RNA virus that is duplicated in a host cell using the enzyme reverse transcriptase to produce DNA from its RNA genome. The DNA is then incorporated into the host's genome by an enzyme called integrase. The virus thereafter replicates as part of the host cell's DNA. So, the information contained in a retroviral gene is used to generate the corresponding protein via the sequence: RNA → DNA → RNA → protein. This extends the fundamental process identified by Francis Crick, in which the sequence is: DNA → RNA → protein.

(18) HIV infection leads to low levels of CD4 cells through several mechanisms. Which of the following ARE NOT SUCH MECHANISMS?

(i) *direct viral killing of infected cells,* ***(ii)*** *increased rates of apoptosis in infected cells*
(iii) *killing of infected CD4 cells by CD8 cytotoxic lymphocytes that recognize infected cells,* ***(iv)*** *inhibition of bone marrow by HIV leading to fewer immune cells,* ***(v)*** *inducing cancer in the blood cells (leukaemia), leading to rapid cell death*

(A) *(ii)* and *(iii)*

(B) *(iii)* and *(v)*

(C) *(iv)* and *(v)*

(D) *(ii)* and *(iv)*

ANSWER: C

HIV infection leads to low levels of $CD4^+$ T cells through three main mechanisms: First, direct viral killing of infected cells; second, increased rates of apoptosis (programmed cell death) in infected cells; and third, killing of infected $CD4^+$ T cells by CD8 cytotoxic lymphocytes that recognize infected cells. When $CD4^+$ T cell numbers decline below a critical level, cell-mediated immunity is lost, and the body becomes progressively more susceptible to opportunistic infections.

(19) Which of the following best represents the estimated per-act risk for acquisition of HIV by exposure route?

(A) blood transfusion > childbirth > sexual intercourse > needle sharing during drug use

(B) blood transfusion > sexual intercourse > needle sharing during drug use > childbirth.

(C) blood transfusion > needle sharing during drug use > childbirth > sexual intercourse

(D) childbirth > sexual intercourse > needle sharing during drug use > blood transfusion.

ANSWER: A

In general, if infected blood comes into contact with any open wound, HIV may be transmitted. This transmission route carries the highest risk and can account for infections in recipients of blood transfusions, although most transfusions are checked for HIV. The transmission of the virus from the mother to the child can occur during pregnancy, at child birth or via breast feeding. In the absence of treatment, the transmission rate up to birth between the mother and child is high. However, where combination antiretroviral therapy and Caesarean section are available, this risk can be greatly reduced. Postnatal mother-to-child transmission may be largely prevented by complete avoidance of breast feeding; however, this has significant associated morbidity.

Like blood transfusion, needle sharing during drug use also carries a high risk if the needles are not sanitized before use.

The majority of HIV infections are acquired through unprotected sexual acts. Although the risk per act is much lower, complacency about HIV leads to this mode of transmission being responsible for the majority of HIV cases. Sexual transmission occurs when infected sexual secretions of one partner come into contact with the genital, oral or rectal mucous membranes of another. Practising safe sex, staying faithful to one partner or abstinence greatly reduces/eliminates this risk.

(20) The following is the sequence of events in the HIV life cycle once inside the human host:

(i) *adsorption of the virus onto receptors on the cell membrane* ***(ii)*** *fusion of the viral envelope with the cell membrane* ***(iii)*** *release of the HIV capsid into the cell* ***(iv)*** *reverse transcription* ***(v)*** *transportation of the double-stranded viral DNA to the nucleus* ***(vi)*** *insertion into the host cell's genome* ***(vii)*** *transcription the translation by the host's mechanisms* ***(viii)*** *cleavage and packaging by HIV protease* ***(ix)*** *budding and maturation*

Which of the steps can be prevented by the use of a condom?

(A) *(i) only*
(B) (i) and *(ii)*
(C) all steps (i) to *(ix)*
(D) None of the above

ANSWER: D

Once inside the human host i.e., once a person is infected, a condom will not prevent HIV from multiplying in his/her body. Only antiretroviral drugs can. But such an individual must practice safe sex to avoid infecting others or getting infected with other HIV strains.

(21) Lichen is a mutuality relationship between …

(A) algae and bacteria.
(B) algae and moss plants.
(C) algae and fungi.
(D) fungi and a moss.

Answer: C

A lichen is, by definition, a simple slow-growing plant that typically forms a low crustlike, leaflike,

or branching growth on rocks, walls, and trees. Lichens are composite plants consisting of a fungus that contains photosynthetic algal cells. Their classification is based upon that of the fungal partner, which in most cases belongs to the subdivision Ascomycotina, and the algal partners are either green algae or cyanobacteria. Lichens obtain their water and nutrients from the atmosphere and can be sensitive indicators of atmospheric pollution.

(22) How is cardiac muscle distinguished from ordinary muscle? Cardiac muscle…

(A) has mitochondria.
(B) can contract quicker.
(C) have no rest period.
(D) has branching fibres.

Answer: D

Cardiac muscle is adapted to be highly resistant to fatigue: it has a large number of mitochondria, enabling continuous aerobic respiration, numerous myoglobins (oxygen-storing pigment), and a good blood supply, which provides nutrients and oxygen. The heart is so tuned to aerobic metabolism that it is unable to pump sufficiently in ischemic conditions. At basal metabolic rates, about 1% of energy is derived from anaerobic metabolism. This can increase to 10% under moderately hypoxic conditions, but, under more severe hypoxic conditions, not enough energy can be liberated by lactate production to sustain ventricular contractions. Unlike skeletal muscle, which contracts in response to nerve stimulation, specialized pacemaker cells at the entrance of the right atrium termed the sinoatrial node display the phenomenon of automaticity and are myogenic, meaning that they are self-excitable without a requisite electrical impulse coming from the central nervous system. The rest of the myocardium conducts these action potentials by way of electrical synapses called gap junctions. Heart muscle differs from its counterpart, skeletal muscle, in that it exhibits rhythmic contractions. The amount of blood pumped by the heart per minute (the cardiac output) varies to meet the metabolic needs of the peripheral tissues (muscle, kidney, brain, skin, liver, heart, and gastrointestinal tract). The cardiac output is determined by the contractile force developed by the muscle cells of the heart (myocytes), as well as by the frequency at which they are activated (rhythmicity). The factors affecting the frequency and force of heart muscle contraction are critical in determining the normal pumping performance of the heart and its response to changes in demand.

(23) Why does the liver contain a lot of iron and recommended for consumption by those who suffer anemia?

(A) The iron of broken down hemoglobin is stored in the liver.
(B) Erythrocytes are manufactured in the liver and a lot of iron is needed.
(C) Iron is broken down in the liver to more usable molecules.
(D) Iron is used in the production of bile.

Answer: A

The liver plays a major role in metabolism and has a number of functions in the body, including

glycogen storage, decomposition of red blood cells, plasma protein synthesis, and detoxification. This organ also is the largest gland in the human body. It produces bile, an alkaline compound which aids in digestion, via the emulsification of lipids. It also performs and regulates a wide variety of high-volume biochemical reactions requiring very specialized tissues. The various functions of the liver are carried out by the liver cells or hepatocytes. The liver performs several roles in carbohydrate metabolism: (i) Gluconeogenesis (the synthesis of glucose from certain amino acids, lactate or glycerol) (ii) Glycogenolysis (the breakdown of glycogen into glucose) (muscle tissues can also do this) (iii) Glycogenesis (the formation of glycogen from glucose) (iv) the breakdown of insulin and other hormones. The liver is responsible for the mainstay of protein metabolism. The liver also performs several roles in lipid metabolism: (i) Cholesterol synthesis (ii) the production of triglycerides (fats). The liver produces coagulation factors I (fibrinogen), II (prothrombin), V, VII, IX, X and XI, as well as protein C, protein S and antithrombin. The liver breaks down haemoglobin, creating metabolites that are added to bile as pigment (bilirubin and biliverdin). The liver breaks down toxic substances and most medicinal products in a process called drug metabolism. This sometimes results in toxication, when the metabolite is more toxic than its precursor. The liver converts ammonia to urea. The liver stores a multitude of substances, including glucose (in the form of glycogen), vitamin B_{12}, iron, and copper. The liver is responsible for immunological effects- the reticuloendothelial system of the liver contains many immunologically active cells, acting as a 'sieve' for antigens carried to it via the portal system. The liver produces albumin, the major osmolar component of blood serum. Red blood cells have an average life span of 120 days. Because red cells cannot synthesize protein, reparative processes are not possible. As red cells age, wear and tear leads to loss of some of their protein, and the activity of some of their essential enzymes decreases. Dead red blood cells are destroyed by reticuloendothelial cells in the liver. Protein, including that of the hemoglobin, is broken down, and the component amino acids are transported through the plasma to be used in the synthesis of new proteins. The iron removed from hemoglobin passes back into the plasma and is transported to the bone marrow, where it may be used in the synthesis of hemoglobin in newly forming red cells. Iron not necessary for this purpose is stored within the reticuloendothelial cells but is available for release and reuse whenever it is required. In the breakdown of red cells, there is no loss to the body of either protein or iron, virtually all of which is conserved and reused. In contrast, the porphyrin ring structure of hemoglobin, to which iron was attached, undergoes a chemical change that enables its excretion from the body. This reaction converts porphyrin, a red pigment, into bilirubin, a yellow pigment. Bilirubin released from reticuloendothelial cells after the destruction of erythrocytes is conveyed through the plasma to the liver, where it undergoes further changes that prepare it for secretion into the bile. The amount of bilirubin produced and secreted into the bile is determined by the amount of hemoglobin destroyed. When the rate of red cell destruction exceeds the capacity of

the liver to handle bilirubin, the yellow pigment accumulates in the blood, causing jaundice.

(24) From which tree is cork harvested?

(A) Maple
(B) Oak
(C) Acacia
(D) Baobab

Answer: B

Cork is the bark of an evergreen type of oak tree called the cork oak (species *Quercus suber*) that is native to the Mediterranean region. Cork consists of the irregularly shaped, thin-walled, wax-coated cells that make up the peeling bark of the birch and many other trees, but, in the restricted commercial sense of the word, only the bark of the cork oak merits the designation of cork. The cork oak grows abundantly in Portugal, Spain, parts of southern France and Italy, and North Africa. The tree is usually about 18 m (60 feet) tall, with a broad, round-topped head and glossy green, hollylike leaves. Cork is obtained from the new outer sheath of bark formed by the inner bark after the original rough outer bark is removed. The outer sheath may then be stripped and will form again. Unlike the inner bark, the outer bark, or cork, is not vital to the tree's survival and functions merely to protect it from the heat and dry winds of the Mediterranean summer. The repeated stripping of cork is possible because the inner bark of the cork oak develops an especially uniform and continuous regenerative tissue. After the outer bark has been peeled, this tissue proliferates sufficient cork cells to the outside so that, in a healthy tree, 2.5–5 cm (1–2 inches) of a uniform new cork sheathing forms in from 3 to 10 years. Stripping this regenerated layer yields commercial cork slabs. The uniqueness of cork derives from its structure of air-filled cells, each of which consists of a watertight, flexible compartment. En masse these cells constitute a remarkably effective insulating medium that is also impervious to liquids. Because of its internal matrix of air pockets, cork is also among the lighter natural substances in weight, being only one-fifth as heavy as water. Specialized plastics and other artificial substances have supplanted cork in a number of its former uses, but cork has retained its traditional importance as a stopper for bottles of wine and other alcoholic beverages. The cork oak lives on average for about 150 years. The tree yields hardly any cork for its first 20 years, and the bark obtained at the first stripping (at about 25 years of age) is rough and uneven and has little commercial value. The bark obtained at the second stripping (several years later) is of better quality, though, and the tree will continue to produce cork thereafter for many decades. The stripping itself is still done by hand and consists of cutting slits in the outer bark, which is then carefully pried loose from the inner bark and peeled away with the help of various levers and wedges. Care is taken not to injure the deeper regenerative layers of the inner bark. The removed peel of cork is boiled or steamed to remove soluble tannic acids from it and increase its flexibility, and its rough woody surface is scraped clean by hand. It is then ready for commercial distribution.

(25) Which of the following does not belong to the Rosaceae (garden rose) family of plants?

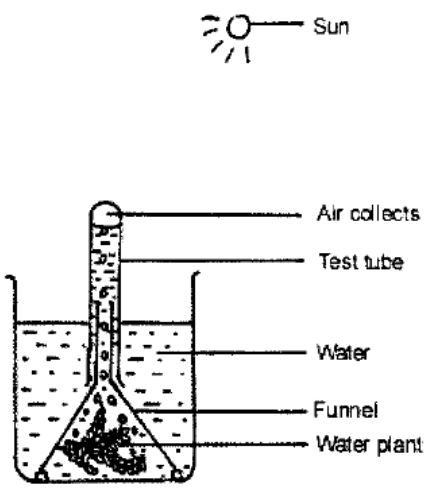
(A) Tomatoes
(B) Apples
(C) Peaches
(D) Almonds

Answer: A

The Rosaceae or rose family is a large family of plants, with about 3,000-4,000 species in 100-120 genera. Traditionally it has been divided into four subfamilies: Rosoideae, Spiraeoideae, Maloideae, and Amygdaloideae. These subfamilies are primarily diagnosed by the structure of the fruits, although this approach is not followed universally. Recent work has identified that the traditional four subfamilies are not all monophyletic, but the structure of the family is still awaiting complete resolution. Identified clades include: Subfamily Rosoideae: Traditionally composed of those genera bearing small fruits, each of which is an achene or drupelet, and often the fleshy part of the fruit (e.g. Strawberry) is the hypanthium or the stalk bearing the carpels. The circumscription is now narrowed (excluding, for example, the tribe Dryadeae), but it still remains a diverse group containing 5 or 6 tribes and 20 or more genera. Rose, blackberry, raspberry, strawberry, Potentilla, Geum. Subfamily Spiraeoideae: Traditionally those genera which bear non-fleshy fruits consisting of five capsules. Now perhaps to be restricted to Spiraea and Sorbaria and their respective allies. Subfamily Maloideae (or Pomoideae): Traditionally this includes those genera (apple, cotoneaster, hawthorn, pear, quince, rowan, whitebeam, etc), whose fruits consist of five capsules (called "cores") in a fleshy endocarp, surrounded by the ripened stem tissue. This fruit is called a pome. To these are added the woody genera Lindleya and Vauquelinia, which share a haploid chromosome count of 17 (x=17) with the pomiferous genera, Kageneckia, in which x=15, and the herbaceous genus Gillenia (x=9), which is the sibling to the remaining maloids. Subfamily Amygdaloideae (or Prunoideae): Traditionally those genera whose fruits consist of a single drupe with a seam, two veins next to the seam, and one vein opposite the seam. Now extended to include the five genera Exochorda, Maddenia, Oemleria, Prinsepia and Prunus (plum, peach, almond, cherry, apricot).

A tomato is any fruit of the numerous cultivated varieties of *Solanum lycopersicum* (formerly *Lycopersicon esculentum*), a plant of the nightshade family (Solanaceae); also, the fruit of *L. pimpinelli folium*, the tiny currant tomato. The Solanaceae family is characteristically ethnobotanical, that is, extensively utilized by humans. It is an important source of food, spice and medicine. However, Solanaceae species are often rich in alkaloids that can range in their toxicity to humans and animals from mildly irritating to fatal in small quantities. The family is also informally known as the nightshade or potato family. The family includes the Datura or Jimson weed, eggplant, mandrake, deadly nightshade or belladonna, capsicum (paprika, chile pepper), potato, tobacco, tomato, and petunia.

(26) Use the diagram below to answer the question that follows.



This apparatus illustrates that...

(A) sunlight affects the rate of transpiration.
(B) oxygen is given off during respiration.
(C) a gas is given off during photosynthesis.
(D) carbon dioxide is used during photosynthesis.

Answer: C

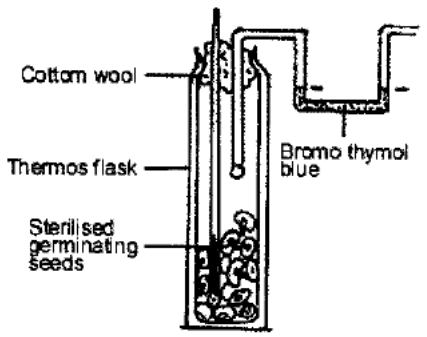
The collection of 'air" at the top of the inverted tube means the plant is using sunlight in a process that produces a gas. This can only be photosynthesis. Photosynthesis is the process by which green plants and certain other organisms transform light energy into chemical energy. During photosynthesis in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds. In chemical terms, photosynthesis is a light-energized oxidation–reduction process. (Oxidation refers to the removal of electrons from a molecule; reduction refers to the gain of electrons by a molecule.) In plant photosynthesis, the energy of light is used to drive the oxidation of water (H_2O), producing oxygen gas (O_2), hydrogen ions (H^+), and electrons. Most of the removed electrons and hydrogen ions ultimately are transferred to carbon dioxide (CO_2), which is reduced to organic products. Other electrons and hydrogen ions are used to reduce nitrate and sulfate to amino and sulfhydryl groups in amino acids, which are the building blocks of proteins. In most green cells, carbohydrates—especially starch and the sugar sucrose—are the major direct organic products of photosynthesis. The overall reaction in which carbohydrates—represented by the general formula (CH_2O)—are formed during plant photosynthesis can be indicated by the following equation:

$$CO_2 + 2H_2O \xrightarrow[\text{green plants}]{\text{light}} (CH_2O) + O_2 + H_2O.$$

This equation is merely a summary statement, for the process of photosynthesis actually involves numerous complex reactions. These reactions occur in two stages: the "light" stage, consisting of photochemical (*i.e.,* light-dependent) reactions; and the "dark" stage, comprising chemical reactions controlled by enzymes (organic catalysts). During the first stage, the energy of light is absorbed and used to drive a series of electron transfers, resulting in the synthesis of the energy-rich compound adenosine triphosphate (ATP) and the electron donor reduced nicotine adenine dinucleotide phosphate (NADPH). During the dark stage, the ATP and NADPH formed in the light reactions are used to reduce carbon dioxide to organic

carbon compounds. This assimilation of inorganic carbon into organic compounds is called carbon fixation.

(27) The diagram below shows a set of apparatus which was used during an investigation. Answer the question that follows.



The complete results after a few hours will be:

(A) A rise in the thermometer reading, the liquid level will rise at Y.
(B) A rise in the thermometer reading, and the liquid will change to yellow.
(C) A rise in the thermometer reading and the liquid level will rise at X.
(D) A rise in the thermometer reading, the liquid will change to yellow and the level will drop at X.

Answer: C

The seeds were sterilized in order to get rid of micro-organisms whose growth might otherwise render the results invalid. Sterilization methods include treatment with ionizing radiation, heating at high temperatures or treating with an antibiotic/chemical solution. In this experiment, the latter was probably done since radiation or heat treatment would kill the seeds! During germination, seeds respire and use oxygen to break down stored food for growth, producing carbon dioxide and heat as waste products. Thus, from the heat generated, the thermometer reading will rise. The carbon dioxide thus produced will push the water in the bent tube (the bromothymol blue solution) slightly to one end, leading to an observable rise in the level of the water. Bromothylmol blue was used because it is very good substances that would have relatively low acidic or basic levels (near a neutral pH) and thus can detect carbonic acid (dissolved carbon dioxide) in water.

(28) What are stem cells?

(A) Embryonic cells with no predetermined route of development.
(B) Cells harvested from the brain stem.
(C) The first cells after mitosis.
(D) The cells found in the fluid of the spinal cord.

Answer: A

A stem cell is an undifferentiated cell that can divide to produce some offspring cells that continue as stem cells and some cells that are destined to differentiate (become specialized). Stem cells are an ongoing source of the differentiated cells that make up the tissues and organs of animals and plants. There is great interest in stem cells because they have potential in the development of therapies for replacing defective or damaged cells resulting from a variety of disorders and injuries, such as Parkinson disease, heart disease, and diabetes.

There are two major types of stem cells: embryonic stem cells and adult stem cells, which are also called tissue stem cells. Embryonic stem cells (often referred to as ES cells) are stem cells that are derived from the inner cell mass of a mammalian embryo at a very early stage of development, when it is composed of a hollow sphere of dividing cells (a blastocyst). Embryonic stem cells from human embryos and from embryos of certain other mammalian species can be grown in tissue culture. Some tissues in the adult body, such as the epidermis of the skin, the lining of the small intestine, and bone marrow, undergo continuous cellular turnover. They contain stem cells, which persist indefinitely, and a much larger number of "transit amplifying cells," which arise from the stem cells and divide a finite number of times until they become differentiated. The stem cells exist in niches formed by other cells, which secrete substances that keep the stem cells alive and active. Some types of tissue, such as liver tissue, show minimal cell division or undergo cell division only when injured. In such tissues there is probably no special stem-cell population, and any cell can participate in tissue regeneration when required.

(29) Why doesn't cheese decay during the maturing process?

(A) It is kept at a low temperature where all bacteria are inactive.

(B) Bacteria ferment the cheese and acids produces by the bacteria help preserving the cheese.

(C) It is covered with a skin of red wax to keep out all bacteria.

(D) The milk is pasteurized and heated to eliminate bacteria initially.

Answer: B

Most cheese is ripened for varying amounts of time in order to bring about the chemical changes necessary for transforming fresh curd into a distinctive aged cheese. These changes are catalyzed by enzymes from three main sources: rennet or other enzyme preparations of animal or vegetable origin added during coagulation, microorganisms that grow within the cheese or on its surface, and the cheese milk itself. The ripening time may be as short as one month, as for Brie, or a year or more, as in the case of sharp cheddar. The ripening of cheese is influenced by the interaction of bacteria, enzymes, and physical conditions in the curing room. The speed of the reactions is determined by temperature and humidity conditions in the room as well as by the moisture content of the cheese. In most cheeses lactose continues to be fermented to lactic acid and lactates, or it is hydrolyzed to form other sugars. As a result, aged cheeses such as Emmentaler and cheddar have no residual lactose. In a similar manner, proteins and lipids (fats) are broken down during ripening. The degree of protein decomposition, or proteolysis, affects both the flavor and the consistency of the final cheese. It is especially apparent in Limburger and some blue-mold ripened cheeses. The eyes, or holes, typical of Swiss-type cheeses such as Emmentaler and Gruyère come from a secondary fermentation that takes place when, after two weeks, the cheeses are moved from refrigerated curing to a warmer room, where temperatures are in the range of 20° to 24° C (68° to 75° F). At this

stage, residual lactates provide a suitable medium for propionic acid bacteria (*Propionibacterium shermanii*) to grow and generate carbon dioxide gas. The unique ripening of blue-veined cheeses comes from the mold spores *Penicillium roqueforti* or *P. glaucum*, which are added to the milk or to the curds before pressing and are activated by air. Air is introduced by "needling" the cheese with a device that punches about 50 small holes into the top. These air passages allow mold spores to grow vegetative cells and spread their greenish blue mycelia, or threadlike structures, through the cheese. *Penicillium* molds are also rich in proteolytic and lipolytic enzymes, so that during ripening a variety of trace compounds also are produced, such as free amines, amino acids, carbonyls, and fatty acids—all of which ultimately affect the flavor and texture of the cheese. Not all cheeses are ripened. Cottage, cream, ricotta, and most mozzarella cheeses are ready for sale as soon as they are made. All these cheeses have sweet, delicate flavors and often are combined with other foods.

(30) Lanolin is a yellow waxy substance secreted by the sebaceous glands of wool bearing animals such as sheep. Which of the following is the function of lanolin?

(A) Lanolin contains natural antibiotics that help ward off diseases.
(B) Lanolin contains aromatic substances that repel pests such as ticks and mosquitoes.
(C) Lanolin is a soap that in the rain washes sheep and keeps them clean.
(D) Lanolin's waterproofing property aids sheep in shedding water from their coats.

Answer: D

Lanolin is a greasy substance obtained from wool and sometimes erroneously called wool fat. It is used either alone or with soft paraffin or lard or other fat as a base for ointments, emollients, skin foods, salves, superfatted soaps, and fur dressing. Lanolin, a translucent, yellowish-white, soft, unctuous, tenacious substance, is readily absorbed by the skin and thus makes an ideal base for medicinal products intended to be absorbed. Lanolin's role in nature is to protect wool and skin against the ravages of climate and the environment; its waterproofing property aids sheep in shedding water from their coats. Lanolin and its many derivatives, not surprisingly, are used extensively in products designed for the protection, treatment and beautification of human skin. Lanolin's complex composition of long chain esters, hydroxy esters, diesters, lanolin alcohols, and lanolin acids means in addition to it being a valuable product in its own right, it is also the starting point for the production of a whole spectrum of lanolin derivatives, which possess wide-ranging chemical and physical properties.

(31) Technology is used to put criminals behind bars. Which one of the methods below is the most commonly used?

(A) DNA testing on blood found at the scene.
(B) DNA testing on hair left at the scene.
(C) Fingerprinting

(D) Odors picked up by Police sniffer dogs

Answer: C

Fingerprints afford an infallible means of personal identification, because the ridge arrangement on every finger of every human being is unique and does not alter with growth or age. Fingerprints serve to reveal an individual's true identity despite personal denial, assumed names, or changes in personal appearance resulting from age, disease, plastic surgery, or accident. The practice of utilizing fingerprints as a means of identification, referred to as dactyloscopy, is an indispensable aid to modern law enforcement. Each ridge of the epidermis (outer skin) is dotted with sweat pores for its entire length and is anchored to the dermis (inner skin) by a double row of peg-like protuberances, or papillae. Injuries such as superficial burns, abrasions, or cuts do not affect the ridge structure or alter the dermal papillae, and the original pattern is duplicated in any new skin that grows. An injury that destroys the dermal papillae, however, will permanently obliterate the ridges. Any ridged area of the hand or foot may be used as identification. However, finger impressions are preferred to those from other parts of the body because they can be taken with a minimum of time and effort, and the ridges in such impressions form patterns (distinctive outlines or shapes) that can be readily sorted into groups for ease in filing.

(32) Which one of the following is an example of sexual reproduction?

(A) Budding in Hydra.

(B) Fragmentation in Spirogyra.

(C) Production of spores in Rhizopus.

(D) Binary fission in bacteria.

Answer: C

Hydra are invertebrate freshwater animals of the class Hydrozoa (phylum Cnidaria). The body of such an organism consists of a thin, usually translucent tube that measures up to about 30 millimeters (1.2 inches) long but is capable of great contraction. The body wall is comprised of two layers of cells separated by a thin, structureless layer of connective tissue called the mesoglea and the enteron, a cavity containing intestinal organs. The lower end of the body is closed, and an opening at the upper end both ingests food and ejects residue. Around this opening is a circlet of 4 to about 25 tentacles. Eggs and sperm appear in separate swellings (gonads) in the outer body layer, and individuals are usually hermaphroditic, (*i.e.,* functional reproductive organs of both sexes occur in the same individual). Gametes are released from the body, and fertilization takes place in the water. Vegetative reproduction by budding is also common. Finger-shaped outpushings of the wall develop mouth and tentacles and finally nip off at the base, forming separate new individuals. Locomotion is by creeping on the adhesive base, or by looping; *i.e.*, tentacles attach to the substrate, the base releases, and the whole body somersaults, enabling the base to attach in a new position. The genus is represented by 20 to 30 species, which differ chiefly in color, tentacle length and number, and gonad position and size. All *Hydra* species feed on other small invertebrate animals such as crustaceans

Spirogyra is a genus of green algae, found only in fresh water and usually free-floating. The slippery unbranched filaments are composed of cylindrical cells containing one or more beautiful spiral green chloroplasts, from which the genus gets its name. The nucleus is suspended in the central vacuole by fine cytoplasmic filaments. Vegetative reproduction is by fragmentation of the filaments. In sexual conjugation, cells of two strands lying side by side are joined by the outgrowths, or conjugation tubes, and the contents of one cell pass into and fuse with the contents of the other. The resulting fused cell (zygote) becomes surrounded by a thick wall and overwinters, while the vegetative filaments die. On bright spring or fall days, there might be masses of *Spirogyra* floating near the surface of streams and ponds, buoyed by oxygen bubbles released during photosynthesis. During the night, when photosynthesis decreases, the masses tend to sink.

Binary fission is reproduction by a separation of the body into two new bodies. In the process of binary fission, an organism duplicates its genetic material, or deoxyribonucleic acid (DNA), and then divides into two parts (cytokinesis), with each new organism receiving one copy of DNA. Each daughter cell can continue to grow at the same rate as its parent. For this process to occur, the cell must grow over its entire surface until the time of cell division, when a new hemispherical pole forms at the division septum in the middle of the cell. In gram-positive bacteria the septum grows inward from the plasma membrane along the midpoint of the cell; in gram-negative bacteria the walls are more flexible, and the division septum forms as the side walls pinch inward, dividing the cell in two. In order for the cell to divide in half, the peptidoglycan structure must be different in the hemispherical cap than in the straight portion of the cell wall, and different wall-cross-linking enzymes must be active at the septum than elsewhere. Binary fission is the primary method of reproduction of prokaryotic organisms.

Sexual reproduction in the fungi consists of three sequential stages: plasmogamy, karyogamy, and meiosis. The diploid chromosomes are pulled apart into two daughter cells, each containing a single set of chromosomes (a haploid state). Plasmogamy, the fusion of two protoplasts (the contents of the two cells), brings together two compatible haploid nuclei. At this point, two nuclear types are present in the same cell, a condition called dikaryotic, but the nuclei have not yet fused. Karyogamy results in the fusion of these haploid nuclei and the formation of a diploid nucleus (*i.e.,* a nucleus containing two sets of chromosomes, one from each parent). The cell formed by karyogamy is called the zygote. In most fungi, the zygote is the only cell in the entire life cycle that is diploid. The dikaryotic state that results from plasmogamy is often a prominent condition in fungi and may be prolonged over several generations. In the lower fungi, karyogamy usually follows plasmogamy almost immediately. In the more evolved fungi, however, karyogamy is separated from plasmogamy. Once karyogamy has occurred, meiosis (cell division that reduces the chromosome number to one set per cell) generally follows immediately and restores the haploid phase. Either the haploid nuclei that result from meiosis or their immediate progeny are generally incorporated in spores called meiospores. A spore is a reproductive cell

capable of developing into a new individual without fusion with another reproductive cell. Spores thus differ from gametes, which are reproductive cells that must fuse in pairs in order to give rise to a new individual. Spores, with exceptions, are agents of asexual reproduction, whereas gametes are agents of sexual reproduction. Spores are produced by bacteria, fungi, and green plants. Bacterial spores serve largely as a resting, or dormant, stage in the bacterial life cycle, serving to preserve the bacterium through periods of unfavorable conditions. Many bacterial spores are highly durable and can germinate even after years of dormancy. Among the fungi, spores serve a function analogous to that of seeds. Produced and released by specialized fruiting bodies, such as the edible portion of the familiar mushrooms, fungal spores germinate and grow into new individuals under suitable conditions of moisture, temperature, and food availability.

(33) Which characteristic is found in insect-pollinated flowers?

(A) Small, inconspicuous flowers with no scent.
(B) Stamens and stigmas hang outside the flower.
(C) Pollen produced in large quantities.
(D) Stamens and pollen are sticky.

ANSWER: D

Flowers that rely on insect pollination are called Entomophilous. The most important insect pollinators are bees, Lepidoptera (e.g. butterflies and moths), flies and beetles. Entomophilous species frequently evolve mechanisms to make themselves more appealing to insects, e.g. brightly colored or scented flowers, nectar, and appealing shapes and patterns. Pollen grains of entomophilous plants are generally larger than the fine pollens of anemophilous (wind pollinated) plants. They usually are of more nutritional value to insects, which may use them for food and inadvertently spread them to other flowers. Bees are probably the most important insect pollinators. Living almost exclusively on nectar, they feed their larvae pollen and honey (a modified nectar). To obtain their foods, they possess striking physical and behavioral adaptations, such as tongues as long as 2 $^{1}/_{2}$ centimeters (one inch), hairy bodies, and (in honeybees and bumblebees) special pollen baskets. Flowers pollinated by bees open in the daytime, attract their insect visitors primarily by bright colors; at close range, special patterns and fragrances come into play. Many bee flowers provide their visitors with a landing platform in the form of a broad lower lip on which the bee sits down before pushing its way into the flower's interior, which usually contains both stamens and pistils. The hermaphroditism of most bee flowers makes for efficiency, because the flower both delivers and receives a load of pollen during a single visit of the pollinator, and the pollinator never travels from one flower to another without a full load of pollen. Indeed, the floral mechanism of many bee flowers permits only one pollination visit. The pollen grains of most bee flowers are sticky, spiny, or highly sculptured, ensuring their adherence to the bodies of the bees. Since one load of pollen contains enough pollen grains to initiate fertilization of many ovules, most individual bee flowers produce many seeds.

(34) Which chemical change takes place in green plants as well as in mammals?

(A) Glucose → glycogen
(B) Glucose → cellulose
(C) Glycogen → glucose
(D) Starch → glucose

ANSWER: D

Both animals and green plants need energy to function. This energy comes from glucose. Glucose undergoes glycolysis to produce acetyl-coA and chemical energy (ATP). Acetyl-coA is then passed onto the Krebs cycle to produce NADH and more ATP. Intermediates of the Krebs cycle are also used to make non-essential amino acids. To produce more energy; the NADH then is passed onto the electron transport chain to produce even more ATP, with oxygen gas that has been inhaled used as the final acceptor of the hydrogen to form metabolic water. In most animals, (one exception is the kangaroo rat!), this water is lost as water vapor during exhalation. This is a brief summary of the process called aerobic respiration.

Starch is a white, granular, organic chemical that is produced by all green plants. Starch is a soft, white, tasteless powder that is insoluble in cold water, alcohol, or other solvents. The basic chemical formula of the starch molecule is $(C_6H_{10}O_5)_n$. Starch is a polysaccharide comprising glucose monomers joined in *a* 1,4 linkages. The simplest form of starch is the linear polymer amylose; amylopectin is the branched form. Starch is manufactured in the green leaves of plants from excess glucose produced during photosynthesis and serves the plant as a reserve food supply. Starch is stored in chloroplasts in the form of granules and in such organs as the roots of the tapioca plant; the tuber of the potato; the stem pith of sago; and the seeds of corn, wheat, and rice. When required, starch is broken down, in the presence of certain enzymes and water, into its constituent monomer glucose units, which diffuse from the cell to nourish the plant tissues. In humans and other animals, starch is broken down into its constituent sugar molecules, which then supply energy to the tissues. Most commercial starch is made from corn, although wheat, tapioca, and potato starch are also used. Commercial starch is obtained by crushing or grinding starch-containing tubers or seeds and then mixing the pulp with water; the resulting paste is freed of its remaining impurities and then dried. Aside from their basic nutritional uses, starches are used in brewing and as thickening agents in baked goods and confections. Starch is used in paper manufacturing to increase the strength of paper and is also used in the surface sizing of paper. Starch is used in the manufacture of corrugated paperboard, paper bags and boxes, and gummed paper and tape. Large quantities of starch are also used in the textile industry as warp sizing, which imparts strength to the thread during weaving

(35) How do birds make sounds?

(A) When the diaphragm relaxes, air is forced out of special air sacs.
(B) They have vocal cords similar to those of humans.
(C) They have special air bags and membranes that vibrate in airways.

(D) The air flows through airways in the skull that serve as resonating chambers.

ANSWER: C

The avian vocal organ is called the syrinx; it is a bony structure at the bottom of the trachea (unlike the larynx at the top of the mammalian trachea). The syrinx and sometimes a surrounding air sac resonate to vibrations that are made by membranes past which the bird forces air. The bird controls the pitch by changing the tension on the membranes and controls both pitch and volume by changing the force of exhalation. It can control the two sides of the trachea independently, which is how some species can produce two notes at once.

(36) Which animals are responsible for the most deaths in humans?

(A) Crocodiles
(B) Snakes
(C) Mosquitoes
(D) Cape Buffaloes

ANSWER: C

Mosquitoes are vectors for malaria; a serious, relapsing infection in humans characterized by periodic attacks of chills and fever, anemia, enlargement of the spleen, and often fatal complications. It is caused by one-celled parasites of the genus Plasmodium that are transmitted to humans by the bite of Anopheles mosquitoes. Malaria can occur in temperate regions, but it is most common in the tropics and subtropics. In many parts of sub-Saharan Africa, entire populations are infected more or less constantly. Malaria is also common in Central America, the northern half of South America, and in South and Southeast Asia. The disease also occurs in countries bordering on the Mediterranean, in the Middle East, and in East Asia. In Europe, North America, and the developed countries of East Asia, malaria is still encountered in travelers arriving or returning from affected tropical zones. Annual cases of malaria worldwide are estimated at 250 million, with more than one million deaths resulting—most of them young children in Africa.

(37) Where do ticks and fleas spend most of their time?

(A) In tall grass waiting for a host
(B) In egg form
(C) On the host
(D) In the larval stage in sand

ANSWER: A

A tick is any of about 825 species of invertebrates in the order Parasitiformes (subclass Acari). Ticks are important parasites of large wild and domestic animals and are also significant as carriers of serious diseases. Although no species is primarily a human parasite, some occasionally attack humans. Hard ticks, such as the American dog tick (*Dermacentor variabilis*), attach to their hosts and feed continuously on blood for several days during each life stage. When an adult female has obtained a blood meal, she mates, drops from the host, and finds a suitable site where she lays her eggs in a mass and dies. Six-legged larvae hatch from the eggs, move up on blades of grass, and wait for a suitable host (usually a mammal) to pass by. The odor of butyric acid,

emanated by all mammals, stimulates the larvae to drop onto and attach to a host. After filling themselves with the host's blood, the larvae detach and moult, becoming eight-legged nymphs. Nymphs also wait for, and board, a suitable host in the same way as larvae. After they have found a host and engorged themselves, they also fall off, and then they moult into adult males or females. Adults may wait for a host for as long as three years. Most hard ticks live in fields and woods, but a few, such as the brown dog tick (*Rhipicephalus sanguineus*), are household pests. Soft ticks differ from hard ticks by feeding intermittently, laying several batches of eggs, passing through several nymphal stages, and carrying on their developmental cycles in the home or nest of the host rather than in fields. Hard ticks damage the host by drawing large amounts of blood, by secreting neurotoxins (nerve poisons) that sometimes produce paralysis or death, and by transmitting diseases, including Lyme disease, Texas cattle fever, anaplasmosis, Rocky Mountain spotted fever, Q fever, tularemia, hemorrhagic fever, and a form of encephalitis. Soft ticks also are carriers of diseases. Adults range in size up to 30 mm (slightly more than 1 inch), but most species are 15 mm or less. They may be distinguished from their close relatives, the mites, by the presence of a sensory pit (Haller's organ)) on the end segment of the first of four pairs of legs. Eyes may be present or absent. This group has a worldwide distribution, and all species are assigned to three families: Argasidae, comprising the soft ticks, and Nuttalliellidae and Ixodidae, together comprising the hard ticks. The family Nuttalliellidae is represented by one rare African species.

(38) In which organelle is ATP found abundantly?

(A) Golgi apparatus
(B) Chloroplast
(C) Mitochondrion
(D) Ribosome

ANSWER: C

Mitochondria and chloroplasts are the powerhouses of the cell. Mitochondria appear in both plant and animal cells as elongated cylindrical bodies, roughly one micrometer in length and closely packed in regions actively using metabolic energy. Mitochondria oxidize the products of cytoplasmic metabolism to generate adenosine triphosphate (ATP), the energy currency of the cell. Chloroplasts are the photosynthetic organelles in plants and some algae. They trap light energy and convert it partly into ATP but mainly into certain chemically reduced molecules that, together with ATP, are used in the first steps of carbohydrate production. Mitochondria and chloroplasts share a certain structural resemblance, and both have a somewhat independent existence within the cell, synthesizing some proteins from instructions supplied by their own DNA.

The Golgi complex is the site of the modification, completion, and export of secretory proteins and glycoproteins. This organelle, first described by the Italian cytologist Camillo Golgi in 1898, has a characteristic structure composed of five to eight flattened, disk-shaped, membrane-defined cisternae arranged in a stack. Secretory proteins and glycoproteins, cell membrane proteins and glycoproteins, lysosomal proteins, and some

glycolipids all pass through the Golgi structure at some point in their maturation. In plant cells, much of the cell wall material passes through the Golgi as well. As the secretory proteins move through the Golgi, a number of chemical modifications may transpire. Important among these is the modification of carbohydrate groups. As described above, many secretory proteins are glycosylated in the ER. In the Golgi, specific enzymes modify the oligosaccharide chains of the glycoproteins by removing certain mannose residues and adding other sugars, such as galactose and sialic acid. These enzymes are known collectively as glycosidases and glycosyltransferases. Some secretory proteins will cease to be transported if their carbohydrate groups are modified incorrectly or not permitted to form. In some cases the carbohydrate groups are necessary for the stability or activity of the protein or for targeting the molecule for a specific destination.

Ribosomes are tiny particle that is present in large numbers in all living cells and serves as the site of protein synthesis. Ribosomes occur both as free particles in prokaryotic and eukaryotic cells and as particles attached to the membranes of the endoplasmic reticulum in eukaryotic cells. Ribosomes can vary in size, although an average ribosome measures about 200 angstroms in diameter and consists of about 40 percent protein and 60 percent RNA. Ribosomes are usually made up of three or four RNA molecules and anywhere from 40 to 80 different proteins. In shape the ribosome is composed of two subunits, a larger one and a smaller one, each of which has a characteristic shape. Ribosomes are very numerous in a cell and account for a large proportion of its total RNA. Ribosomes are the sites at which information carried in the genetic code is converted into protein molecules. Ribosomal molecules of mRNA determine the order of tRNA molecules that are bound to triplets of amino acids (codons). The order of tRNA molecules ultimately determines the amino acid sequence of a protein because molecules of tRNA catalyze the formation of peptide bonds between the amino acids, linking them together to form proteins. The newly formed proteins detach themselves from the ribosome site and migrate to other parts of the cell for use.

(39) When a piece of liver is put in hydrogen peroxide, oxygen is given off. The chemical in the liver that is responsible for the reaction is….

(A) an enzyme.
(B) an acid.
(C) a buffer.
(D) alcohol.

ANSWER: A

The enzyme responsible for this reaction (hydrogen peroxide decomposition to water and oxygen) is called catalase. Found extensively in mammalian tissues, catalase prevents the accumulation of and protects the body tissues from damage by peroxide, which is continuously produced by numerous metabolic reactions. All known animals use catalase in every organ, with particularly high concentrations occurring in the liver. One unique use of catalase occurs in bombardier beetle. The beetle has two sets of chemicals ordinarily stored separately in its paired glands. The larger of the pair, the storage

chamber or reservoir, contains hydroquinones and hydrogen peroxide, whereas the smaller of the pair, the reaction chamber, contains catalases and peroxidases. To activate the spray, the beetle mixes the contents of the two compartments, causing oxygen to be liberated from hydrogen peroxide. The oxygen oxidizes the hydroquinones and also acts as the propellant. A rare hereditary metabolic disorder caused by lack of the enzyme catalase is called acatalasia. Although a deficiency of catalase activity is noted in many tissues of the body, including the red blood cells, bone marrow, liver, and skin, only about half of the affected persons have symptoms, which consist of recurrent infections of the gums and associated oral structures that may lead to gangrenous lesions. Such lesions are rare after puberty. The disorder has been most frequently reported in Japanese and Korean populations; its estimated frequency in Japan is approximately 2 in 100,000.

(40) Bacteria and algae could be classified as plants because they….

(A) are green.
(B) have cell walls.
(C) can produce their own food.
(D) survive in the form of seed and not in eggs.

ANSWER: B

Bacteria, archaebacteria, and blue-green algae are prokaryotes and fall under the kingdom Monera. Archaebacteria are unicellular organisms that are prokaryotic (that is, do not have a membrane-bound nucleus and other internal units) but that differ in certain physiological and genetic features from bacteria, the most prominent prokaryotes. Archaea have some features in common with bacteria as well as eukaryotes (organisms whose cells contain nuclear membranes), but evidence suggests that archaea are more closely related to eukaryotes than to bacteria

The blue-green algae, also called cyanobacteria, are traditionally placed with the other algae (e.g., seaweeds) and are studied more by botanists than by microbiologists. Blue-green algae may be either unicellular or filamentous, and they behave like true plants, photosynthesizing in a way that resembles green plants rather than bacteria. Many move by gliding, as do some bacteria and some true unicellular algae. They are often extremely abundant around hot springs or at the edges of muddy ponds, and, though they are resistant to harsh environments, blue-green algae are killed by many drugs (e.g., antibiotics) used against bacteria. Perhaps they are best regarded as representing a group close to the main evolutionary line that gave rise to the eukaryotic plants.

(41) Plants do NOT react to the stimulus of…

(A) light
(B) water
(C) gasses
(D) gravity

ANSWER: C

No experiment can prove that plants grow towards a gas as the gas will have to be contained within an impervious medium, yet the plant will have to sense its presence in order to grow away from or towards it! The response or

orientation of a plant or certain lower animals to a stimulus that acts with greater intensity from one direction than another is called tropism. It may be achieved by active movement or by structural alteration. Forms of tropism include phototropism (response to light), geotropism (response to gravity), chemotropism (response to particular substances), hydrotropism (response to water), thigmotropism (response to mechanical stimulation), traumatotropism (response to wound lesion), and galvanotropism, or electrotropism (response to electric current). Most tropic movements are orthotropic; i.e., they are directed toward the source of the stimulus. Plagiotropic movements are oblique to the direction of stimulus. Diatropic movements are at right angles to the direction of stimulus.

Plants respond to a variety of external stimuli by utilizing hormones as controllers in a stimulus-response system. Directional responses of movement are known as tropisms and are positive when the movement is toward the stimulus and negative when it is away from the stimulus. When a seed germinates, the growing stem turns upward toward the light, and the roots turn downward away from the light. Thus, the stem shows positive phototropism and negative geotropism, while the roots show negative phototropism and positive geotropism. In this example, light and gravity are the stimuli, and directional growth is the response. The controllers are certain hormones synthesized by cells in the tips of the plant stems. These hormones, known as auxins, diffuse through the tissues beneath the stem tip and concentrate toward the shaded side, causing elongation of these cells and, thus, a bending of the tip toward the light. The end result is the maintenance of the plant in an optimal condition with respect to light.

(42) Which one is not part of a flower?

(A) Anther
(B) Sepal
(C) Seeds
(D) Ovary

ANSWER: C

Seeds are found in ripened ovaries, long after the flower has disappeared. A flower is the reproductive portion of any plant in the division Magnoliophyta (Angiospermae), commonly called flowering plants or angiosperms. As popularly used, the term “flower” especially applies when part or all of the reproductive structure is distinctive in color and form. Basically, each flower consists of a floral axis upon which are borne the essential organs of reproduction (stamens and pistils) and usually accessory organs (sepals and petals); the latter may serve to both attract pollinating insects and protect the essential organs. The floral axis is a greatly modified stem; unlike vegetative stems, which bear leaves, it is usually contracted, so that the parts of the flower are crowded together on the stem tip, the receptacle. The flower parts are usually arrayed in whorls (or cycles) but may also be disposed spirally, especially if the axis is elongate. There are commonly four distinct whorls of flower parts: (1) an outer calyx consisting of sepals; within it lies (2) the corolla, consisting of petals; (3) the androecium, or group of stamens; and in the centre is (4) the gynoecium, consisting of the pistils. The sepals and petals together make up the perianth, or

floral envelope. The sepals are usually greenish and often resemble reduced leaves, while the petals are usually colorful and showy. Sepals and petals that are indistinguishable, as in lilies and tulips, are sometimes referred to as tepals. The androecium, or male parts of the flower comprise the stamens, each of which consists of a supporting filament and an anther, in which pollen is produced. The gynoecium, or female parts of the flower, comprise the pistils, each of which consists of an ovary, with an upright extension, the style, on the top of which rests the stigma, the pollen-receptive surface. The ovary encloses the ovules, or potential seeds. A pistil may be simple, made up of a single carpel, or ovule-bearing modified leaf; or compound, formed from several carpels joined together. A flower having sepals, petals, stamens, and pistils is complete; lacking one or more of such structures, it is said to be incomplete. Stamens and pistils are not present together in all flowers. When both are present the flower is said to be perfect, or bisexual, regardless of a lack of any other part that renders it incomplete. A flower that lacks stamens is pistillate, or female, while one that lacks pistils is said to be staminate, or male. When the same plant bears unisexual flowers of both sexes, it is said to be monoecious (e.g., tuberous begonia, hazel, oak, corn); when the male and female flowers are on different plants, the plant is dioecious (e.g., date, holly, cottonwood, willow); when there are male, female, and bisexual flowers on the same plant, the plant is termed polygamous.

(43) Which factor is not needed for the germination of seeds?

(A) Water
(B) Light
(C) Oxygen
(D) Heat

ANSWER: B

Germination is the sprouting of a seed, spore, or other reproductive body, usually after a period of dormancy. Seed germination depends on many factors, both internal and external. The most important external factors include: water, oxygen, temperature, light (for many plants the least critical in the early stages) and the correct soil conditions. Every variety of seed requires a different set of variables for successful germination. This depends greatly on the individual seed variety and is closely linked to the ecological conditions in the plants' natural habitat. Germination sometimes occurs early in the development process; the mangrove (Rhizophora) embryo develops within the ovule, pushing out a swollen rudimentary root through the still-attached flower. In peas and corn (maize), the cotyledons (seed leaves) remain underground; in other species (beans, sunflowers, etc.), the hypocotyl (embryonic stem) grows several inches above the ground, carrying the cotyledons into the light, in which they become green and often leaf-like.

(44) What is the main function of the cilia in the respiratory tract of humans? They….

(A) promote the liberation of carbon dioxide.
(B) secrete mucus.
(C) remove mucus.
(D) enlarge the surface area for gaseous exchange.

ANSWER: C

Cilia are short eyelash-like filaments that are numerous on tissue cells of most animals and provide the means for locomotion of protozoans of the phylum Ciliophora. Cilia may be fused in short transverse rows to form membranelles or in tufts to form cirri. Capable of beating in unison, cilia move mammalian ova through oviducts, generate water currents to carry food and oxygen past the gills of clams, carry food through the digestive systems of snails, circulate cerebrospinal fluid of animals, and clean debris from the respiratory systems of mammals. The respiratory tract is covered in an epithelium, the type of which varies down the tract. There are glands and mucus produced by goblet cells in parts, as well as smooth muscles, elastin or cartilage. Most of the epithelium (from the nose to the bronchi) is covered in pseudostratified columnar ciliated epithelial cells, commonly called respiratory epithelium. The cilia beat in one direction, moving mucus towards the throat where it is swallowed. Moving down the bronchioles, the cells get more cuboidal in shape but are still ciliated. In modified form, cilia trigger the discharge of stinging devices in jellyfish and give rise to the light-sensitive rods of the mammalian retina and the odor-detecting units of olfactory neurons.

(45) Which one of the following does not have sensory receptors?

(A) Retina in the eye.
(B) Olfactory cells in the nose.
(C) Corpuscles of Langerhans in the skin.
(D) Taste buds.

ANSWER: C

Organisms have a variety of sensory structures that respond to different stimuli, such as light, pressure, or chemicals, all of which are forms of energy. Once excited, these sensory receptors convert the energy of the stimulus into a behavioral response of the organism. In general, sense cells, or receptors, located superficially in an organism receive signals from outside the organism and are parts of the exteroceptive system. Receptors located inside the body receive signals from changes taking place inside the body and belong to the interoceptive system. On activation, sensory cells cause reactions appropriate to their location; they are said to respond with their local sign. Photoreceptors are sensitive to light changes. They contain photopigments for absorption of light. The variety of photopigments in different cells determines the number of colors that can be distinguished. It is interesting to note that in insects, among other animals, color sensitivity is extended into the ultraviolet range, though it is short in the red range. Cells especially sensitive to infrared radiation are found in the remarkable pit organs of vipers, which enable the snake to locate warm-blooded prey from a distance even when it freezes into immobility.

In the skin of warm-blooded animals, nerve endings, with or without accessory structures, are present that react especially to warming or to cooling. Well-known organs of chemical reception are those of smell and of taste. Except in cases in which there is great specificity to one substance, as, for example, the sex attractant in insects, the spectrum of chemoreceptive cells is broad. The sense of taste was long thought to be

mediated by narrow, separate fibres for acid, bitter, sweet, and sour sensations; this viewpoint is now being replaced by one in which the spectra are considerably wider. Frogs have been shown to have taste cells that react specifically to distilled water. Chemoreceptors are also present as interoceptors, a well-known example being the carotid body in certain vertebrates; this organ monitors oxygen pressure in the carotid artery, which supplies the brain with blood. Mechanoreceptors are the most widespread type of sense receptor and the most varied with regard to localization, sensitivity, and type of nerve-impulse firing. There are numerous subdivisions of the mechanoreceptive sense, such as touch, pain, sound, gravity, and muscle tone. Examples in humans include the naked nerve endings in the cornea of the eye; the Pacinian corpuscles in the skin, with their multilayered sheath-like covers; and the hair cells in the inner ear. Impulse formation may continue for as long as stimulus lasts, thus giving a continuous (tonic) type of discharge, or be limited and proportional to the rate of change of the stimulus, thus producing an abrupt (phasic) discharge. A remarkable type of mechanoreceptor occurs in the elastic organs of crustacean legs; movement-sensitive cells fire for the time a joint moves in one direction, and others fire for the opposite movement.

In addition to melanocytes, human epidermis contains another system of dendritic cells called Langerhans cells (after their discoverer, the German physician Paul Langerhans, in 1868) which do not manufacture pigment. Their distribution extends farther toward the skin surface than that of the pigment cells. Their function remained obscure until it was realized that they are a vital part of the immunologic mechanism. Langerhans cells can be looked upon as “sentinel” cells of the immune system. By virtue of their situation, they are among the first cells to come into contact with foreign particulate substances encountering the skin. Their function is aided by the large surface area created by the dendritic processes of the cell. By means of specialized receptors on the cell membrane, the Langerhans cell recognizes invading as opposed to host molecules. By conveying this information to the lymphoid system, the body is able to mount a defensive immunologic response to the foreign material.

(46) Which hormone is responsible for the development of the placenta during pregnancy in mammals?

(A) Estrogen
(B) Growth hormone
(C) Progesterone
(D) Follicle Stimulating Hormone (FSH)

Answer: A

Estrogen is any of a group of hormones that primarily influence the female reproductive tract in its development, maturation, and function. There are three major hormones—estradiol, estrone, and estriol—among the estrogens, estradiol being the predominant one. The major sources of estrogens are the ovaries and the placenta (the temporary organ that serves to nourish the fetus and remove its wastes); additional small amounts are secreted by the adrenal glands and by the male testes. It is believed that the egg follicle (the saclike structure that holds the immature egg) and

interstitial cells (certain cells in the framework of connective tissue) in the ovary are the actual production sites of estrogens in the female. Estrogen levels in the bloodstream seem to be highest during the egg-releasing period (ovulation) and after menstruation, when tissue called the corpus luteum replaces the empty egg follicle. Estrogens affect the ovaries, vagina, fallopian tubes, uterus, and mammary glands. In the ovaries, estrogens help to stimulate the growth of the egg follicle; they also stimulate the pituitary gland in the brain to release hormones that assist in follicular development. Once the egg is released, it travels through the fallopian tubes on its way to the uterus in the fallopian tubes estrogens are responsible for developing a thick muscular wall and for the contractions that transport the egg and sperm cells. The young female uterus, if deprived of estrogens, does not develop into its adult form; the adult uterus that does not receive estrogens begins to show tissue degeneration. Estrogens essentially build and maintain the endometrium—a mucous membrane that lines the uterus; they increase the endometrium's size and weight, cell number, cell types, blood flow, protein content, and enzyme activity. Estrogens also stimulate the muscles in the uterus to develop and contract; contractions are important in helping the wall to slough off dead tissue during menstruation and during the delivery of a child and of the placenta. The cervix, the tip of the uterus, which projects into the vagina, secretes mucus that enhances sperm transport; estrogens are thought to regulate the flow and thickness of the mucous secretions. The growth of the vagina to its adult size, the thickening of the vaginal wall, and the increase in vaginal acidity that reduces bacterial infections are also correlated to estrogen activities. In the breasts the actions of estrogens are complexly interrelated with those of other hormones, and their total significance is not easily defined; they are, however, responsible for growth of the breasts during adolescence, pigmentation of the nipples, and the eventual cessation of the flow of milk. Estrogens also influence the structural differences between the male and female bodies. Usually the female bones are smaller and shorter, the pelvis is broader, and the shoulders are narrower. The female body is more curved and contoured because of fatty tissue that covers the muscles, breasts, buttocks, hips, and thighs. The body hair is finer and less pronounced, and the scalp hair is usually more permanent. The voice box is smaller and the vocal cords shorter, giving a higher-pitched voice in females than in males. In addition, estrogens suppress the activity of sebaceous (oil-producing) glands and thereby reduce the likelihood of acne in the female.

Progesterone is the hormone secreted by the female reproductive system that functions mainly to regulate the condition of the inner lining (endometrium) of the uterus. Progesterone is produced by the ovaries, placenta, and adrenal glands; in the ovaries the site of production is the corpus luteum tissue, which begins to form prior to an egg's release and continues to grow into the empty follicular space once the egg has left the follicle (a capsule of tissue around the egg). The released egg, if it is fertilized by the male sperm cell, becomes implanted in the uterus, and a placenta forms. The placenta then produces progesterone during the period of pregnancy. If the egg is not fertilized, progesterone is secreted by the ovaries until a

few days before menstruation, at which time the level of progesterone drops sufficiently to stop the growth of the uterine wall and to cause it to start to break down, and menstruation ensues. Progesterone prepares the wall of the uterus so that the lining is able to accept a fertilized egg and so that the egg can be implanted and develop. It also inhibits muscular contractions of the uterus that would probably cause the wall to reject the adhering egg.

The *follicle stimulating hormone (FSH)* is one of two gonadotropic hormones (i.e., hormones concerned with the regulation of the activity of the gonads, or sex glands) produced by the pituitary gland. FSH, a glycoprotein operating in conjunction with luteinizing hormone (LH), stimulates development of the graafian follicle, a small, egg-containing vesicle in the ovary of the female mammal; in the male, it promotes the development of the tubules of the testes and the differentiation of sperm. Though in the male the presence of FSH is necessary for the maturation of spermatozoa, additional FSH may not be required for months because testosterone can maintain this activity. In the female, however, there is a rhythmic, or cyclical, increase and decrease of FSH, which is essential for monthly ovulation.

(47) Which of the following animals were used in the first experiments to do pregnancy tests in humans?

(A) White rats
(B) Spur-toed frog
(C) Field mice
(D) Dogs

Answer: B

Biological tests for pregnancy depend upon the production by the placenta (the temporary organ that develops in the womb for the nourishing of the embryo and the elimination of its wastes) of chorionic gonadotropin, an ovary-stimulating hormone. In practice, the tests have an accuracy of about 95 percent, although false-negative tests may run as high as 20 percent in a series of cases. False-negative reports are frequently obtained during late pregnancy when the secretion of chorionic gonadotropin normally decreases. The possibility not only of false-negative but also of false-positive tests makes the tests, at best, probable rather than absolute evidence of the presence or absence of pregnancy. Chorionic gonadotropin in a woman's blood or urine indicates only that she is harboring living placental tissue. It does not tell anything about the condition of the foetus. In fact, the greatest production of chorionic gonadotropin occurs in certain placental abnormalities and disorders that can develop in the absence of a fetus. Tests using immature mice (the Aschheim-Zondek test) and immature rats have been found to be extremely accurate. Tests using rabbits (the Friedman test) have been largely replaced by the more rapid and less expensive frog and toad tests. The use of the female South African claw-toed tree toad *Xenopus laevis*, is based on the discovery that this animal will ovulate and extrude visible eggs within a few hours after it has received an injection of a few milliliters of urine from a pregnant woman. The male common frog, Rana *pipiens*, will extrude spermatozoa when treated in the same way. Both of these tests are

considered somewhat unsatisfactory because false-positive reactions are not uncommon.

(48) Under which conditions will plants have a low transpiration rate?

(A) High temperatures
(B) High humidity
(C) Strong winds
(D) Lots of ground water available

Answer: B

Transpiration is the plant's loss of water, mainly through the stomates of leaves. Stomates consist of two guard cells that form a small pore on the surfaces of leaves. The guard cells control the opening and closing of the stomates in response to various environmental stimuli. Darkness, internal water deficit, and extremes of temperature tend to close stomates and decrease transpiration; illumination, ample water supply, and optimum temperature open stomates and increase transpiration. The exact significance of transpiration is disputed; its roles in providing the energy to transport water in the plant and in aiding in heat dissipation in direct sunlight (by cooling through evaporation of water) have been challenged. Stomatal openings are necessary to admit carbon dioxide to the leaf interior and to allow oxygen to escape during photosynthesis, hence transpiration has been considered by some authorities to be merely an unavoidable phenomenon that accompanies the real functions of the stomates.

(49) Which of the following diseases cannot, in any way, be attributed to water?

(A) Cholera
(B) Malaria
(C) Scurvy
(D) Yellow fever

Answer: C

Cholera is an intestinal disease that is the archetype of waterborne illnesses. It spreads by the fecal–oral route: infection spreads through a population when feces containing the bacterium contaminate water that is then ingested by individuals. Transmission of the disease can also occur with food that has been irrigated, washed, or cooked with contaminated water. Foods that have the greatest potential to transmit the disease include shellfish and seafood, especially if eaten raw; fruits and vegetables grown in soil that has been either fertilized with human excrement (night soil) or irrigated with raw sewage; and foods packed in contaminated ice. *Vibrio cholerae* is a member of the family Vibrionaceae, which includes three medically important genera of water-dwelling bacteria. It is a short, gram-negative, rod-shaped bacterium that appears curved when isolated. There are about 140 types of *V. cholerae*, based on the classification of a protein called the O antigen in the bacterium's cell wall. The only strains of *V. cholerae* known to cause cholera—strains O1 and O139—have the ability to produce a type of toxin called an enterotoxin. Not all *V. cholerae* O1 produce the toxin.

Scurvy (also called vitamin C deficiency) is one of the oldest-known nutritional disorders of humankind, caused by a dietary lack of vitamin C (ascorbic acid), a nutrient found in many fresh fruits and vegetables, particularly the citrus fruits. Vitamin C is important in the formation of

collagen (an element of normal tissues), and any deficiency of the vitamin interferes with normal tissue synthesis, a problem that underlies the clinical manifestations of the disorder. Scurvy is characterized by swollen and bleeding gums with loosened teeth, soreness and stiffness of the joints and lower extremities, bleeding under the skin and in deep tissues, slow wound healing, and anemia.

Yellow fever is an acute infectious disease, one of the great epidemic diseases of the tropical world, though it sometimes has occurred in temperate zones as well. The disease, caused by a flavivirus, infects humans, all species of monkeys, and certain other small mammals. The virus is transmitted from animals to humans and among humans by several species of mosquitoes. Yellow fever appears with a sudden onset of fever, chills, headache, backache, nausea, and vomiting. The skin and eyes may appear yellow—a condition known as jaundice and a sign that gives rise to the disease's popular name. There is no specific treatment for those with yellow fever beyond good nursing and supportive care. However, yellow fever is an outstanding example of a completely preventable disease. People can be rendered immune to the virus through vaccination, and outbreaks can be contained by eliminating or controlling mosquito populations. Thanks to such measures, the great yellow fever epidemics of the late 19th and early 20th centuries are no more, though the disease is still present in tropical Africa and South America, where access to vaccine is sometimes lacking and the virus is held in vast natural reservoir by forest monkeys.

(50) External fertilization is found in ….

(A) aquatic organisms and some terrestrial organisms such as frogs.
(B) aquatic organisms only.
(C) organisms with an organ to introduce sperm into the female's body.
(D) in terrestrial animals only.

Answer: A

External fertilization is a form of fertilization in which a sperm cell is united with an egg cell external to the body of the female. Thus, the fertilization is said to occur "externally". This is distinct from internal fertilization where the union of the egg and sperm occur inside the female after insemination through copulation. In sexual reproduction, there must be some way of getting the sperm to the egg. Since sperm are designed to be motile in a watery environment, aquatic animals can make use of the water in which they live. In many aquatic animals such as coral or Hydra, eggs and sperm are simultaneously shed into the water, and the sperm swim through the water to fertilize the egg in a process known as broadcast fertilization. In many fish species, including salmon, the female will deposit unfertilized eggs in the substrate and the male will swim by and fertilize them. Many land plants make use of external fertilization as well. For example, bees and butterflies brush against pollen when gathering nectar from flowers and spread them to another flower of the same species, pollinating that plant.

(51) Which one of the following is true about growth responses in plants?

(A) Roots are positively geotropic and negatively hydrotropic.
(B) Shoots are negatively phototropic and positively geotropic.
(C) Shoots are positively phototropic and negatively geotropic.
(D) Roots are negatively geotropic and positively phototropic.

Answer: C

Tropism is a response or orientation of a plant or certain lower animals to a stimulus that acts with greater intensity from one direction than another. It may be achieved by active movement or by structural alteration. Forms of tropism include phototropism (response to light), geotropism (response to gravity), chemotropism (response to particular substances), hydrotropism (response to water), thigmotropism (response to mechanical stimulation), traumatotropism (response to wound lesion), and galvanotropism, or electrotropism (response to electric current). Most tropic movements are orthotropic; *i.e.,* they are directed toward the source of the stimulus. Plagiotropic movements are oblique to the direction of stimulus. Diatropic movements are at right angles to the direction of stimulus.

(52) Identify the correct combination of characteristics for a good absorption surface in the human body.

(A) Thin walled, large surface area, dense blood capillary network
(B) Thin walled, small surface area, dense capillary network
(C) Thick walled, large surface area, dense blood capillary network
(D) Thin walled, large surface area, sparse blood capillary network

Answer: A

The best example of this absorption surface is the small intestine. It is a long, narrow, folded or coiled tube extending from the stomach to the large intestine; it is the region where most digestion and absorption of food takes place. It is about 6.7 to 7.6 meters (22 to 25 feet) long, highly convoluted, and contained in the central and lower abdominal cavity. A thin membranous material, the mesentry, supports and somewhat suspends the intestines. The mesentery contains areas of fat that help retain heat in the organs, as well as an extensive web of blood vessels. Nerves lead to the small intestine from two divisions of the autonomic nervous system: parasympathetic nerves initiate muscular contractions that move food along the tract (peristalsis), and sympathetic nerves suppress intestinal movements.

(53) Which one of the following is not an adaptation against water loss?

(A) Hairy leaves.
(B) Stomata on the under surface of leaves.
(C) Tolerance of a narrow temperature range.
(D) Tough exoskeletons of insects.

Answer: C

Land animals and plants have adapted to their relatively dry environments and those in areas where water is scarce, even more so. Drought tolerance refers to the degree to which a plant is adapted to arid or drought conditions.

Desiccation tolerance is an extreme degree of drought tolerance. Plants naturally adapted to dry conditions are called xerophytes. Drought tolerant plants typically make use of either C4 carbon fixation or crassulacean acid metabolism (CAM) to fix carbon during photosynthesis. Both are improvements over the more common but more basal C3 pathway in that they are more energy efficient. CAM is particularly good for arid conditions because carbon dioxide can be taken up at night, allowing the stomata to stay closed during the heat of day and thus reducing water loss. Many adaptations for dry conditions are structural, including the following: (i) adaptations of the stomata to reduce water loss, such as reduced numbers or waxy surfaces; (ii) water storage in succulent above-ground parts or water-filled tubers; (iii) adaptations in the root system to increase water absorption and (iv) trichomes (small hairs) on the leaves to absorb atmospheric water. The exoskeletons of arthropods contain rigid and resistant components that fulfil a set of functional roles including protection, excretion, sensing, support, feeding and (for terrestrial organisms) acting as a barrier against desiccation. Some mammals are also extraordinarily adapted to habitats. An example is the Kangaroo rat, found in arid and semi-arid areas of Canada, the USA and Mexico that retain some grass or other vegetation. They have very efficient kidneys. The kangaroo rat has a longer loop of Henle in the nephrons which permits a greater magnitude of countercurrent multiplication and thus a larger medullary vertical osmotic gradient. As a result, these rodents can produce urine that is concentrated up to an osmolarity of almost 6,000 mosm/liter, which is five times more concentrated than maximally concentrated human urine at 1,200 mosm/liter. Because of this tremendous concentration ability, kangaroo rats never have to drink; the H_2O produced metabolically within their cells during oxidation of foodstuff (food plus O_2 yields $CO_2 + H_2O$ + energy) is sufficient for their body. Kangaroo rats lose so little water that they can recover 90% of the loss by using metabolic water gaining the remaining 10% from the small amount of water in their diet. Kangaroo rats lose water mainly by evaporation during gas exchange and gain water mainly from cellular metabolism.

(54) A patient whose gallbladder is surgically removed is most likely to encounter problems with….

(A) Production of acids.
(B) Excretion of urea.
(C) Breakdown of fats.
(D) Absorption of mineral salts.

Answer: C

The bile acids and their salts are detergents that emulsify fats in the gut during digestion. They are synthesized from cholesterol in the liver by a series of reactions that introduce a hydroxyl group into ring B and ring C and shorten the acyl side chain of ring D to seven carbons with the terminal carbon changed to a carboxyl group. The resulting molecule, cholic acid—as well as chenodeoxycholic acid (a close relative lacking the OH on ring C)—are usually found in the form of their salts, in which the amino acids taurine and glycine are chemically linked to the side-chain carboxyl group. These detergents are secreted from the liver into the gall bladder,

where they are stored before being released through the bile duct into the small intestine. After performing an emulsifying action that is essential in fat digestion, they are reabsorbed in the lower small intestine, returned through the blood to the liver, and reused. This cyclic process, called the eneterohepatic circulation, handles 20 to 30 grams of bile acids per day in human beings. The small fraction that escapes this circulation is lost in the feces. This is the major excretory route for cholesterol (though a smaller fraction is lost through the normal sloughing of dead skin cells).

(55) Athletes who do their training at high altitudes usually do well during running competitions. The best explanation for this is that their….

(A) Leg muscles relax and contract easily.
(B) Bodies are very resistant to water loss.
(C) Lung capacity is large.
(D) Blood oxygen-carrying capacity is large.

Answer: D

Altitude training traditionally called training at an altitude camp, or now commonly using altitude simulation tents or mask based hypoxicator systems is the practice by some endurance athletes of training at high altitude, usually over 2,500 m (8,000 ft) above sea level, for several weeks. At this altitude although the air still contains approximately 20.9% oxygen, the barometric pressure and thus the partial pressure of oxygen is reduced. The body adapts to the relative lack of oxygen by increasing the concentration of red blood cells and hemoglobin. Proponents claim that when such athletes return to sea level (where they are competing) they will still have a higher concentration of red blood cells for 10-14 days. Some athletes live permanently at high altitude, only returning to sea level to compete, but their training may suffer due to less available oxygen for workouts. A larger concentration of red blood cells allows more oxygen to be supplied to the muscles allowing higher performance. Increases in red blood cell mass are stimulated by an increase in erythropoietin (EPO). The body naturally produces EPO to regulate red blood cell mass and should not be confused with synthetic EPO. Synthetic EPO injections and blood doping are illegal in athletic competition because they cause an increase in red blood cells beyond the individual athlete's natural limits. This increase, unlike the increase caused by altitude training, can be dangerous to an athlete's health as the blood may become too thick and cause heart failure. The natural secretion of EPO by the human kidneys can be increased by altitude training, but the body has limits on the amount of natural EPO that it will secrete, thus avoiding the harmful side effects of the illegal doping.

(56) The reason why it is important to keep newly born babies in warm clothing is that they….

(A) are very susceptible to diseases and the clothing serves as a barrier to germs.
(B) are most used to confinement and not used to openness.
(C) have a large surface area to volume ratio and lose a lot of heat.
(D) have a small surface area to volume ratio and lose a lot of heat.

Answer: C

The ratio between the surface area and volume of cells and organisms has an enormous impact on their biology. For example, many aquatic microorganisms have increased surface area to increase their drag in the water. This reduces their rate of sink and allows them to remain near the surface with less energy expenditure. If you have 3 cubes: one 2 cm each side, one 1 cm each side and one 0.5 cm each side...the SA/Vol ratio will double every single time i.e.: 2 cm cube would be 3:1 (surface area of a cube is length x breadth and there are 6 sides thus 2x2x6 = 24 cm^2. Its volume is length x breadth x height = 2x2x2 = 8); the 1 cm cube would be 6:1 and the 0.5 cm cube would be 12:1 This practically shows that every single time, the surface area doubles. Humans cannot rely on diffusion for their whole body. However, animals such as flatworms and leeches can, as they have less volume. An increased surface area to volume ratio also means increased exposure to the environment. Greater surface area allows more of the surrounding water to be sifted for food. Individual organs in animals are often based on the principle of greater surface area. The lung is an organ with numerous internal branching that increases the surface area through which oxygen is passed into the blood and carbon dioxide is released from the blood. The intestine has a finely wrinkled internal surface, increasing the area through which nutrients are absorbed by the body. This is done to increase the surface area in which diffusion of oxygen and carbon dioxide in the lungs and diffusion of nutrients in villi of the small intestine can occur. Cells can get around having a low surface area to volume ratio by being long and thin (nerve cells) or convoluted (microvilli). Increased surface area can also lead to biological problems. More contact with the environment through the surface of a cell or an organ (relative to its volume) increases loss of water and dissolved substances. High surface area to volume ratios also present problems of temperature control in unfavorable environments.

(57) Where best would you grow a garden fern?

(A) Open, windy place.
(B) Sunny, dry place.
(C) Dry, shady place.
(D) Moist, shady place.

Answer: D

The ferns are extremely diverse in habitat, form, and reproductive methods. In size alone they range from minute filmy plants only 2 to 3 millimeters (0.08 to 0.12 inch) tall to huge tree ferns 10 to 25 meters (30 to 80 feet) in height. Some are twining vines; others float on the surface of ponds. The majority of ferns inhabit warm, damp areas of the Earth. Growing profusely in tropical areas, ferns diminish in number with increasingly higher latitudes and decreasing supplies of moisture. Few are found in dry, cold places. There are four particular types of habitats that ferns are found in: moist, shady forests; crevices in rock faces, especially when sheltered from the full sun; acid wetlands including bogs and swamps; and tropical trees, where many species are epiphytes.

(58) If in an accident you severely injured your tongue and lost the ability to taste and recognize sweetness, which part of your tongue would have been damaged?

(A) The anterior free end
(B) The middle part.
(C) The posterior edge close to the throat.
(D) The sides.

Answer: A

The mammalian tongue consists of a mass of interwoven, striated muscles interspaced with glands and fat and covered with mucous membrane. In humans the front tips and margins of the tongue usually touch the teeth, aiding in swallowing and speech. The top surface, or dorsum, contains numerous projections of the mucous membrane called papillae. They contain taste buds sensitive to food flavors and serous glands that secrete some of the fluid in saliva, a substance that moistens the oral cavity and helps lubricate food particles. The base, or upper rear portion, of the tongue has no papillae, but aggregated lymphatic tissue (lingual tonsils) and serous and mucus-secreting glands are present. The inferior, or under, surface leads from the tip of the tongue to the floor of the mouth; its mucous membrane is smooth, devoid of papillae, and purple in color from the many blood vessels present. The root, the remainder of the underside that lies on the mouth's floor, contains bundles of nerves, arteries, and muscles that branch to the other tongue regions. Nerves from the tongue receive chemical stimulation from food in solution that gives the sensation of taste. There are four fundamental taste sensations, which derive from receptors that have specific topographical distribution: salt and sweet at the tip of the tongue, bitter at the base, and acid or sour along the borders. The total flavor of a food comes from the combination of taste, smell, touch, texture or consistency, and temperature sensations. Small taste buds situated on the tongue's top surface transmit these flavor sensations to the nervous system. Among the disorders to which the tongue is subject are cancer, leukoplakia (white patches), fungus infection, congenital defects, and a variety of symptoms caused by disease elsewhere in the body. Surgical removal of this organ makes speech and swallowing difficult.

(59) Why are arteries thicker walled than veins?

(A) Arteries carry oxygenated blood.
(B) Arteries branch to form arterioles.
(C) Arteries carry blood under pressure.
(D) Arteries convey blood to all organs.

Answer: C

In human physiology, an artery is any of the vessels that, with one exception, carry oxygenated blood and nourishment from the heart to the tissues of the body. The exception, the pulmonary artery, carries oxygen-depleted blood to the lungs for oxygenation and removal of excess carbon dioxide. Arteries are muscular and elastic tubes that must transport blood under a high pressure exerted by the pumping action of the heart. The pulse, which can be felt over an artery lying near the surface of the skin, results from the alternate expansion and contraction of the arterial wall as the beating heart forces blood

into the arterial system via the aorta. Large arteries branch off from the aorta and in turn give rise to smaller arteries until the level of the smallest arteries, called arterioles, is reached. The threadlike arterioles carry blood to networks of microscopic vessels called capillaries, which supply nourishment and oxygen to the tissues and carry away carbon dioxide and other products of metabolism by way of the veins. The largest artery is the aorta, which arises from the left ventricle of the heart. The aorta arches briefly upward before continuing downward close to the backbone; the arteries that supply blood to the head, neck, and arms arise from this arch and travel upward. As it descends along the backbone, the aorta gives rise to other major arteries that supply the internal organs of the thorax. After descending to the abdomen, the aorta divides into two terminal branches, each of which supplies blood to one leg. Each artery, no matter what its size, has walls with three layers, or coats. The innermost layer, or tunica intima, consists of a lining, a fine network of connective tissue, and a layer of elastic fibres bound together in a membrane pierced with many openings. The tunica media, or middle coat, is made up principally of smooth (involuntary) muscle cells and elastic fibres arranged in roughly spiral layers. The outermost coat, or tunica adventitia, is a tough layer consisting mainly of collagen fibres that act as a supportive element. The large arteries differ structurally from the medium-sized arteries in that they have a much thicker tunica media and a somewhat thicker tunica adventitia.

(60) Since the discovery of penicillin, fungi have been used as a source of many clinically useful drugs. Which of the following drugs is NOT of fungal origin?

(A) Cyclosporin, an immunosuppressant drug used to avoid rejection in organ transplantation.
(B) Mycophenolate, an immunosuppressant drug used to prevent rejection in organ transplantation.
(C) Paclitaxel, a mitotic inhibitor used in cancer chemotherapy.
(D) None of the above.

Answer: C

Cyclosporin was initially isolated from the fungus *Tolypocladium inflatum*. It is a cyclic non-ribosomal peptide of 11 amino acids and contains a single D-amino acid, which are rarely encountered in nature.

Mycophenolate is derived from the fungus *Penicillium stoloniferum*.

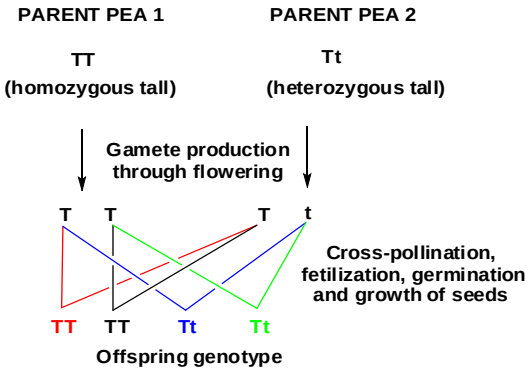
Paclitaxel (taxol) was isolated from the bark of the Pacific yew tree, *Taxus brevifolia.*

(61) Suppose that in the sweet pea “T” is the gene for tallness and “t” is the gene for shortness. In a genetic cross between two plants, one heterozygous and the other homozygous tall, which one of the following would be true about the offspring?

(A) They are all phenotypically similar.
(B) They all have similar genotypes.
(C) Three are tall and one is short.
(D) One is tall and three are short.

Answer: A

The cross over is best depicted as follows:



Since "T" is dominant, the offspring will all be tall even though half of them are heterozygous short.

(62) Why would it be impossible to drown and kill a cockroach by holding its head down under water?

(A) Cockroaches have lived for many centuries and are tolerant of many dangers.
(B) Cockroaches can survive without oxygen for many hours.
(C) Cockroaches take in air through holes situated elsewhere away from the head.
(D) Cockroaches have no blood and respire anaerobically.

Answer: C

Cockroaches, like all insects, breathe through a system of tubes called tracheae. The tracheae of insects are attached to the spiracles, excluding the head. Thus, all insects, including cockroaches, can breathe without a head. The valves open when the CO_2 level in the insect rises to a high level; then the CO_2 diffuses out of the tracheae to the outside and fresh O_2 diffuses in. The tracheal system brings the air directly to cells because they branch continually like a tree until their finest divisions tracheoles are associated with each cell, allowing gaseous oxygen to dissolve in the cytoplasm lying across the fine cuticle lining of the tracheole. CO_2 diffuses out of the cell into the tracheole. Insects do not have lungs and thus do not actively breathe in the vertebrate lung manner. However, in some very large insects the diffusion process may not be sufficient to provide oxygen at the necessary rate and body musculature may contract rhythmically to forcibly move air out and in the spiracles and one can actually call this breathing.

(63) Cellular respiration involves the substances/concepts below

(i) Oxygen
(ii) Carbon dioxide
(iii) Energy
(iv) Water
(v) Carbohydrates

Which one of the following equations correctly represents the substances in cellular respiration?

(A) (ii) +(iii) = (i) +(iv) + (v)
(B) (v) +(iv) = (i) +(ii) + (iii)
(C) (iii) +(v) = (i) +(ii) + (iv)
(D) (v) +(i) = (ii) +(iii) + (iv)

Answer: D

Cellular respiration is the process by which organisms combine oxygen with foodstuff molecules, diverting the chemical energy in these substances into life-sustaining processes and discarding, as waste products, carbon dioxide and water. Organisms that do not depend on oxygen degrade foodstuffs in a process called fermentation. One objective of the degradation of foodstuffs is to transduce the energy contained in chemical bonds into the energy-rich compound adenosine triphosphate (ATP). In eukaryotic cells the enzymes that catalyze the individual steps involved in respiration and energy conservation are located in highly organized rod-shaped compartments of the cell called mitochondria. In micro-organisms the enzymes occur as components of the cell membrane. For the most part, the major foodstuffs (carbohydrates, fats, and proteins) are made available for the energy-yielding process by degradation to a two-carbon fragment (acetyl group) that, when combined as acetyl coenzyme A, provides the fuel for an important sequence of metabolic reactions called the Krebs/citric acid cycle cycle. Each pair of hydrogen atoms removed from a participant in the Krebs cycle provides a pair of electrons that—through the action of a series of iron-containing hemoproteins, the cytochromes—eventually reduces one atom of oxygen to form water. In 1951 it was discovered that the transfer of one pair of electrons to oxygen results in the formation of three molecules of ATP. This process, called oxidative phosphorylation, is the major mechanism by which the large amounts of energy in foodstuffs are conserved and made available to the cell. The series of steps by which electrons flow to oxygen permits a gradual lowering of the energy of the electrons.

(64) The table below lists a number of diseases and their causative agents. Choose the disease(s) which can be treated with amoxicillin.

Disease	**Causative Agent**
Rubella	*Togaviridae*
Typhoid	*Salmonella typhi*
Dermatophytosis	*Tinea capitis*
Malaria	*Plasmodium falciparum*

(A) Rubella and Malaria
(B) Typhoid
(C) Dermatophytosis and Typhoid
(D) Malaria

ANSWER: B

Amoxicillin is a moderate-spectrum, bacteriolytic, betalactam antibiotic used to treat bacterial infections caused by susceptible microorganisms. It is usually the drug of choice within the class because it is better absorbed, following oral administration, than other β-lactam antibiotics. Amoxicillin acts by inhibiting the synthesis of bacterial cell walls. Amoxicillin is susceptible to degradation by β-lactamase-producing bacteria, which are resistant to a broad spectrum of β-lactam antibiotics, such as penicillin. For this reason, it is often combined with clavulanic acid, a β-lactamase inhibitor. This increases effectiveness by reducing its susceptibility to β-lactamase resistance.

Rubella, also called German measles, is caused by a virus and thus, cannot be treated with amoxicillin.

Malaria, caused by a protist, can be treated with other antibiotics such as tetracyclines, which kill by a different mode of action, but not amoxicillin.

Typhoid fever, caused by *Salmonella typhi,* a rod shaped, flagellated, aerobic, Gram-negative bacterium, can be treated with amoxicillin.

Dermatophytosis or ringworm is a clinical condition caused by fungal infection of the skin in humans. It can be treated with antifungal agents such as miconazole, which works by inhibiting the synthesis of ergosterol, a critical component of fungal cell membranes.

(65) Who is the first person to observe (see and reveal the existence of) bacteria?

(A) Louis Pasteur
(B) Antonie van Leeuwenhoek
(C) Sir Alexander Fleming
(D) Edward Jenner

ANSWER: B

Antonie Philips van Leeuwenhoek (October 24, 1632 – August 26, 1723) was a Dutch tradesman and scientist. He considered to be the first microbiologist and is best known for his work on the improvement of the microscope and for his contributions towards the establishment of microbiology. Using his handcrafted microscopes, he was the first to observe and describe single celled organisms (including bacteria), which he originally referred to as *animalcules*, and which we now refer to as micro-organisms.

Louis Pasteur (December 27, 1822 – September 28, 1895) was the French chemist and microbiologist whose contributions were among the most varied and valuable in the history of science and industry. It was he who proved that microorganisms cause fermentation and disease; pioneered the use of vaccines for rabies, anthrax, and chicken cholera; saved the beer, wine, and silk industries of France and other countries; performed important pioneer work in stereochemistry; and originated the process known as pasteurization.

Alexander Fleming (6 August 1881– 11 March 1955) was the Scottish scientist who serendipitously discovered penicillin in 1928. The chemical structure of penicillin was determined by Dorothy Crowfoot Hodgkin in the early 1940s, enabling synthetic production. A team of Oxford research scientists led by Australian Howard Walter Florey and including Ernst Boris Chain and Norman Heatley discovered a method of mass producing the drug. Florey and Chain shared the 1945 Nobel Prize in Medicine or Physiology with Fleming for this work.

(66) Some bacteria are parasites and cause a variety of diseases. Which of the following is not a bacterial disease?

(A) Kaposi’s sarcoma
(B) Legionnaires' disease
(C) Crohn's disease
(D) None of the above

ANSWER: A

Kaposi's sarcoma (KS) is a tumor caused by Human herpes virus 8 (HHV8). It was originally

described by Moritz Kaposi a Hungarian dermatologist, in 1872. It became more widely known as one of the AIDS defining illnesses in the 1980s. In KS associated with immunosuppression, treating the cause of the immune system dysfunction can slow or stop the progression of KS. In 40% or more of patients with AIDS-associated Kaposi's sarcoma, the Kaposi lesions will shrink upon first starting highly active antiretroviral therapy (HAART).

Legionnaires' disease is a potentially fatal infectious disease caused by the Gram-negative aerobic bacterium *Legionella pneumophila*. It is characterized by high fever and pneumonia.

Crohn's disease is an inflammatory disease of the intestines that may affect any part of the gastrointestinal tract, from the mouth to the anus, causing a wide variety of symptoms. Crohn's disease is thought to be an autoimmune disorder, in which the body's immune system attacks the gastrointestinal tract, causing inflammation

(67) Bacteria do not only cause diseases, but produce medicines that are beneficial to mankind. Which of the following is a medical drug of bacterial origin?

(A) Streptomycin, used in the treatment of tuberculosis.
(B) Cyclosporin, used to prevent rejection in organ transplant recipients.
(C) Nevirapine, used in the treatment of HIV-AIDS.
(D) Vincristine, used in the treatment of cancer.

ANSWER: A

Streptomycin, is an antibiotic synthesized by the soil organism *Streptomyces griseus*. Streptomycin was discovered by American biochemists Selman Waksman, Albert Schatz, and Elizabeth Bugie in 1943. The drug acts by interfering with the ability of a microorganism to synthesize certain vital proteins. It was the first antimicrobial agent developed after penicillin and the first antibiotic effective in treating tuberculosis. Because it was effective against a wide variety of diseases, streptomycin was used often, with the result that many initially sensitive microorganisms, including the bacterium that causes tuberculosis, became resistant to the antibiotic.

Nevirapine is an anti-HIV drug that falls in the non-nucleoside reverse transcriptase inhibitor (NNRTI) class of antiretrovirals. Both nucleoside and non-nucleoside reverse transcriptase inhibitors inhibit the same target, the reverse transcriptase enzyme, which transcribes viral RNA into DNA. Unlike nucleoside reverse transcriptase inhibitors, which bind at the enzyme's active site, NNRTIs bind allosterically at a distinct site away from the active site termed the NNRTI pocket.

Vincristine (brand name, Oncovin), is a nitrogen containing polycyclic natural product (alkaloid) from the herbaceous plant *Catharanthus roseus* (Madagascar periwinkle). Vincristine is biosynthesized by the coupling of indole alkaloids vindoline and catharanthine in the vinca plant. Vincristine binds to tubulin dimers, inhibiting assembly of microtubule structures. Disruption of the microtubules arrests mitosis in metaphase. Therefore, the vinca alkaloids affect all rapidly dividing cell types including cancer

cells, but also those of intestinal epithelium and bone marrow.

(68) Certain genera of Gram-positive bacteria can form highly resistant, dormant structures called endospores. Which of the following bacteria does not form endospores?

(A) *Bacillus anthracis*
(B) *Clostridium tetani*
(C) *Escherichia coli*
(D) None of the above.

ANSWER: C

An endospore is a dormant, tough, and temporarily non-reproductive structure produced by certain bacteria. It is a stripped-down, dormant form to which the bacterium can reduce itself. Endospore formation is usually triggered by a lack of nutrients, and usually occurs in Gram-positive bacteria, especially *Bacillus* and *Clostridium* genera. In endospore formation, the bacterium divides within its cell wall. One side then engulfs the other. Endospores enable bacteria to lay dormant for extended periods, even centuries. They can survive without nutrients. They are resistant to ultraviolet radiation, desiccation, high temperature, extreme freezing and chemical disinfectants.

(69) Antibacterial agents (antibiotics) are commonly classified based on their mechanism of action, chemical structure, or spectrum of activity. Which of the following is NOT a mode of action of known antibacterial drugs?

(A) Inhibition of peptidoglycan synthesis.
(B) Inhibition of protein synthesis.
(C) Inhibition of lipid biosynthesis.
(D) Inhibition of microtubule depolymerization

ANSWER: D

Bacteria are prokaryotes and do not have microtubules. Microtubules are a component of the cytoskeleton. These rope-like polymers of tubulin can grow as long as 25 micrometers and are highly dynamic. Microtubules are important for maintaining cell structure, providing platforms for intracellular transport, forming the spindle during mitosis, as well as other cellular processes.

(70) Setae (chaetae) are:

(A) hairs or bristles of the annelids used in locomotion.
(B) excretory organs in annelids.
(C) locomotory organs found in flatworms.
(D) digestive organs in the annelids.

ANSWER: A

Annelids have a thin, horny cuticle pierced by pores through which epidermal glands secrete mucus. In some marine annelids, glands are also present that secrete materials constituting a parchmentlike or calcareous tube within which the worm dwells. Earthworms and leeches secrete cocoons from a specialized epidermis in a region of the body known as the clitellum. A major feature of all annelids except leeches is the possession of bristles, or chaetae, of which there are many varieties. The bulk of each

chaeta is secreted by a single cell, though the surrounding lateral cells may contribute materials that bring about its hardening. Setae help earthworms attach to the surface and prevent backsliding during peristaltic motion. These hairs are what make it difficult to pull a worm straight from the ground.

(71) Which of the following are examples of vestigial structures?

(A) Your tailbone.
(B) Nipples on male mammals.
(C) Sixth fingers found on some humans.
(D) Your kneecap.

ANSWER: A

Vestigial structures are those that have their original function in a species through evolution. In humans, examples are the vermiform appendix, the coccyx, or tailbone (a remnant of a lost tail); the plica semilunaris on the inside corner of the eye (a remnant of the nictitating membrane); and muscles in the ear and other parts of the body.

(72) If you put an unripe banana in a bag with a ripe apple, it will quickly ripen because of the hormone …. produced by the apple.

(A) cytokinin
(B) gibberellin
(C) abscisic acid
(D) None of the above.

ANSWER: D

Growth in plants is regulated by a variety of plant hormones, including auxins, gibberellins, cytokinins, and growth inhibitors, primarily abscisic acid and ethylene. The distribution of *auxins*, which promote the lengthwise growth of plants, is correlated with the distribution of the growth regions of the plant. In addition to promoting normal growth in plant length, auxins influence the growth of stems toward the light (phototropism) and against the force of gravity (geotropism). The phototropic response occurs because greater quantities of auxin are distributed to the side away from the light than to the side toward it; the geotropic response occurs because more auxin accumulates along the lower side of the coleoptile than along the upper side. The downward growth of roots is also associated with a greater quantity of auxin in their lower halves.

Gibberellins are named after the fungus *Gibberella fujikuroi,* which produces excessive growth and poor yield in rice plants. One gibberellin is gibberellic acid (GA_3), which is present in higher plants as well as in fungi; many related compounds have structural variations that correlate with marked differences in effectiveness. Gibberellins, abundant in seeds, are also formed in young leaves and in roots; they move upward from the roots in the xylem (woody tissue) and thus do not show the movement characteristic of auxins. Evidence suggests that gibberellins promote the growth of main stems, especially when applied to the whole plant.

Cytokinins are compounds derived from a nitrogen-containing compound (adenine). One cytokinin is 6-furfurylaminopurine (kinetin); other compounds derived from adenine with effects

similar to those of kinetin, and certain compounds derived from another nitrogen-containing compound, urea, are conveniently referred to as cytokinins, although not all are natural products. Cytokinins are synthesized in roots, from which, like the gibberellins, they move upward in the xylem and pass into the leaves and the fruit. Required for normal growth and differentiation, cytokinins act, in conjunction with auxins, to promote cell division and to retard senscence, which, at least in its early stages, is an organized phase of metabolism and not just a breakdown of tissue. An example of senescence is the yellowing of isolated leaves, which occurs as proteins are broken down and chlorophyll is destroyed. Cytokinins, which prevent yellowing by stabilizing the content of protein and chlorophyll in the leaf and the structure of chloroplasts, are used commercially in the storage of green vegetables.

Growth inhibitors of various types have been identified in plants. The best characterized one is abscisic acid, which is chemically related to the cytokinins. It is probably universally distributed in higher plants and has a variety of actions; for example, it promotes abscission (leaf fall), the development of dormancy in buds, and the formation of potato tubers. The mode of action of abscisic acid has not yet been clarified but is thought to involve the direct inhibition of the synthesis of RNA and protein.

Another growth inhibitor is *ethylene*, which is a natural product of plants, formed possibly from linolenic acid (a fatty acid) or from methionine (an amino acid). Ethylene promotes abscission in senescent leaves, perhaps by facilitating the destruction of auxin. Its effects extend beyond that of inhibiting growth; in fruit, for example, ethylene is regarded as a ripening hormone. Involved in its action in fruit is another factor, perhaps auxin or another growth-regulating hormone, which influences the ethylene sensitivity of the tissues.

(73) Which of the following is NOT an advantage of social groupings of animals?

(A) Increased ability to detect, repel or confuse predators.
(B) Increased hunting efficiency.
(C) Increased likelihood of finding mates.
(D) None of the above.

ANSWER: D

By social behavior animals gain: (1) food and other resources, (2) reproductive advantages, and (3) shelter and space. They are enabled to avoid (4) physical and other small hazards, (5) competitors, and (6) predators or other large dangers. The first and third of these gains are reactions to desirable things of small (1) and medium to large size (3) respectively; the fourth and sixth are reactions to undesirable things of these sizes. The value of being social in getting food is obvious in the case of hunting bands. Cooperative hunting has been found among wolves and African hunting dogs, hyenas, lions, killer whales, porpoises, cormorants, white pelicans, pairs of eagles and of ravens, tuna when chasing small fish, army ants, primitive and modern men, and many other animals. Animals that hunt cooperatively can trap, chase, and tear apart prey that would otherwise be too fast, strong, or large for them. It was noted that sex is a way of combining desirable genes from

different lines, genes that otherwise might slowly or never get together. In many lines of animals, parental behavior is clearly useful in protecting or teaching the young. This normally requires the adult to have fewer young. The careful parent loses in time and energy and number of offspring but comes to prevail in evolution if it has more descendants than does a careless parent that lets its young die. Social behavior is often used in habitat selection and shelter selection, even to the extent of making it possible for the animal to improve the environment it finds. Cooperative building of structures is well known in humans, prairie dogs, rats (whose tunnel systems rival the catacombs in complexity), beavers, certain weaver finches, wasps, bees, termites, and many others; symbiotic use of structures occurs in many animals. Social behavior can also help animals avoid small hazards. This includes avoiding heat or cold and wet or dry situations as well as preening or grooming to keep off dirt, parasites, and other small environmental hazards. A goose cleaving the air for its companions at the front of a V-shaped flock, a parent bird brooding its young or sheltering it from the Sun, a group of creepers roosting together to help each other survive the cold winter night, and a group of baboons grooming each other to pick off ticks furnish other examples. Dangers from competition are avoided by agonostic behavior. The five basic types of agonistic behavior are aggressive display (threat), submissive display (appeasement), attack, avoidance, and fighting. The final reason for social behavior, and one of the most important, is to avoid predators or other large dangers. Just as animals can sometimes overcome large prey by grouping to attack it, so they can sometimes overcome large predators by grouping to defend against them. Cooperative and spirited attacks upon predators occur in most animals that protect their young and are a regular phenomenon in gull and tern colonies, in baboon troupes, in bees and wasps, and many others. “Mobbing” is a similar phenomenon in which the attack is not carried all the way to the predator but so harasses it that it departs or at least is prevented from getting its prey. The massed effect of many mobbing birds is more intimidating to a predator than is mobbing by one or two birds. Grouping also helps against predators because a predator is distracted by the “confusion effect” of so many shapes, sounds, or smells. Another advantage of the group or flock is that many eyes can see a predator more quickly than can one pair of eyes.

(74) Why do many animals defend territories?

(A) To monopolize the resources within the territory.
(B) To avoid predation.
(C) To secure over-wintering sites.
(D) To avoid each other.

ANSWER: A

The term territory refers to any geographical area that an animal of a particular species consistently defends against conspecifics (and, occasionally, animals of other species). Animals that defend territories in this way are referred to as capricornius. The most obvious examples of the "classic" territory are birds and fish. Animals like these defend territories that contain their nest site and sufficient food resources for

themselves and their young. Defense rarely takes the form of overt fights: more usually there is a highly noticeable display, which may be visual (as in the red breast of the robin), auditory (as in much bird song, or the calls of gibbons) or olfactory, through the deposit of scent marks. Many territorial mammals use scent-marking to signal the boundaries of their territories; the marks may be deposited by urination, by defecation, or by rubbing parts of the bodies that bear specialized scent glands against the substrate. For example, dogs and other canids scent-mark by urination and defecation, while cats scent-mark by rubbing their faces and flanks against objects. Territoriality is only shown by a minority of species. More commonly, an individual or a group of animals will have an area that it habitually uses but does not necessarily defend; this is called its home range. The home ranges of different groups often overlap, and in the overlap areas the groups will tend to avoid each other rather than seeking to expel each other. Within the home range there may be a core area that no other individual group uses, but again this is as a result of avoidance rather than defence. Behavioral ecologists have argued that food distribution determines whether a species will be territorial or not. Territoriality is only expected to emerge where there is a focused resource that provides enough for the individual or group, within a boundary that is small enough to be defended without the expenditure of too much effort.

(75) If a population is above carrying capacity, what must happen?

(A) It must immediately crash.

(B) It can remain stable indefinitely.

(C) If the species is territorial, it can continue to increase.

(D) It must eventually decline.

ANSWER: D

Carrying capacity is the average population density or population size of a species below which its numbers tend to increase and above which its numbers tend to decrease because of shortages of resources. The carrying capacity is different for each species in a habitat because of that species' particular food, shelter, and social requirements.

(76) Which of the following is an example of commensal relationship?

(A) Orchids growing on tree limbs.

(B) Flowering plants and their pollinators.

(C) Lupines and blue butterflies.

(D) Monarch and viceroy butterflies.

ANSWER: A

Commensalism is a term employed in ecology to describe a relationship between two living organisms where one benefits and the other is not significantly harmed or helped. It is derived from the English word *commensal*, meaning the sharing of food, and used of human social interaction. The word derives from the Latin *com mensa*, meaning *sharing a table*. Commensalism can be in several forms, for example: (i) Phoresy: One animal attaching to another animal for transportation only. This concerns mainly arthropods, examples of which are mites on insects (such as beetles, flies or bees), Phoresy can be either obligate or facultative (induced by

environmental conditions); (ii) Inquilism: Using a second organism for housing. Examples are epiphytic plants (such as many orchids) which grow on trees, or birds that live in holes in trees; (iii) Metabiosis: A more indirect dependency, in which the second organism uses something the first created, however after the death of the first. An example is the hermit crab that use gastropod shells to protect their bodies.

(77) The reservoir for carbon on earth is….

(A) coal, oil and natural gas.
(B) plants.
(C) CO_2 in the atmosphere.
(D) methane (CH_4) in the atmosphere.

ANSWER: C

The carbon cycle is the biogeochemical cycle by which carbon is exchanged between the biosphere, geosphere, hydrosphere and atmosphere of the earth. The cycle is usually thought of as four major reservoirs of carbon interconnected by pathways of exchange. The reservoirs are the atmosphere, the terrestrial biosphere (which usually includes freshwater systems and non-living organic material, such as soil carbon), the oceans (which includes dissolved inorganic carbon and living and non-living marine biota), and the sediments (which includes fossil fuels). The annual movements of carbon, the carbon exchanges between reservoirs, occur because of various chemical, physical, geological, and biological processes. The ocean contains the largest active pool of carbon near the surface of the Earth, but the deep ocean part of this pool does not rapidly exchange with the atmosphere. The global carbon budget is the balance of the exchanges (incomes and losses) of carbon between the carbon reservoirs or between one specific loop (e.g., atmosphere - biosphere) of the carbon cycle. An examination of the carbon budget of a pool or reservoir can provide information about whether the pool or reservoir is functioning as a source or sink for carbon dioxide. Carbon exists in the earth's atmosphere primarily as the gas carbon dioxide (CO_2). Although it is a very small part of the atmosphere overall (approximately 0.04% on a molar basis, though rising), it plays an important role in supporting life. Other gases containing carbon in the atmosphere are methane and chlorofluorocarbons (the latter is entirely man-made). The overall atmospheric concentration of these greenhouse gases has been increasing in recent decades, contributing to global warming. Carbon is taken from the atmosphere in several ways:

(i) When the sun is shining, plants perform photosynthesis to convert carbon dioxide into carbohydrates releasing oxygen in the process. This process is most prolific in relatively new forests where tree growth is still rapid; (ii) At the surface of the oceans towards the poles, sea water becomes cooler and more carbonic acid is formed as CO_2 becomes more soluble. This is coupled to the ocean's thermohaline circulation which transports dense surface water into the ocean's interior. Carbon can be released back into the atmosphere in many different ways:

(i) Through the respiration performed by plants and animals. This is an exothermic reaction and it involves the breaking down of glucose (or other organic molecules) into carbon dioxide and water; (ii) Through the decay of animal and plant matter. Fungi and bacteria break down the

carbon compounds in dead animals and plants and convert the carbon to carbon dioxide if oxygen is present, or methane if not; (iii) Through combustions of organic material which oxidizes the carbon it contains, producing carbon dioxide (and other things, like water vapor); (iv) Burning fossil fuels such as coal, petroleum products and natural gas releases carbon that has been stored in the geosphere for millions of years; (v) Production of cement: carbon dioxide is released when limestone (calcium carbonate) is heated to produce lime (calcium oxide), a component of cement; (vi) At the surface of the oceans where the water becomes warmer, dissolved carbon dioxide is released back into the atmosphere; (vii) Volcanic eruptions and metamorphism release gases into the atmosphere. Volcanic gases are primarily water vapor, carbon dioxide and sulphur dioxide. The carbon dioxide released is roughly equal to the amount removed by silicate weathering; so the two processes, which are the chemical reverse of each other, sum to roughly zero, and do not affect the level of atmospheric carbon dioxide on time scales of less than about 100,000 yr.

(78) The biological process whereby carbon is returned to its reservoir is

(A) photosynthesis.
(B) burning of fossil fuels.
(C) cellular respiration.
(D) nitrification.

Answer: C

See the answer to question 77 above for a detailed discussion.

(79) Very little cyanide (HCN, KCN or NaCN) is required to kill an adult human because

(A) cyanide kills by binding to heart muscles, and little of it is enough to induce a heart attack.
(B) cyanide instantly collapses the lungs and kills by asphyxiation.
(C) a few cyanide molecules are enough to instantly kill all liver cells.
(D) None of the above.

Answer: D

Cyanide poisoning occurs when a living organism is exposed to a compound that produces cyanide ions (CN^-) when dissolved in water. The cyanide ion halts cellular respiration by inhibiting an enzyme in mitochondria called cytochrome c oxidase. The enzyme cytochrome c oxidase or is a large transmembrane protein complex found in bacteria and mitochondria. It is the last enzyme in the respiratory electron transport chain of mitochondria (or bacteria) located in the mitochondrial (or bacterial) membrane. It receives an electron from each of four cytochrome c molecules, and transfers them to one oxygen molecule, converting molecular oxygen to two molecules of water. In the process, it binds four protons from the inner aqueous phase to make water, and in addition translocates four protons across the membrane, helping to establish a trans-membrane difference of proton electrochemical potential that the ATP synthase then uses to synthesize ATP. Cyanide and carbon monoxide bind to cytochrome c oxidase, thus competitively inhibiting the protein

from functioning which results in chemical asphyxiation of cells.

(80) Ovoviviparity, is a mode of reproduction in which

(A) the female lays eggs before fertilization, and the male lays its sperm on top of the newly laid eggs.
(B) internal fertilization occurs and the embryo develops within the mother, attached by a placenta, until birth
(C) seeds are produced and germinate before they detach from the parent plant.
(D) embryos develop inside eggs that are retained within the mother's body until they are ready to hatch.

ANSWER: D

Ovoviviparity, ovovivipary, or ovivipary, is a mode of reproduction in animals in which embryos develop inside eggs that are retained within the mother's body until they are ready to hatch. Ovoviviparous animals are similar to viviparous species in that there is internal fertilization and the young are born live, but differ in that there is no placental connection and the unborn young are nourished by egg yolk; the mother's body does provide gas exchange (respiration). Ovoviviparity is employed by many aquatic life forms such as some fish, reptiles and invertebrates.

(81) Emergency contraception or the morning-after pill refers to contraceptive measures that, if taken after sex, may prevent pregnancy. These drugs work by

(A) inhibiting mitosis in the newly formed zygote and lead to auto-abortion.
(B) inducing early menstruation.
(C) killing sperm before fertilization can occur.
(D) preventing ovulation, or fertilization and possibly post-fertilization implantation.

ANSWER: D

Emergency contraceptive pills (ECPs)—sometimes simply referred to as the "morning-after pill"—are drugs that act both to prevent ovulation or fertilization and possibly post-fertilization implantation of an embryo). ECPs are distinct from medical abortion methods that act after implantation. Emergency contraceptive pills may contain higher doses of the same hormones (estrogens, progestins, or both) found in regular contraceptive pills. Taken after unprotected sexual intercourse or contraceptive failure, such higher doses may prevent pregnancy from occurring. The drug mifepristone, a synthetic steroid, can be used as emergency contraception. Higher doses of mifepristone can disrupt implantation and, unlike levonorgestrel, mifepristone is effective in terminating established pregnancies. Thus, it can be used either as an ECP or as an abortifacient, depending on whether it is used before or after implantation.

(82) Chlorine is often added as the last step in municipal water treatment. The reason for chorine use is;

(A) chlorine promotes the growth of fungi that produce antibiotics and help sanitize the water

(B) as a toxic gas used in World War I, chlorine's presence deters theft and vandalism of municipal water infrastructure.

(C) chlorine is a reducing agent and helps precipitate undesirable heavy metals out of drinking water.

(D) None of the above.

ANSWER: D

Chlorination is the process of adding the element chlorine to water as a method of water purification to make it fit for human consumption as drinking water. Water which has been treated with chlorine is effective in preventing the spread of disease. The use of chlorine has greatly reduced the prevalence of waterborne disease as it is effective against almost all bacteria and viruses. Chlorination is also used to sterilize the water in swimming pools and as a disinfection stage in sewage treatment. When chlorine is added to water, hypochlorous acid (an oxidizing agent) and hydrochloric acid (a strong acid) form: ($Cl_2 + H_2O \rightarrow HClO + HCl$).

(83) Which of the following has the greatest potential to provide all of the world's electricity needs without any damage to the environment?

(A) Nuclear energy

(B) Solar energy

(C) Wind power

(D) Hydroelectricity

ANSWER: B

Harnessing solar energy and its uses are limited only by human ingenuity. The Sun is an extremely powerful energy source, and sunlight is by far the largest source of energy received by the Earth, but its intensity at the Earth's surface is actually quite low. The Earth receives 174 petawatts (PW = 10^{15} Watts) of incoming solar radiation at the upper atmosphere. Approximately 30% is reflected back to space while the rest is absorbed by clouds, oceans and land masses. The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 exajoules (EJ = 10^{18} Joules) per year. In 2002, this was more energy in one hour than the world used in one year. Photosynthesis captures approximately 3,000 EJ per year in biomass. The amount of solar energy reaching the surface of the planet is so vast that in one year it is about twice as much as will ever be obtained from all of the Earth's non-renewable resources of coal, oil, natural gas, and mined uranium combined.

Hydroelectricity is electrical power produced through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy. Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of CO_2 than fossil fuel powered energy plants. Worldwide, an installed capacity of 777 gigawatts supplied 2998 terawatts of hydroelectricity in 2006. This was approximately 20% of the world's electricity, and accounted for about 88% of electricity from renewable sources. Whilst hydroelectricity has great potential, unlike solar energy, it is not limitless because there are only so many perennial rivers in the world that

can sustain large dams for significant power generation. In addition, dam construction requires a large amount of material (steel for reinforcement and cement) as well as moving large masses of earth and in some cases, relocation of animals and human settlements (please read about the construction of China's Three Gorges Dam or Brazil's Itaipu Dam to better understand this).

(84) Cholera is an infection of the small intestines caused by the bacterium *Vibrio cholerae.* Inside the small intestine, cholera bacteria

(A) produce the cholera toxin, an oligomeric complex made up of six protein subunits, which leads to secretion of H_2O, Na^+, K^+, Cl^-, and HCO_3^- into the lumen of the small intestine leading to profuse diarrhea and rapid dehydration.

(B) produce the cholera toxin, a concoction of chemicals which leads to secretion of H_2O, Na^+, K^+, Cl^-, and HCO_3^- into the lumen of the small intestine leading to profuse diarrhea and rapid dehydration.

(C) produce the cholera toxin, a powerful antibiotic that kills all intestinal flora and leads to diarrhea for the body to expel them.

(D) produce the cholera toxin, a nephrotoxin that shuts down the kidneys and leads to diarrhea as the body's only mode of excretion.

ANSWER: A

The cholera toxin is an oligomeric complex made up of six protein subunits: a single copy of the A subunit (part A), and five copies of the B subunit (part B), connected by a disulfide bond. The five B subunits form a five-membered ring that binds to GM1 gangliosides on the surface of the intestinal epithelium cells. The A1 portion of the A subunit is an enzyme that ADP ribosylates G-proteins, while the A2 chain fits into the central pore of the B subunit ring. Upon binding, the complex is taken into the cell via receptor-mediated endocytosis. Once inside the cell, the disulfide bond is reduced and the A1 subunit is freed to bind with a human partner protein called ADP ribosylation factor 6. Binding exposes its active site, allowing it to permanently ribosylate the Gs alpha subunit of the heterotrimeric G-protein. This results in constitutive cAMP production, which in turn leads to secretion of H_2O, Na^+, K^+, Cl^-, and HCO_3^- into the lumen of the small intestine and rapid dehydration

(85) Leukemia is generally difficult to treat because

(A) it affects the blood, a liquid organ, thus precluding surgery.

(B) the question statement is false, leukemia is fully curable by treatment with platinum salts.

(C) the question statement is false, leukemia is fully curable by bone marrow transplantation.

(D) the question statement is false, leukemia is simply treated by repeated blood transfusions and bone marrow transplants.

ANSWER: A

Leukemia is a cancer of the blood or bone marrow characterized by an abnormal increase of blood cells, usually leukocytes (white blood cells). Leukemia is a broad term covering a spectrum of diseases. Leukemia is clinically and pathologically subdivided into a variety of large groups. The first division is between its acute and chronic forms, and additionally, the diseases are subdivided according to which kind of blood cell is affected. This split divides leukemia into lymphoblastic and myeloid leukemia. Acute leukemia is characterized by the rapid increase of immature blood cells. This crowding makes the bone marrow unable to produce healthy blood cells. Immediate treatment is required in acute leukemia due to the rapid progression and accumulation of the malignant cells, which then spill over into the bloodstream and spread to other organs of the body. Acute forms of leukemia are the most common forms of leukemia in children.

Chronic leukemia is distinguished by the excessive build up of relatively mature, but still abnormal, white blood cells. Typically taking months or years to progress, the cells are produced at a much higher rate than normal cells, resulting in many abnormal white blood cells in the blood. Whereas acute leukemia must be treated immediately, chronic forms are sometimes monitored for some time before treatment to ensure maximum effectiveness of therapy. Chronic leukemia mostly occurs in older people, but can theoretically occur in any age group. Most forms of leukemia are treated with medical drugs, typically combined into a multi-drug chemotherapeutic regimen. Some are also treated with radiation therapy. In some cases, a bone marrow transplant is useful.

(86) The black mamba (*Dendroaspis polylepis*) is the longest venomous snake in Africa, with its venom consisting mainly of neurotoxins. Its bite delivers about 100–120 mg of venom on average and the mortality rate is nearly 100%, unless the snakebite victim is promptly treated with antivenin. Where in South Africa are you LEAST LIKELY to encounter a black mamba in the wild?

(A) Rural KwaZulu-Natal
(B) Central Limpopo
(C) Rural outskirts of Gauteng
(D) North-West Province

ANSWER: C

The black mamba lives in Africa, from Southern Sudan south-eastwards to northern KwaZulu-Natal, then north-easterly through Botswana and Namibia to Angola and south-eastern Democratic Republic of Congo. With exceptions in Kenya and Zambia, the black mamba is not commonly found above altitudes of 1000 meters.

(87) Mongooses are notable for their resistance to snake toxins and prey on black mambas. The reason for mongoose resistance to snake venoms is that

(A) mongooses naturally produce snake antivenin in their blood.
(B) the red blood cells of mongooses contain cobalt, not iron, which does not bind snake venoms.

(C) they have mutations in their nicotinic acetylcholine receptor which prevent the neurotoxin present in snake venom from binding to the receptor.

(D) NONE of the above

ANSWER: C

Mongooses are the main predators of the black mamba. They usually prey on young snakes and eggs. Mongooses are notable due to their resistance to snake toxins. This resistance is caused by mutations in their nicotinic acetylcholine receptor. These mutations prevent the neurotoxin present in snake venom from binding to the receptor, thus preventing the associated toxicity. Because of the mongoose's resistance to mamba venom, adult mambas have trouble fighting them off, although mongooses seldom attack adult snakes as they are too large for the mammals to kill with ease.

Use the following information to answer questions 88, 89, 90, 91, 92 and 93.

A vitamin is an organic compound required as a nutrient in tiny amounts by an organism. Vitamins are classified by their biological and chemical activity, and have diverse biochemical functions.

(88) The two people credited with the discovery of vitamins and were awarded the Nobel Prize in Physiology or Medicine for this achievement are

(A) Christiaan Eijkman and Frederick Hopkins.

(B) Carl F. Cori and Gerty T. Cori.

(C) Louis Ascorbate and Robert Riboflavin.

(D) Hans Krebs and Fritz Lipmann.

ANSWER: A

That diseases could result from some dietary deficiencies was investigated by Christiaan Eijkman, who in 1897 discovered that feeding unpolished rice instead of the polished variety to chickens helped to prevent beriberi in the chickens. The following year, Frederick Hopkins postulated that some foods contained "accessory factors"—in addition to proteins, carbohydrates, fats, et cetera—that were necessary for the functions of the human body Hopkins and Eijkman were awarded the Nobel Prize in Physiology or Medicine in 1929 for their discovery of several vitamins.

(89) Which vitamin is essential for the synthesis of DNA and has led to the invention of the anticancer drug methotrexate?

(A) Vitamin B_1.

(B) Vitamin B_{12}

(C) Vitamin B_9

(D) Viamin B_3

ANSWER: C

Methotrexate is an antimetabolite and antifolate drug used in treatment of cancer, autoimmune diseases and as an abortifacient in the induction of medical abortions. It acts by inhibiting the metabolism of folic acid. It is a chemical analogue of folic acid (vitamin B_9).

(90) Eating the liver of a polar bear is lethal as it leads to an overdose of which vitamin?

(A) Cyanocobalamin
(B) Pantothenic acid
(C) Phylloquinone
(D) Retinol

ANSWER: D

Retinol, the animal form of vitamin A, is a fat-soluble vitamin important in vision and bone growth. Retinol is ingested in a precursor form; animal sources (liver and eggs) contain retinyl esters, whereas plants such as carrots contain pro-vitamin A carotenoids. Too much vitamin A in retinoid form can be harmful or fatal. The body converts the dimerized form, carotene, into vitamin A as it is needed. Therefore high levels of carotene are not toxic compared to the ester (animal) forms. The livers of certain animals, especially those adapted to polar environments, often contain amounts of vitamin A that would be toxic to humans. Thus, vitamin A toxicity is typically reported in Arctic explorers and people taking large doses of synthetic vitamin A.

(91) Which vitamin is used in the biosynthesis of the biochemical reductant NADPH?

(A) Vitamin B_{12}
(B) Vitamin B_5
(C) Vitamin B_3
(D) NONE of the above.

ANSWER: C

Niacin, also known as vitamin B_3 or nicotinic acid, is a precursor to NAD/NADH and NADP/NADPH, which play essential metabolic roles in living cells. Niacin is involved in both DNA repair, and the production of steroid hormones in the adrenal gland.

(92) Which vitamin is a precursor to calcitriol, a hormone that regulates among other things, the concentration of calcium and phosphate in the bloodstream, promoting the healthy mineralization and growth of bones?

(A) Vitamin C
(B) Vitamin D
(C) Vitamin E
(D) Vitamin K

ANSWER: B

Calcitriol (also called 1,25-dihydroxycholecalciferol or 1,25-dihydroxyvitamin D_3, is the hormonally active form of vitamin D with three hydroxyl groups. It increases the level of calcium (Ca^{2+}) in the blood by (1) increasing the uptake of dietary calcium from the gut into the blood, (2) decreasing the transfer of calcium from blood to the urine by the kidney, and (3) increasing the release of calcium into the blood from bone.

(93) Which vitamin, when lacking in the diet, leads to a disease classically described by "the three D's": diarrhea, dermatitis and dementia?

(A) Vitamin C
(B) Vitamin B_3

(C) Vitamin B_{12}

(D) Vitamin B_5

ANSWER: B

Pellagra is a vitamin deficiency disease most commonly caused by a chronic lack of niacin (vitamin B_3) in the diet. It is classically described by "the three D's": diarrhea, dermatitis and dementia.

(94) Which of the following is not an attribute of self-pollination by plants?

(A) It's most often seen in short-lived annual species and plants that colonize new locations.

(B) It may include *autogamy*, or *geitonogamy.*

(C) It limits the variety of progeny and may depress plant vigour.

(D) Plants adapted to self pollinate often have taller stamens than carpels.

ANSWER: D

Self-pollination occurs when pollen from one flower pollinates the same flower or other flowers of the same individual. It is thought to have evolved under conditions when pollinators were not reliable vectors for pollen transport, and is most often seen in short-lived annual species and plants that colonize new locations. Self pollination may include *autogamy*, where pollen moves to the female part of the same flower; or *geitonogamy*, when pollen is transferred to another flower on the same plant. Plants adapted to self-fertilize often have similar stamen and carpel lengths. Plants that can pollinate themselves and produce viable offspring are called self-fertile. Plants that cannot fertilize themselves are called self-sterile, a condition which mandates cross pollination for the production of offspring.

(95) The terms *anemophily* and *hydrophily* refer, respectively, to

(A) pollination by wind, and by water.

(B) clinging tightly, of seeds to ovaries, and swimming of pollen grains in the style.

(C) plant growth in rocky areas, and plant growth in water.

(D) plant death due to lack of water, and water retention by plants.

ANSWER: A

Abiotic pollination refers to situations where pollination is mediated without the involvement of other organisms. Only 10% of flowering plants are pollinated without animal assistance. The most common form of abiotic pollination, anemophily, is pollination by wind. This form of pollination is predominant in grasses, most conifers, and many deciduous trees. Hydrophily is pollination by water and occurs in aquatic plants which release their pollen directly into the surrounding water. About 80% of all plant pollination is biotic i.e., requires animals as agents.

(96) Three types of foot posture exist in mammals: (1) plantigrade, (2) digitigrade, and (3) unguligrade. The animals that exemplify these, respectively, are:

(A) Bear; cat; horse

(B) Donkey; dog; baboon

(C) Baboon, bear, cat

(D) Gorilla, horse and dog

ANSWER: A

The foot is the terminal part of the leg of a land vertebrate, on which the creature stands. In most two-footed and many four-footed animals, the foot consists of all structures below the ankle joint: heel, arch, digits, and contained bones such as tarsals, metatarsals, and phalanges; in mammals that walk on their toes and in hoofed mammals, it includes the terminal parts of one or more digits. The major function of the foot in land vertebrates is locomotion. Three types of foot posture exist in mammals: (1) plantigrade, in which the surface of the whole foot touches the ground during locomotion (e.g., human, baboon, bear), (2) digitigrade, in which only the phalanges (toes, fingers) touch the ground, while the ankle and wrist are elevated (e.g., dog, cat), and (3) unguligrade, in which only a hoof (the tip of one or two digits) touches the ground—a specialization of running animals (e.g., horse, deer). In primates the foot, like the hand, has flat nails protecting the tips of the digits, and the undersurface is marked by creases and friction-ridge patterns. In most primates the foot is adapted for grasping (i.e., is prehensile), with the first digit set at an angle from the others. The foot may be used for manipulation in addition to its use in climbing, jumping, or walking. The human foot is nonprehensile and is adapted for a form of bipedalism distinguished by the development of the stride—a long step, during which one leg is behind the vertical axis of the backbone—which allows great distances to be covered with a minimum expenditure of energy.

(97) Someone with blood group A can donate blood to all people with blood group(s)

(A) B

(B) AB and A

(C) O

(D) AB only

ANSWER: B

The human ABO blood groups were discovered by Austrian-born American biologist Karl Landsteiner in 1901. Landsteiner found that there are substances in the blood, antigens and antibodies, that induce clumping of red cells when red cells of one type are added to those of a second type. He recognized three groups—A, B, and O—based on their reactions to each other. A fourth group, AB, was identified a year later by another research team. Red cells of the A group clump with donor blood of the B group; those of the B group clump with blood of the A group; those of the AB group clump with those of the A or the B group because AB cells contain both A and B antigens; and those of the O group do not generally clump with any group, because they do not contain either A or B antigens. The application of knowledge of the ABO system in blood transfusion practice is of enormous importance, since mistakes can have fatal consequences.

Blood group AB individuals have both A and B antigens on the surface of their red blood cells (RBCs) and their blood serum does not contain any antibodies against either A or B antigen. Therefore, an individual with type AB blood can

receive blood from any group (with AB being preferable), but can donate blood only to another group AB individual.

Blood group A individuals have the A antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the B antigen. Therefore, a group A individual can receive blood only from individuals of groups A or O (with A being preferable), and can donate blood to individuals of groups A or AB.

Blood group B individuals have the B antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the A antigen. Therefore, a group B individual can receive blood only from individuals of groups B or O (with B being preferable), and can donate blood to individuals of groups B or AB.

Blood group O (or blood group zero in some countries) individuals do not have either A or B antigens on the surface of their RBCs, but their blood serum contains IgM anti-A antibodies and anti-B antibodies against the A and B blood group antigens. Therefore, a group O individual can receive blood only from a group O individual, but can donate blood to individuals of any ABO blood group (i.e., A, B, O or AB). If anyone needs a blood transfusion in a dire emergency, and if the time taken to process the recipient's blood would cause a detrimental delay, O Negative blood can be issued. Blood group O is the most common blood type throughout the world, particularly among peoples of South and Central America. Type B is prevalent in Asia, especially in northern India. Type A also is common all over the world; the highest frequency is among the Blackfoot Indians of Montana and in the Sami people of northern Scandinavia. The ABO antigens are developed well before birth and remain throughout life. Children acquire ABO antibodies passively from their mother before birth, but by three months infants are making their own—it is believed the stimulus for such antibody formation is from contact with ABO-like antigenic substances in nature. Erythroblastosis fetalis (hemolytic disease of the newborn) is a type of anemia in which the red blood cells of the fetus are destroyed by the maternal immune system because of a blood group incompatibility between the fetus and its mother, particularly in matings where the mother is type O and the father type A.

(98) The frontal lobe of the brain comprises

(A) the rearmost lobe in each cerebral hemisphere of the brain.

(B) the part of the brainstem that links the medulla oblongata and the thalamus

(C) gray matter relaying sensory information and acting as a centre for pain perception.

(D) areas concerned with behavior, learning, personality, and voluntary movement.

ANSWER: D

The frontal lobe is an area in the brain of mammals located at the front of each cerebral hemisphere and positioned anterior to (in front of) the parietal lobes and above and anterior to the temporal lobes. It is separated from the parietal lobe by the primary motor cortex, which controls voluntary movements of specific body parts. The frontal lobe contains most of the

dopamine-sensitive neurons in the cerebral cortex. The dopamine system is associated with reward, attention, long-term memory, planning, and drive.

(99) Which one of the following is under the control of the parasympathetic nervous system?

(A) Speeding up the thinking process
(B) Tension in musculature
(C) Relaxation of the blood vessels
(D) Decreased blood flow to the gut

ANSWER: D

The parasympathetic nervous system primarily modulates visceral organs such as glands. Responses are never activated en masse as in the fight-or-flight sympathetic response. While providing important control of many tissues, the parasympathetic system, unlike the sympathetic system, is not crucial for the maintenance of life. The parasympathetic nervous system is organized in a manner similar to the sympathetic nervous system. Its motor component consists of preganglionic and postganglionic neurons. Both pre- and postganglionic neurons secrete acetylcholine as a neurotransmitter, but, like sympathetic ganglion cells, they also contain other neuroactive chemical agents that function as co-transmitters.

Parasympathetic nerve fibers regulate the iris and lens of the eye. Various secretory glands located in the head are under parasympathetic control. These include the lacrimal gland, which supplies tears to the cornea of the eye; salivary glands (sublingual, submandibular, and parotid glands), which produce saliva; and nasal mucous glands, which secrete mucus throughout the nasal air passages. The parasympathetic preganglionic neurons that regulate these functions originate in the reticular formation of the medulla oblongata. Preganglionic parasympathetic fibres of the 10th cranial (vagus) nerve arise from two different sites in the medulla oblongata. Neurons that slow heart rate arise from a part of the ventral medulla called the nucleus ambiguus, while those that control functions of the gastrointestinal tract arise from the dorsal vagal nucleus. After exiting the medulla in the vagus nerve and traveling to their respective organs, the fibers synapse on ganglion cells embedded in the organs themselves. The vagus nerve also contains visceral afferent fibers that carry sensory information from organs of the neck (larynx, pharynx and trachea), chest (heart and lungs), and gastrointestinal tract into a visceral sensory nucleus located in the medulla called the solitary tract nucleus. The parasympathetic system activates digestive processes while the sympathetic system inhibits them. The sympathetic system inhibits digestive processes by two mechanisms: (1) contraction of circular smooth muscle sphincters located in the distal portion of the stomach (pyloric sphincter),small intestine (ileo-cecal sphincter), and rectum (internal anal sphincter), which act as valves to prevent the oral-to-anal passage (as well as reverse passage) of digestive products; and (2) inhibition of motor neurons throughout the length of the gut. In contrast, the parasympathetic system provides messages only to myenteric motor neurons.

(100) Depending on the temperature in the room you are writing this exam in, you might be shivering because it is cold, or sweating because it is too warm (or just having cold sweats because of nervousness). The part of your brain responsible for this is

(A) the medulla oblongata
(B) the pituitary gland
(C) the pons
(D) None of the above

ANSWER: D

The part of the brain that performs this function is the cerebral cortex. This is a sheet of neural tissue outermost to the cerebrum of the mammalian brain. It plays a key role in memory, attention, perceptual awareness, thought, language and consciousness.

The medulla oblongata is the lower half of the brainstem. It contains the cardiac, respiratory, vomiting and vasomotor centers and deals with autonomic, involuntary functions, such as breathing, heart rate and blood pressure.

The pons contains nuclei that relay signals from the forebrain to the cerebellum, along with nuclei that deal primarily with sleep, respiration, swallowing, bladder control, hearing, equilibrium, taste, eye movement, facial expressions, facial sensation and posture.

The pituitary gland, or hypophysis, is an endocrine gland at the bottom of the hypothalamus at the base of the brain. It secretes nine hormones that regulate homeostasis.

Study the following Table on hormones and their physiological functions carefully and answer questions 101, 102, 103, 104 and 105. Please note that the functions of these hormones may be mismatched.

Hormone	**Function**
Insulin	Stops the use of fat as an energy source by inhibiting glycogenolysis.
Adrenaline	Increases blood glucose and fatty acids, providing substrates for energy production within cells throughout the body
Follicle Stimulating Hormone	Stimulates the maturation of germ cells in both males and females.
Growth Hormone	Increases calcium retention and protein synthesis, and promotes gluconeogenesis in the liver.
Thyroxine	Regulates protein, fat and carbohydrate metabolism and increase the body's sensitivity to catecholamines.

(101) Which hormone(s) in the above table, have their biological function INCORRECTLY listed?

(A) Adrenaline
(B) Growth Hormone and Thyroxine
(C) Insulin and Follicle Stimulating Hormone.
(D) NONE of the above.

ANSWER: D

The table contains hormones correctly matched to their functions.

(102) Which hormone in the options below is structurally classified as a catecholamine?

(A) Adrenaline
(B) Thyroxine
(C) Follicle Stimulating Hormone
(D) Growth Hormone

ANSWER: A

Epinephrine and norepinephrine, also called adrenaline and noradrenaline, are two separate but related hormones secreted by the medulla of the adrenal glands. They are also produced at the ends of sympathetic nerve fibres, where they serve as chemical mediators for conveying the nerve impulses to effector organs. Chemically, the two compounds differ only slightly; and they exert similar pharmacological actions, which resemble the effects of stimulation of the sympathetic nervous system. They are, therefore, classified as sympathomimetic agents. The systematic chemical name os adrenaline is *(R)*-4-(1-hydroxy-2-(methylamino)ethyl)benzene-1,2-diol. Benzene diols (with the two hydroxyl groups on neighboring carbons, i.e.,1,2-diols) are called catechols.

(103) Frederick Sanger was awarded the 1958 Nobel Prize in Chemistry for the elucidation of the structure of which hormone?

(A) Growth Hormone
(B) Insulin
(C) Follicle Stimulating Hormone
(D) Thyroxine

ANSWER: B

Frederick Sanger (born Aug. 13, 1918), is an English biochemist who was twice the recipient of the Nobel Prize for Chemistry. He was awarded the prize in 1958 for his determination of the structure of the insulin molecule, (a polypeptide composed of 51 amino acids). He shared the prize (with Paul Berg and Walter Gilbert) in 1980 for his determination of base sequences in nucleic acids.

(104) Which one of the following hormones, when deficient in a human being, leads to fatigue decreased energy, depressed mood, decreased muscle strength, decreased muscle mass, thin and dry skin, increased adipose tissue, and decreased bone density?

(A) Adrenaline
(B) Thyroxine
(C) Insulin
(D) Growth Hormone

ANSWER: D

Growth hormone (GH), also called somatotropin, is a peptide hormone that stimulates growth, cell reproduction and regeneration in humans and other animals. It stimulates the growth of essentially all tissues of the body, including bone. Growth hormone is a 191-amino acid, single-chain polypeptide that is synthesized, stored, and secreted by somatotropic cells within the lateral wings of the anterior pituitary gland. Deficiency in childhood results in stunted growth and delayed sexual maturity. In adults, deficiency is rare and results in, among others, reduced muscle mass and strength, reduced energy, reduced bone mass, impaired concentration and memory loss, and lipid abnormalities.

(105) Which of the five hormones listed in the table are peptide hormones?

(A) Adrenaline and Thyroxine
(B) Thyroxine and Growth Hormone
(C) Growth Hormone, Follicle Stimulating Hormone and Insulin
(D) Growth Hormone and Insulin

ANSWER: C

Follicle-stimulating hormone (FSH), is one of two gonadotropic hormones (*i.e.,* hormones concerned with the regulation of the activity of the gonads, or sex glands) produced by the pituitary gland. FSH is a dimeric glycoprotein Each monomeric unit is a protein molecule with a sugar attached to it; two of these make the full, functional protein. The protein dimer contains 2 polypeptide units, labeled alpha and beta subunits. The alpha subunit and contains 92 amino acids. The beta subunit has 111 amino acids (FSH β), which confers its specific biologic action and is responsible for interaction with the FSH receptor. The sugar part of the hormone is composed of fucose, galactose, mannose, galactosamine, glucosamine and sialic acid. FSH, operating in conjunction with luteinizing hormone (LH), stimulates development of the graafian follicle, a small, egg-containing vesicle in the ovary of the female mammal; in the male, it promotes the development of the tubules of the testes and the differentiation of sperm. Though in the male the presence of FSH is necessary for the maturation of spermatozoa, additional FSH may not be required for months because testosterone can maintain this activity

Alzheimer's disease is a degenerative brain disorder that develops in mid-to-late adulthood. It results in a progressive and irreversible decline in memory and a deterioration of various other cognitive abilities. Given this information, please answer questions 106, 107, 108, 109 and 110 below.

(106) Which of the following is TRUE about Alzheimer's disease?

(i) It is a protein misfolding disease caused by accumulation of abnormally folded amyloid proteins in the brain
(ii) It is characterized by loss of neurons and synapses in the cerebral cortex and certain subcortical regions.
(iii) Progressive deterioration eventually hinders independence, with subjects being unable to perform most common activities of daily living.

(A) (i) and (ii)
(B) (ii) and (iii)
(C) (i) and (iii)
(D) (i), (ii) and (iii)

ANSWER: D

All the statements about Alzheimer's disease listed above, are true.

(107) Several medications are available by prescription to treat the symptoms of Alzheimer's disease. Which one of the following classes of medications is NOT used in Alzheimer's?

(A) *N*-methyl-d-aspartate receptor antagonists.
(B) Acetylcholine esterase inhibitors
(C) Protein synthesis inhibitors
(D) Antipsychotic drugs.

ANSWER: C

Five medications are currently used to treat the cognitive manifestations of AD: four are acetylcholinesterase inhibitors (tacrine, rivastigmine, galantamine and donepezil) and the other (memantine) is an *N*-methyl-d-aspartate receptor antagonists. Antipsychotic drugs are modestly useful in reducing aggression and psychosis in Alzheimer's disease with behavioral problems, but are associated with serious adverse effects.

(108) One way to confirm Alzheimer's disease diagnosis is through the use of imaging techniques such as SPECT. What does this stand for?

(A) Single photon emission computed tomography.
(B) Simple positron ejection computed tomography.
(C) Simple photovoltaic elucidated computer tomography.
(D) None of the above.

ANSWER: A

Single photon emission computed tomography (SPECT) is an imaging technique used in biomedical research and in diagnosis. SPECT is similar to positron emission tomography (PET), in which a compound labeled with a positron-emitting radionuclide is injected into the body; however, its pictures are not as detailed as those produced using PET. SPECT is much less expensive than PET because the tracers it uses have a longer half-life and do not require an accelerator nearby to produce them. It can be used to diagnose or evaluate a wide range of conditions, including diseases of the heart, cancer and injuries to the brain.

(109) The vast majority of cases of Alzheimer's disease are sporadic. What does this mean?

(A) The disease is not generally genetic.
(B) The disease starts in another part of the body then ends up in the brain.
(C) The disease is caused by the accumulation of antibiotics in the blood-brain barrier which cause genetic mutations later in life.
(D) None of the above

ANSWER: A

A sporadic disease is one that does not run in families, i.e., it is not genetic.

(110) Caring for an Alzheimer's patient at home puts a great burden and stress on the caregiver. Which one of the following is not one of the concerns for such caregivers?

(A) Giving up one's career.
(B) Withdrawing from most social activities to be home all the time.
(C) Advocating for more funding for research into the disease.
(D) Advocating for euthanasia for those in the advanced stages of the disease.

ANSWER: D

Euthanasia, also called mercy killing , act or practice of painlessly putting to death persons suffering from painful and incurable disease or incapacitating physical disorder or allowing them to die by withholding treatment or withdrawing artificial life-support measures. Because there is no specific provision for it in most legal systems, it is usually regarded as either suicide (if performed by the patient himself) or murder (if performed by another). A physician may, however, lawfully decide not to prolong life in cases of extreme suffering, and he may administer drugs to relieve pain even if this shortens the patient's life.

Enzymes are large biological molecules responsible for the thousands of chemical transformations that sustain life. They are highly selective catalysts, greatly accelerating both the rate and specificity of metabolic reactions. Use this information to answer questions (111), (112), (113), (114) and (115).

(111) Which of the following is TRUE about enzymes?

(A) Enzymes do they alter the equilibrium of reactions they catalyze.
(B) Enzymes are mainly globular proteins but some are RNA.
(C) To generate the name of an enzyme, the suffix *-ase* is added to the name of its substrate.
(D) ALL of the above are TRUE.

ANSWER: D

All the statements above, about enzymes, are true. The biological processes that occur within all living organisms are chemical reactions, and most are regulated by enzymes. Without enzymes, many of these reactions would not take place at a perceptible rate. Enzymes catalyze all aspects of cell metabolism. This includes the digestion of food, in which large nutrient molecules (such as proteins, carbohydrates, fats and nucleic acids) are broken down into smaller molecules, as well as building of these and the interconversion of their building blocks (amino acids to sugars, and sugars to fats), among many others.

(112) Who is/are the first person(s) to prove the existence of enzymes?

(A) Eduard Buchner
(B) Hans Adolf Krebs
(C) Melvin Calvin

(D) Leonor Michaelis and Maud Menten

ANSWER: A

In 1897, Eduard Buchner submitted his first paper on the ability of yeast extracts that lacked any living yeast cells to ferment sugar. In a series of experiments, he found that the sugar was fermented even when there were no living yeast cells in the mixture. He received the 1907 Nobel Prize in Chemistry "for his biochemical research and his discovery of cell-free fermentation". Enzymes are usually named according to the reaction they carry out. Typically, to generate the name of an enzyme, the suffix *-ase* is added to the name of its substrate (e.g., lactase for the enzyme that hydrolyzes lactose) or the type of reaction it catalyzes (e.g., DNA polymerase forms DNA polymers).

Sir Hans Adolf Krebs, (born Aug. 25, 1900, Hildesheim, Germany.—died Nov. 22, 1981, Oxford, England.), was a German-born British biochemist who received (with Fritz Lipmann) the 1953 Nobel Prize for Physiology or Medicine for the discovery in living organisms of the series of chemical reactions known as the tricarboxylic acid cycle (also called the citric acid cycle, or Krebs cycle). These reactions involve the conversion—in the presence of oxygen—of substances that are formed by the breakdown of sugars, fats, and protein components to carbon dioxide, water, and energy-rich compounds.

Melvin Calvin,(born April 8, 1911, St. Paul, Minnesota, U.S.—died January 8, 1997, Berkeley, California), was an American biochemist who received the 1961 Nobel Prize for Chemistry for his discovery of the chemical pathways of photosynthesis.

Leonor Michaelis was a German biochemist, and Maud Menten a Canadian biochemist and the two of them worked together and formulated one of the simplest and best-known models of enzyme kinetics. Called the Michaelis-Menten enzyme kinetics model, it takes the form of an equation describing the rate of enzymatic reactions, by relating reaction rate v to [S], the concentration of a substrate. .

(113) Enzymes adopt a specific three dimensional structure and may employ organic and inorganic cofactors to assist in catalysis. Which one of the following is not a common inorganic factor in enzymes?

(A) Zn
(B) Mn
(C) Mo
(D) Sc

ANSWER: D

Scandium (Sc; atomic number 21) is a rare-earth metal present in most of the deposits of rare earth and uranium compounds, but it is extracted from these ores in only a few mines worldwide. Because of the low availability and the difficulties in the preparation of metallic scandium, which was first done in 1937, it took until the 1970s before applications for scandium were developed. The positive effects of scandium on aluminum alloys were discovered in the 1970s, and its use in such alloys remains its only major application. The global trade of the pure metal is around a hundred pounds a year on average. Scandium has no known biological function.

(114) Enzymes activity can be inhibited, either reversibly, or irreversibly. Which of the following is FALSE?

(A) In competitive inhibition, the substrate and inhibitor *compete* for access to the enzyme's active site.
(B) In mixed inhibition, the inhibitor binds to a different site on an enzyme called the allosteric site, which changes the conformation of the enzyme so that the affinity of the substrate for the active site is reduced.
(C) Irreversible inhibition is different from irreversible enzyme inactivation in that the inhibitors are generally specific for one class of enzyme active site and do not inactivate all proteins.
(D) NONE of the above is FALSE.

ANSWER: D

All the statements above are true.

(115) Which of the following medical drugs work by inhibiting enzymes?

(A) cis-Platin, used in the treatment of cancer.
(B) Fuzeon, used in the treatment of HIV-AIDS
(C) Artemisinin, used in the treatment of malaria.
(D) NONE of the above.

ANSWER: D

cis-Platin [chemical formula *cis*-$PtCl_2(NH_3)_2$] binds to and causes crosslinking of DNA, which ultimately triggers apoptosis (programmed cell death).

Fuzeon (Enfuvirtide) works by disrupting the HIV-1 molecular machinery at the final stage of fusion with the target cell, preventing uninfected cells from becoming infected. It is a peptide molecule and was designed to mimic components of the HIV-1 fusion machinery and displace them, preventing normal fusion. Drugs that disrupt fusion of virus and target cell are termed entry inhibitors.

Chemically, artemisinin is a sesquiterpene lactone containing an unusual peroxide bridge. This peroxide is believed to be responsible for the drug's mechanism of action. Although there is no consensus regarding the mechanism through which artemisinin and its derivatives kill the parasites, several lines of evidence indicate that artemisinins exert their antimalarial action by perturbing redox homeostasis in malaria parasites.