NATIONAL SCIENCE OLYMPIAD

LIFE SCIENCES: 2011

1. The statement "*we are chemical beings*" means:

(A) humans respond negatively to chemicals, which explains why some people have allergies against certain foods and medicines.

(B) human beings are chemical systems with a motley of chemical transformations sustaining them.

(C) humans are selective in what chemicals we consume since some of them are acutely poisonous.

(D) NONE of the above.

ANSWER: (B)

All living organisms are underpinned by a combination of many chemical processes/transformations occurring within them. By controlling information flow through biochemical signalling and the flow of chemical energy through metabolism; biochemical processes give rise to the seemingly magical phenomenon of life.

2. The statement "*we are water beings*" means

(A) humans followed the evolutionary path: mammals → birds → reptiles → amphibians → fish, which explains why we can swim.

(B) humans breathe out water vapour, a by-product of oxidative phophorylation.

(C) water comprises the largest proportion of human cells.

(D) NONE of the above.

ANSWER: (C)

All known forms of life depend on water. Water is vital both as a solvent in which many of the body's solutes dissolve and as an essential part of many metabolic processes within the body. The cell's cytosol is a complex mixture of substances dissolved in water, which makes up about 70% of the total volume of a typical cell. In prokaryotes, most of the chemical reactions of metabolism take place in the cytosol, while a few take place in membranes or in the periplasmic space. In eukaryotes, while many metabolic pathways still occur in the cytosol, others are contained within organelles.

In anabolism, water is removed from molecules (through energy requiring enzymatic chemical reactions) in order to grow larger molecules (e.g. starches, triglycerides and proteins for storage of fuels and information). In catabolism, water is used to break bonds in order to generate smaller molecules (e.g. glucose, fatty acids and amino acids to be used for fuels for energy use or other purposes). Without water, these particular metabolic processes could not exist, hence the need for living

organisms to drink water (or use water produced during oxidative phosphorylation).

3. A snake kept as a pet can never be taught to know and remember even its keeper because

(A) a snake has only one lung which limits its oxygen intake and thus learning capabilities.
(B) the venom in a snake's fangs slowly kills its brain cells, diminishing its cognitive abilities
(C) snakes are obstreperous animals that only live to kill, eat and reproduce.
(D) snake brains are very small, with the parts useful for cognitive abilities absent.

ANSWER: (D)

The cerebrum comprises what most people think of as the "brain" (in the sense of intelligence) It lies in front or on top of the brainstem and in humans is the largest and most well-developed of the five major divisions of the brain. The cerebrum is the newest structure in the phylogenetic sense sense, with mammals having the largest and most well-developed among all species. The cerebrum directs the conscious or volitional motor functions of the body. The primary sensory areas of the cerebral cortex receive and process visual, auditory, somatosensory, gustatory and olfactory, information. Together with association cortical areas, these brain regions synthesize sensory information into our perceptions of the world around us. Explicit or declarative (factual) memory formation is attributed to the hippocampus and associated regions of the medial temporal lobe. Implicit or procedural memory such as complex motor behaviors, involve the basal ganglia.

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

(A) cyanide kills by binding to heart muscles, and little of it is enough to induce a heart attack.
(B) cyanide instantly collapses the lungs and kills by asphyxiation.
(C) it renders cells unable to use oxygen, by binding to cytochrome c oxidase.
(D) a few cyanide molecules are enough to instantly kill all liver cells.

ANSWER: (C)

Cyanide poisoning occurs when a living organism is exposed to a compound that produces cyanide ions (CN^-) when dissolved in water. The cyanide ion halts cellular respiration by inhibiting an enzyme in mitochondria called cytochrome c oxidase. The enzyme cytochrome c oxidase or is a large transmembrane protein complex found in bacteria and mitochondria. It is the last enzyme in the respiratory electron transport chain of mitochondria (or bacteria) located in the mitochondrial (or

bacterial) membrane. It receives an electron from each of four cytochrome c molecules, and transfers them to one oxygen molecule, converting molecular oxygen to two molecules of water. In the process, it binds four protons from the inner aqueous phase to make water, and in addition translocates four protons across the membrane, helping to establish a trans-membrane difference of proton electrochemical potential that the ATP synthase then uses to synthesize ATP. Cyanide and carbon monoxide bind to cytochrome c oxidase, thus competitively inhibiting the protein from functioning which results in chemical asphyxiation of cells.

5. The most effective antidote to cyanide poisoning is hydroxocobalamin. The reason why it works so well is because

(A) it captures cyanide to form cyanocobalamin (vitamin B_{12}) which is then eliminated through urine.
(B) it temporarily takes over the functions of hemoglobin and gives the body a chance to naturally rid itself of cyanide.
(C) it oxidizes cyanide to the relatively harmless cyanate,
(D) NONE of the above

ANSWER: (A)

Hydroxocobalamin, a form of vitamin B_{12} made by bacteria, and sometimes denoted vitamin B_{12a}, is used to bind cyanide to form the harmless cyanocobalamin form of vitamin B_{12}. Cyanocobalamin is then eliminated through the urine. Hydroxocobalamin works both within the intravascular space and within the cells to combat cyanide intoxication. This versatility contrasts with methemoglobin, which acts only within the vascular space as an antidote. Administration of sodium thiosulfate improves the ability of the hydroxocobalamin to detoxify cyanide poisoning. This treatment is so effective and innocuous but it is relatively expensive and not universally available.

6. Ovoviviparity, is a mode of reproduction in which

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

ANSWER: (D)

Ovoviviparity, ovovivipary, or ovivipary, is a mode of reproduction in animals in which embryos develop inside eggs that are retained within the mother's body until they are ready to hatch. Ovoviviparous animals

are similar to viviparous species in that there is internal fertilization and the young are born live, but differ in that there is no placental connection and the unborn young are nourished by egg yolk; the mother's body does provide gas exchange (respiration). Ovoviviparity is employed by many aquatic life forms such as some fish, reptiles and invertebrates.

USE THE FOLLOWING INFORMATION TO ANSWER QUESTIONS 7, 8, 9 AND 10.

Yellow fever is an acute viral hemorrhagic disease. The yellow fever virus is transmitted by the bite of the often crepuscular female mosquito, *Aedes aegypti*, and is found in tropical areas in South America and Africa. It has no known cure but a vaccine against it, vaccine 17D, was developed in 1937 by the South African microbiologist Max Theiler, whilst working at the Rockefeller Institute.

7. A crepuscular animal is one that is active during

(A) daytime.
(B) twilight.
(C) nighttime.
(D) NONE of the above.

ANSWER: (B)

Crepuscular is a term used to describe some animals that are primarily active during twilight (at dawn and at dusk). The word is derived from the Latin word *crepusculum*, meaning "twilight." Crepuscular is thus in contrast with diurnal and nocturnal behavior. Crepuscular animals may also be active on a bright moonlit night. The patterns of activity are thought to be an anti-predator adaptation. Many predators forage most intensely at night, while others are active at mid-day and see best in full sun. Thus the crepuscular habit may reduce predation. Additionally, in hot areas, it may be a way of avoiding thermal stress while capitalizing on available light.

8. The 17D vaccine was and is still produced

(A) from the attenuated virus cultured in chicken eggs.
(B) from the brains of mice infected with yellow fever.
(C) from the blood serum of those who suffered and survived yellow fever.
(D) NONE of the above.

ANSWER: (A)

The 17D vaccine consists of a live, but attenuated, strain of the yellow fever virus called 17D, cultured in chicken eggs. The 17D vaccine has been used commercially since the 1950s. The mechanisms of attenuation and immunogenicity for the 17D strain are not known. However, this vaccine is very safe, with few adverse reactions having been reported and millions of doses administered, and highly effective with over 90% of those vaccinated developing a

measurable immune response after the first dose.

9. Another hemorrhagic disease is Ebola. This disease is caused by

(A) the Ebola virus, which belongs to the family *Filoviridae.*
(B) the Ebola virus, which belongs to the family *Rhabdoviridae.*
(C) the Ebola virus, which belongs to the family *Paramyxoviridae.*
(D) the Ebola bacterium, which belongs to the same family as *Mycobacterium tuberculosis.*

ANSWER: (A)

Ebola hemorrhagic fever is a viral hemorrhagic fever caused by the Ebola virus, a member of the *Filoviridae* family The virus is named after the Ebola River Valley in the Democratic Republic of the Congo (formerly Zaire), which is near the site of the first recognized outbreak in 1976 at a mission hospital. The virus interferes with the endothelial cells lining the interior surface of blood vessels and with coagulation. As the blood vessel walls become damaged and destroyed, the platelets are unable to coagulate, patients succumb to hypovolemic shock. Ebola is transmitted through bodily fluids, while conjunctiva exposure may also lead to transmission. It has a very high fatality rate, up to 90% in some epidemics.

10. In recognition of saving millions of lives by developing the yellow fever vaccine, Max Theiler was awarded

(A) the Nobel Prize in Medicine or Physiology in 1951.
(B) the J.D. Rockefeller Prize, by John Davison Rockefeller, Jr. in 1951.
(C) the USA's National Medal of Science, by President George W. Bush in 2002.
(D) South Africa's Order of Mapungubwe, by President Thabo Mbeki in 2002.

ANSWER: (A)

Max Theiler (born 30 January 1899, Pretoria, South Africa; died 11 August 1972, New Haven, CT, USA) was awarded The 1951 Nobel Prize in Physiology or Medicine *"for his discoveries concerning yellow fever and how to combat it"*. Other Honours awarded to him include the Chalmer's Medal of the Royal Society of Tropical Medicine and Hygiene (London, 1939), the Flattery Medal (Harvard, 1945), and the Lasker Award of the Lasker Foundation (1949).

11. Tay-Sachs disease is an abnormality that causes a relentless deterioration of mental and physical abilities that commences around six months of age and usually results in death by the age of four. It is an autosomal recessive genetic disorder, which means

(A) two alleles of the gene must be present, one from each parent, and located on a chromosome other than X or Y.

(B) two alleles of the gene must be present, one from each parent, and located on either chromosome X or Y.

(C) one allele of the gene must be present, from either parent, and located on a chromosome other than X or Y.

(D) one allele of the gene must be present, from either parent, and located on the X or Y chromosome.

ANSWER: (A)

In humans and many other species, sex is determined by two sex chromosomes called the X chromosome and the Y chromosome. Human females are typically XX, males are typically XY. The remaining pairs of chromosome are found in both sexes and are called autosomes; genetic traits due to loci on these chromosomes are described as autosomal, and may be dominant or recessive. Genetic traits on the X and Y chromosomes are called sex linked, because they tend to be characteristic of one sex or the other. Females have two copies of every gene locus found on the X chromosome, just as for the autosomes, and the same dominance relationships apply. Males however have only one copy of each X-chromosome gene locus, and are described as hemizygous for these genes. For a recessive autosomal trait to be phenotypically observed, two copies of the gene must be present.

12. Tay-Sachs disease is caused by insufficient activity of an enzyme called hexosaminidase A. The biological function of this enzyme is to

(A) catalyze the biodegradation of fatty acid derivatives known as gangliosides.

(B) catalyze the amination of hexoses.

(C) catalyze the deamination of hexose sugars.

(D) catalyze the removal of ammonia in the blood as urea.

ANSWER: (A)

TSD is caused by insufficient activity of an enzyme called hexosaminidase A that catalyzes the biodegradation of fatty acid derivatives known as gangliosides. Hexosaminidase A is a vital hydrolytic enzyme, found in the lysosomes, that breaks down lipids. When Hexosaminidase A is no longer functioning properly, the lipids accumulate in the brain and interfere with normal biological processes. Gangliosides are made and biodegraded rapidly in early life as the brain develops. Hydrolysis of GM2-ganglioside requires three proteins. Two of them are subunits of hexosaminidase A, and the third is a small glycolipid transport protein, the GM2 activator protein (GM2A), which acts as a substrate specific cofactor for the enzyme.

Patients and carriers of Tay-Sachs disease can be identified by a simple blood test that measures hexosaminidase A activity.

13. Haemophilia is a group of hereditary genetic disorders that impair the body's ability to control blood clotting, which is used to stop bleeding when a blood vessel is broken. It is a recessive, X-chromosome-linked disorder, which means:

(A) it affects females more severely since they carry two X-chromosomes.
(B) It affects males less since they carry only one X chromosome thus less of the defective gene.
(C) it affects both males and females equally.
(D) it is more likely to show up males than females.

ANSWER: (D)

X-linked inherited diseases occur far more frequently in males because they only have one X chromosome. Females must receive a copy of the gene from both parents to have such a recessive disease. However, they will still be carriers if they receive one copy of the gene. Recessive genes on the X chromosome that cause serious diseases are usually passed from female carriers to their ill sons and carrier daughters. This is because males, who always have the disease and are not just carriers, would have to father a daughter to pass on the gene. This is unlikely because severe genetic diseases often cause death in childhood or early adulthood.

14. There is no cure for hemophilia, but several therapeutic interventions can be made to manage the disease. Which one of the following can be safely used in this regard?

(A) regular infusions of clotting factors: factor VIII in haemophilia A or factor IX in haemophilia B.
(B) regular administration of aspirin, which has anti-inflammatory and anti-platelet effects and can decrease the risk of a heart attack.
(C) regular co-administration of warfarin and vitamin K, both required for blood clotting.
(D) NONE of the above.

ANSWER: (A)

Although there is no cure for haemophilia, it can be controlled with regular infusions of the deficient clotting factor, i.e. factor VIII in haemophilia A or factor IX in haemophilia B. Factor replacement can be either isolated from human blood serum recombinant, or a combination of the two. Some haemophiliacs develop antibodies (inhibitors) against the replacement factors given to them, so the amount of the factor has to be increased or non-human replacement products must be given, such as porcine factor VIII.

Anticoagulants such as heparin and warfarin are contraindicated for people with haemophilia as these can aggravate clotting difficulties. Also contraindicated are those drugs which have "blood thinning" side effetcs. For instance, medications which contain aspirin, ibuprofen, or naproxen sodium should not be taken.

15. Phenylketonuria is an autosomal recessive genetic metabolic disorder metabolic in which phenylalanine accumulates in the body and is converted into phenyl pyruvate. Individuals, especially children diagnosed with this disorder must keep their intake of phenylalanine extremely low to prevent mental retardation and other metabolic complications. The disease is characterized by a deficiency in the hepatic enzyme phenylalanine hydroxylase, which is necessary for:

(A) incorporating phenylalanine into proteins.
(B) deamination of excess phenylalanine for excretion.
(C) converting phenylalanine into tyrosine.
(D) removal of the hydroxyl group on phenylalanine.

ANSWER: (C)

Phenylalanine hydroxylase (PAH) is necessary to metabolize the amino acid phenylalanine to the amino acid tyrosine. When PAH is deficient, phenylalanine accumulates and is converted into phenyl pyruvate (also known as phenylketone), which is detected in the urine, hence the name phenylketonuria.

Use the following information to answer Questions 16, 17 and 18.

The Kruger National Park (KNP) was proclaimed by Paul Kruger, President of the Transvaal Republic, in 1898 to protect the wildlife of the South African Lowveld

16. Which of the following cannot be found in the Kruger Park?
(i) cobs, pens and cygnets
(ii) leatherbacks and loggerheads
(iii) mocking, and humming birds

(A) (i)
(B) (i) and (ii)
(C) (ii) and (iii)
(D) ALL of the above.

ANSWER: (D)

Swans, genus *Cygnus*, are birds of the family Anatidae, which also includes geese and ducks. Swans are grouped with the closely related geese in the subfamily Anserinae where they form the tribe Cygnini. Young swans are known as *cygnets*, from the Latin word *cygnus* ("swan") and the Old French suffix -*et* ("little"); an adult male is a *cob*, from Middle English *cobbe* (leader of a group); an adult female is a *pen*. Swans are

generally found in temperate environments, rarely occurring in the tropics. Four (or five) species occur in the Northern Hemisphere, one species is found in Australia and New Zealand and one species is distributed in southern South America. They are absent from tropical Asia, Central America, and the entirety of Africa.

Leatherbacks and loggerheads are sea turtles. The leatherback turtle (*Dermochelys coriacea*) is the largest of all living sea turtles and the fourth largest modern reptile behind three crocodilians It is the only living species in the genus *Dermochelys*. It can easily be differentiated from other modern sea turtles by its lack of a bony shell. Instead, its carapace is covered by skin and oily flesh.

The loggerhead sea turtle (*Caretta caretta*), or loggerhead, is an oceanic turtle distributed throughout the world. It is a marine reptile, belonging to the family Cheloniidae. The loggerhead is the world's largest hard-shelled turtle, measuring up to 213 centimeters (84 in) long when fully grown. The adult loggerhead sea turtle weighs approximately 135 kilograms (300 lb). The skin ranges from yellow to brown in color, and the shell is typically reddish-brown. There are no external differences in gender until the turtle becomes an adult, the most obvious difference being that adult males have thicker tails and shorter plastrons than the females.

Mockingbirds are a group of New World passerine birds from the Mimidae family. They are best known for the habit of some species mimicking the songs of other birds and the sounds of insects and amphibians often loudly and in rapid succession. There are about 17 species in three genera.

Hummingbirds are birds comprising the family Trochilidae. They are among the smallest of birds, and include the smallest existing bird species, the bee hummingbirds. They can hover in mid-air by rapidly flapping their wings 12–90 times per second (depending on the species). They can also fly backwards, and are the only group of birds able to do so. Their English name derives from the characteristic hum made by their rapid wing beats. Hummingbirds drink nectar, a sweet liquid inside flowers. Since nectar is a poor source of nutrients, hummingbirds meet their needs for proteins, vitamins, minerals and fatty acids by preying on insects. Hummingbirds are found natively in the Americas, from southern Alaska to the Caribbean. The majority of species occur in tropical and subtropical Central and South America.

17. Which of the following foreign national parks is nearly the same size (surface area) as the Kruger Park?

(A) America’s Yellowstone National Park
(B) Botswana & South Africa’s Kgalagadi Transfrontier Park
(C) Tanzania’s Serengeti National Park

(D) Russia's Yugyd Va National Park.

ANSWER: (D)

The Kruger National Park is one of the largest game reserves in Africa. It covers 18,989 square kilometres (7,332 sq mi) and extends 360 kilometres (220 mi) from north to south and 65 kilometres (40 mi) from east to west. The park is part of the Kruger to Canyons Biosphere, an area designated by UNESCO as an International Man and Biosphere Reserve (the "Biosphere"). The Kruger National Park is divided into six eco-systems: Baobab sandveld, Mopane scrub, Lebombo knobthorn-marula bushveld, mixed acacia thicket, Combretum-silver clusterleaf woodland on granite and riverine forest. Altogether it has roughly 1,982 species of plants. Out of the 517 species of birds found at Kruger, 253 are residents, 117 non-breeding migrants, and 147 nomads. All the big five game animals are found at Kruger National Park, which has more species of mammals than any other African Game Reserve (at 147 species). Also resident in the park are 114 species of reptile, including crocodiles.

Kgalagadi Transfrontier Park is a large wildlife preserve and conservation area straddling the border between South Africa and Botswana and comprises two adjoining national parks: Kalahari Gemsbok National Park in South Africa and Gemsbok National Park in Botswana. The total area of the park is 38,000 square kilometres (15,000 sq mi). Approximately three-quarters of the park lie in Botswana and one-quarter in South Africa. The park has abundant, varied wildlife. It is home to large mammalian predators such as black-maned Kalahari lions, cheetahs, leopards and hyenas. Migratory herds of large herbivores such as blue wildebeest, springbok, eland and red hartebeest also live and move seasonally within the park, providing sustenance for the predators. More than 200 species of bird can be found in the park.

Yellowstone National Park, established by the US Congress and signed into law by President Ulysses S. Grant on March 1, 1872 is a national park located primarily in the US State of Wyoming, though it also extends into Montana and Idaho. Yellowstone is known for its wildlife and its many geothermal features. It has many types of ecosystems, but the subalpine forest is dominant. Yellowstone National Park spans an area of 3,468 square miles (8,980 km^2), comprising lakes, canyons, rivers and mountains Yellowstone lake is one of the largest high-altitude lakes in North America and is centered over the Yellowstone caldera, the largest supervolcano on the continent. The caldera is considered an active volcano; it has erupted with tremendous force several times in the last two million years. The geothermal features in Yellowstone are fuelled by this ongoing volcanism. Hundreds of species of mammals, birds, fish and reptiles have been documented in the park and the vast forests and grasslands also include unique species

of plants. Grizzly bears, wolves, and free-ranging herds of bison and elk also live in the park.

The Serengeti National Park is a large national park in Serengeti area, Tanzania. It is most famous for its annual migration of over one and a half million white bearded (or brindled) wildebeest and 250,000 zebra. Serengeti National Park is widely regarded as the best wildlife reserve in Africa due to its density of predators and prey. The park covers 14,763 km² (5,700 square miles) of grassland plains and savanna as well as riverine forest and woodlands. As well as the migration of ungulates, the park is well known for its healthy stock of other resident wildlife, particularly the Big Five, as well as giraffes. The park also boasts about 500 bird species, including ostriches. As a result of the biodiversity and ecological significance of the area, the park has been listed by UNESCO as one of the World Heritage Sites.

Yugyd Va National Park is a national park in the Komi Republic, a constituent republic of the Russian Federation, in North-eastern Europe. It is Russia's and Europe's largest national park. The Yugyd Va park covers 18,917 square kilometers in the Northern Ural Mountains and adjacent foothills and flatlands. More than half of the park is covered with the taiga boreal; the rest is mostly tundra, found at higher elevations. There are also some 20 km² of meadows, both alpine ones and those in the river valleys. Some 180 bird species live in the park, some of them quite rare. Twenty fish species are know to inhabit the park's rivers and lakes. There are also five amphibian species and one reptile species in the park. The park also houses many mammals, including wolves, foxes, bears, reindeer and moose.

18. Which of the following is NOT one of the problems the Kruger Park's management has to deal with from time to time?

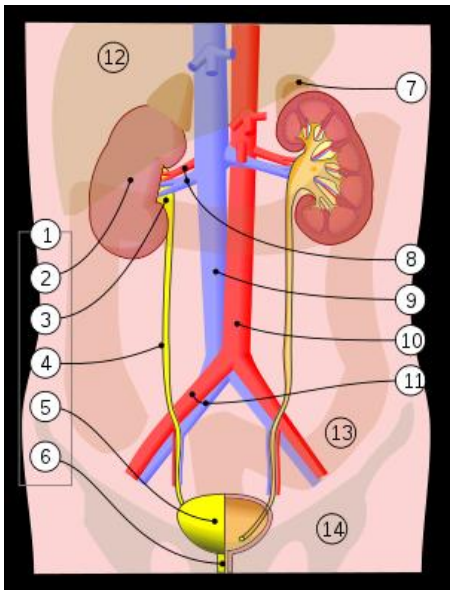
(A) Foot and Mouth disease among buffalos.
(B) Death of lions from tuberculosis.
(C) Inexplicable death of crocodiles.
(D) Seasonal anthrax outbreaks among impala herds.

ANSWER: (D)

Anthrax is an acute disease caused by the bacteria *Bacillus anthracis*. Most forms of the disease are lethal, and it affects both humans and other animals. There are effective vaccines against anthrax, and some forms of the disease respond well to antibiotic treatment. Anthrax commonly infects wild and domesticated herbivorous mammals which ingest or inhale the spores while grazing. Ingestion is thought to be the most common route by which herbivores contract anthrax. Carnivores living in the same environment may become infected by consuming infected animals. Diseased animals can spread anthrax to humans,

either by direct contact (e.g. inoculation of infected blood to broken skin) or consumption of a diseased animal's flesh. There haven't been any reports of major outbreaks of this disease in the Kruger Park or we would have all heard about it, because of its highly contagious and deadly nature.

Use the diagram below to answer questions 19, 20, 21, 22, 23, 24 and 25.



19. The part labeled 9 is called ------ and its function is to ------

(A) inferior vena cava; carry de-oxygenated blood from the lower half of the body into the right atrium of the heart.

(B) abdominal aorta; supply blood to much of the abdominal cavity.

(C) Renal vein; carries deoxygenated blood away from the kidney.

(D) Renal artery; carries oxygenated blood to the kidney.

ANSWER: (B)

The abdominal aorta is the largest artery in the abdominal cavity. As part of the aorta, it is a direct continuation of the descending aorta. It has several branches and supplies blood to much of the abdominal cavity.

20. Tobacco smoking is the main known contributor to cancer that affects structure

(A) 5

(B) 7

(C) 11

(D) NONE of the above.

ANSWER: (A)

Bladder cancer refers to any of several types of malignant growths of the urinary bladder. It is a disease in which abnormal cells multiply without control in the bladder. The bladder is a hollow, muscular organ that stores urine; it is located in the pelvis. Tobacco smoking is the main known contributor to urinary bladder cancer: in most populations, smoking is associated with over half of bladder cancer cases in men and one-third of cases among women. There is a linear relationship between smoking and risk, and quitting smoking reduces the risk. There is a markedly higher incidence of bladder cancer in men than women. Smoking can only partially explain this higher incidence.[One other reason is

that the androgen receptor, which is much more active in men than in women, plays a major part in the development of the cancer.

21. Kidney stones normally cause obstruction (and attendant pain) of the structure

(A) 2
(B) 4
(C) 6
(D) 8

ANSWER: (B)

Kidney stones, or *Renal calculi*, are crystal aggregations of dissolved dissolved minerals in urine; calculi typically form inside the kidneys or ureters. Renal calculi can vary in size from as small as grains of sand to as large as grapefruit. Kidney stones typically leave the body by passage in the urine stream, and many stones are formed and passed without causing symptoms. If stones grow to sufficient size before passage -- on the order of at least 2-3 millimeters -- they can cause obstruction of the ureter. The resulting distention with urine can cause severe episodic pain, most commonly felt in the flank, lower abdomen and groin (a condition called renal colic).

22. The function of structure 2 is controlled by

(A) antidiuretic hormone, luteinizing hormone and adrenalin.
(B) antidiuretic hormone, adrenalin and insulin.
(C) aldosterone, adrenalin and thyroxine.
(D) antidiuretic hormone, aldosterone and parathyroid hormone.

ANSWER: (D)

The kidney participates in whole-body homeostasis, regulating acid-base balance, electrolyte concentrations, extracellular fluid volume, and regulation of blood pressure. The kidney accomplishes these homeostatic functions both independently and in concert with other organs, particularly those of the endocrine system. Any significant rise in plasma osmolarity is detected by the hypothalamus, which communicates directly with the posterior pituitary gland. An increase in osmolality causes the gland to secrete antidiuretic hormone (ADH), resulting in water reabsorption by the kidney and an increase in urine concentration.

Aldosterone increases the reabsorption of sodium ions and water and the release (secretion) of potassium ions in the distal convoluted tubules of the kidneys. This increases blood volume and, therefore, increases blood pressure.

The parathyroid hormone enhances active reabsorption of calcium and magnesium from distal tubules and the thick ascending limb. As bone is degraded both calcium and phosphate are released. It also greatly increases the excretion of phosphate, with a net loss in plasma phosphate concentration. By increasing the calcium:phosphate ratio

more calcium is therefore free in the circulation.

23. Detection of glucose in the urine is normally an indication of diabetes. The reason why glucose is excreted is because

(A) the proximal tubule can only reabsorb a limited amount of glucose and high glucose levels in the blood overwhelm it.
(B) diabetes slowly kills nephrons, leading to kidney failure and the need for renal dialysis.
(C) Kidneys are controlled by insulin, and a lack thereof renders them useless.
(D) NONE of the above

ANSWER: (A)

Renal glucose reabsorption is the part of renal physiology that deals with the retrieval of filtered glucose, preventing it from disappearing from the body through the urine. If glucose is not reabsorbed by the kidney, it appears in the urine, in a condition known as glucosuria, which is a symptom of diabetes. When the glucose concentration in the blood is raised beyond its renal threshold (about 10 mmol/L, although this may be altered in certain conditions, such as pregnancy), reabsorption of glucose in the proximal renal tubuli is incomplete, and part of the glucose remains in the urine). This increases the osmotic pressure of the urine and inhibits reabsorption of water by the kidney, resulting in increased urine production (polyuria) and increased fluid loss. Lost blood volume will be replaced osmotically from water held in body cells and other body compartments, causing dehydration and increased thirst (polydipsia).

24. The basic filtration unit of the kidney is called the

(A) glomerulus.
(B) Bowman's capsule.
(C) Malphigian corpuscle.
(D) Henle's loop.

ANSWER: (C)

A glomerulus is a capillary tuft that performs the first step in filtering blood to form urine. It is surrounded by Bowman's capsule in nephrons of the vertebrate kidney. A glomerulus and its surrounding Bowman's capsule constitute a renal corpuscle (also called the Malphigian corpuscle), the basic filtration unit of the kidney. The rate at which blood is filtered through all of the glomeruli, and thus the measure of the overall renal function, is the glomerular filtration rate (GFR).

25. A urinary tract infection is a bacterial infection that affects any part of the urinary tract. The main etiologic agent is

(A) *Escherichia coli*.
(B) *Clostridium tetani*.

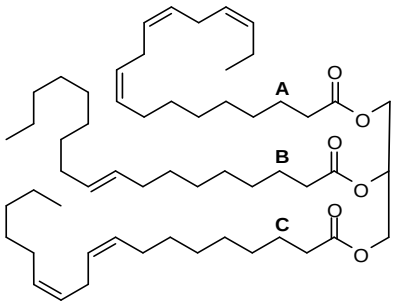
(C) *Trichophyton rubrum*.

(D) *Staphylococcus aureus*.

ANSWER: (A)

A urinary tract infection (UTI) is a bacterial infection that affects any part of the urinary tract. The main etiologic agent is Escherichia coli. Although urine contains a variety of fluids, salts, and waste products, it does not usually have bacteria in it. When bacteria get into the bladder or kidney and multiply in the urine, they may cause a UTI. he most common type of UTI is acute cystitis often referred to as a bladder infection. An infection of the upper urinary tract or kidney is known as pyelonephritis, and is potentially more serious. Although they cause discomfort, urinary tract infections can usually be easily treated with a short course of antibiotics. Symptoms include frequent feeling and/or need to urinate, pain during urination, and cloudy urine.

Carefully study the following structure, isolated from some plant, and answer questions 26, 27, 28, 29 and 30.



26. The depicted structure is a triacyl glyceride because

(A) it is an ester of three fatty acids and 1,2,3-propanetriol.

(B) it is an ester of three α,β-unsaturated acids and glycerol.

(C) it is an ester of three alkynyl acids and glycerol.

(D) it is an ester of three α,β-unsaturated acids and 1,2,3-propanetriol.

ANSWER: (A)

A triglyceride (or triacylglyceride) is an ester derived from glycerol and three fatty acids It is the main constituent of vegetable oil and animal fats. Glycerol has the IUPAC name 1,2,3-propanetriol. Note that none of the fatty acid fragments is α,β-unsaturated (contains a carbon-carbon double bond immediately after the carbon-oxygen bond) and none of them is alkynyl (i.e., contains an alkyne (carbon-carbon triple bond).

27. Which of the fragments labeled A, B and C are deemed essential fatty acids?

(A) A & B

(B) A & C

(C) B & C

(D) A, B & C

ANSWER: (B)

Essential fatty acids are those that cannot be constructed within the human body from

other components and therefore must be obtained from the diet. Fragment A is derived from *α-Linolenic acid,* a carboxylic acid with an 18-carbon chain and three *cis* double bonds. The first double bond is located at the third carbon from the *n* end (also called the omega end, it is the end furthest from the carbonyl group). Thus, α-linolenic acid is a polyunsaturated omega-3 fatty acid.

Linoleic acid (LA) is an unsaturated omega-6 fatty acid. It is has an 18-carbon chain and two *cis* double bonds; the first double bond is located at the sixth carbon from the omega end. Linoleic acid (LA) is used in the biosynthesis of arachidonic acid and thus some prostaglandins. It is found in the lipids of cell membranes and is abundant in many vegetable oils.

28. Which of the fragments labeled A, B and C is an omega-6-fatty acid?

(A) C
(B) A
(C) B
(D) NONE of the above

ANSWER: (A)

An omega-6-fatty acid must have a double bond located at the sixth carbon from the omega end.

29. Which of the fragments labeled A, B and C is a geometric isomer of oleic acid, abundant in olive oil and human adipose tissue?

(A) A
(B) B
(C) C
(D) NONE of the above

ANSWER: (B)

Oleic acid is a monounsaturated omega-9 fatty acid found in various animal and vegetable sources. It has the formula $CH_3(CH_2)_7CH=CH(CH_2)_7COOH$. Triglyceride esters of oleic acid compose the majority of olive oil, peanut oil, pecan oil and it is also abundantly present in many animal fats. The *trans*-isomer of oleic acid is called elaidic acid.

30. Which of the fragments labeled A, B and C is an omega-3 fatty acid?

(A) B
(B) C
(C) A
(D) NONE of the above.

ANSWER: (C)

An omega-3-fatty acid must have a double bond located at the third carbon from the omega end.

31. A relaxer is a special type of lotion or crème usually containing a strong alkaline (although it can also contain a perm salt such as ammonium thioglycate) used in the treatment

hair with a type of permanent. This treatment relaxes the curls of the recipient, giving it its name. The chemical process that occurs on the hair is

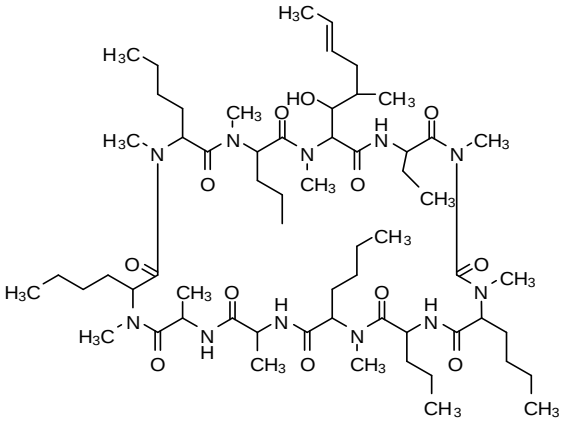
A. disruption of disulfide bonds in the hair, making it straight.
B. neutralization of acidic amino acids on the hair's keratin fibres.
C. impregnation of hair with fatty acids, making it flexible.
D. disruption of hydrogen bonds within the hair strands, leading to straightening.

ANSWER: (A)

The primary component of hair fibre is keratin. Keratins are proteins, long chains (polymers) of amino acids. Keratin proteins form the cytoskeleton (miniature skeleton within a cell) of all epidermal cells. Keratins contain a high proportion of the smallest of the 20 amino acids, glycine, whose "side group" is a single hydrogen atom; also the next smallest, alanine, with a small and uncharged methyl group. In the case of β-sheets, this allows sterically unhindered hydrogen bonding between the amino and carboxylgroups of peptide bonds on adjacent protein chains, facilitating their close alignment and strong binding. Fibrous keratin molecules can twist around each other to form helical intermediate filaments. In addition to intra- and intermolecular hydrogen bonds, keratins have large amounts of the sulfur-containing amino acid cysteine, required for the disulfide briges that confer additional strength and rigidity by permanent, thermally-stable cross-linking—a role sulfur bridges also play in vulcanised rubber. Chemical treatment of hair such as relaxing, disrupts these disulfide links.

Use the following information to answer questions 32, 33, 34, 35, and 36.

Cyclosporin (see structure below) is an immunosuppressant drug widely used in post-allogeneic organ transplant to reduce the risk of organ rejection.



32. Structurally, cyclosporin can be classified as:

A. a macro-cyclic beta-lactam (penicillin-like) with several pendant hydrocarbon chains.
B. a cyclic carbohydrate with several amino groups.
C. a cyclic fatty acid with several pendant amino-hydrocarbon chains.

D. a cyclic, non-ribosomal peptide of 11 amino acids.

ANSWER: (D)

Ciclosporin A, the main form of the drug cyclosporine, is a cyclic non-ribosomal peptide of 11 amino acids (an undecapeptide) produced by the fungus *Tolypocladium inflatum Gams*, initially isolated from a Norwegian soil sample. Its systematic (IUPAC) name is [*R*-[[*R**,*R**-(*E*)]]-cyclic(L-alanyl-D-alanyl- *N*-methyl-L-leucyl- *N*-methyl-L-leucyl- *N*-methyl-L-valyl-3-hydroxy-*N*,4-dimethyl-L-2-amino-6-octenoyl-L-α-amino-butyryl-*N*-methylglycyl-*N*-methyl-L-leucyl-L-valyl- *N*-methyl-L-leucyl). The immuno-suppressive effect of cyclosporin was discovered on January 31, 1972, by employees of Sandoz (now Novartis) in Basel, Switzerland, in a screening test on immune-suppression. The success of Ciclosporin A in preventing organ rejection was shown in liver transplants performed by Dr Thomas Starzl at the University of Pittsburgh hospital. Ciclosporin was subsequently approved for use in 1983. Apart from in transplant medicine, ciclosporin is also used in psoriasis and infrequently in rheumatoid arthritis and related diseases.

33. Which of the following amino acids or derivatives thereof, are absent in the structure of cyclosporin?

(A) Histidine

(B) Proline

(C) Serine

(D) ALL of the above

ANSWER: (D)

Refer to the answer to question 32. None of these amino acids feature in the IUPAC name and structure of cyclosporine.

34. People on cyclosporin treatment often have to take antibiotics for life. This is because

(A) antibiotics enhance the activity of cyclosporin.

(B) the antibiotics reduce the likelihood of heart attacks, a lethal side effect of cyclosporine.

(C) the antibiotics prevent cyclosporin from inhibiting meiosis, which is necessary for fertility.

(D) NONE of the above

ANSWER: (D)

Because cyclosporine lowers the immunity of those on treatment, this makes the susceptible to a variety of (opportunistic) infections), hence the need to take antibiotics.

35. The discovery of cyclosporine was by

(A) a group of scientists working for the pharmaceutical company Sandoz, in 1969.

(B) the late Dr Christiaan Barnard, a South African heart surgeon who performed the first successful human heart transplant.

(C) scientists working at America's Centers for Disease Control in Atlanta.

(D) Frederick Sanger, who won two Nobel prizes in Chemistry for this achievement.

ANSWER: (A)

Refer to the answer to question 32.

36. Because of its mode of action, cyclosporine is prescribed in the management of other diseases. Which of the following cannot be one of those diseases?

(A) Liver cancer

(B) Breast cancer

(C) Malaria

(D) ALL of the above

ANSWER: (D)

All the listed diseases require a strong immune system for the patient to survive, thus, cyclosporine cannot be used for their treatment. Cancer is a class of diseases in which a cell or a group of cells display *uncontrolled growth* (division beyond the normal limits), *invasion* (intrusion on and destruction of adjacent tissues), and sometimes metastasis (spread to other locations in the body via lymph or blood). Thus, cancer is treated with methods that inhibit and kill rapidly dividing cells, through a combination of surgery, radiation therapy and chemotherapy (medical drugs).

Malaria is a serious, relapsing infection in humans characterized by periodic attacks of chills and fever, anaemia, spelomegaly (enlargement of the spleen), and often fatal complications. It is caused by one-celled parasites of the genus *Plasmodium* that are transmitted to humans by the bite of *Anopheles* mosquitoes. It is treated with a combination of drugs that kill the parasites, each targeting a specific enzyme/developmental stage/organelle of the parasite.

37. Huge quantities of fertilizer are produced annually in South Africa. This is applied to the soil by farmers in order to increase the amount of plant nutrients in the soil. The most important nutrient element(s) required by plants is/are:

(A) Nitrogen, Phosphorus and Potassium.

(B) Nitrogen, Phosphorus and Calcium.

(C) Nitrogen and Phosphorus only.

(D) Nitrogen only.

ANSWER: (A)

Plants, as autotrophic organisms, use light energy to photosynthesize sugars from CO_2 and water. They also synthesize amino acids and vitamins from carbon fixed in photosynthesis and from inorganic elements garnered from the environment. Certain key

elements are required, or essential, for the complex processes of metabolism to take place in plants. The required concentrations of each essential and beneficial element vary over a wide range. The essential elements required in relatively large quantities for adequate growth are called macroelements. Nine minerals make up this group: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), phosphorus (P), and sulfur (S).

Seven other essential mineral elements are required in smaller amounts (0.01 percent or less) and are called microelements. These are iron (Fe), chlorine (Cl), manganese (Mn), boron (B), copper (Cu), molybdenum (Mo), and zinc (Zn). The specific required percentages may vary considerably with species, genotype (or variety), age of the plant, and environmental conditions of growth.

A macronutrient is the actual chemical form or compound in which the macroelement enters the root system of a plant. The macronutrient source of the macroelement nitrogen, for example, is the nitrate ion (NO_3^-). Carbon dioxide from the atmosphere provides the carbon atoms and two-thirds of the oxygen required by plants. Water taken from the soil provides about one-third of the oxygen and much of the hydrogen. Soil provides macroelements and microelements from mineral complexes, parent rock, and decaying organisms.

Modern chemical fertilizers include one or more of the three elements that are most important in plant nutrition: nitrogen, phosphorus, and potassium. Of secondary importance are the elements sulfur, magnesium, and calcium. Nitrogen is an essential component of all proteins. Nitrogen deficiency most often results in stunted growth. Phosphorus is important in plant bioenergetics. As a component of ATP, phosphorus is needed for the conversion of light energy to chemical energy (ATP) during photosynthesis. Phosphorus can also be used to modify the activity of various enzymes by phosphorylation, and can be used for cell signalling.

Since ATP can be used for the biosynthesis of many plant biomolecules, phosphorus is important for plant growth and flower/seed formation. Potassium regulates the opening and closing of the stoma by a potassium ion pump. Since stomata are important in water regulation, potassium reduces water loss from the leaves and increases drought tolerance. Potassium deficiency may cause necrosis or interveinal chlorosis.

38. Fatty acids, proteins and enzymes are all organic macromolecules with important functions in the human body. Which of the following statements is/are true of the structure of these macromolecules?

I. A fatty acid contains a long hydrophobic carbon chain attached

to a hydrophilic carboxylic acid group at one end.

II. A protein consists of two amino acids linked by a peptide bond which is formed from the reaction of the $–COO^-$ group of one amino acid with the $–NH_3^+$ group of the other amino acid.

III. Nearly all enzymes are globular proteins.

(A) II only
(B) I and II only
(C) I, II and III
(D) I and III only

ANSWER: (D)

II is not accurate because it actually describes a dipeptide; a protein is a polypeptide containing more than 50 amino acids in a chain.

39. The antibiotic AUGMENTIN® contains amoxycillin and potassium clavulanate. The purpose of the clavulanate is:

(A) to act as a probiotic.
(B) to improve the flavour.
(C) to increase the solubility of the amoxicillin.
(D) to bind irreversibly to β-lactamases produced by bacteria.

ANSWER: (D)

Amoxycillin and other penicillin antibiotics contain a β-lactam ring as part of their structure and this ring is essential for the antibiotic activity. Certain bacteria produce β-lactamases and the bacteria can use this enzyme to break the β-lactam ring of amoxycillin, making it ineffectual as an antibiotic. Clavulanic acid is a natural product that contains a β-lactam group, similar to that found in amoxycillin and other penicillins. When potassium clavulanate is present with amoxycillin (as in AUGMENTIN®) the bacterial β-lactamase reacts with the clavulanate and makes a stable enzyme complex (irreversible reaction) and this prevents the β-lactamases from being able to inactivate the amoxycillin, making sure that it maintains its effectiveness as an antibiotic.

40. Like all beta-lactams, amoxicillin kills bacteria by

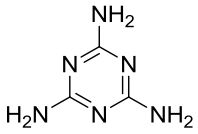
(A) inhibiting the synthesis of bacterial cell walls
(B) inhibiting bacterial protein synthesis.
(C) inhibiting bacterial DNA replication.
(D) inhibiting the bacterial pentose phosphate pathway.

ANSWER: (D)

β-Lactam antibiotics are a broad class of antibiotics, consisting of all antibiotic agents that contains a β-Lactam nucleus in its molecular structure. This includes penicillin derivatives (penems), cephalosporins (cephems), monobactams and carbapenems. β-Lactam antibiotics work by inhibiting cell wall synthesis by the bacterial

organism and are the most widely used group of antibiotics.

41. Baby milk formula from China was recently responsible for many infants becoming ill. This milk formula was found to contain melamine, below, which can be described as:



(A) a triazine.
(B) a heterocyclic compound.
(C) a means of artificially enhancing the apparent protein content of the milk formula.
(D) ALL of the above.

ANSWER: (D)

Melamine is a triazine (triaza = three nitrogens) and it is a heterocyclic compound (a ring compound containing at least one non-carbon atom as part of the ring). Melamine was deliberately and illegally added to the baby milk formula to increase the apparent protein content of the milk, as the test that is used for proteins actually tests for the percentage of nitrogen present. Thus, because melamine contains a large number of nitrogen atoms, it increases the percentage nitrogen content of the milk formula, giving a higher apparent protein content.

42. A South African frog is notable for its use in the first well-documented method of pregnancy testing (still in use today) when it was discovered that the urine from pregnant women induced the frog's oocyte production. This frog is scientifically known as:

(A) *Rana pipiens*.
(B) *Bufo bufo*.
(C) *Xenopus laevis*.
(D) *Rana esculenta*

ANSWER: (C)

The African clawed frog *Xenopus laevis*, is a species of South African aquatic frog of the genus Xenopus. Its name is derived from the three short claws on each hind foot, which it uses to tear apart its food. The word *Xenopus* means "strange foot" and *laevis* means "smooth". Although *X. laevis* does not have the short generation time and genetic simplicity generally desired in genetic model organism, it is an important model organism in developmental biology. *Xenopus* oocytes provide an important expression system for molecular biology. By injecting DNA or mRNA into the oocyte or developing embryo, scientists can study the protein products in a controlled system.

X. laevis is also notable for its use in the first well-documented method of pregnancy testing when it was discovered that the urine from pregnant women induced *X. laevis* oocyte production. Human chorionic

gonadotropin (HCG) is a hormone found in substantial quantities in the urine of pregnant women.

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

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

ANSWER: (D)

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

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

(A) in water, chlorine forms HCl, a strong acid; and HOCl, an oxidizing agent, both of which kill pathogens
(B) as a toxic gas used in World War I, chlorine's presence deters theft and vandalism of municipal water infrastructure.
(C) chlorine is a reducing agent and helps precipitate undesirable heavy metals out of drinking water.
(D) chlorine promotes the growth of fungi that produce antibiotics and help sanitize the water.

ANSWER: (A)

Chlorination is the process of adding the element chlorine to water as a method of water purification to make it fit for human consumption as drinking water. Water which has been treated with chlorine is effective in preventing the spread of disease. The use of chlorine has greatly reduced the prevalence of waterborne disease as it is effective against almost all bacteria and viruses. Chlorination is also used to sterilize the

water in swimming pools and as a disinfection stage in sewage treatment. When chlorine is added to water, hypochlorous and hydrochloric acids form, an oxidizing agent and a strong acid, respectively ($Cl_2 + H_2O \rightarrow HClO + HCl$).

45. Another water purification/treatment method is the use of ozone. Which of the following is/are advantages of ozone over chlorine use?

(A) Ozone has a very high oxidation potential.
(B) Ozone is a cost-effective method of treating water, since it is produced on demand
(C) Ozone does not remain in the water after treatment or leave a taste or odour.
(D) ALL of the above.

ANSWER: (D)

The largest use of ozone is in the preparation of pharmaceuticals, synthetic lubricants, and many other commercially useful organic compounds, where it is used to sever carbon-carbon bonds. It can also be used for bleaching substances and for killing microorganisms in air and water sources. Many municipal drinking water systems kill bacteria with ozone instead of the more common chlorine Ozone has a very high oxidation potential, does not form organochlorine compounds, nor does it remain in the water after treatment. Where electrical power is abundant, ozone is a cost-effective method of treating water, since it is produced on demand and does not require transportation and storage of hazardous chemicals. Once it has decayed, it leaves no taste or odor in drinking water

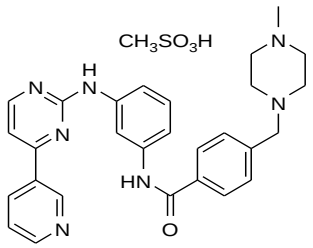
46. Cholera is an infection of the small intestines caused by the bacterium *Vibrio cholerae* and transmitted primarily through contaminated drinking water or food. Inside the small intestine, cholera bacteria

(A) produce the cholera toxin, an oligomeric complex made up of six protein subunits, which leads to secretion of H_2O, Na^+, K^+, Cl^-, and HCO_3^- into the lumen of the small intestine leading to profuse diarrhoea and rapid dehydration.
(B) produce the cholera toxin, a concoction of chemicals which leads to secretion of H_2O, Na^+, K^+, Cl^-, and HCO_3^- into the lumen of the small intestine leading to profuse diarrhoea and rapid dehydration
(C) produce the cholera toxin, a powerful antibiotic that kills all intestinal flora and leads to diarrhoea for the body to expel them.
(D) produce the cholera toxin, a nephrotoxin that shuts down the kidneys and leads to diarrhoea as the body's only mode of excretion.

ANSWER: (A)

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

47. Gleevec (see structure below) is an anti-cancer drug developed by the pharmaceutical company Novartis. It was approved by the US Food and Drug Administration (FDA) in 2003 for the treatment of chronic myeloid leukaemia. The functional groups present in Gleevec are:



(A) benzene ring, amino group, amide group, sulfonic acid group, heterocycle.

(B) benzene ring, alcohol group, ester group, alkyl group, sulfonamide group.

(C) benzene ring, amino group, alkyne group, sulfonic acid group, ketone.

(D) amino group, benzene ring, alkyl group, amide group, carboxylic acid group.

ANSWER: (A)

A ring that contains as part of it, an atom other than carbon is called a heterocycle. There are three of these in Gleevec, in addition to two benzene rings. There are also three amino groups (nitrogens bonded to a hydrogen and/or carbon fragments), an amide bond and additionally, as a counter ion to one of the amino groups, a methane sulfonic acid group.

48. Leukaemia is generally difficult to treat because

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

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

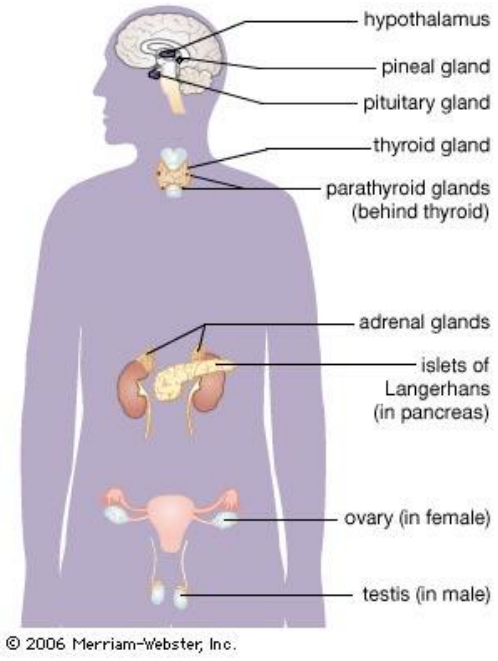
(C) the question statement is false, leukaemia is fully curable by bone marrow transplantation.

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

ANSWER: (A)

Leukaemia is a cancer of the blood or bone marrow characterized by an abnormal increase of blood cells, usually leukocytes (white blood cells). Leukemia is a broad term covering a spectrum of diseases. Leukemia is clinically and pathologically subdivided into a variety of large groups. The first division is between its acute and chronic forms, and additionally, the diseases are subdivided according to which kind of blood cell is affected. This split divides leukemias into lymphoblastic and myeloid leukaemias. Acute leukaemia is characterized by the rapid increase of immature blood cells. This crowding makes the bone marrow unable to produce healthy blood cells. Immediate treatment is required in acute leukemia due to the rapid progression and accumulation of the malignant cells, which then spill over into the bloodstream and spread to other organs of the body. Acute forms of leukemia are the most common forms of leukemia in children. Chronic leukaemia is distinguished by the excessive build up of relatively mature, but still abnormal, white blood cells. Typically taking months or years to progress, the cells are produced at a much higher rate than normal cells, resulting in many abnormal white blood cells in the blood. Whereas acute leukemia must be treated immediately, chronic forms are sometimes monitored for some time before treatment to ensure maximum effectiveness of therapy. Chronic leukemia mostly occurs in older people, but can theoretically occur in any age group. Most forms of leukemia are treated with medical drugs, typically combined into a multi-drug chemotherapeutic regimen. Some are also treated with radiation therapy. In some cases, a bone marrow transplant is useful.

Use the following diagram to answer questions 49, 50, 51, 52, 53, 54, 55, 56, 57, and 58



49. An orchidectomy is the surgical removal of which gland(s)?

(A) The pineal gland
(B) The ovaries
(C) An adrenal gland
(D) Testicles

ANSWER: (D)

Orchidectomy is a surgical procedure to remove a testicle and the full spermatic cord through an incision in the abdomen. The procedure is generally performed by a urologist. If the orchidectomy is performed to diagnose cancer, the testicle and spermatic cord are then sent to a pathologist to determine the makeup of the tumour, and the extent of spread within the testicle and cord

50. The surgical removal of which gland, will lead to detection of glucose in urine?

(A) The thyroid gland
(B) The ovaries
(C) The testicles
(D) NONE of the above

ANSWER: (D)

The pancreas, by secreting the hormones Insulin and glucagon, regulate sugar levels in the blood. Thus, its surgical removal, as might happen in the case of pancreatic cancer, will lead to type 1 diabetes.

51. In case of accidental leakage of radioactive material in nuclear plants, people, especially children, in the surrounding areas are given potassium iodide tablets. This is to protect the functions of which gland(s)?

((A) The testicles
(B) The ovaries
(C) The pituitary gland
(D) NONE of the above

ANSWER: (D)

Iodine in food is absorbed by the body and preferentially concentrated in the thyroid where it is needed for the functioning of that gland (production of thyroxine). When radioactive iodine (^{131}I) is present in high levels in the environment from radioactive fallout, it can be absorbed through contaminated food, and will also accumulate in the thyroid. As it decays, it may cause damage to the thyroid. The primary risk from exposure to high levels of ^{131}I is the chance occurrence of thyroid cancer in later life. A common treatment method for preventing iodine-131 exposure is by saturating the thyroid with regular, non-radioactive iodine-127. This prevents the thyroid from absorbing the radioactive iodine-131, thereby avoiding the damage caused by radiation to the body. This treatment method is most commonly accomplished by administering potassium iodide to those at risk.

52. Luteinizing hormone, which in females triggers ovulation, is produced by which gland?

(A) The ovaries
B) The pineal gland
(C) The pituitary gland
(D) NONE of the above

ANSWER: (C)

Luteinizing hormone (LH)) is a hormone produced by the anterior pituitary gland. In the *female*, an acute rise of LH triggers ovulation and corpus luteum development. In the *male*, it stimulates Leydig cell production of testosterone.

53. Antidiuretic hormone, also called vasopressin, controls the re-absorption of molecules in the tubules of the kidneys by affecting the tissue's permeability. This hormone is produced by which gland?

(A) The adrenal glands
(B) The parathyroid gland
(C) The pituitary gland
(D) NONE of the above

ANSWER: (C)

Vasopressin, or antidiuretic hormone (ADH), is a is a peptide hormone that controls the reabsorption of molecules in the tubules of the kidneys by affecting the tissue's permeability. It also increases peripheral vascular resistance, which in turn increases arterial blood pressure. It plays a key role in homeostasis, and the regulation of water, glucose, and salts in the blood. It is derived from a precursor that is synthesized in the hypothalamus and stored in vesicles at the posterior pituitary. Most of it is stored in the posterior pituitary to be released into the bloodstream.

54. The hormone angiotensin, causes blood vessels to constrict, and drives blood pressure up. It also stimulates the release of aldosterone from the adrenal cortex. Angiotensin is produced by which gland(s)?

(A) The adrenal glands
(B) The thyroid gland
(C) The pituitary gland
(D) NONE of the above

ANSWER: (D)

Angiotensin is an oligopeptide in the blood that causes vasoconstriction, increased blood pressure, and release of aldosterone from the adrenal cortex. It is a hormone and a powerful dipsogen. It is derived from the precursor molecule angiotensinogen, a serum globulin produced in the liver and it plays an important role in the rennin-angiotensin system.

55. In the case of cardiac arrest (cessation of normal blood circulation due to failure of the heart to contract effectively) during

intense sporting action such as rugby, a hormone normally produced by which gland, can be used to reverse this?

(A) The testicles (testosterone)
(B) The thyroid gland (thyroxine)
(C) The pancreas (insulin)
(D) NONE of the above

ANSWER: (D)

Adrenaline, produced by the adrenal glands, is used as a drug to treat cardiac arrest and other cardiac dysrhythmias resulting in diminished or absent cardiac output. Its actions are to increase peripheral resistance via α_1 receptor-dependent vasoconstriction and to increase cardiac output via its binding to β_1 receptors.

56. Follicle Stimulating Hormone regulates the development, growth, sexual maturation, and reproductive processes of the body. It is produced by

(A) the testicles (in males) and ovaries (in females).
(B) the adrenal glands.
(C) the thyroid and parathyroid glands.
(D) the pituitary gland.

ANSWER: (D)

The pituitary gland secretes hormones regulating homeostasis, including tropic hormones that stimulate other endocrine glands. It is functionally connected to the hypothalamus by the median eminence. Located at the base of the brain, the pituitary is composed of two lobes: the anterior pituitary (adenohypophysis) and the posterior pituitary (neurohypophysis). The pituitary is functionally linked to the hypothalamus by the pituitary stalk, whereby hypothalamic releasing factors are released and, in turn, stimulate the release of pituitary hormones. Although the pituitary gland is known as the master endocrine gland, both of its lobes are under the control of the hypothalamus. The anterior pituitary synthesizes and secretes important endocrine hormones, such as Adrenocorticotropic hormone (ACTH), Prolactin (PRL), Thyroid-stimulating hormone (TSH), Growth Hormone (GH), Endorphins, Follicle-stimulating hormone (FSH) and Luteinizing hormone (LH). These hormones are released from the anterior pituitary under the influence of the hypothalamus. The posterior pituitary stores and releases Oxytocin and Antidiuretic hormone (ADH, also known as vasopressin).

57. Which gland secretes a hormone that affects the modulation of wake/sleep patterns and seasonal functions?

(A) The testicles (in males) and ovaries (in females).
(B) The pituitary gland.
(C) The adrenal glands.
(D) NONE of the above.

ANSWER: (D)

The pineal gland is a small endocrine gland in the vertebrate brain. It produces melatonin, a hormone that affects the modulation of wake/sleep patterns and photoperiodic (seasonal) functions.

58. Prolactin is a peptide hormone primarily associated with lactation. In breastfeeding, the act of a baby suckling stimulates the production of prolactin, which fills the breast with milk via a process called lactogenesis. Prolactin is produced by which gland(s)?

(A) The ovaries.
(B) The thyroid gland.
(C) The pituitary gland.
(D) The adrenal glands.

ANSWER: (C)

See the answer to question 56.

59. The black mamba (*Dendroaspis polylepis*) is the longest venomous snake in Africa, averaging around 2.5 meters. The venom of the black mamba consists mainly of neurotoxins, and its bite delivers about 100–120 mg of venom on average. The mortality rate is nearly 100%, unless the snakebite victim is promptly treated with antivenom. Where in South Africa are you MOST LIKELY to encounter a black mamba in the wild?

(A) Port Elizabeth
(B) Kimberly
(C) Nelspruit
(D) Amanzimtoti

ANSWER: (C)

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

60. Apart from being considered one of the world's deadliest snakes, the black mamba is also one of the most feared snakes in Africa due to its potent venom, large size, and the ferocity of its attacks. However, mongooses are notable for their resistance to snake toxins and prey on black mambas. The reason for mongoose resistance to snake venoms is that

(A) mongooses naturally produce snake antivemon in their blood.
(B) the red blood cells of mongooses contain cobalt, not iron, which does not bind snake venoms.
(C) they have mutations in their nicotinic acetylcholine receptor which prevent

the neurotoxin present in snake venom from binding to the receptor.

(D) NONE of the above

ANSWER: (D)

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

61. The South African Institute for Medical Research produces antivenom to treat all black mamba bites from different localities. They do so by

(A) isolating it from the blood of mongooses.

(B) injecting the diluted venom into a goat, allowing the animal to produce antibodies against the venom then harvest the antibodies from the animal's blood.

(C) injecting the venom into chicken eggs and then harvest the antivenom from the blood of the hatched chicks.

(D) cloning the mamba venom genes into bacteria to let them produce the venon and antivenom.

ANSWER: (B)

Antivenom is created by milking venom from the desired snake, spider or insect. The venom is then diluted and injected into a horse, sheep, goat or cat. The subject animal will undergo an immune response to the venom, producing antibodies against the venom's active molecule which can then be harvested from the animal's blood and used to treat envenomation. Internationally, antivenoms must conform to the standards of Pharmacopoeia and the World Health Organization (WHO).

Use the following information to answer questions 62, 63, 64, 65, 66, 67, and 68.

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

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

(A) Christiaan Eijkman and Frederick Hopkins.

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

(C) Louis Pasteur and Robert Koch.

(D) Hans Krebs and Fritz Lipmann.

ANSWER: (A)

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

63. Which vitamin imparts the yellow colour to vitamin supplement solutions, and the unusual fluorescent yellow colour to the urine of persons who take vitamin supplements?

(A) Vitamin A (from carrots).
(B) Vitamin D.
(C) Biotin.
(D) Riboflavin.

ANSWER: (D)

Riboflavin,also known as vitamin B_2, is an easily absorbed micronutrient with a key role in maintaining health in humans and other animals. It is the central component of the cofactors FAD and FMN, and is therefore required by all flavoproteins. As such, vitamin B_2 is required for a wide variety of cellular processes. It plays a key role in energy metabolism, and for the metabolism of fats, ketone bodies, carbohydrates and proteins. Riboflavin is best known visually as the vitamin which imparts the orange colour to solid B-vitamin preparations, the yellow colour to vitamin supplement solutions, and the unusual fluorescent yellow colour to the urine of persons who supplement with high-dose B-complex preparations

64. Which vitamin is essential for the synthesis of DNA and has led to the invention of the anticancer drug methotrexate?

(A) Vitamin B_1.
(B) Vitamin B_{12}
(C) Vitamin B_9
(D) Viamin B_3

ANSWER: (C)

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

65. Eating the liver of a polar bear is lethal as it leads to an overdose of which vitamin?

(A) Cyanocobalamin
(B) Pantothenic acid

(C) Phylloquinone

(D) Retinol

ANSWER: (B)

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

66. Which vitamin is used in the biosynthesis of the biochemical reductant NADPH?

(A) Vitamin B_{12}

(B) Vitamin B_5

(C) Vitamin B_3

(D) NONE of the above.

ANSWER: (C)

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

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

(A) Vitamin C

(B) Vitamin D

(C) Vitamin E

(D) Vitamin K

ANSWER: (B

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

68. Which vitamin, when lacking in the diet, leads to a disease classically described by "the three D's": diarrhoea, dermatitis and dementia?

(A) Vitamin C

(B) Vitamin B_3

(C) Vitamin B_{12}

(D) Vitamin B_5

ANSWER: (B)

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

69. If the definition of a fruit is a ripened ovary, which one of the following does not qualify as a fruit?

(A) Chestnut

(B) Apple

(C) Tomato

(D) NONE of the above.

ANSWER: (D)

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

70. Which of the following is not an attribute of self-pollination by plants?

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

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

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

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

ANSWER: (D)

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

71 The terms *anemophily* and *hydrophily* refer, respectively, to

(A) pollination by wind, and by water.

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

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

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

ANSWER: (A)

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

72. Which characteristic is found in insect-pollinated flowers?

(A) Pollen is small, light and smooth.
(B) Pollen produced in large quantities.
(C) Stamens and stigmas hang outside the flower.
(D) Stamens and pollen are sticky

ANSWER: (D)

Flowers that rely on insect pollination are called Entomophilous. The most important insect pollinators are bees, Lepidoptera (butterflies and moths), flies, and beetles. Entomophilous species frequently evolve mechanisms to make themselves more appealing to insects, e.g. brightly coloured or scented flowers, nectar, and appealing shapes and patterns. Pollen grains of entomophilous plants are generally larger than the fine pollens of anemophilous (wind pollinated) plants. They usually are of more nutritional value to insects, which may use them for food and inadvertently spread them to other flowers. Bees are probably the most important insect pollinators. Living almost exclusively on nectar, they feed their larvae pollen and honey (a modified nectar). To obtain their foods, they possess striking physical and behavioural adaptations, such as tongues as long as 2 $^{1}/_{2}$ centimetres (one inch), hairy bodies, and (in honeybees and bumblebees) special pollen baskets. Flowers pollinated by bees open in the daytime, attract their insect visitors primarily by bright colours; at close range, special patterns and fragrances come into play.

Many bee flowers provide their visitors with a landing platform in the form of a broad lower lip on which the bee sits down before pushing its way into the flower's interior, which usually contains both stamens and pistils. The hermaphroditism of most bee flowers makes for efficiency, because the flower both delivers and receives a load of pollen during a single visit of the pollinator, and the pollinator never travels from one flower to another without a full load of pollen. Indeed, the floral mechanism of many bee flowers permits only one pollination visit. The pollen grains of most bee flowers are sticky, spiny, or highly sculptured, ensuring their adherence to the bodies of the bees.

Since one load of pollen contains enough pollen grains to initiate fertilization of many ovules, most individual bee flowers produce many seeds.

73. Acetyl coenzyme A carboxylase (ACCase) is part of the first step of lipid synthesis. Thus, ACCase inhibitors are used as herbicides and affect cell membrane production in the meristems of the plant. The ACCases of grasses are more sensitive to these herbicides. Which of the following plants are most likely to die upon exposure to an ACCase inhibitor?

(A) Rye
(B) Maize
(C) Oats
(D) ALL of the above

ANSWER: (A)

All of the above plants are grasses. Rye (*Secale cereale*) is a grass grown extensively as a grain and as a forage crop. It is a member of the wheat tribe (Triticeae) and is closely related to barley and wheat. Rye grain is used for flour, rye bread, beer, whiskeys, and animal fodder.

Maize, also called corn, is a grass domesticated by indigenous people in Mesoamerica in prehistoric times. Later the crop spread through much of the Americas. Between 1250 and 1700, nearly the whole continent had gained access to the crop. Any significant or dense populations in the region developed a great trade network based on surplus and varieties of maize crops. After European contact with the Americas in the late 15th and early 16th centuries, explorers and traders carried maize back to Europe and introduced it to other countries through trade. Maize spread to the rest of the world due to its popularity and ability to grow in diverse climates.

74. Which biologist was the first man to demonstrate how blood flows through the arteries and veins?

(A) Aristotle
(B) William Harvey
(C) Edward Jenner
(D) Galileo Galilei

ANSWER: (B)

William Harvey (April 1, 1578 – June 3, 1657) was an English medical doctor/physician, who is credited with being the first to correctly describe, in exact detail, the systemic circulation and properties of blood being pumped around the body by the heart.

75. Why doesn't cheese decay during the maturing process?

(A) It is kept at a low temperature where all bacteria are inactive.
(B) The milk is pasteurised and heated to eliminate bacteria initially.
(C) Preservatives are added to kill the bacteria.

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

ANSWER: (D)

Most cheese is ripened for varying amounts of time in order to bring about the chemical changes necessary for transforming fresh curd into a distinctive aged cheese. These changes are catalyzed by enzymes from three main sources: rennet or other enzyme preparations of animal or vegetable origin added during coagulation, microorganisms that grow within the cheese or on its surface, and the cheese milk itself. The ripening time may be as short as one month, as for Brie, or a year or more, as in the case of sharp cheddar. The ripening of cheese is influenced by the interaction of bacteria, enzymes, and physical conditions in the curing room.

The speed of the reactions is determined by temperature and humidity conditions in the room as well as by the moisture content of the cheese. In most cheeses lactose continues to be fermented to lactic acid and lactates, or it is hydrolyzed to form other sugars. As a result, aged cheeses such as Emmentaler and cheddar have no residual lactose. In a similar manner, proteins and lipids (fats) are broken down during ripening. The degree of protein decomposition, or proteolysis, affects both the flavour and the consistency of the final cheese. It is especially apparent in Limburger and some blue-mold ripened cheeses. The eyes, or holes, typical of Swiss-type cheeses such as Emmentaler and Gruyere come from a secondary fermentation that takes place when, after two weeks, the cheeses are moved from refrigerated curing to a warmer room, where temperatures are in the range of 20° to 24° C (68° to 75° F). At this stage, residual lactates provide a suitable medium for propionic acid bacteria (*Propionibacterium shermanii*) to grow and generate carbon dioxide gas.

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

76. Lichen is a mutuality relationship between …

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

ANSWER: (C)

A lichen is any of about 15,000 species of thallophytic plantlike organisms that consist of a symbiotic association of algae (usually green) and fungi (mostly ascomycetes and basidiomycetes). Lichens were once classified as single organisms until the advent of microscopy, when the association of algae and fungi became evident. There is still some discussion about how to classify lichens. Lichens have been used by humans as food and as sources of medicine and dye. They also provide two-thirds of the food supply for the caribou and reindeer that roam the far northern ranges.

The composite body of a lichen is called a thallus (plural thalli). The homoeomerous type of thallus consists of numerous algal cells (called the phycobionts) distributed among a lesser number of fungal cells (called the mycobionts). The heteromerous thallus differs in that it has a predominance of fungal cells. Hairlike growths that anchor the thallus to its substrate are called rhizines. Lichens that form a crustlike covering that is thin and tightly bound to the substrate are termed crustose. Squamulose lichens are small and leafy with loose attachments to the substrate. Foliose lichens are large and leafy, reaching diameters of several feet in some species, and are usually attached to the substrate by their large, plate-like thalli at the centre.

77. Where do ticks spend most of their time?

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

ANSWER: (A)

A tick is any of about 825 species of invertebrates in the order Parasitiformes (subclass Acan). Ticks are important parasites of large wild and domestic animals and are also significant as carriers of serious diseases. Although no species is primarily a human parasite, some occasionally attack humans. Hard ticks, such as the American dog tick (*Dermacentor variabilis*), attach to their hosts and feed continuously on blood for several days during each life stage.

When an adult female has obtained a blood meal, she mates, drops from the host, and finds a suitable site where she lays her eggs in a mass and dies. Six-legged larvae hatch from the eggs, move up on blades of grass, and wait for a suitable host (usually a mammal) to pass by. The odour of butyric acid, emanated by all mammals, stimulates the larvae to drop onto and attach to a host. After filling themselves with the host's blood, the larvae detach and moult, becoming eight-legged nymphs. Nymphs also wait for,

and board, a suitable host in the same way as larvae. After they have found a host and engorged themselves, they also fall off, and then they moult into adult males or females.

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

78. What activates a tick and get it to attach to its host?

(A) The smell of blood.
(B) Body heat emitted by mammals.
(C) The odour of butyric acid emitted by all mammals.
(D) NONE of the above.

ANSWER: (C)

See the answer to question 77.

79. In which organelle is ATP found abundantly?

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

ANSWER: (B AND C)

Mitochondria and chloroplasts are the powerhouses of the cell. Mitochondria appear in both plant and animal cells as elongated cylindrical bodies, roughly one micrometre in length and closely packed in regions actively using metabolic energy. Mitochondria oxidize the products of cytoplasmic metabolism to generate ATP, the energy currency of the cell. Chloroplasts are the photosynthetic organelles in plants and some algae. They trap light energy and convert it partly into ATP but mainly into certain chemically reduced molecules that, together with ATP, are used in the first steps of carbohydrate production. Mitochondria

and chloroplasts share a certain structural resemblance, and both have a somewhat independent existence within the cell, synthesizing some proteins from instructions supplied by their own DNA.

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

(A) Bear; cat; horse
(B) Donkey; dog; baboon
(C) Baboon, bear, cat
(D) Gorilla, horse and dog

ANSWER: (A)

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

81. When a piece of liver is put in hydrogen peroxide, oxygen is given off. The enzyme in the liver that is responsible for the reaction is….

(A) catalase
(B) peroxide kinase
(C) peroxide oxidase
(D) peroxide dehydrogenase

ANSWER: (A)

The enzyme responsible for this reaction (hydrogen peroxide decomposition to water and oxygen) is called catalase. Found extensively in mammalian tissues, catalase prevents the accumulation of and protects the body tissues from damage by peroxide, which is continuously produced by

numerous metabolic reactions. All known animals use catalase in every organ, with particularly high concentrations occurring in the liver. One unique use of catalase occurs in bombardier beetle. The beetle has two sets of chemicals ordinarily stored separately in its paired glands. The larger of the pair, the storage chamber or reservoir, contains hydroquinones and hydrogen peroxide, whereas the smaller of the pair, the reaction chamber, contains catalases and peroxidases. To activate the spray, the beetle mixes the contents of the two compartments, causing oxygen to be liberated from hydrogen peroxide. The oxygen oxidizes the hydroquinones and also acts as the propellant. A rare hereditary metabolic disorder caused by lack of the enzyme catalase is called acatalasia.

Although a deficiency of catalase activity is noted in many tissues of the body, including the red blood cells, bone marrow, liver, and skin, only about half of the affected persons have symptoms, which consist of recurrent infections of the gums and associated oral structures that may lead to gangrenous lesions. Such lesions are rare after puberty. The disorder has been most frequently reported in Japanese and Korean populations; its estimated frequency in Japan is approximately 2 in 100,000.

82. Plants do not react to the stimulus of……

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

ANSWER: (A)

No experiment can prove that plants grow towards a gas as the gas will have to be contained within an impervious medium, yet the plant will have to sense its presence in order to grow away from or towards it! The response or orientation of a plant or certain lower animals to a stimulus that acts with greater intensity from one direction than another is called tropism. It may be achieved by active movement or by structural alteration.

Forms of tropism include phototropism (response to light), geotropism (response to gravity), chemotropism (response to particular substances), hydrotropism (response to water), thigmotropism (response to mechanical stimulation), traumatotropism (response to wound lesion), and galvanotropism, or electrotropism (response to electric current). Most tropic movements are orthotropic; i.e., they are directed toward the source of the stimulus. Plagiotropic movements are oblique to the direction of stimulus. Diatropic movements are at right angles to the direction of stimulus.

Plants respond to a variety of external stimuli by utilizing hormones as controllers in a stimulus-response system. Directional responses of movement are known as

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

83. Which fact about photosynthesis is INCORRECT?

(A) Water, CO_2, chlorophyll and sunlight are mainly needed.
(B) It takes place in the grana, in the chloroplasts, in the palisade cells and in the mesophyll in a leaf.
(C) Some plants photosynthesise at 5 ºC and others at 70 ºC.
(D) The two biochemical phases are glycolysis and the Krebbs cycle.

ANSWER: (D)

During photosynthesis in green plants, light energy is captured and used to convert water, carbon dioxide, and minerals into oxygen and energy-rich organic compounds. In chemical terms, photosynthesis is a light-energized oxidation-reduction process. (Oxidation refers to the removal of electrons from a molecule; reduction refers to the gain of electrons by a molecule.) In plant photosynthesis, the energy of light is used to drive the oxidation of water (H_2O), producing oxygen gas (O_2), hydrogen ions (H^+), and electrons. Most of the removed electrons and hydrogen ions ultimately are transferred to carbon dioxide (CO_2), which is reduced to organic products.

Other electrons and hydrogen ions are used to reduce nitrate and sulfate to amino and sulfhydryl groups in amino acids, which are the building blocks of proteins. In most green cells, carbohydrates—especially starch and the sugar sucrose—are the major direct organic products of photosynthesis. The overall reaction in which carbohydrates—represented by the general formula (CH_2O)—are formed during plant photosynthesis can be indicated by the following equation:

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

84. Under which conditions will plants have a low transpiration rate?

(A) High temperatures
(B) High humidity

(C) Strong winds

(D) More light

ANSWER: (B)

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

85. The part of the brain YOU are using to answer all the questions in this examination is the…..

(A) Brain stem.

(B) Cerebellum

(C) Medulla oblongata

(D) Cerebrum

ANSWER: (B)

The human brain weighs about 1,500 grams (3 pounds) and constitutes about 2 percent of total body weight. It consists of three major divisions: (1) the massive paired hemispheres of the cerebrum, (2) the brainstem, consisting of the thalamus, hypothalamus, epithalamus, subthalamus, midbrain, pons, and medulla oblongata, and (3) the cerebellum. The cerebrum, derived from the telencephalon, is the largest, uppermost portion of the brain. It is involved with sensory integration, control of voluntary movement, and higher intellectual functions, such as speech and abstract thought.

The cerebellum (“little brain”) overlies the posterior aspect of the pons and medulla oblongata and fills the greater part of the posterior fossa of the skull. It consists of two paired lateral lobes, or hemispheres, and a midline portion known as the vermis. The cerebellar cortex appears very different from the cerebral cortex in that it consists of small leaflike laminae called folia. The cerebellum functions as a kind of computer, providing a quick and clear response to sensory signals. It plays no role in sensory perception, but it exerts profound influences upon equilibrium, muscle tone, and the coordination of voluntary motor function. Because the input and output pathways both cross, a lesion of