



**45th NATIONAL BIOLOGY OLYMPIAD
BIOLOGY; 5th MARCH 2009
DETAILED ANSWERS**

The answers in this booklet have been compiled from a variety of sources, mainly WIKIPEDIA, as well as Encyclopaedia Britannica and a variety of textbooks.

1. Which of the following is not a component of DNA
- A. Adenine
 - B. Uracil
 - C. Guanine
 - D. Phosphate

ANSWER: B

Uracil is found in RNA and complementarily pairs with adenine through hydrogen bonding. It replaces thymine during DNA transcription. Methylation of uracil by the enzyme thymidylate synthase produces thymine, a base found in DNA. Uracil can base pair with any of the bases depending on how the molecule arranges itself on the helix but readily pairs with adenine because the methyl group is repelled into a fixed position. In the Uracil/Adenine base pair, Uracil is the hydrogen bond acceptor and can form two hydrogen bonds. Uracil can also bind with a ribose sugar to form a ribonucleoside called. When a phosphate attaches to uridine, uridine 5'-monophosphate is produced.

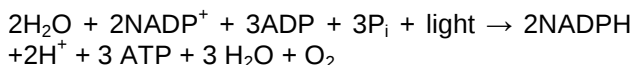
When fluorine is reacted with uracil, 5-fluorouracil is produced. This compound is an anticancer drug sold under the trade names sold under the brand names Adrucil, Carac, Efudex and Fluoroplex. It closely resembles uracil itself and gets erroneously inserted into the growing RNA chain during replication. This then halts transcription. More importantly, 5-fluorouracil blocks the activity of the enzyme thymidylate synthase. Because 5-Fluorouracil is similar in shape to, but does not perform the same chemistry as uracil, the drug retards the activity of RNA synthesis enzymes, thereby stopping the growth of cancerous cells.

2. Which of following processes are involved in photosynthesis?
- A. Reduction of NADP to NADPH
 - B. Capturing Light Energy

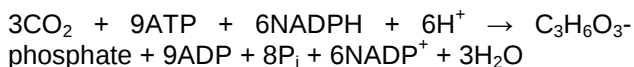
- C. Generation of ATP
- D. All of the above

ANSWER: D

In the light-dependent reactions during photosynthesis, one molecule of chlorophyll absorbs one photon and loses one electron. This electron is passed to a modified form of chlorophyll called pheophytin, which passes the electron to a quinone molecule, allowing the start of a flow of electrons down an electron transport chain that leads to the ultimate reduction of NADP to NADPH. In addition, this creates a proton gradient across the chloroplast membrane; its dissipation is used by ATP synthase for the concomitant synthesis of ATP. The chlorophyll molecule regains the lost electron from a water molecule through a process called photolysis, which releases an oxygen (O₂) molecule. The overall equation for the light-dependent reactions under the conditions of non-cyclic electron flow in green plants is:



In the light-independent or dark reactions, the enzyme RuBisCO captures CO₂ from the atmosphere and in a process that requires the newly formed NADPH, called the Calvin-Benson Cycle, releases three-carbon sugars, which are later combined to form sucrose and starch. The overall equation for the light-independent reactions in green plants is



3. The site of photosynthesis in a chloroplast is the
- A. Stroma
 - B. Thylakoids
 - C. Plastoglobule
 - D. Ribosome

ANSWER: B

In plants and algae, photosynthesis takes place in organelles called chloroplasts. A typical plant cell contains about 10 to 100 chloroplasts. The chloroplast is enclosed by a membrane. This membrane is composed of a phospholipid inner membrane, a phospholipid outer membrane, and an intermembrane space between them. Within the membrane is an aqueous fluid called the stroma. The stroma contains stacks (grana) of thylakoids, which are the site of photosynthesis. The thylakoids are flattened disks, bounded by a membrane with a lumen or thylakoid space within it. The site of photosynthesis is the thylakoid membrane, which contains integral and peripheral membrane protein

complexes, including the pigments that absorb light energy, which form the photosystems.

4. Which of the following options are correct: Insulin is produced in the (i) pituitary gland (ii) islets of Langerhans and is responsible for the (iii) uptake of sugar (iv) release of sugar from tissues.

- A. i and iii
- B. ii and iii
- C. i and iv
- D. ii and iv

ANSWER: B

Insulin is a peptide hormone composed of 51 amino acids and has a molecular weight of 5808 Daltons. It is produced in the islets of Langerhans in the pancreas. Insulin causes cells in the liver, muscle and fat tissue to take up glucose from the blood, storing it as glycogen in the liver and muscle, and stopping use of fat as an energy source. When insulin is absent (or low), glucose is not taken up by body cells, and the body begins to use fat as an energy source, for example, by transfer of lipids from adipose tissue to the liver for mobilization as an energy source. When control of insulin levels fails, it results in the disease diabetes mellitus.

5. Which of the following characteristics are primary characteristics of a dicotyledon (i) adventitious root formation, (ii) two seed leaves, and (iii) reticulated leaf veins?

- A. i and ii
- B. i and iii
- C. ii and iii
- D. i, ii and iii

ANSWER: C

Aside from cotyledon number (in seeds), other broad differences have been noted between monocots and dicots. The flower parts in monocots are multiples of three while in dicots are multiples of four or five. In monocots, the stem vascular bundles are scattered, while in dicots they are in a ring. In monocots, stems rarely show secondary growth; in dicots, stems frequently have secondary growth. In monocots, pollen has one furrow or pore while in dicots they have three. The roots are adventitious in monocots, while in dicots they develop from the radicle. Lastly, in monocots, the major leaf veins are parallel, while in dicots they are reticulated.

6. The tube used for pressure equalization and mucus drainage in the inner ear is known as the...

- A. Fallopian tube
- B. Tracheal tube
- C. Eustachian tube
- D. None of the above

ANSWER: C

The *Eustachian tube* (also called the auditory tube or pharyngotympanic tube) is a tube that links the pharynx to the middle ear. In adults the Eustachian tube is approximately 35 mm long. It is named after the sixteenth century Italian anatomist Bartolomeo Eustachio. Normally the human Eustachian tube is closed, but it can open to let a small amount of air through to equalize the pressure between the middle ear and the atmosphere. The Eustachian tube also drains mucus from the middle ear. Upper airway infections or allergies can cause the Eustachian tube to become swollen, trapping bacteria and causing ear infections. Earaches (otitis) are more common in children because the tube is more horizontal, shorter and has a smaller floppier opening, making the movement of fluid more difficult.

The *Fallopian tubes*, (named after Gabriele Fallopio, an Italian anatomist and physician of the sixteenth century), are two very fine tubes lined with cilia, leading from the ovaries of female mammals into the uterus. The tube connects the ovary to the uterus as the egg passes through it in a woman's body. Its different segments are the infundibulum with its fimbriae near the ovary, the ampullary region that represents the major portion of the lateral tube, the isthmus which is the narrower part of the tube that links to the uterus, and the interstitial part that transverses the uterine musculature. When an ovum is developing in an ovary, it is encapsulated in a sac known as an ovarian follicle. On maturity of the ovum, the follicle and the ovary's wall rupture, allowing the ovum to escape. The egg is caught by the fimbriated end of the Fallopian tube and travels to the ampulla where typically the sperm are met and fertilization occurs; the fertilized ovum, now a zygote, travels towards the uterus aided by activity of tubal cilia and activity of the tubal muscle. After about five days the embryo enters the uterine cavity and implants about a day later.

In vertebrates, the *trachea*, or windpipe, is a tube that connects to the pharynx or larynx, allowing the passage of air to the lungs. It is lined with ciliated cells and with mucosal cells which produce This mucus lines the cells of the trachea to trap inhaled foreign particles which the cilia then waft upwards towards their larynx and then the pharynx where it can either be swallowed into the stomach or expelled as phlegm. In invertebrates trachea refers to the open respiratory system composed of spiracles, tracheae, and tracheoles that land based arthropods have evolved to transport gases to and from tissues. The smallest tubes, tracheoles,

penetrate cells and serve as sites of diffusion for water, oxygen, and carbon dioxide. Gas may be conducted through the respiratory system by means of active ventilation or passive diffusion.

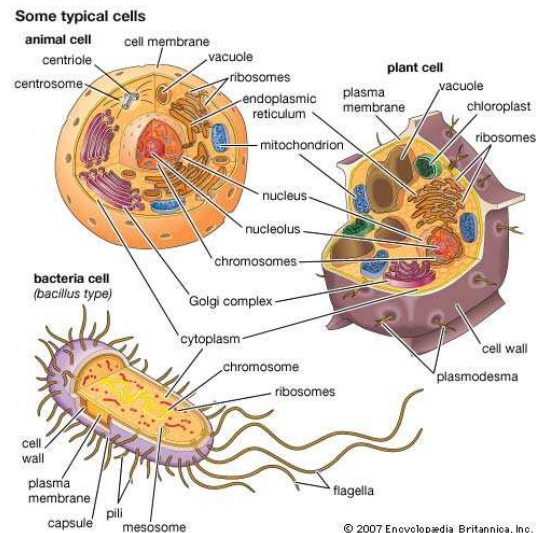
7. The fundamental differences between a plant and animal cell are (i) the presence of a cell wall (ii) large vacuoles and (iii) the presence of mitochondria.

- A. i and ii
- B. i and iii
- C. ii and iii
- D. i, ii and iii

ANSWER: A (Encyclopaedia Britannica)

Depicted below are some typical cells found in nature. Animal cells do not contain chloroplasts and cell walls and they have smaller vacuoles. Plant cells are quite different from the cells of the other eukaryotic organisms. Their distinctive features are:

- (i) a large central vacuole (enclosed by a membrane, the tonoplast), which maintains the cell's turgor and controls movement of molecules between the cytosol and sap,
- (ii) a primary cell wall containing cellulose, hemicellulose and pectin, deposited by the protoplast on the outside of the cell membrane; this contrasts with the cell walls of fungi, which contain chitin, and that of bacteria, in which peptidoglycans are the main structural molecules;
- (iii) the plasmodesmata, linking pores in the cell wall that allow each plant cell to communicate with other adjacent cells; this is different from the functionally analogous system of gap junctions between animal cells.
- (iv) plastids, especially chloroplasts, that contain chlorophyll, the pigment that gives plants their green colour and allows them to perform photosynthesis;
- (v) higher plants, including conifers and Angiosperms lack the flagella and centrioles that are present in animal cells.



8. Pellagra is disease which results from a deficiency in protein and vitamin...

- A. Vitamin B1
- B. Vitamin B2
- C. Vitamin B3
- D. Vitamin B12

ANSWER: C

Pellagra is a deficiency disease most commonly caused by a chronic lack of niacin (vitamin B₃) in the diet. It may result from deficiency of tryptophan an essential amino acid that the body converts to niacin. It may also result from alterations in protein metabolism in disorders such as carcinoid syndrome. The most common symptoms are "the three D's": diarrhoea, dermatitis, and dementia. Niacin is converted to nicotinamide and then to NAD and NADP in the body. NAD⁺ is a coenzyme found in all living cells. NAD⁺ is involved in redox reactions, carrying electrons from one reaction to another. These electron transfer reactions are the main function of NAD⁺. However, it is also used in other cellular processes, notably as a substrate of enzymes that add or remove chemical groups from proteins during post-translational modifications. Because of the importance of these functions, the enzymes involved in NAD⁺ metabolism are targets for medical drug discovery.

9. The common name for fungi that decompose the lignin component of wood is...

- A. white rot fungi
- B. brown rot fungi
- C. green rot fungi
- D. yellow rot fungi

ANSWER: B

Dry rot (or brown rot) refers to the decay of timber in buildings and other wooden structures caused by

certain fungi. Dry rot fungi decay cellulose in wood leaving behind the lignin as the brown crumbly remains.

10. Chondrogenesis refers to the stage of embryo development when of the following occurs:

- A. blood vessel development
- B. organ development
- C. bone development
- D. cartilage development

ANSWER: D

Chondrification (also known as chondrogenesis) is the process by which cartilage is formed from condensed mesenchyme tissue, which differentiates into chondrocytes and begins secreting the molecules that form the extracellular matrix. Early in foetal development, the greater part of the skeleton is cartilaginous. This temporary cartilage is gradually replaced by bone, a process that ends at puberty. In contrast, the cartilage in the joints remains unossified during the whole of life and is, therefore, permanent.

11. Consider a relationship between an organism of one species living in conjunction with another organism from a different species. If one organism is granted an advantage from this mutualistic growth while not granting any advantage or disadvantage to the second organism, this is known as...

- A. Parasitism
- B. Commensalism
- C. Mutualism
- D. Symbiotism

ANSWER: B

In ecology, commensalism is a class of relationship between two organisms where one organism benefits but the other is unaffected. There are three other types of association: mutualism (where both organisms benefit), competition (where both organisms are harmed), and parasitism (one organism benefits and the other one is harmed). A well known example of mutualism is the relationship between ungulates (such as cows) and bacteria within their rumens. The ungulates benefit from the cellulase produced by the bacteria, which facilitates plant matter digestion; the bacteria benefit from having a stable supply of nutrients within the host animal. Classic examples of parasitism include bacterial infections and interactions between vertebrate hosts and diverse animals such as tapeworms, flukes, malaria parasites (*Plasmodium*) and fleas.

12. The main classification of teeth found in herbivores is:

- A. Incisors
- B. Canines
- C. Molars
- D. Shearers

ANSWER: C

The shape of the animal's teeth is related to its diet. For example, plant matter is hard to digest, so herbivores have many molars for chewing/grinding. Carnivores, on the other hand, need canines to kill prey and to tear meat. Omnivores such as humans will have all four types of teeth; incisors for cutting, canines, premolars and molars for grinding.

13. The largest species of fish in the world is...

- A. Blue Whale
- B. Ocean Sunfish
- C. Whale Shark
- D. Beluga Sturgeon

ANSWER: C

Sharks are a type of fish with a full cartilaginous skeleton (their skeletons are made of cartilage, not bone, hence the class: Chondrichthyes). Sharks are diverse, with 440 species, ranging in size from the small dwarf lantern shark, *Etmopterus perryi*, a deep sea species of only 17 centimetres in length, to the whale shark, *Rhincodon typus*, the largest fish, which reaches approximately 12 metres and which feeds only on plankton, squid and small fish through filter feeding.

Whales are not fish but marine mammals. The blue whale (*Balaenoptera musculus*) belongs to the suborder of baleen whales called Mysticeti. At up to 33 meters in length and 180 metric tons in weight, it is the largest animal on the planet.

The beluga or European sturgeon (*Huso huso*) is a species of fish in the sturgeon family (Acipenseridae). It is found primarily in the Caspian and Black sea basins, and occasionally in the Adriatic sea. These fish may reach a length of up to 8.6 m and weigh as much as 2,700 kg. However, Beluga of such great sizes are always very old (continuing to grow throughout life) and have become increasingly rare in recent decades due to the heavy fishing of this species. Today, Belugas that are caught are generally 142–328 cm long and weigh 19–264 kg. The female beluga is typically 20% larger than the male. These fish are heavily fished for the female's valuable roe,—known as beluga caviar.

The ocean sunfish, *Mola mola*, is the heaviest known bony fish in the world. It has an average adult weight of 1,000 kg and length of 1.8 m. The species is native to tropical and temperate waters around the

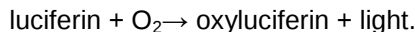
globe. It resembles a fish head with a tail, and its main body is flattened laterally. Sunfish can be as tall as they are long when their dorsal and ventral fins are extended.

14. The enzyme used to create light, termed bioluminescence, in biological organisms such as fireflies is known as...

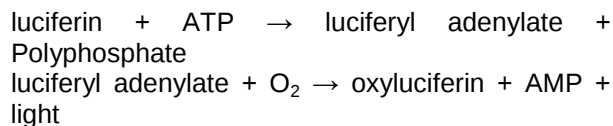
- A. Luminol
- B. Luminase
- C. Helioase
- D. Luciferase

ANSWER: D

Luciferase is a generic term for the class of oxidative enzymes used in bioluminescence and is distinct from a photoprotein. One famous example is the firefly luciferase from the firefly *Photinus pyralis*. In luminescent reactions, light is produced by the oxidation of a luciferin, (a pigment):



The most common luminescent reactions release CO₂ as a product. The rates of this reaction between luciferin and oxygen are extremely slow until they are catalyzed by luciferase, sometimes mediated by the presence of cofactors such as calcium ions or ATP. The reaction catalyzed by firefly luciferase takes place in two steps:



The reaction is very energetically efficient: nearly all of the energy input into the reaction is transformed into light.

15. Micro-organisms which prefer to live in extremely cold conditions are known as...

- A. Psychrophiles
- B. Thermophiles
- C. Barophiles
- D. Halophiles

ANSWER: A

A *piezophile* (also called a *barophile*) is an organism which thrives at high pressures, such as deep sea bacteria or archaea. They are generally found on ocean floor, where pressure often exceeds 380 atmospheres (38MPa). The high pressures experienced by these organisms can cause the normally fluid cell membrane to become waxy and relatively impermeable to nutrients. Evolution has forced these organisms to adapt in

novel ways to become tolerant of these pressures in order to colonize deep sea habitats.

A *thermophile* is an organism that thrives at relatively high temperatures, between 45 and 80°C.). Many thermophiles are archaea. thermophiles are found in various geothermally heated regions of the earth such as hot springs. As a prerequisite for their survival, thermophiles contain enzymes that can function at high temperature. Some of these enzymes are used in molecular biology (for example, heat-stable DNA polymerases for polymerase chain reactions), and in washing agents.

Psychrophiles or *Cryophiles* are extremophilic organisms that are capable of growth and reproduction in cold temperatures. They can be contrasted with thermophiles, which thrive at unusually hot temperatures. The environments they inhabit are ubiquitous on Earth, as a large fraction of our planetary surface experiences temperatures lower than 15°C. They are present in alpine and arctic soils, polar ice and glaciers. Psychrophiles, most of which are archaea or bacteria, are characterized by lipid cell membranes chemically resistant to the stiffening caused by extreme cold, and often create protein 'antifreezes' to keep their internal space liquid and protect their DNA even in temperatures below water's freezing point.

Halophiles are extremophile organisms that thrive in environments with very high concentrations of salt. In order to survive the high salinities, halophiles employ two differing strategies to prevent desiccation through osmotic movement of water out of their cytoplasm. Both strategies work by increasing the internal osmolarity of the cell. In the first (that is employed by the majority of bacteria, some archaea, yeasts and algae), organic compounds are accumulated in the cytoplasm. The second, more radical, adaptation involves the selective influx of potassium (K⁺) ions into the cytoplasm.

16. Pores, located on the underside of leaves are known as...

- A. Peduncles
- B. Polypores
- C. Stomata
- D. Vestibules

ANSWER: C

The *peduncle* is a stem, usually green and without leaves, though sometimes coloured or supporting small leaves. The peduncle may be ramified, in which case the ramifications are called pedicels.

Polypores are a group of tough, leathery poroid mushrooms similar to boletes, but typically lacking a distinct stalk. Polypores are often found on rotting logs, and are rot-resistant to the extent that they themselves often last long enough for moss to grow

on them. Rot-resistance is due to the mushroom's ability to produce compounds with anti-pathogenic activity.

Stomata are pores found in the leaf and stem epidermis and are used for gaseous exchange. The pore is bordered by a pair of specialized parenchyma cells known as guard cells which are responsible for regulating the size of the opening. Air containing carbon dioxide and oxygen enters the plant through these openings where it is used in photosynthesis and respiration, respectively. Oxygen produced by photosynthesis in the spongy layer cells (parenchyma cells with pectin) of the leaf interior exits through these same openings. Also, water vapor is released into the atmosphere through these pores in a process called transpiration. Dicotyledons usually have more stomata on the lower epidermis than the upper epidermis. Monocotyledons, on the other hand, usually have the same number of stomata on the two epidermises. In plants with floating leaves, stomata may be found only on the upper epidermis; submerged leaves may lack stomata entirely.

17. Which of the following plants are not an invasive species?

- A. Silver Wattle
- B. Jacaranda
- C. Water Hyacinth
- D. Aloe

ANSWER: D

Invasive species are non-indigenous species (e.g. plants or animals) that adversely affect the habitats they invade economically, environmentally or ecologically. It has been used in this sense by government organizations as well as conservation groups. Thus, in the South African context, aloes are not invasive as they are native to Africa and is common in the Cape and in the mountains of tropical Africa. Aloe is a genus containing about four hundred species of flowering succulent plants. The most common and well known of these is *Aloe vera*.

Jacaranda is a genus of 49 species of flowering plants in the family Bignoniaceae, native to tropical and subtropical regions of South (especially Brazil) and Central America. Several species are widely grown as ornamental plants throughout the subtropical regions of the world, valued for their intense flower displays. Pretoria is popularly known as The Jacaranda City due to the enormous number of Jacaranda trees planted as street trees and in parks and gardens. In flowering time the city appears blue/purple in colour when seen from the nearby hills because of all the Jacaranda trees.

Silver wattle is the common name of two plant species; *Acacia sclerosperma*, and *Acacia dealbata* both in the family Fabaceae. Both are trees native to Australia. *Acacia sclerosperma* occurs on floodplains and along water-courses throughout the arid north-west corner of Western Australia. *Acacia dealbata* is most common in the southeastern Australia and is widely cultivated as an ornamental plant in warm temperate regions of the world. It is a fast growing evergreen tree growing up to 30 m tall, typically a pioneer species after fire. The leaves are bipinnate, glaucous blue-green to silvery grey, and the flowers are produced in large racemose inflorescence made up of numerous smaller globose bright yellow flowerheads.

Water hyacinth is a free-floating perennial aquatic plant native to tropical South America. With broad, thick, glossy, ovate leaves, water hyacinth may rise above the surface of the water as much as 1 meter in height. The leaves are 10–20 cm across, and float above the water surface. They have long, spongy and bulbous stalks. The feathery, freely hanging roots are purple-black. An erect stalk supports a single spike of 8-15 conspicuously attractive flowers, mostly lavender to pink in colour with six petals.

18. Which of the following sources of energy are not currently being studied as an alternative for fossil fuels?

- A. Bio-ethanol
- B. Bio-diesel
- C. Hydrogen
- D. Helium

ANSWER: D

Helium (He) is the element with atomic number 2 and an atomic weight of 4.0026. It is a colorless, odorless, tasteless, non-toxic, inert monoatomic gas that appears top in the noble gas group (8 or 18) in the periodic table. Its boiling and melting points are the lowest among the elements and it exists only as a gas except in extreme conditions. Next to hydrogen, it is the second most abundant element in universe, and accounts for 24% of the elemental mass of our galaxy. Because it is inert, it has no value as a fuel.

19. Arrange the following in increasing order of complexity: (i) organ, (ii) tissue, (iii) cell, (iv) system

- A. ii, iii, iv, i
- B. iii, ii, i, iv
- C. iii, i, ii, iv
- D. i, iii, iv, ii

ANSWER: B

The vertebrate body consists of biological systems which are constituted by organs which are made of tissues, which in turn are made of cells; all anchored on a bony or cartilaginous skeleton with connective tissue. An example of an organ system is the nervous system which is responsible for collecting, transferring and processing information. It comprises the brain, the spinal cord, peripheral nerves and nerves. The nervous system is primarily made up of two categories of cells: neurons and glial cells.

20. Which one of the following hormones is not involved in the menstrual cycle:

- A. oestrogen
- B. follicle stimulating hormone
- C. prolactin
- D. progesterone

ANSWER: C

Estrogens are a group of steroid compounds, named for their importance in the estrous cycle, and functioning as the primary female sex hormone. Estrogens are produced primarily by developing follicles in the ovaries, the corpus luteum, and the placenta. Luteinizing (LH) stimulate the production of estrogen in the ovaries. Estrogens promote the development of female secondary sexual characteristics, such as breasts, and are also involved in the thickening of the endometrium and other aspects of regulating the menstrual cycle.

Progesterone is a steroid hormone involved in the female menstrual cycle, pregnancy (supports gestation) and embryogenesis of humans and other species. Progesterone is produced in the ovaries (specifically after ovulation in the corpus luteum), the adrenal glands (near the kidney), and, during pregnancy, in the placenta.

Follicle-stimulating hormone (FSH) is a glycoprotein synthesized and secreted by gonadotropes of the anterior pituitary gland in humans and other animals. FSH regulates the development, growth, pubertal maturation, and reproductive processes of the body. FSH and luteinizing hormone (LH) act synergistically in reproduction.

Prolactin or Luteotropic hormone is a peptide hormone secreted mainly by the anterior pituitary gland and is primarily associated with lactation. In breastfeeding, the act of an infant sucking the nipple stimulates the production of prolactin, which fills the breast with milk via a process called lactogenesis, in preparation for the next feed. Oxytocin, another hormone, is also released, which triggers milk let-down.

21. Which part of the brain is involved with spatial memory and has been implicated in navigation in birds?

- A. Hippocampus
- B. Cerebellum
- C. Medulla
- D. Hypothalamus

ANSWER: A

The hippocampus is a major component of the brains of humans and other mammals. It belongs to the limbic system and plays important roles in long term memory and spatial navigation. Like the cerebral cortex, with which it is closely associated, it is a paired structure, with mirror-image halves in the left and right sides of the brain. In humans and other primates, the hippocampus is located inside the medial temporal lobe, beneath the cortical surface.

The cerebellum is a region of the brain that plays an important role in motor control. It is also involved in some cognitive functions such as attention and language, and probably in some emotional functions such as regulating fear and pleasure responses, but its function in movement is the most clearly understood. The cerebellum does not initiate movement, but it contributes to coordination, precision, and accurate timing. It receives input from sensory systems and from other parts of the brain and spinal cord, and integrates these inputs to fine tune motor activity. Because of this fine-tuning function, damage to the cerebellum does not cause paralysis, but instead produces disorders in fine movement, equilibrium, posture and motor learning.

The hypothalamus is a portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine via the pituitary gland (hypophysis). The hypothalamus controls body temperature, hunger, thirst, fatigue and circadian cycles.

The medulla oblongata is the lower half of the brainstem. In discussions of neurology and similar contexts where no ambiguity will result, it is often referred to as simply the medulla. The medulla contains the cardiac, respiratory, vomiting and vasomotor centers and deals with autonomic functions, such as breathing, heart rate and blood pressure.

22. The function of the myelin sheath in a neuron is to

- A. transmit signals to other neurons
- B. increase the speed of transmission of a signal
- C. store neurotransmitters
- D. allow for gaseous exchange

ANSWER: A

Myelin is an electrically insulating material that forms a layer, the myelin sheath, usually around only the axon of a neuron. It is essential for the proper functioning of the nervous system. Myelin is composed of about 80% lipid and about 20% protein. The main purpose of a myelin layer (or *sheath*) is to increase the speed at which impulses propagate along the myelinated fiber.

23. There has recently been a long debate with respect to the how much of our personality and other traits are due to the genes we inherit vs. the degree to which our personalities are shaped by our upbringing. This debate is known as:

- A. Darwin vs. Nobel
- B. Parents vs. Science
- C. Genes vs. Jeans
- D. Nature vs. Nurture

ANSWER: D

The nature versus nurture debates concern the relative importance of an individual's innate qualities ("nature", i.e. genetic make-up) versus personal experiences ("nurture", i.e. the environment) in determining or causing individual differences in physical and behavioral traits. In order to disentangle the effects of genes and environment, behavioral geneticists perform adoption and twin studies. In one kind of study, identical twins reared apart are compared to randomly selected pairs of people. The twins share identical genes, but different family environments. In another kind of twin study, identical twins reared together (who share family environment and genes) are compared to fraternal twins reared together (who also share family environment but only share half their genes). Another condition that permits the disassociation of genes and environment is adoption. In one kind of adoption study, biological siblings reared together (who share the same family environment and half their genes) are compared to adoptive siblings (who share their family environment but none of their genes).

24. The connection between two neurons is known as a:

- A. neurogap
- B. septum
- C. lamella
- D. synapse

ANSWER: D

Neurons are highly specialized for the processing and transmission of cellular signals. Given the

diversity of functions performed by neurons in different parts of the nervous system, there is, as expected, a wide variety in the shape, size, and electrochemical properties of neurons. The anatomist Camillo Golgi grouped neurons into two types; type I with long axons used to move signals over long distances and type II with short axons, which can often be confused with dendrites. Type I cells can be further divided by where the cell body or soma is located. The basic morphology of type I neurons, represented by spinal motor neurons, consists of a cell body called the soma and a long thin axon which is covered by the myelin sheath. Around the cell body is a branching dendritic tree that receives signals from other neurons. The end of the axon has branching terminals (axon terminal) that release neurotransmitters into a gap called the synaptic cleft between the terminals and the dendrites of the next neuron.

25. With reference to food, the acronym GI is used to represent:

- A. Glaucoma index
- B. Glycaemic index
- C. Glucose index
- D. Green index

ANSWER: B

The glycemic index (abbreviated GI) is a measure of the effects of carbohydrates on blood sugar levels. Carbohydrates that break down quickly during digestion and release glucose rapidly into the blood stream have a high GI; carbohydrates that break down more slowly, releasing glucose more gradually into the bloodstream, have a low GI. A lower glycemic index suggests slower rates of digestion and absorption of the foods' carbohydrates and may also indicate greater extraction from the liver and periphery of the products of carbohydrate digestion. A lower glycemic response usually equates to a lower insulin demand but not always, and may improve long-term blood glucose control and blood lipids.

26. Which of the following is not an antibiotic:

- A. Erythropoietin
- B. Ampicillin
- C. Streptomycin
- D. Penicillin

ANSWER: A

Erythropoietin is a glycoprotein hormone that controls erythropoiesis or red blood cell production. It is a cytokine for erythrocyte (red blood cell) precursors in the bone marrow. Also called hematopoietin or hemopoietin, it is produced by the peritubular capillary endothelial cells in the kidney,

and is the hormone that regulates red blood cell production. It also has other known biological functions. For example, erythropoietin plays an important role in the brain's response to neuronal injury. EPO is also involved in the wound healing process.

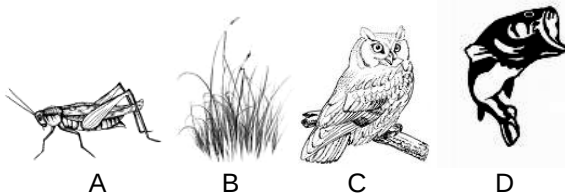
27. Meat is to Carnivores as dead organic matter is to...

- A. Omnivores
- B. Detritivores
- C. Herbivores
- D. None of the above

ANSWER: B

Detritivores, also known as detritus feeders or saprophages, are heterotrophs that obtain nutrients by consuming detritus (decomposing organic matter). By doing so, they contribute to decomposition and the nutrient cycles. Detritivores are an important aspect of many ecosystems. They can live on any soil with an organic component, and even live in marine ecosystems. Typical detritivorous animals include millipedes, woodlice, dung flies, many terrestrial worms, sea stars and, and some sedentary polychaetes such as amphitrites. Many species of bacteria, fungi and protists, unable to ingest discrete lumps of matter, instead live by absorbing and metabolising on a molecular scale. Scavengers are typically not thought to be detritivores, as they generally consume larger quantities of organic matter.

28. Considering the following animals: which would be the secondary predator:



- A. A
- B. B
- C. C
- D. D

ANSWER: C

Grasshoppers are herbivores and eat grass. Fresh water fish, such as trout, generally feed on other fish, and soft bodied aquatic invertebrates, such as flies, molluscs and worms. Thus, in this context they can be deemed the primary predator. The owls are birds of prey of the order Strigiformes, comprising 200 species. Most are solitary and nocturnal and hunt mostly small mammals, insects and other birds. A few species specialize in

hunting fish (and would thus be secondary predators in this context). They are found in all regions of the Earth except Antarctica, most of Greenland, and some remote islands.

29. A lichen is a symbiotic relationship between a

- A. fungus and algae
- B. animal and plant
- C. bacterium and plant
- D. plant and fungus

ANSWER: A (Encyclopaedia Britannica)

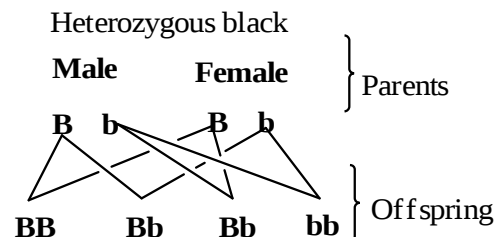
Lichen is, by definition, a simple slow-growing plant that typically forms a low crustlike, leaflike, or branching growth on rocks, walls, and trees. Lichens are composite plants consisting of a fungus that contains photosynthetic algal cells. Their classification is based upon that of the fungal partner, 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.

30. A scientist mates two black mice. 75% of their offspring are black, the other 25% are white. The scientist can assume that the genotype of the parents were:

- A. BB X Bb
- B. Bb X Bb
- C. Bb X bb
- D. BB X bb

ANSWER: B

From the outcome of this breeding experiment, it is evident that black colour is dominant and white recessive. The only way white offspring can result in breeding by two black mice if both parents carry an allele of the recessive gene. The genetic makeup of the offspring would be:



25% of the offspring will be homozygous black (BB), 50% heterozygous black like their parents (Bb) and 25% white as they carry both recessive alleles (bb).

31. An octopus is an example of a cephalopod, what are the key features used to define an animal as a cephalopod?

- A. tentacles, water propulsive movement and lack of gills
- B. black ink defense mechanism, herbivorous diet and intelligence
- C. water propulsive movement, ability to change colour and cartilaginous skeleton
- D. hydrostatic skeleton or foot, bilateral body symmetry and prominent head

ANSWER: D

A cephalopod (from Greek meaning "head-feet") is any member of the mollusc class Cephalopoda, characterized by bilateral body symmetry, a prominent head, and a modification of the mollusk foot, a muscular hydrostat, into the form of arms or tentacles. Cephalopods are widely regarded as the most intelligent of the invertebrates and have well developed senses and large brains; larger than the brains of gastropods. Cephalopods have advanced vision, can detect gravity with statocysts, and have a variety of chemical sense organs. Octopuses use their tentacles to explore their environment and can use them for depth perception. Cephalopods are the only mollusks with a closed circulatory system. They have two branchial hearts that move blood through the capillaries of the gills. A single systemic heart then pumps the oxygenated blood through the rest of the body. Like most molluscs, cephalopods use hemocyanin, a copper-containing protein, rather than hemoglobin to transport oxygen. Cephalopods exchange gasses with the seawater by forcing water through their gills, which are attached to the roof of the organism.

32. What do the appendix of a human and the hipbone of a whale have in common?

- A. Homologous structures
- B. Analogous structures
- C. Vestigial structures
- D. Similar structures

ANSWER: C

The vermiform appendix is a blind-ended tube connected to the caecum, from which it develops during embryogenesis. The caecum is a pouch-like structure of the colon. The appendix is located near the junction of the small and large intestines. Given the appendix's propensity to cause death by infection, and general good health of people who have had their appendix removed the appendix is traditionally thought to have no function in the human body. The most common explanation for the appendix's existence in humans is that it's a

vestigial structure which has lost its original function.

Like all mammals, whales breathe air, are warm-blooded and nurse their young with milk from mammary glands. Beneath the skin lies a layer of fat called blubber, which stores energy and insulates the body. Whales have a spinal column, a vestigial pelvis bone, and a four-chambered heart. The neck vertebrae are typically fused, trading flexibility for stability during swimming. Whales breathe via blowholes which are located on the top of the head, allowing the animal to remain mostly submerged whilst breathing.

33. Why are viruses considered to be non-living?

- A. they do not self reproduce
- B. they do not eat
- C. they are at the bottom of the food chain
- D. they do not use oxygen

ANSWER: B

Living organisms undergo metabolism, maintain homeostasis, possess a capacity to grow, respond to stimuli, reproduce and, through natural selection, adapt to their environment in successive generations. More complex living organisms can communicate through various means. Viruses are most often considered replicators rather than forms of life. They possess genes, evolve by natural selection and replicate by creating multiple copies of themselves through self-assembly. However, viruses do not metabolise and require a host cell to make new products.

34. Down Syndrome is a disease which is caused by having an extra chromosome 21. What is the alternative name for this disease?

- A. Monosomy 21
- B. Disomy 21
- C. Heterosomy 21
- D. Trisomy 21

ANSWER: D

Down's syndrome, trisomy 21, or trisomy G, is a chromosomal disorder caused by the presence of all or part of an extra chromosome 21. It is named after John Langdon Down, the British physician who described the syndrome in 1866. The disorder was identified as a chromosome 21 trisomy by Jerome Lejeune in 1959. Down syndrome is a chromosomal abnormality characterized by the presence of an extra copy of genetic material on the 21st chromosome, either in whole (trisomy 21) or part (such as due to translocations). The effects of the extra copy vary greatly among people, depending on the extent of the extra copy, genetic history, and pure chance. Down syndrome occurs in all human

populations, and maternal age influences the chances of conceiving a baby with Down syndrome, with older women carrying the greatest risk. Often Down syndrome is associated with some impairment of cognitive ability and physical growth, and a particular set of facial characteristics. Down syndrome in a fetus can be identified with amniocentesis during pregnancy or in a baby at birth. Individuals with Down syndrome tend to have a lower than average cognitive ability, often ranging from mild to moderate developmental disabilities. A small number have severe to profound mental disability.

35. What major impact did Gregor Johann Mendel have on biology?

- A. he solved the structure of DNA
- B. he discovered the first antibiotic
- C. he discovered genetics
- D. he discovered that infection could be transferred by bacteria

ANSWER: C

Gregor Johann Mendel (July 20, 1822 – January 6, 1884) was an Austrian monk and scientist, who gained posthumous fame as the figurehead of the new science of genetics for his study of the inheritance of certain traits in pea plants. Mendel showed that the inheritance of these traits follows particular laws, which were later named after him. The significance of Mendel's work was not recognized until the turn of the 20th century. The independent rediscovery of these laws formed the foundation of the modern science of genetics.

36. The function of the placenta during pregnancy is...

- A. to produce hormones to maintain pregnancy
- B. nutrient and waste exchange
- C. to hide the foetus from the immune system during development
- D. all of the above

ANSWER: D

The placenta is an organ that connects the developing fetus to the uterine wall to allow nutrient uptake, waste elimination and gas exchange via the mother's blood supply. In preparation for implantation, the uterine endometrium undergoes 'decidualization'. Spiral arteries in the decidua are remodelled so that they become less convoluted and their diameter is increased. This increases maternal blood flow to the placenta and also decreases resistance so that shear stress is reduced. The relatively high pressure as the maternal blood enters the

intervillous space through these spiral arteries bathes the villi in blood. An exchange of gases takes place. As the pressure decreases, the deoxygenated blood flows back through the endometrial veins. Deoxygenated fetal blood passes through umbilical arteries to the placenta.

At the junction of umbilical cord and placenta, the umbilical arteries branch radially to form chorionic arteries. Chorionic arteries also branch before they enter into the villi. In the villi, they form an extensive arteriocapillary venous system, bringing the fetal blood extremely close to the maternal blood; but no mixing of fetal and maternal blood occurs. The perfusion of the intervillous spaces of the placenta with maternal blood allows the transfer of nutrients and oxygen from the mother to the fetus and the transfer of waste products and carbon dioxide back from the fetus to the mother. Nutrient transfer to the fetus is both actively and passively mediated by proteins called nutrient transporters that are expressed within placental cells.

The placenta and fetus may be regarded as a foreign allograft inside the mother, and thus must evade from attack by the mother's immune system. For this purpose, the placenta uses several mechanisms. Among them, it secretes Neurokinin B containing phosphocholine molecules and there is presence of small lymphocytic suppressor cells in the fetus that inhibit maternal cytotoxic T cells by inhibiting the response to interleukin 2.

Questions 37, 38, and 39 are based on the table below

Measurement

1 mm (millimetre) = 10^{-3} m or 1 m = 1000 mm

1 μ m (micrometre) = 10^{-6} m or 1 mm = 1000 μ m

1 nm (nanometre) = 10^{-9} m or 1 μ m = 1000 nm

A comparison of sizes of cells, cell structures, bacteria and viruses is given below.

CELL, STRUCTURE, or BACTERIUM	CELL VIRUS	SIZE
Chloroplasts		$\pm 1 \mu\text{m}$
Frog egg		$\pm 1 \text{ mm}$
Viruses		$\pm 10 - 100 \text{ nm}$
Bacteria		$\pm 1 - 10 \mu\text{m}$

37. Which of the objects listed below is the largest?

- A Chloroplasts

- B Frog egg
- C Viruses
- D Bacteria

ANSWER: B

The sizes are already given in the table and the measurement conversions provided in the question statement!

38. Which of the objects listed below is the smallest?

- A Chloroplasts
- B Frog egg
- C Viruses
- D Bacteria

ANSWER: C

The sizes are already given in the table and the measurement conversions provided in the question statement!

39. If you had an eyepiece with a magnification of 10, and an objective lens with a magnification of 10, you would be able to see:

- A Viruses and Frogs' eggs
- B Bacteria and Chloroplasts
- C Viruses and Bacteria
- D Chloroplasts and Frogs' eggs

ANSWER: B

There are two basic configurations of the conventional optical microscope in use, the simple (one lens) and compound (many lenses). The components of the optical transmission microscope are (1) ocular lens, or eyepiece, (2) objective turret, (3) objective lenses (4) coarse adjustment knob, (5) fine adjustment knob, (6) object holder or stage, (7) mirror or light (illuminator) and (8) a diaphragm and condenser. The eyepiece is a cylinder containing two or more lenses to bring the image to focus for the eye. Typical magnification values for eyepieces include 5x, 10x and 2x. In some high performance microscopes, the optical configuration of the objective lens and eyepiece are matched to give the best possible optical performance. At the lower end of the microscope tube one or more objective lenses are screwed into a circular nose piece which may be rotated to select the required objective lens. Typical magnification values of objective lenses are 4x, 5x, 10x, 20x, 40x, 50x and 100x. Some high performance objective lenses may require matched eyepieces to deliver the best optical performance. The actual power or magnification of an optical microscope is the product of the powers of the ocular (eyepiece),

usually about 10x, and the objective lens being used. Viruses are way too small to be viewed under simple optical microscopes and frog eggs are readily visible to the naked eye!

40. Why are gases that lead to global warming known as greenhouse gases?

- A. They absorb and emit radiation in the infra-red spectrum of light and thus prevents heat from leaving the earth's surface, which is similar to a greenhouse since it retains heat
- B. They absorb light in the green spectrum since they are similar in colour and thereby heat the earth's atmosphere, which is why the roof of a greenhouse is usually green in colour
- C. The gases enhance plant growth which in turn leads to increased respiration and higher energy loss from plants in the form of heat, similar to the way that plants grow better in a greenhouse
- D. The gases act as condensation nuclei in the atmosphere and cause increased cloud cover which in turn results in retention of heat, similar to the way that condensate forms on the surface of a greenhouse and insulates it from heat exchange.

ANSWER: A

The major natural greenhouse gases are water vapor, , which causes about 36-70% of the greenhouse effect on Earth (not including clouds); carbon dioxide, which causes 9-26%; methane, which causes 4-9%, and ozone, which causes 3-7%. The major atmospheric constituents (N_2 and O_2) are not greenhouse gases, because homonuclear diatomic molecules (e.g. N_2 , O_2 , H_2) do not emit in the infrared as there is no net change in the dipole moment of these molecules.

The greenhouse effect: When sunlight reaches the Earth's surface, some is absorbed and warms the earth. Because the earth is much cooler than the sun, it radiates energy at much longer wavelengths than the sun; some of these longer wavelengths are absorbed by greenhouse gases in the atmosphere before they are lost to space. The absorption of this long wave radiant energy warms the atmosphere (the atmosphere also is warmed by transfer of sensible and latent heat from the surface). greenhouse gases also emit long wave radiation both upward to space and downward to the surface. The downward part of this long wave radiation emitted by the atmosphere is the "greenhouse effect." The term is in fact a misnomer, as this process is not the primary mechanism that warms greenhouses! A greenhouse is a structure with a glass or plastic roof and frequently glass or plastic walls; it heats up because incoming solar radiation

from the sun warms plants, soil, and other things inside the building faster than heat can escape the structure. Air warmed by the heat from hot interior surfaces is retained in the building by the roof and wall.

41. Why are zooplankton important constituents of the aquatic food web?

- A. They are an important nutrient for organisms on higher trophic levels.
- B. They act as a conduit for packaging of organic material
- C. They consume phytoplankton and help prevent algal blooming
- D. All of the above

ANSWER: D

Zooplankton are the heterotrophic (sometimes detritivorous) type of plankton. Plankton are organisms drifting in the water column of oceans, seas and bodies of fresh water. Zooplankton is a broad categorisation spanning a range of organism sizes that includes both small protozoans and large metazoans. Through their consumption and processing of phytoplankton (and other food sources), zooplankton play an important role in aquatic food webs, both as a resource for consumers on higher trophic levels (including fish), and as a conduit for packaging the organic material in the biological pump. Since they are typically of small size, zooplankton can respond relatively rapidly to increases in phytoplankton abundance.

42. What name is given to the structure of a protein when it is folded into a 3D shape?

- A. Primary Structure
- B. Secondary Structure
- C. Tertiary Structure
- D. Quaternary Structure

ANSWER: C

There are four levels of protein structure, which are:

- (i) Primary structure- the amino acid sequence of the peptide chains as determined by genes.
- (ii) Secondary structure- highly regular sub-structures (alpha helices, beta sheets and random coils), which are locally defined, meaning that there can be many different secondary motifs present in one single protein molecule.
- (iii) Tertiary structure- three-dimensional structure of a single protein molecule; a spatial arrangement of the secondary structures. It also describes the completely folded and compacted polypeptide chain.

(iv) Quaternary structure- complex of several protein molecules or polypeptide chains, usually called protein subunits in this context, which function as part of the larger assembly or protein complex.

43. What is the name of the mixture from which the first organism is said to have arisen?

- A. Buffered Soup
- B. Primordial Soup
- C. Primeval Soup
- D. Pangean Soup

ANSWER: B

In 1924, Alexander Oparin argued that a "primeval soup" of organic molecules could be created in an oxygen-free atmosphere through the action of sunlight. These would combine in ever-more complex fashions until they formed coacervate droplets. These droplets would grow by fusion with other droplets, and reproduce through fission into daughter droplets, and so have a primitive metabolism in which those factors which promote "cell integrity" survive, those that do not become extinct. Around the same time, J.B.S. Haldane suggested that the Earth's pre-biotic oceans—very different from their modern counterparts—would have formed a "hot dilute soup" in which organic compounds could have formed. This idea was called *biopoiesis*, the process of living matter evolving from self-replicating but non-living molecules. The two hypotheses were confirmed decades later by the results of the Miller–Urey experiment, conducted by Stanley Miller and Harold Urey. Simulating hypothetical conditions thought at the time to be present on the early earth, the experiment managed to produce amino acids from water, methane, ammonia and hydrogen. Considered to be the classic experiment on the origin of life, it was conducted in 1952 and published in 1953.

44. Which of the following hormones is used as a birth control agent and how does it prevent conception?

- A. Luteinising hormone – prevents the mature follicle from developing
- B. Progesterone – tricks the body into thinking it is already pregnant
- C. Thyroid stimulating hormone – prevents the body from producing oestrogen, required for development of the endometrium
- D. Adrenalin – causes spermatozoa to behave erratically

ANSWER: B

Progesterone, produced in the ovaries, the adrenal glands and during pregnancy, in the placenta, is

sometimes called the "hormone of pregnancy" and it has many roles relating to the development of the foetus. Progesterone converts the endometrium to its secretory stage to prepare the uterus for implantation. At the same time progesterone affects the vaginal epithelium and cervical mucus, making it thick and impermeable to sperm. If pregnancy does not occur, progesterone levels will decrease, leading, in the human, to menstruation. Normal menstrual bleeding is progesterone-withdrawal bleeding.

45. In biogeography, the term Gondwanan is often used to describe a species which may be present in which of the following combinations of continents?

- A. North America, South America and Asia
- B. South America, North America and Africa
- C. Australasia, Africa and South America
- D. Asia, Africa and Europe

ANSWER: C

Gondwana, originally Gondwanaland, is the name given to a southern precursor supercontinent. Its final geological suturing occurred between 570 and 510 million years ago, joining East Gondwana to West Gondwana. While the corresponding northern-hemisphere continent Laurasia moved further north, Gondwana drifted south. It included most of the landmasses in today's southern hemisphere, including Antarctica, South America, Africa, Madagascar, Australia and New Zealand as well as the Indian subcontinent. The adjective "Gondwanan" is in common use in biogeography when referring to patterns of distribution of living organisms, typically when the organisms are restricted to two or more of the now-discontinuous regions that were once part of Gondwana.

46. Which of the following options are functions of proteins in your body? (i) fight infection, (ii) transport oxygen, (iii) DNA translation?

- A. i, ii and iii
- B. i and ii only
- C. i and iii only
- D. ii and iii only

ANSWER: A

Proteins are the chief actors within the cell, said to be carrying out the duties specified by the information encoded in genes. They can be informally divided into three main classes, which correlate with typical tertiary structures: globular proteins, fibrous proteins and membrane proteins. Almost all globular proteins are water-soluble and include enzymes, antibodies and

carriers/transporters such as haemoglobin. Fibrous proteins are often structural, such as collagen, the major component of connective tissue, or keratin, the protein component of hair and nails. Membrane proteins often serve as receptors or provide channels for polar or charged molecules to pass through the cell membrane.

47. Antonie van Leeuwenhoek is also known as 'The Father of...

- A. Modern Botany
- B. Microbiology
- C. Molecular Biology
- D. Nanotechnology

ANSWER: B

Antonie Philips van Leeuwenhoek (born on October 24, 1632 and died on August 26, 1723) was a Dutch tradesman and scientist from Delft, Netherlands. He is commonly known as "the father of Microbiology", and considered to be the first microbiologist. He 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. He was also the first to record microscopic observations of muscle fibers, bacteria, spermatozoa and blood flow in capillaries.

48. What is the pathogenic agent that causes bovine spongiform encephalitis?

- A. Bacteria
- B. Virus
- C. Prion
- D. Fungus

ANSWER: C

Bovine spongiform encephalopathy (BSE), commonly known as mad-cow disease is a fatal, neurodegenerative disease in cattle that causes a spongy degeneration in the brain and spinal cord. BSE has a long incubation period, about 4 years, usually affecting adult cattle at a peak age onset of four to five years, all breeds being equally susceptible. The infectious agent in BSE is believed to be a specific type of misfolded protein called a prion. Those prions carry the disease between individuals and cause deterioration of the brain. A British inquiry into BSE concluded that the epidemic was caused by cattle, which are normally herbivores, being fed the remains of other cattle in the form of meat and bone meal, which caused the infectious agent to spread. It is believed by most scientists that the disease may be transmitted to human beings who eat the brain or spinal cord of infected carcasses. In humans, it is known as *new variant*

Creutzfeldt-Jakob disease and by October 2009, it had killed 166 people in Britain and 44 elsewhere with the number expected to rise because of the disease's long incubation period.

49. Patients diagnosed with HIV will become immuno-compromised and develop AIDS. What explanation below may best be used to describe this state?

- A. Patients are more susceptible to infection
- B. Patients can infect other people with HIV
- C. Patients tend to produce more white blood cells
- D. Patients tend to produce fewer varieties of antibody but in great abundance

ANSWER: A

Acquired immune deficiency syndrome or acquired immunodeficiency syndrome (AIDS) is a disease of the human immune system caused by the human immunodeficiency virus (HIV). This condition progressively reduces the effectiveness of the immune system and leaves individuals susceptible to opportunistic infections and tumors. HIV is transmitted through direct contact of a mucous membrane or the bloodstream with a bodily fluid containing HIV, such as blood, semen, vaginal fluid, preseminal fluid and breast milk. AIDS is the most severe acceleration of infection with HIV. HIV is a retrovirus that primarily infects vital organs of the human immune system such as CD4⁺ T cells, macrophages and dendritic cells. It directly and indirectly destroys CD4⁺ T cells. Once HIV has killed so many CD4⁺ T cells that there are fewer than 200 of these cells per microliter (μL) of blood, cellular immunity is lost and opportunistic infections invade the body, a condition known as AIDS.

50. What causes allergies?

- A. antibiotics
- B. antihistamines
- C. antibodies
- D. antigens

ANSWER: D

An allergy is a disorder of the immune system and allergic reactions occur to normally harmless environmental substances known as allergens. These reactions are acquired, predictable, and rapid. Strictly, allergy is one of four forms of hypersensitivity and is called *type I* (or *immediate*) hypersensitivity. It is characterized by excessive activation of certain white blood cells called mast cells and basophils by a type of antibody known as IgE, resulting in an extreme inflammatory response. Common allergic reactions include

eczema, hives, hay fever, asthma attacks, food allergies, and reactions to the venom of stinging insects such as wasps and bees.

51. What is the primary biological function of the spleen?

- A. protects against infection
- B. produces bile for enhancing the uptake of vitamins in the gastrointestinal tract
- C. produces hormones to regulate skin dilation
- D. monitors and regulates white blood cell numbers in the bloodstream

ANSWER: A

The spleen is an organ found in virtually all vertebrates with important roles in regard to red blood cells and the immune system. It removes old red blood cells and holds a reserve in case of hemorrhagic shock, especially in animals like horses (not in humans), while recycling iron. It synthesizes antibodies in its white pulp and removes, from blood and lymph node circulation, antibody-coated bacteria along with antibody-coated blood cells. Recently, it has been found to contain, in its reserve, half of the body's monocytes, within the red pulp, that, upon moving to injured tissue (such as the heart), turns into dendritic cells and macrophages while aiding wound healing. It is one of the centers of activity of the reticuloendothelial system and can be considered analogous to a large lymph node as its absence leads to a predisposition toward certain infections.

52. A light year is the distance light travels in one year. Light travels 300 000 km in one second. How many kilometres are there in a light year?

- A. 2 519 200 000 km
- B. $3\,075\,840 \times 10^5$ km
- C. $9,22752 \times 10^{11}$ km
- D. $4,32 \times 10^{11}$ km

ANSWER: C (Incorrect but closest approximation!)

A light-year, (symbol: ly) is a unit of length, equal to just under 10 trillion kilometres (i.e., 10^{16} metres). As defined by the International Astronomical Union (IAU), a light-year is the distance that light travels in a vacuum in one Julian year. There are 365.25 days in a year, 24 hours in a day, 60 minutes in one hour and 60 seconds in one minute. Thus, there are $60 \times 60 \times 24 \times 365.25 = 31\,557\,600$ seconds in a year. This means $31\,557\,600 \times 300\,000 = 9.46728 \times 10^{12}$ km.

53. Which of the following statements about the human eye are correct?

- (i) The cornea bends light rays
- (ii) The choroid contains many blood vessels
- (iii) The sclera is the innermost layer of the eye
- (iv) The blind spot is found on the retina

- A. (ii), (iii) and (iv)
- B. (i), (ii) and (iv)
- C. (i), (ii) and (iii)
- D. (ii) and (iii)

ANSWER: B

The eye is made up of three coats, enclosing three transparent structures. The outermost layer is composed of the cornea and sclera. The cornea is the transparent front part of the eye that covers the iris, pupil and anterior chamber. Together with the lens, the cornea refracts light, accounting for approximately two-thirds of the eye's total optical power. The middle layer consists of the choroid, ciliary body and iris. The innermost is the light sensitive retina, which gets its circulation from the vessels of the choroid as well as the retinal vessels, which can be seen in an ophthalmoscope. Light striking the retina initiates a cascade of chemical and electrical events that ultimately trigger nerve impulses. These are sent to various visual centers of the brain through the fibers of the optic nerve. The sclera, also known as the *white part of the eye*, is the opaque, fibrous, protective, outer layer of the eye containing collagen and elastic fiber. The physiological blind spot is the place in the visual field that corresponds to the lack of light-detecting photoreceptor cells on the optic disc of the retina where the optic nerve passes through it.

54. Which of the following are correct regarding the secretion from endocrine glands? The secretions ...

- (i) reach their target cells through the blood.
- (ii) reach their target cells through ducts.
- (iii) are known as hormones.
- (iv) never reach any target cells.

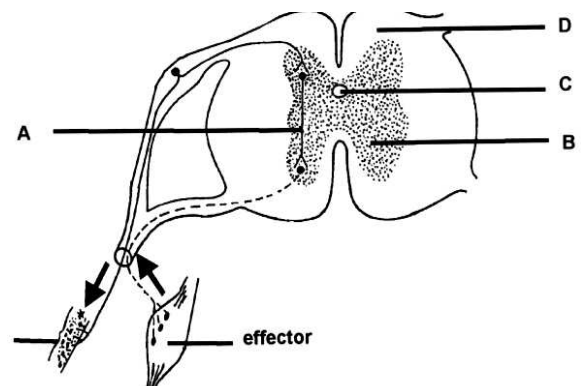
- A. (iii) and (iv)
- B. (i) and (iii)
- C. (ii) and (iii)
- D. (i), (iii) and (iv)

ANSWER: B

A hormone is a chemical released by a cell in one part of the body that sends out messages that affect cells in other parts of the organism. Only a small amount of hormone is required to alter cell metabolism. It is essentially a chemical messenger that transports a signal from one cell to another. All multicellular organisms, including plants,

produce hormones. Hormones in animals are often transported in the blood. Cells respond to a hormone when they express a specific receptor for that hormone. The hormone binds to the receptor protein, resulting in the activation of a signal transduction mechanism that ultimately leads to cell type-specific responses. Endocrine glands secrete hormones directly into the bloodstream, while exocrine glands secrete mainly non-hormone proteins (such as enzymes, mucus, saliva, milk, etc) directly into a duct, and from the duct they either flow into the bloodstream or directly to the target tissues.

55. Study the diagram below and answer the question that follow:



A = Interneuron; B = Grey matter
C = central canal; D = Receptor

There is one mistake in the diagram.

- A. C is the neural canal and not central canal
- B. B is the white matter and not gray matter
- C. A is the sensory neuron and not interneuron
- D. The direction of arrows indicating pathway of impulse is incorrect.

ANSWER: D

In the nervous system, afferent neurons (otherwise known as sensory or receptor neurons), carry nerve impulses from receptors or sense organs *toward* the central nervous system. Afferent neurons communicate with specialized interneurons. Efferent nerves – otherwise known as motor or effector neurons – carry nerve impulses *away* from the central nervous system to effectors such as muscles or glands. An interneuron (also called relay neuron, association neuron or local circuit neuron) is a multipolar neuron which connects afferent neurons and efferent neurons in neural pathways. Like motor neurons, interneuron cell bodies are always located in the central nervous system. The dorsal root (or posterior root) is the afferent sensory root of a spinal nerve. It contains lightly myelinated and unmyelinated axons of small diameter. These

transmit pain and temperature sensation from the body. The ventral root (or anterior root) is the efferent motor of a spinal nerve.

56. Which of the following animals with a surface area:volume ratio as indicated will be most likely to hibernate?

- A. $0,32 \text{ cm}^2$ for each one cm^3 .
- B. $0,12 \text{ cm}^2$ for each one cm^3 .
- C. $0,88 \text{ cm}^2$ for each one cm^3 .
- D. $0,46 \text{ cm}^2$ for each one cm^3 .

ANSWER: B

The ratio between the surface area and volume of cells and organisms has an enormous impact on their biology. An increased surface area to volume ratio means increased exposure to the environment. Organisms exhibit a variety of modifications, both physiological and anatomical, to compensate for changes in the surface area to volume ratio associated with size differences. One example of this is the higher metabolic rates found in smaller homeotherms. Because of their large surface area relative to volume, small animals lose heat at much higher rates than large animals, and therefore must produce more heat to offset the effects of thermal conductance. For that reason, an animal with a larger surface area compared to volume is less likely to hibernate and must eat continuously.

57. The table below represents the composition of liquids in the different parts of the human kidney. The volume of liquid passing through each part of the kidney in an hour is also included as the total flow per hour. The quantities of the various substances are expressed as grams per liter liquid. Study the table below and answer the questions that follow:

Component	Plasma in afferent arteriole	Glomerular filtrate	Urine
Urea	0,03	0,03	2,0
Glucose	0,20	0,20	0
Amino acids	0,06	0,06	0
Large proteins	8,00	0	0
Salts	0,72	0,72	1,5
Total flow per hour	14,0 l	2,8 l	0,05 l

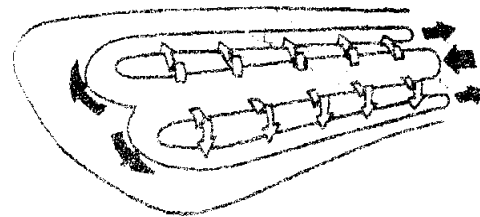
The amount of urine lost by the body per day, is

- A. 1,5
- B. 2,0
- C. 1,2
- D. 1,4

ANSWER: C

In a 24 hour day, given in the table above an hourly flow of 0.05 litres, 1.2 liters of urine will be produced. To eliminate soluble wastes, which are toxic, most animals have excretory systems. In humans soluble wastes are excreted by way of the urinary system, which consists of the kidneys, ureters, urinary bladder and urethra. The kidneys extract the soluble wastes from the bloodstream, as well as excess water, sugars, and a variety of other compounds. Remaining fluid contains high concentrations of urea and other substances, including toxins, which are then expelled from the body. The amount of urine produced depends on numerous factors including state of hydration, activities, environmental factors, size, and health. In adult humans the average production is about 1 - 2 L per day. Producing too much or too little urine can be a sign of disease and needs medical attention.

58. Study the following diagram and answer the question that follows:



HEAT-EXCHANGE MECHANISM IN THE FLIPPER OF A DOLPHIN

The diagram shows that heat is

- A. transferred from the artery to the vein.
- B. transferred from the vein to the artery.
- C. transferred from the vein to the artery and vice versa.
- D. stored in the artery by a reduction in blood supply.

ANSWER: A

A flipper is a typically flat limb evolved for movement through water. Various creatures have evolved flippers, for example most fish (wherein they are called fins), as well as certain mammals (cetaceans - whales and dolphins; pinnipeds - seals), reptiles (turtles) and birds (penguins). In many cases, flippers are analogous to the wing of a bird, having the properties of an airfoil and being used to propel an aquatic animal through the water.

A heat exchanger is a device built for efficient heat transfer from one medium to another. The media may be separated by a solid wall so that they never mix, or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants and also found naturally as part of temperature control mechanisms by animals. Based on the direction of the flow of the liquids or mediums exchanging heat, there are two basic designs or heat exchangers; Concurrent Flow- wherein the two fluids flow in the same direction, and Countercurrent Flow- wherein the two flows move in opposite directions. In countercurrent flow, the system can maintain a nearly constant gradient between the two flows over their entire length. With a sufficiently long length and a sufficiently low flow rate this can result in almost all of the property (heat in this case) being transferred. Countercurrent heat exchangers occur naturally in the circulation system of fish and whales. Arteries to the skin carrying warm blood are intertwined with veins from the skin carrying cold blood, causing the warm arterial blood to exchange heat with the cold venous blood. This reduces the overall heat loss in cold waters.

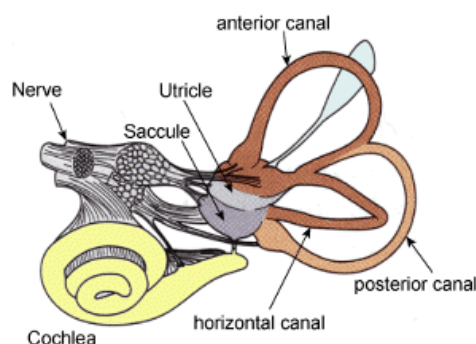
59. Which of the following is/are responsible for the balance of the body?

- (i) Semicircular canals
- (ii) Utriculus
- (iii) Cochlea

- A. (i) only
- B. (ii) only
- C. (i) and (ii) only
- D. (ii) and (iii) only

ANSWER: C

Equilibrioception or sense of balance is one of the physiological senses. It helps prevent humans and other animals from falling over when walking or standing still. Balance is the result of a number of body systems working together. Specifically, in order to achieve balance the eyes (visual system), ears (vestibular system) and the body's sense of where it is in space (proprioception) ideally need to be intact. The vestibule is the region of the inner ear where the semicircular canals converge, close to the cochlea (the hearing organ).



The vestibular system works with the visual system to keep objects in focus when the head is moving. This is called the vestibulo-ocular reflex (VOR). As our movements consist of rotations and translations, the vestibular system comprises two components: the semicircular canal system, which indicate rotational movements; and the otoliths (urticulus and saccule), which indicate linear accelerations. The vestibular system sends signals primarily to the neural structures that control our eye movements, and to the muscles that keep us upright.

60. Various parts of the nervous system are mentioned below. Study the list and select from it the correct sequence to which the statements refer.

- (i) Motor neuron
- (ii) Cerebrum
- (iii) Cerebellum
- (iv) sensory neuron
- (v) hypothalamus
- (vi) medulla oblongata

1. Centre for regulation of sleep
2. Centre for regulation of breathing
3. Maintains balance and muscle tone
4. Conducts impulse to effectors
5. Observation of sight and hearing
6. Situated outside central nervous system

- A. (ii), (v), (iii), (vi), (i) and (iv)
- B. (iv), (v), (vi), (ii), (i) and (iii)
- C. (ii), (iii), (vi), (v), (i) and (iv)
- D. (v), (vi), (iii), (i), (ii) and (iv)

ANSWER: D

The *cerebellum* is a region of the brain that plays an important role in motor control. It is also involved in some cognitive functions such as attention and language, and probably in some emotional functions such as regulating fear and pleasure responses.

The *cerebrum* or telencephalon, together with the diencephalon, constitutes the forebrain. It is the most anterior or, especially in humans, most superior region of the vertebrate central nervous

system. It directs the conscious or volitional motor functions of the body. It also receives and process visual, auditory, somatosensory, gustatory and olfactory information. In addition, it is the centre of memory, learning and language/communication.

The *hypothalamus* is a portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland. The hypothalamus controls body temperature, hunger, thirst, fatigue, and circadian cycles..

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

A *motor neuron* is a neuron located in the central nervous system (CNS) that project their axons outside the CNS and directly or indirectly control muscles. The motor neuron is often associated with efferent neuron, primary neuron, or alpha motor neurons.

Sensory neurons are the neurons responsible for converting external stimuli from the environment into internal stimuli. They are activated by sensory input (vision, touch, hearing, etc.), and send projections into the CNS that convey sensory information to the brain or spinal cord. Unlike neurons of the central nervous system, whose inputs come from other neurons, sensory neurons are activated by physical modalities such as light, sound, and temperature.

61. Which of the following are structural adaptations of a root hair to facilitate absorption of water from the soil?

- (i) Large vacuole with low water concentration in cell sap
- (ii) Thin cell wall and permeable
- (iii) Large number of stomata
- (iv) Root hair cell is elongated

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

ANSWER: C

The three major functions of roots are:

(1) absorption of water and inorganic nutrients, (2) anchoring of the plant body to the ground and (3) storage of food and nutrients. In response to the concentration of nutrients, roots also synthesise cytokinin, which acts as a signal as to how fast the shoots can grow. Roots often function in storage of food and nutrients. The roots of most vascular plant species enter into symbiosis with certain

fungi to form mycorrhizas, and a large range of other organisms including bacteria also closely associate with roots. The parts of a root are the xylem, the epidermis, the cortex, the root cap, the root hairs, the phloem, and the cambium. Root hair cells have a large surface area, relative to the other cells, that helps them absorb water and minerals more efficiently

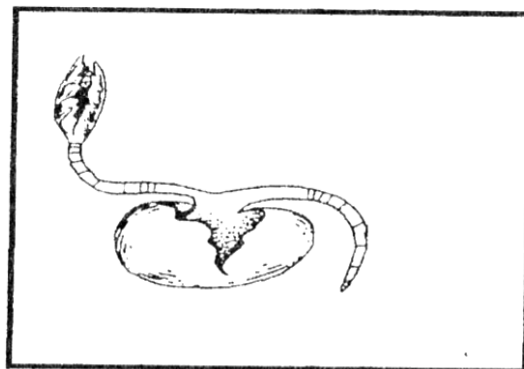
62. If the root hairs of a plant were covered with Vaseline, the effect on the plant would be ...

- A. more water is absorbed
- B. less water is absorbed
- C. more water would be lost
- D. the rate at which water is absorbed would increase.

ANSWER: B

A water impermeable/repellent coating on a root would prevent osmotic movement of water into the root. Plants growing in arid regions have a waxy cuticle on their leaves to prevent excessive water loss through transpiration.

Questions 63 and 64 are based on the diagram below:



63. The root in this diagram shows a response known as

- A. positive phototropism
- B. positive geotropism
- C. negative geotropism
- D. hydrotropism

ANSWER: B

Gravitropism (or geotropism) is a turning or growth movement by a plant or fungus in response to gravity. Roots show *positive gravitropism* and stems show *negative gravitropism*. That is, roots grow in the direction of gravitational pull (i.e., downward) and stems grow in the opposite direction (i.e., upwards). Roots bend in response to gravity due to a regulated movement of the plant hormone auxin known as polar auxin transport. In roots, an increase

in the concentration of auxin will inhibit cell expansion; therefore, the redistribution of auxin in the root can initiate differential growth in the elongation zone resulting in root curvature.

64. The stem in this diagram shows a response known as

- A. positive phototropism
- B. negative phototropism
- C. negative geotropism
- D. positive hydrotropism

ANSWER: C

Refer to the answer to Question 63 above. In both roots and stems auxin accumulates towards the gravity vector on the lower side. In roots, this results in the inhibition of cell expansion on the lower side and the concomitant curvature of the roots towards gravity (positive gravitropism). In stems, the auxin also accumulates on the lower side, however in this tissue it increases cell expansion and results in the shoot curving up

65. A plant which was accidentally given too much fertilizer started to wilt and died after two days. The probable reason was that the

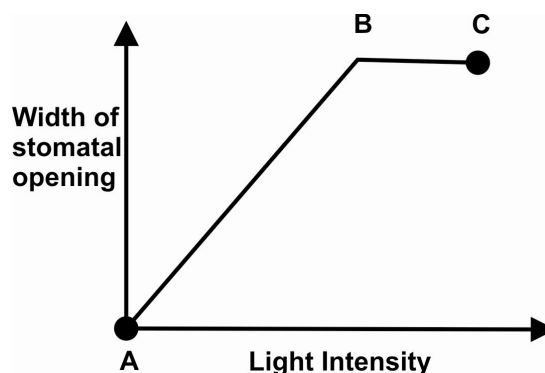
- A. cell membranes became impermeable to water
- B. water potential of the soil solution was lower than the water potential in the vacuoles of root hairs
- C. root hairs absorbed too much fertilizer
- D. fertilizer increased the water potential of the soil water

ANSWER: B

Fertilizers are soil supplements applied to promote plant growth; the main nutrients present in fertilizer are nitrogen, phosphorus, sulfur, calcium, magnesium and potassium (the 'macronutrients') and other nutrients: chlorine, manganese, iron, zinc, copper, molybdenum and selenium (the 'micronutrients') are added in smaller amounts. Fertilizers can be divided into two groups: inorganic and organic. They are usually directly applied to soil. Over-fertilization of a vital nutrient can be as detrimental as under-fertilization. "Fertilizer burn" can occur when too much fertilizer is applied, resulting in a drying out of the roots and damage or even death of the plant. Fertilizer burn is defined as leaf scorch resulting from over-fertilization, usually referring to excess nitrogen salts. It is the result of desiccation of plant tissues due to chemiosmosis, creating a state of hypertonicity. Fertilizer burn can be remedied by soaking the soil with water to flush out excess

salts. It can be prevented by applying only dilute or controlled-release fertilizer products.

Questions 66, 67 are based on the graph below which indicates the relationship between the width of a stomatal pore and light intensity:



66. Which of the following conditions exist in the guard cells at A just before they progress towards the conditions at point B and C on the graph?

- (i) Solutes begin to enter
- (ii) Has a low water potential
- (iii) Has a high turgor pressure
- (iv) Has a low turgor pressure

- A. (i) and (ii)
- B. (ii) and (iii)
- C. (i) and (iv)
- D. (i), (ii) and (iv)

ANSWER: B

A stoma (plural stomata) is a pore, found in the leaf and stem epidermis that is used for gaseous exchange. The pore is bordered by a pair of specialized parenchyma cells known as guard cells which are responsible for regulating the size of the opening. Air containing carbon dioxide and oxygen enters the plant through these openings where it is used in photosynthesis and respiration respectively. Oxygen, the by-product of photosynthesis in the spongy layer cells of the leaf interior, exits through these same openings. Water vapour is also released into the atmosphere through these pores in a process called transpiration. When conditions are conducive to stomatal opening (e.g., high light intensity and high humidity), a proton pump drives protons (H^+) from the guard cells. This means that the cells' electric potential becomes increasingly negative. The negative potential opens potassium voltage-gated channels and so an uptake of potassium ions (K^+) occurs. To maintain this internal negative voltage so that entry of potassium ions does not stop, negative ions balance the influx of potassium. In some cases chloride ions enter, while

in other plants the organic ion malate is produced in guard cells. This in turn increases the osmotic pressure inside the cell, drawing in water through osmosis. This increases the cell's volume and turgor pressure. Then, because of rings of cellulose microfibrils that prevent the width of the guard cells from swelling, and thus only allow the extra turgor pressure to elongate the guard cells, whose ends are held firmly in place by surrounding epidermal cells, the two guard cells lengthen by bowing apart from one another, creating an open pore through which gas can move.

67. Why did the width of the stomatal opening not increase further after B?

- The concentration of soluble substances at B and C was optimal and water potential in the guard cells remained high
- The concentration of soluble substances at B and C was the same and the turgor pressure in the guard cells remained low.
- The turgor pressure of the guard cells at B is high and the water potential in the guard cells at C is low.
- The water potential in the guard cells at B was high and the turgor pressure in the guard cells at C remained low

ANSWER: A

The stomatal opening can only reach a certain maximum which occurred at light intensity at point B and remained constant afterwards despite increase in luminous intensity (B to C).

68. Which of the following show peristaltic movements?

- Small intestine
 - Uterus
 - Tongue
 - Eyelids
 - Oesophagus
- (i), (ii) and (v)
 - (i) and (ii) only
 - (i) and (v) only
 - (i), (iii) and (iv)

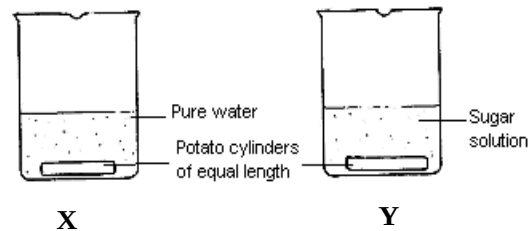
ANSWER: C

Peristalsis is a radially symmetrical contraction of muscles which propagates in a wave down the muscular tube. In humans, peristalsis is found in the contraction of smooth muscle to propel contents through the digestive tract. In much of the gastrointestinal tract, smooth muscles contract in sequence to produce a peristaltic wave which forces a ball of food (called a bolus while in the

oesophagus and gastrointestinal tract and chyme in the stomach) along the gastrointestinal tract. Peristaltic movement is initiated by circular smooth muscles contracting behind the chewed material to prevent it from moving back into the mouth, followed by a contraction of longitudinal smooth muscles which pushes the digested food forward.

The questions 69, 70 and 71 are based on the following diagram

69.



If the potato cylinders were left in the solutions for 24 hours, which of them would be longer?

- X and Y would have increased in length equally
- X would be longer
- Y would be longer
- Both would be unchanged.

ANSWER: B

A *hypertonic* solution contains a greater concentration of impermeable solutes than the solution on the other side of the membrane. When a cell is left to stand in a hypertonic solution (such as a saturated sugar solution) the water will be drawn out of the cell into the solution, by osmosis. If water molecules continue to diffuse out of the cell, it will cause the cell to shrink

A *hypotonic* solution contains a lesser concentration of impermeable solutes than the solution on the other side of the membrane. When a cell's cytoplasm is bathed in a hypotonic solution (such as pure water) the water will be drawn out of the solution and into the cell by osmosis. If water molecules continue to diffuse into the cell, it will cause the cell to swell.

70. Why did the potato cylinders have to be the same length and diameter?

- So that the variables of length and diameter would be controlled
- Because the sugar solution is only absorbed by cylinders of a specific diameter
- So that we could see the difference in length
- It is easier to use the same cork borer for all the cylinders

ANSWER: A

We needed to start with cylinders of exactly the same dimensions to make observations easier.

71. Account for any changes observed in the length of the cylinders.

- A There were no changes to account for
- B Cylinder X had a lower water potential and thus expanded when water entered
- C Cylinder Y had a lower water potential and thus expanded when water entered
- D Cylinder X had a higher water potential and thus expanded when water entered

ANSWER: B

The potato piece X was placed in a hypotonic solution (pure water) and thus water moved into it by osmosis.

Questions 73 and 74 are based on the following characteristics:

- I. Are sensitive to pH and heat
- II. Some can be classified as polysaccharides
- III. The monomers are amino acids
- IV. Are in soluble in water, but insoluble in ether

73. Which of the characteristics is/are applicable to carbohydrates?

- A. I and IV
- B. I and II
- C. I and III
- D. II and IV

ANSWER: D

A carbohydrate is an organic compound with the general formula $C_m(H_2O)_n$. From this formula, carbohydrates can be viewed as hydrates of carbon, hence their name. Most of them are water soluble but insoluble in simple organic solvents. The carbohydrates (saccharides) are divided into four chemical groupings: monosaccharides, disaccharides, oligosaccharides and polysaccharides. In general, the monosaccharides and disaccharides, which are smaller (lower molar mass) carbohydrates, are commonly referred to as sugars. Carbohydrates perform numerous roles in living things. Among others, simple sugars are a source of energy in cellular respiration, whilst polysaccharides serve for the storage of energy (e.g., starch and glycogen) and as structural components (e.g., cellulose in plants and chitin in arthropods). The 5-carbon monosaccharide ribose is an important component of coenzymes (e.g., ATP, FAD and NAD) and the backbone of the

genetic molecule known as RNA. The related deoxyribose is a component of DNA.

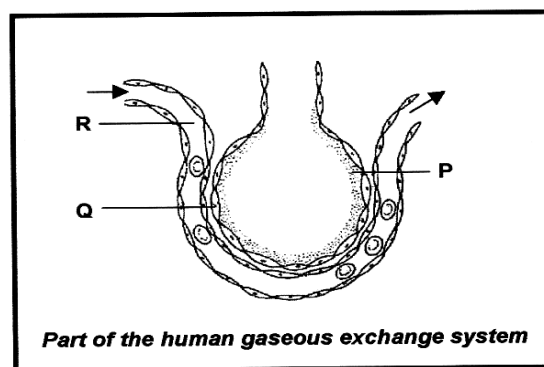
74. Which of these characteristics is /are applicable to proteins?

- A. II and IV
- B. I and II
- C. I and III
- D. III and IV

ANSWER: C

Proteins (also known as polypeptides) are organic compounds made of amino acids arranged in a linear chain and folded into a globular form. The amino acids in a polymer are joined together by the peptide bonds between the carboxyl and amino groups of adjacent amino acid residues. Each protein has its own unique amino acid sequence that is specified by the nucleotide sequence of the gene encoding this protein. The genetic code is a set of three-nucleotide sets called codons and each three-nucleotide combination designates an amino acid. Proteins exhibit up to four levels of structural organization called primary, secondary, tertiary and quaternary. Certain conditions alter the structures of proteins (denatures them). These high temperatures, extremes of pH or high salt concentrations and have particularly pronounced effects on enzymes.

Questions 75, 76 and 77 are based on the accompanying diagram. Study the diagram and answer the questions that follow:



75. The cells marked Q are

- A. Columnar epithelium
- B. Squamous epithelial cells
- C. Ciliated epithelial cells
- D. Cuboidal cells

ANSWER: B

An alveolus (plural: alveoli, from Latin *alveolus*, "little cavity") is an anatomical structure that has the form of a hollow cavity. Found in the lung, the pulmonary

alveoli are spherical outcroppings of the respiratory sites of gas exchange with the blood. Alveoli are particular to mammalian lungs. Different structures are involved in gas exchange in other vertebrates. They contain some collagen and elastic fibres, and they are lined with epithelium. The elastic fibers allow the alveoli to stretch as they fill with air when breathing in. They then spring back during breathing out in order to expel the carbon dioxide-rich air. The alveolar membrane is the gas-exchange surface. Each human lung contains about 300 million alveoli. Each alveolus is wrapped in a fine mesh of capillaries covering about 70% of its area. An adult alveolus has an average diameter of 200 to 300 microns, with an increase in diameter during inhalation. There are three major alveolar cell types in the alveolar wall: (i) Type I (squamous alveolar) cells, which form the structure of an alveolar wall; (ii) Type II (great alveolar) cells which secrete pulmonary surfactant to lower the surface tension of water and allows the membrane to separate, thereby increasing the capability to exchange gases. Surfactant is continuously released by exocytosis; and (iii) Macrophages, which destroy foreign material, such as bacteria.

76. The blood vessel labelled R is a branch of the

- A. Pulmonary vein
- B. Hepatic portal vein
- C. Hepatic vein
- D. Pulmonary artery

ANSWER: A

A pulmonary vein is a large blood vessel of the human circulatory that carries blood from the lungs to the left atrium of the heart. There are two pulmonary veins, two from each lung. They carry oxygenated blood, which is unusual since almost all other veins carry deoxygenated blood. They commence in a capillary net-work upon the walls of the alveolar air sacs, where they are continuous with the capillary ramifications of the pulmonary artery, and, joining together, form one vessel for each lobule. The pulmonary arteries carry blood from the heart to the lungs. They are the only arteries (other than umbilical arteries in the fetus) that carry deoxygenated blood.

77. Which of the following functions are performed by the substance labelled P?

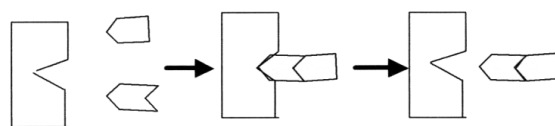
- (i) Prevents cells from drying out
- (ii) Protects against mechanical injury
- (iii) Allows gases to diffuse in a dissolved state
- (iv) Facilitates breathing movement

- A. (i) and (ii)
- B. (i) and (iii)
- C. (i), (ii) and (iv)
- D. (i), (ii), (iii) and (iv)

ANSWER: D

Reinflation of the alveoli following exhalation is made easier by pulmonary surfactant, which is a phospholipid and protein mixture that reduces surface tension in the thin fluid coating within all alveoli. The fluid coating is produced by the body in order to facilitate the transfer of gases between blood and alveolar air. The surfactant is produced by great alveolar cells (granular pneumonocytes).

Questions 78 and 79 refer to the accompanying diagrams:



78. What process is illustrated by the sequence of diagrams?

- A. Anabolism
- B. Catabolism
- C. Absorption
- D. Hydrolysis

ANSWER: A

One way of categorizing metabolic processes, whether at the cellular, organ or organism level is as 'anabolic' or as 'catabolic'. *Anabolism* is the set of metabolic pathways that construct molecules from smaller units. These reactions require energy, in the form of ATP. *Catabolism* is the direct opposite of anabolism, with bigger molecules broken down to smaller ones. Anabolic and catabolic reactions are catalyzed by enzymes.

Hydrolysis is a chemical process in which a molecule is cleaved into two parts by the addition of a molecule of water. One fragment of the parent molecule gains a proton (H^+) from the additional water molecule. The other group collects the remaining hydroxyl group (OH^-). Hydrolytic reactions can be catalyzed by acids, bases or enzymes. In living systems, most biochemical reactions, including ATP hydrolysis, take place during the catalysis of enzymes. The catalytic action of enzymes allows the hydrolysis of proteins, fats, oils, and carbohydrates. As an example, one may consider proteases, enzymes that aid digestion by causing hydrolysis of peptide bonds in proteins. They catalyze the hydrolysis of interior peptide bonds in peptide chains, as opposed to exopeptidases, another class of enzymes that catalyze the hydrolysis of terminal peptide bonds, liberating one free amino acid at a time.

79. Which property of the enzymes is illustrated by the sequence of the diagrams?

Enzymes

- A. speed up reaction
- B. lower the activation energy
- C. are proteins
- D. are specific in their function

ANSWER: D

We have no way of telling whether this reaction would be slower without the enzyme as there is no control experiment, thus, option A cannot be the answer. Neither can we tell whether the activation energy is lowered from the diagram as this would require measurements. The dummy depicted as the enzyme has no appearance of any known protein, ruling out option C. We can only see that the "enzyme" allows the binding of the bottom (invaginated wedge) first into which the top wedge then fits, making Option D the only correct answer.

Enzymes are mainly proteins that catalyze chemical reactions. In enzymatic reactions, the molecules at the beginning of the process are called substrates, and the enzyme converts them into different molecules, called the products. Almost all processes in a biological cell need enzymes to occur at significant rates. Since enzymes are selective for their substrates and speed up only a few reactions from among many possibilities, the set of enzymes made in a cell determines which metabolic pathways occur in that cell. Like all catalysts, enzymes work by lowering the activation energy ($E_a^{\ddagger}$) for a reaction, thus dramatically increasing the rate of the reaction. As with all catalysts, enzymes are not consumed by the reactions they catalyze, nor do they alter the equilibrium of these reactions. However, enzymes do differ from most other catalysts by being much more specific. A few RNA molecules called ribozymes also catalyze reactions, with an important example being some parts of the ribosome.

80. Which one of the following produces more energy per ton than any other energy source in the production of heat which is used to turn water into steam, and the steam is used to drive a turbine that powers a generator?

- A. Platinum
- B. Uranium
- C. Carbon
- D. Wood

ANSWER: B

Uranium is a silvery-white metal in the actinide series of the periodic table with atomic number 92. The uranium nucleus binds between 141 and 146 neutrons, establishing six isotopes, the most common of which are U-238 (146 neutrons) and U-235 (143 neutrons). All isotopes are unstable and uranium is weakly radioactive. In nature, uranium is found as uranium-238 (99.284%), uranium-235 (0.711%), and a very small amount of uranium-234 (0.0058%). Many contemporary uses of uranium exploit its unique nuclear properties; its ability to undergo nuclear fission. Uranium-235 has the distinction of being the only naturally occurring fissile isotope. Uranium-238 is both fissionable by fast neutron bombardment and fertile (capable of being transmuted to fissile plutonium-239 in a nuclear reactor). While uranium-238 has a small probability to fission spontaneously or when bombarded with fast neutrons, the much higher probability of uranium-235 to fission when bombarded with slow neutrons generates the heat in nuclear reactors used as a source of power. One kilogram of uranium-235 can theoretically produce about 80 trillion joules of energy (8×10^{13} joules), assuming complete fission; as much energy as 3000 tons of coal. Uranium-235 also provides the fissile material for nuclear weapons.

Look at the following in order to answer questions 81 and 82:

- (i) sweat
- (ii) shivering
- (iii) cold food
- (iv) hot drink
- (v) blood capillaries in skin become narrower
- (vi) cold showers
- (vii) much physical exercise
- (viii) rapid breathing (panting)

81. Which of the above are ways in which the body of the human being can gain heat?

- A. (i), (ii), (iii) and (v)
- B. (iii), (v), (vi) and (viii)
- C. (ii), (vii), (iv) and (v)
- D. (iii), (i), (vi) and (viii)

ANSWER: C

Thermoregulation is the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature is very different. This process is one aspect of homeostasis: a dynamic state of stability between an animal's internal environment and its *external* environment. If the body is unable to maintain a normal temperature and it increases significantly above normal, a condition known as hyperthermia occurs. The opposite condition, when body temperature

decreases below normal levels, is known as hypothermia. The skin assists in homeostasis (keeping different aspects of the body constant e.g. temperature). It does this by reacting differently to hot and cold conditions so that the inner body temperature remains more or less constant. Vasodilation and sweating are the primary modes by which humans attempt to lose excess body heat. In hot conditions:

(i) Sweat glands under the skin secrete sweat (a fluid containing mostly water with some dissolved ions) which travels up the sweat duct, through the sweat pore and onto the surface of the skin. This causes heat loss via evaporative cooling; however, a lot of essential water is lost. (ii) The hairs on the skin lie flat, preventing heat from being trapped by the layer of still air between the hairs. (iii) Arteriole vasodilation occurs, this is the process of relaxation of smooth muscle in arteriole walls allowing increased blood flow through the artery. This redirects blood into the superficial capillaries in the skin increasing heat loss by convection and conduction.

Most animals can't sweat efficiently. Cats and dogs only have sweat glands on the pads of their feet. Horses and humans are two of the few animals capable of sweating. Many animals pant rather than sweat, this is because the lungs have a large surface area and are highly vascularized. Air is inhaled, cooling the surface of the lungs and is then exhaled losing heat and some water vapour. Effective thermoregulation is reduced in hot, humid environments.

82. Which of the above are ways in which the body of the human being can lose heat?

- A. (i), (iii) and (iv)
- B. (i), (iii) and (vi)
- C. (iv), (iii) and (vii)
- D. (iii), (i), (vi) and (viii)

ANSWER: B

Refer to the detailed explanation in the answer to question 81 above.

83. Twenty five beetles are taken from a container and marked. They are returned to the group in the container to mix with the rest of the beetles. During the second capture it is found that five of the twenty are marked. The total number of beetles in the group could be approximately:

- A. 50
- B. 100
- C. 150
- D. 200

ANSWER: C

The five of the marked beetles out of twenty beetles captured in the second random capture represents 25% of the captured sample. This could suggest that the originally captured 25 for marking were 25% of the total beetles (**X**) in the container. This makes the total number of bees approximately:

$$X \times 25/100 = 25$$

$$\text{Therefore } X = 100$$

84. Which of the following biomes has the greatest species diversity?

- A. Temperate Rain Forest
- B. Grassland
- C. Temperate deciduous forest
- D. Coral Reef

ANSWER: D

Coral reefs are aragonite structures produced by living animal colonies, found in marine waters containing few nutrients. In most healthy reefs, stony corals are predominant. Stony corals are built from colonial polyps that secrete an exoskeleton of calcium carbonate. Reefs grow best in shallow, clear, sunny and agitated waters. The accumulation of skeletal material produces formation that supports the living corals and a great variety of other animal and plant life. Often called "rainforests of the sea", coral reefs form some of the most diverse ecosystems on earth. They occupy less than 1% of the world ocean surface, yet they provide a home for 25% of all marine species, including fishes, mollusks, echinoderms, and sponges.

Rainforests are forests characterized by high rainfall. There are two types, the tropical rainforests, and the temperate rainforests. *Tropical rainforests* are found 10 degrees north or south of the equator. They are common in Asia, Australia, Africa, South and Central America and on the Pacific Islands, with annual rainfall between 1750–2000 mm. *Temperate rainforests* are coniferous or broad leaf forests that occur in the temperate zones (mean annual temperature between 4 and 12 degrees Celsius) and receive high rainfall (over 1400 mm per annum). These are found mainly North and South America, Europe, and scattered in other parts of the globe. Between 40 and 75% of all species in the world are indigenous to the rainforests, with the tropical rainforests contributing a large portion of these. Many natural medicines have been discovered in tropical rainforests, and they are also responsible for 28% of the world's oxygen turnover, processing it through photosynthesis from carbon dioxide and solar energy. The undergrowth in a rainforest is

restricted in many areas by the lack of sunlight at ground level. This makes it possible for people and other animals to walk through the forest.

85. What enzyme does HIV use to convert RNA to DNA?

- A. DNA gyrase
- B. RNA polymerase
- C. DNA helicase
- D. Reverse transcriptase

ANSWER: D

Reverse transcriptase, also known as RNA-dependent DNA polymerase, is a DNA polymerase that transcribes single-stranded RNA into double-stranded DNA. It also helps in the formation of a double helix DNA once the RNA has been reverse transcribed into a single strand cDNA. Normal transcription involves the synthesis of RNA from DNA; hence, reverse transcription is the *reverse* of this. Reverse transcriptase was discovered by Howard Temin and independently by David Baltimore in 1970. The two shared the 1975 Nobel Prize in Physiology or Medicine with Renato Dulbecco for their discovery.

RNA polymerase (RNAP or RNAPol) is an enzyme that produces RNA. In cells, RNAP is needed for constructing RNA chains from DNA genes as templates, a process called transcription. RNA polymerase enzymes are essential to life and are found in all organisms and many viruses. In chemical terms, RNAP is a nucleotidyl transferase that polymerizes ribonucleotides at the 3' end of an RNA transcript.

Helicases are a class of enzymes that move directionally along a nucleic acid helix, separating two annealed nucleic acid strands (i.e., DNA, RNA or RNA-DNA hybrid) using energy derived from ATP hydrolysis.

DNA gyrase, often referred to simply as gyrase, is an enzyme that unwinds double stranded DNA. This causes supercoiling of the DNA. Many antibiotics work by attacking bacterial DNA gyrase. DNA gyrase is a type II topoisomerase that introduces negative supercoils (or relaxes positive supercoils) into DNA by looping the template so as to form a crossing, then cutting one of the double helices and passing the other through it before releasing the break, changing the linking number by two in each enzymatic step. This process occurs in prokaryotes (particularly in bacteria), whose single circular DNA is cut by DNA gyrase and the two ends are then twisted around each other to form supercoils.

86. Which group of plants has vascular tissue but does not produce seeds?

- I. Mosses
- II. Ferns
- III Gymnosperms

- A. I
- B. II
- C. III
- D. II & III

ANSWER: B

Botanically, *mosses* are bryophytes, or non-vascular plants. They can be distinguished from the apparently similar liverworts by their multi-cellular rhizoids. Other differences are not universal for all mosses and all liverworts, but the presence of clearly differentiated "stem" and "leaves", the lack of deeply lobed or segmented leaves, and the absence of leaves arranged in three ranks, all point to the plant being a moss.

A *fern* is any one of a group of about 12,000 species of plants. Unlike mosses they have xylem and phloem (making them vascular plants). They have stems, leaves and roots like other vascular plants. Ferns do not have either seeds or flowers, they reproduce via spores.

A *seed* is a small embryonic plant enclosed in a covering called the seed coat, usually with some stored food. It is the product of the ripened ovule of gymnosperms and angiosperms which occurs after fertilization and some growth within the mother plant. The formation of the seed completes the process of reproduction in seed plants (started with the development of flowers and pollination), with the embryo developed from the zygote and the seed coat from the integuments of the ovule. Seeds have been an important development in the reproduction and spread of flowering plants, relative to more primitive plants like mosses, ferns and liverworts, which do not have seeds and use other means to propagate themselves. This can be seen by the success of seed plants (both gymnosperms and angiosperms) in dominating biological niches on land, from forests to grasslands both in hot and cold climates.

87. The sight of cows grazing in a field is a common occurrence. Why is it, when a herd of cows grazes across a field that they all face in the same direction? It is an example of:

- A. territorial behaviour
- B. habituation
- C. reaction to the prevailing wind conditions,
- D. reducing head to head conflicts between dominant and subordinate animals

ANSWER: B

Habituation is the psychological process in humans and animals in which there is a decrease in psychological response and behavioral response to a stimulus after repeated exposure to that stimulus over some time. Habituation is very similar to acclimation, in that repetition of certain behaviors that are rewarding to a life form will likely be continued, or ingrained in a habitual manner. For example, for all life forms on earth, obtaining life-sustaining resources that exist externally from those beings, such as food, water and shelter, is a habituated behavior. The learning underlying habituation is a fundamental or basic process of biological systems and does not require conscious motivation or awareness to occur.

Territorial animals defend areas that contain a nest, den or mating 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 specialised 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.

88 A manuscript of a theory of evolution identical to Darwin's one year before the publication of *The Origin of Species*?

- A. Hutton
- B. Malthus
- C. Cuvier
- D. Wallace

ANSWER: C

Alfred Russel Wallace (8 January 1823 – 7 November 1913) was a British naturalist, explorer, geographer, anthropologist and biologist. He is best known for independently proposing a theory of evolution due to natural selection that prompted Charles Darwin to publish his own theory. An 1855 paper on the "introduction" of species, written by Alfred Russel Wallace, claimed that patterns in the geographical distribution of species and fossils could be explained if every new species always came into existence near an already existing, closely related species. Charles Lyell (14 November 1797 – 22 February 1875; a British lawyer, geologist and Charles Darwin's close

friend) recognized the implications of Wallace's paper and its possible connection to Darwin's work, although Darwin did not, and in the spring of 1856 Lyell urged Darwin to publish his theory to establish priority. Darwin was torn between the desire to set out a full and convincing account and the pressure to quickly produce a short paper. He decided he did not want to expose his ideas to review by an editor as would have been required to publish in an academic journal. On 14 May 1856, he began a "sketch" account, and by July had decided to produce a full technical treatise on species. His *On the Origin of Species*, was published on 24 November 1859

89. Which of the following countries has the most volcanoes?

- A. Indonesia
- B. USA
- C. Japan
- D. Italy

ANSWER: A

Japan is an archipelago of 6,852 islands. The four largest islands are Honshu, Hokkaido, Kyushu and Shikoku, together accounting for 97% of Japan's land area. Most of the islands are mountainous and may volcanic, for example, Japan's highest peak, Mount Fuji, is a volcano. The Smithsonian Institution (www.volcano.si.edu) lists 136 volcanoes in Japan, quite a few of them extinct, scattered around the country's several islands.

The Republic of Indonesia is a country in Southeast Asia and Oceania. Indonesia comprises 17500 islands. With a population of around 230 million people, it's the world's fourth most populous country and has the world's largest population of Muslims. The five largest islands are Java, Sumatra, Kalimantan (the Indonesian part of Borneo), New Guinea (shared with Papua New Guinea), and Sulawesi. Indonesia's location on the edges of the Pacific, Eurasian and Australian tectonic plates makes it the site of numerous volcanoes and frequent earthquakes. Indonesia has at least 150 active volcanoes including Krakatoa and Tambora, both famous for their devastating eruptions in the 19th century. The eruption of the Toba supervolcano, approximately 70,000 years ago, was one of the largest eruptions ever, and a global catastrophe.

90. The deadliest volcanoes tend to occur in the presence of this geologic phenomenon.

- A. Erosion
- B. Conservative-margin plate tectonics
- C. Convection
- D. Subduction

ANSWER: D

Subduction is the process that takes place at convergent boundaries by which one tectonic plate moves under another tectonic plate, sinking into the earth's crust as the plates converge. A subduction zone is an area on earth where two tectonic plates move towards one another and subduction occurs. Subduction zones involve an oceanic plate sliding beneath either a continental plate or another oceanic plate. Subduction zones are often noted for their high rates of volcanism, earthquakes and mountain building. The most common perception of a volcano is of a conical mountain, spewing lava and poisonous gases from a crater at its summit. This describes a stratovolcano, one of many types of volcano. Stratovolcanoes are also known as composite volcanoes, created from several structures during different kinds of eruptions. They are common in subduction zones. Strato/composite volcanoes are made of cinders, ash and lava. Cinders and ash pile on top of each other, lava flows on top of the ash, where it cools and hardens, and then the process begins again. Classic examples include Mount Fuji in Japan, and Mount Vesuvius in Italy. In recorded history, explosive eruptions by stratovolcanoes have posed the greatest hazard to civilizations.

91. If you lived on Earth during the past two millennia and died as a result of volcanic activity, statistically this was the most likely cause of your death

- A. Tsunami
- B. Lava
- C. Mud and ash
- D. Starvation

ANSWER: D

Large, explosive volcanic eruptions inject water vapor, carbon dioxide, sulfur dioxide (SO₂), hydrogen chloride (HCl), hydrogen fluoride (HF) and ash into the stratosphere to heights of 16–32 kilometres above the Earth's surface. The most significant impacts from these injections come from the conversion of sulfur dioxide to sulfuric acid (H₂SO₄), which condenses rapidly in the stratosphere to form fine sulfate aerosols. The aerosols increase the earth's reflection of radiation from the sun back into space - and thus cool the earth's lower atmosphere or troposphere. This can precipitate what is called a volcanic winter.

In 1600, the Huaynaputina in Peru erupted, leading to a very cold 1601. Russia had its worst famine in 1601 to 1603. From 1600 to 1602, Switzerland, Latvia and Estonia had exceptionally

cold winters. The wine harvest was late in 1601 in France, and in Peru and Germany wine production collapsed. The 1815 eruption of Mount Tambora, a stratovolcano in Indonesia, occasioned mid-summer frosts in New York State and June snowfalls in New England in what came to be known as the "Year Without a Summer" of 1816.

92. Which of the following is NOT a benefit of volcanic activity?

- A. Geothermal power
- B. Soil fertilization
- C. Valuable metal deposits
- D. Glacier melting

ANSWER: D

The sulfate aerosols originating from volcanic eruptions also promote complex chemical reactions on their surfaces that alter chlorine and nitrogen chemical species in the stratosphere. As the aerosols grow and coagulate, they settle down into the upper troposphere where they serve as nuclei for cirrus and further modify the earth's radiation balance. Most of the hydrogen chloride (HCl) and hydrogen fluoride (HF) are dissolved in water droplets in the eruption cloud and quickly fall to the ground as acid rain. The injected ash also falls rapidly from the stratosphere; most of it is removed within several days to a few weeks. Finally, explosive volcanic eruptions release the greenhouse gas carbon dioxide and thus provide a deep source of carbon for biogeochemical cycles. Large injections of aerosols from volcanic eruptions may cause visual effects such as unusually colorful sunsets and affect global climate mainly by cooling it. Volcanic eruptions also provide the benefit of adding nutrients to the soil through the weathering process of volcanic rocks. These fertile soils assist the growth of plants and various crops. Volcanic eruptions can also create new islands, as the magma cools and solidifies upon contact with ocean water.

93. Nobel Prize in Physiology or Medicine 2006 "for their discovery of RNA interference – gene slicing by double-stranded RNA" went to which researchers.

- A. Andrew Z. Fire and Craig C. Mello
- B. Kaashief Jacobs and Ayesha Davids
- C. Barry J. Marshall and J. Robin Warren
- D. Paul C. Lauterbur and Sir Peter Mansfield

ANSWER: A (www.nobelprize.org)

The following is an excerpt from the Nobel Prize Presentation Speech by Professor Göran K. Hansson, Member of the Nobel Assembly at

Karolinska Institute, Chairman of the Nobel Committee for Physiology or Medicine, December 10, 2006.



Andrew Z. Fire



Craig C. Mello

"In their brilliant paper from 1998, Andrew Fire and Craig Mello demonstrated that double-stranded RNA activates an enzymatic mechanism that leads to gene silencing, with the genetic code in the RNA molecule determining which gene to silence. Today, we call this mechanism RNA interference. Continued research has shown that our cells use RNA interference to regulate thousands of genes. Through RNA interference, the pattern of gene expression is fine-tuned in such a way that each cell uses precisely those genes that are needed for building its proteins. Today we also know that RNA interference helps to protect us against viruses and jumping genes. Finally, RNA interference can be used to control gene expression in the laboratory – and hopefully soon also in clinical medicine."

94. Which of the following does NOT represent an alteration to a chromosome?

- A. translocation
- B. inversion
- C. deletion
- D. nondisjunction

ANSWER: C

Chromosomal aberrations are disruptions in the normal chromosomal content of a cell, and are a major cause of genetic conditions in humans, such as Down's syndrome. Most common are (i) Deletion– loss of part of a chromosome, (ii) Duplication– extra copies of a chromosome or parts thereof, (iii) Inversion– reverse the direction of a part of a chromosome and (iv) Translocation– part of a chromosome breaks off and attaches to another chromosome,

Some chromosome abnormalities do not cause disease in carriers, such as translocation or chromosomal inversion, although they may lead to a higher chance of birthing a child with a chromosome disorder. Nondisjunction ("not coming apart") is the failure of chromosome pairs to separate properly during cell division. This could arise from a failure of homologous chromosomes

to separate in meiosis I, or the failure of sister chromatids to separate during meiosis II or mitosis. The result of this error is a cell with an imbalance of chromosomes. Such a cell is said to be aneuploid. Loss of a single chromosome ($2n-1$), in which the daughter cell(s) with the defect will have one chromosome missing from one of its pairs, is referred to as a monosomy. Gaining a single chromosome results in the daughter cell(s) having one chromosome in addition to its pairs, a defect referred to as a trisomy. Down's syndrome is a chromosomal abnormality characterized by the presence of an extra copy of genetic material on the 21st chromosome, either in whole (trisomy 21) or a part thereof (such as due to translocations).

95. Which of the following may pass across the mammalian placenta?

- I. maternal antibodies
 - II. maternal lymphocytes
 - III. alcohol
 - IV. viruses
 - V. erythrocytes
-
- A. I, II & III
 - B. II, III & IV
 - C. I, IV & V
 - D. I, III & IV

ANSWER: A

The placenta is an organ that connects the developing fetus to the uterine wall to allow nutrient uptake, waste elimination and gas exchange via the mother's blood supply. In preparation for implantation, the uterine endometrium undergoes 'decidualization'. Spiral arteries in the decidua are remodelled so that they become less convoluted and their diameter is increased. This increases maternal blood flow to the placenta and also decreases resistance so that shear stress is reduced. The relatively high pressure as the maternal blood enters the intervillous space through these spiral arteries bathes the villi in blood. An exchange of gases takes place. As the pressure decreases, the deoxygenated blood flows back through the endometrial veins. Deoxygenated fetal blood passes through umbilical arteries to the placenta.

At the junction of umbilical cord and placenta, the umbilical arteries branch radially to form chorionic arteries. Chorionic arteries also branch before they enter into the villi. In the villi, they form an extensive arteriocapillary venous system, bringing the fetal blood extremely close to the maternal blood; but no mixing of fetal and maternal blood occurs. The perfusion of the intervillous spaces of the placenta with maternal blood allows the transfer of nutrients and oxygen from the mother to the fetus and the

transfer of waste products and carbon dioxide back from the fetus to the mother. Nutrient transfer to the fetus is both actively and passively mediated by proteins called nutrient transporters that are expressed within placental cells.

96. In a disputed paternity case, the following blood groups were identified:

Mother	- Group A
Baby	- Group O
Mr Rich	- Group A
Mr Famous -	Group B

Which of the following statements is true?

- A. Both men could be the father (either man could be the father).
- B. Mr Rich cannot be the father.
- C. Mr Famous cannot be the father.
- D. Neither man could be the father.

ANSWER: D

The most common type of blood grouping is the ABO grouping. Red blood cells have a protein coat on their surface which distinguishes them. According to this blood is divided into four groups: (i) A (A oligosaccharide is present), (ii) B (B oligosaccharide is present), (iii) AB (A and B oligosaccharides are present), and (iv) O (neither A nor B, only their precursor H oligosaccharide present). A child will inherit the blood type of both the mother and the father. With the mother's blood type being A, if Mr Rich was the father, the child's blood type would have been AA. If Mr Famous was the father, the child's blood type would have been AB. **Please note that blood tests can only prove that one is not the parent!** There are millions of people sharing the same blood type so a man who shares the same blood type with a child is not necessarily the father to that child. DNA testing is currently the most advanced and accurate technology to determine parentage. In a DNA parentage test, the probability of parentage is 0% when the alleged parent is not biologically related to the child and the probability of paternity typically greater than 99.9% when the alleged parent is biologically related to the child.

97. Which of the following statements about the work of Gregor Mendel are correct?

- I. He concluded that the characteristics of an organism are determined by internal factors (genes) which occur in pairs.

- II. He concluded that only one of a pair of factors can be represented in a single gamete.
- III. He concluded that factors are linked if they occur on the same chromosome.
- IV. He concluded that each member of a pair of factors can combine randomly with either member of another pair.
- V. He concluded that independent segregation must occur during metaphase I of meiosis.

- A. I & II
- B. II & III
- C. III & IV
- D. I, II & IV

ANSWER: D

The principles of heredity were written by the Austrian monk Gregor Mendel in 1865. Mendel discovered that by crossing white flower and purple flower plants, the result was not a blend. Rather than being a blend of the two, the offspring was purple flowered. He then conceived the idea of heredity units, which he called "factors", one of which is a recessive characteristic and the other dominant. Mendel said that factors, later called genes, normally occur in pairs in ordinary body cells, yet segregate during the formation of sex cells. Each member of the pair becomes part of the separate sex cell. The dominant gene, such as the purple flower in Mendel's plants, will hide the recessive gene, the white flower. After Mendel self-fertilized the F1 generation and obtained the 3:1 ratio, he correctly theorized that genes can be paired in three different ways for each trait: AA, aa, and Aa. The capital "A" represents the dominant factor and lowercase "a" represents the recessive. (The last combination listed above, Aa, will occur roughly twice as often as each of the other two, as it can be made in two different ways, Aa or aA.)

Mendel stated that each individual has two factors (which in modern scientific terms are called alleles) for each trait, one from each parent. The two factors may or may not contain the same information. If the two factors are identical, the individual is called homozygous for the trait. If the two factors have different information, the individual is called heterozygous.

Mendel summarized his findings in two laws; the Law of Segregation and the Law of Independent Assortment. The Law of Segregation states that when any individual produces gametes, the copies of a gene separate, so that each gamete receives only one copy. A gamete will receive one allele or the other. The direct proof of this was later found when the process of meiosis came to be known. In meiosis the paternal and maternal chromosomes get separated and the alleles with the characters are

segregated into two different gametes. The Law of Independent Assortment, also known as "Inheritance Law", states that alleles of different genes assort independently of one another during gamete formation. This is actually only true for genes that are not linked to each other.

98. In a food chain isolated from others, which of the following (measured in kJ m^{-2}) is numerically the greatest?

- A. Net primary production in plants
- B. First carnivore consumption
- C. Herbivore assimilation
- D. Herbivore respiration

ANSWER: A

In an isolated food chain where there is no animal/plant exchange with the rest of the ecosystem, primary consumers (herbivores) have to multiply at a very fast rate to replenish those eaten by carnivores. This is not always possible, depending on the life span/ time taken to reach reproductive maturity by the herbivores. In all likelihood, herbivore population declines, and eventually get exterminated, leading to the death of the carnivores. This will leave only the primary consumers in the food chain which will flourish.

Food chains are overly simplistic as representations of the relationships of living organisms in nature. Most consumers feed on multiple species and in turn, are fed upon by multiple other species. A food web is a series of related food chains displaying the movement of energy and matter through an ecosystem. Links in food webs primarily connect feeding relations among species. Biodiversity within ecosystems can be organized into vertical and horizontal dimensions. The vertical dimension represents feeding relations that become further removed from the base of the food chain up toward top predators. The horizontal dimension represents the abundance or biomass at each level. When the relative abundance or biomass of each functional feeding group is stacked into their respective trophic levels they naturally sort into a 'pyramid of numbers'. Functional groups are broadly categorized as autotrophs (or primary producers), heterotrophs (or consumers), and detritivores (decomposers). Heterotrophs can be further sub-divided into different functional groups, including: strict primary consumers (strict herbivores), secondary consumers (predators that feed exclusively on herbivores) and tertiary consumers (predators that feed on a mix of herbivores and predators). Omnivores do not fit neatly into a functional category because they eat both plant and animal tissues.

99. The water transport tissue of a plant is also known as

- A. Xylem
- B. Phloem
- C. Bark
- D. Pith

ANSWER: A

Vascular plants (also known as higher plants) are those plants that have lignin-containing tissues for conducting water, minerals, and photosynthetic products through the plant. Vascular plants include the ferns, club mosses, flowering plants and conifers. Nutrients and water from the soil and the organic compounds produced in leaves are distributed to specific areas in the plant through the xylem and phloem. The xylem draws water and nutrients up from the roots to the upper sections of the plant's body, and the phloem conducts other materials, such as the sucrose produced during photosynthesis, which gives the plant energy to keep growing and seeding. The xylem consists of tracheids, which are dead hard-walled hollow cells arranged to form tiny tubes to function in water transport. A tracheid cell wall usually contains the polymer lignin. The phloem however consists of living cells called sieve tube members. Between the sieve-tube members are sieve plates, which have pores to allow molecules to pass through. Sieve-tube members lack such organs as nuclei or ribosomes, but cells next to them, the companion cells, function to keep the sieve-tube members alive.

100. An organism that gets energy from light and organic matter is known as

- A. Photoorganoheterotroph
- B. Photolithoautotroph
- C. Photolithoheterotroph
- D. Chemolithoautotroph

ANSWER: A

Autotrophs such as green plants make their own food. Organisms that cannot do so are called heterotrophs. In respiration, firstly, we require a primary source of energy. In phototrophs, light is absorbed in photo receptors and transformed into chemical energy. In chemotrophs, bond energy is released from a chemical compound. Secondly, we require electron donors (chemicals) for redox reactions to occur that give off energy. If this redox donor is an organic compound, then this brings a designation organotroph. If the redox donor is inorganic, then the designation lithotroph is used.