KVPY-SX 2016 (BIOLOGY)

PART-I

1. Which of the following molecules is a primary acceptor of CO_2 in photosynthesis?

   (a) Pyruvate (b) 3-phosphoglycerate

   (c) Phosphoenol pyruvate (d) Oxaloacetate

2. Which one of the following pairs of molecules never forms a hydrogen bond between them?

   (a) Water and water (b) Water and glucose

   (c) Water and ethanol (d) Water and octane

3. Lactase hydrolyses lactose into

   (a) Glucose + glucose (b) Glucose + galactose

   (c) Galactose + galactose (d) Galactose + fructose

4. Which of the following statements is incorrect regarding biological membrane?

   (a) It is composed of lipids and proteins

   (b) Peripheral proteins are loosely associate with the membrane

   (c) Integral proteins span the lipid bilayer

   (d) Lipids and membrane proteins do not provide structural and functional asymmetry

5. The percentage of sunlight captured by plants is

   (a) 2-10% (b) 10-20% (c) 60-80% (d) 100%

6. The hard-outer layer of pollens, named exine, is made of

   (a) Cellulose (b) tapetum (c) sporopollenin (d) pectin

7. Insectivorous plants such as Venus fly trap catch and digest insects in order to supplement the deficiency of

   (a) Sulphur (b) Nitrogen (c) Potassium (d) Phosphorus

8. Which of the following statements about nucleosome is true?
   (a) It consists of only DNA
   (b) It is a nucleus-like structure found in prokaryotes
   (c) It consists of DNA and proteins
   (d) It consists of only histone proteins

9. Epithelial cells in animals are held by specialized junctions, one of them being "Gap junction". Function of a "Gap junction" is to
   (a) Facilitate cell-cell communication by rapid transfer of small molecules
   (b) Cement the neighboring cells
   (c) Stop substances from leaking
   (d) Provide gaps in the tissue to facilitate uptake of small molecules across tissues

10. Which of the following statements is true about glandular epithelium in salivary gland?
   (a) It consists of isolated single cells
   (b) It consists of multicellular cluster of cells
   (c) Its secretions are endocrine
   (d) It consists of squamous epithelial cells

11. Which one of the following ion pairs is involved in nerve impulses?
   (a) Na^+, K^+ (b) Na^+, Cl^- (c) K^+, Cl^- (d) K^+, Ca^{2+}

12. Which of the following hormones that controls blood pressure is secreted by human heart?
   (a) Erythropoietin (b) Atrial natriuretic factor
   (c) ACTH (d) Glucocorticoid

13. Oxytocin and vasopressin are synthesized in
   (a) Hypothalamus (b) Adrenal gland
   (c) Pituitary gland (d) Ovary

14. If you exhale multiple times into a conical flask containing lime water through a single inlet fixed through a stop cork, lime water will?
(a) Become cooler (b) Turn milky
(c) Remain unchanged (d) Turn yellow

15. The path of passage of stimulus when you accidentally touch a hotplate is
(a) Receptor → Brain → Muscles (b) Muscles → Spinal cord → Receptor
(c) Muscles → Brain → Receptor (d) Receptor → Spinal cord → Muscles

16. In the presence of glucose and lactose, *Escherichia coli* utilizes glucose. However, lactose also enters the cells because
(a) low level of permease is always present in the cell
(b) it uses the same transporter as glucose
(c) if diffuses through the bacterial cell membrane
(d) it is transported through porins

17. Passive immunization is achieved by administering
(a) Heat killed vaccines (b) Toxoids
(c) Live attenuated vaccines (d) Antibodies

18. Which of the following anions neutralize the acidic pH of the chyme that enters into the duodenum from the stomach?
(a) $H_2PO_4^-$ (b) HSO_4^- (c) HCO_3^- (d) CH_3COO^-

19. If $^{14}CO_2$ is added to a suspension of photosynthesizing chloroplasts, which of the following will be the first compound to be radioactive?
(a) ATP (b) NADPH
(c) NADH (d) 3-phosphoglycerate

20. Which of the following species makes the largest true flower in the world?
(a) *Amorphophallus titanium* (b) *Rafflesia arnoldii*
(c) *Nelumbo nucifera* (d) *Helianthus annuus*

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PART-II

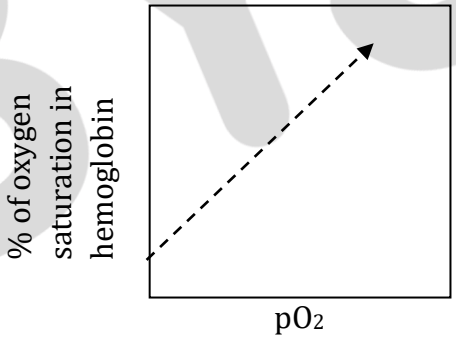
21. Match the following organelles in Group I with the structures in Group II. Choose the correct combination.

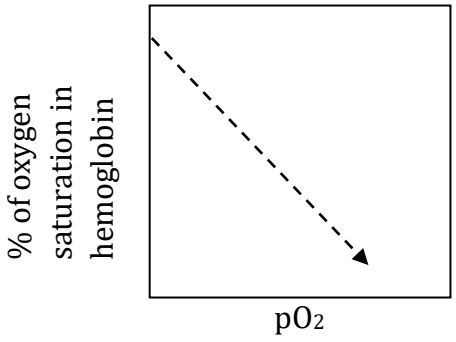
	Group I		Group II
P	Mitochondrion	(i)	Cisternae
Q	Golgi	(ii)	Cristae
R	Chloroplast	(iii)	Thylakoids
S	Centrosome	(iv)	Radial spokes

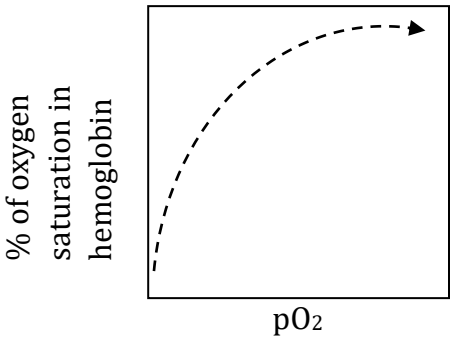
(a) P-(ii) , Q-(i), R-(iii), S-(iv)
(b) P-(iii), Q-(i), R-(ii), S-(iv)
(c) P-(iv), Q-(i), R-(ii), S-(iii)
(d) P-(iv), Q-(ii), R-(i), S-(iii)

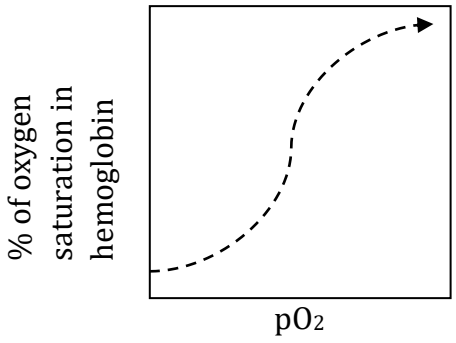
22. A human population containing 200 individuals has two alleles at the 'T' locus, named *T* and *t*. *T*, which produces tall individuals, is dominant over *t*, which produces short individuals. If the population has 90 *TT*, 40 *Tt* and 70 *tt* genotypes, what will be the frequencies of these two alleles in this population?
(a) *T*, 0.50; *t*, 0.50
(b) *T*, 0.55; *t*, 0.45
(c) *T*, 0.45; *t*, 0.35
(d) *T*, 0.90; *t*, 0.10

23. Which of the following graphs best describes the oxygen dissociation curve where pO_2 is the partial pressure of oxygen?

(a)


(b)


(c)


(d)


24. Which of the following best describes the DNA content and the number of chromosomes at the end of S and M phases of the cell cycle in mitosis, if the DNA content of the cell in the beginning of cell cycle (G1 phase) is considered as C and the number of chromosomes 2N?

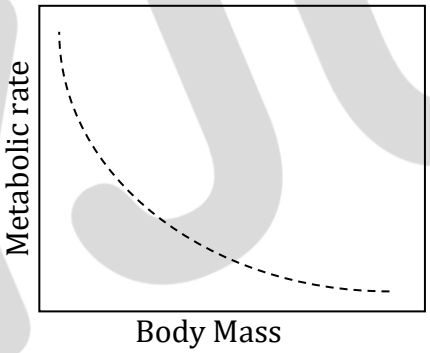
(a) 2C and 2N for S phase; 2C and 2N for M phase

(b) 2C and N for S phase; 2C and N for M phase

(c) 2C and 2N for S phase; C and 2N for M phase

(d) C and N for S phase; C and 2N for M phase

25. Study the following graph of metabolic rate of various terrestrial mammals as a function of their body mass and choose the correct option below.



(a) Animals are distributed throughout the curve with the smaller animals towards the left and progressively bigger animals towards the right

(b) The smaller animals below a certain critical mass cluster at the left end of the curve and the larger animals above the critical mass cluster on the right end

(c) Animals are distributed throughout the curve with the larger animals towards the left and progressively smaller animals towards the right

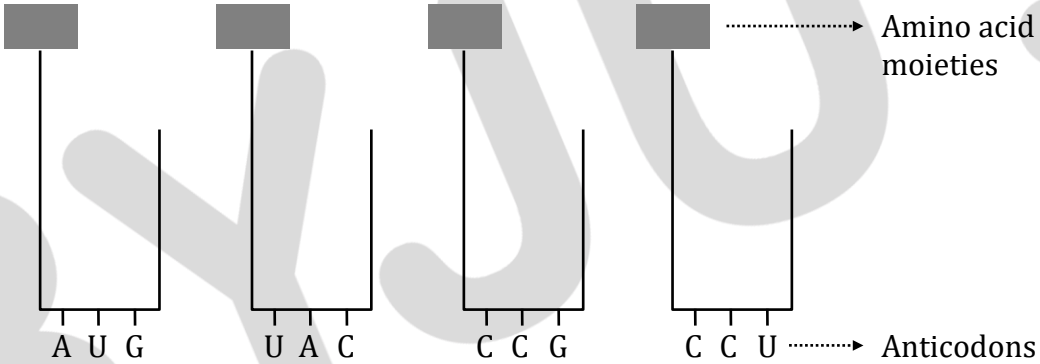
(d) The larger animals above a certain critical mass cluster at the left end of the curve and the smaller animals below the critical mass cluster on the right end.

26. Match the human disorders shown in Group I with the biochemical processes in Group II. Choose the correct combination

	Group I		Group II
P	Phenylketonuria	(i)	Melanin synthesis
Q	Albinism	(ii)	Conversion of Phenylalanine to Tyrosine
R	Homocystinuria	(iii)	Tyrosine degradation
S	Argininemia	(iv)	Methionine metabolism
		(v)	Urea Synthesis

(a) P-(ii), Q-(i), R-(iv), S-(v) (b) P-(i), Q-(iv), R-(ii), S-(v)
(c) P-(ii), Q-(i), R-(v), S-(iii) (d) P-(v), Q-(iii), R-(i), S-(ii)

27. An mRNA is transcribed from a DNA segment having the base sequence 3'-TACATGGGTCCG-5'. What will be the correct order of binding of the four amino acyl-tRNA complexes given below during translation of this mRNA?



(a) a, b, c, d (b) b, a, c, d (c) c, d, a, b (d) b, a, d, c

28. If the initial number of template DNA molecules in a PCR reaction is 1000, the number of product DNA molecules at the end of 20 cycles will be closest to
(a) 10^3 (b) 10^6 (c) 10^9 (d) 10^{12}

29. The allele for black hair (B) is dominant over brown hair (b) and the allele for brown eye (E) is dominant over blue eye (e). Out of the offsprings obtained upon mating a black-haired and brown-eyed individual (BbEe) with a brown-haired and brown-eyed individual (bbEE), the ratio of brown-haired and brown-eyed individuals to black- haired and brown-eyed individuals is
(a) 2 : 1 (b) 3 : 1 (c) 1 : 1 (d) 1 : 2

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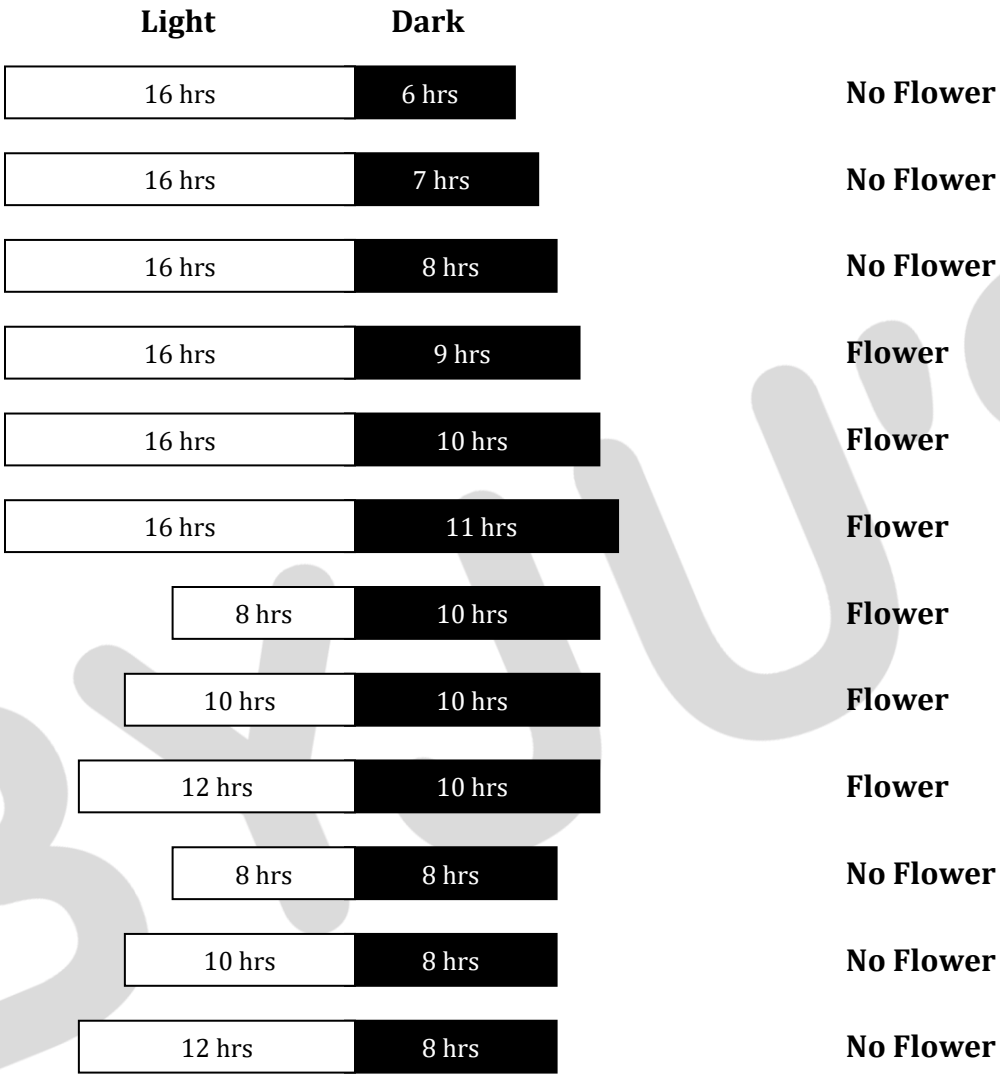
30. In an experiment represented in the schematic below, a plant species was grown in different day and night cycles and its photoperiodic flowering behaviour was noted. This species is a



(a) Short day plant and actually measures day length to flower

(b) Short day plant and actually measures night length to flower

(c) Long day plant and actually measures night length to flower

(d) Long day plant and actually measures day length to flower

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ANSWER KEY

1.	(c)	2.	(d)	3.	(b)	4.	(d)	5.	(a)
6.	(c)	7.	(b)	8.	(c)	9.	(a)	10.	(b)
11.	(a)	12.	(b)	13.	(a)	14.	(b)	15.	(d)
16.	(a)	17.	(d)	18.	(c)	19.	(d)	20.	(b)
21.	(a)	22.	(b)	23.	(d)	24.	(c)	25.	(a)
26.	(a)	27.	(d)	28.	(c)	29.	(c)	30.	(b)

SOLUTIONS

PART-I

1. (c)

In C_4 plants, initial fixation of carbon dioxide occurs in mesophyll cells. The primary acceptor of CO_2 i.e., Phosphoenol pyruvate (PEP) combines with CO_2 in the presence of PEP carboxylase or PEP case to form oxaloacetic acid, which is the first stable carbon dioxide fixation product in C_4 pathway.

2. (d)

Hydrogen bonding is a special type of dipole-dipole attraction between molecules, not a covalent bond to a hydrogen atom. It results from the attractive force between a hydrogen atom covalently bonded to a very electronegative atom such as N, O, or F atom and another very electronegative atom. C_8H_{18} is non-polar so, no hydrogen bonding occurs between them.

3. (b)

Lactose → Glucose + Galactose

Lactose is a disaccharide which hydrolyzes into glucose and galactose by breaking of glycosidic bonds. Normally when a person eats something containing lactose, an enzyme in the small intestine called lactase breaks it down into simpler sugar forms called glucose and galactose. These simple sugars are then easily absorbed into the bloodstream and turned into energy — fuel for our bodies.

It is a prominent sugar, present in milk which is metabolized in the intestine.

4. (d)

The cell membrane is an asymmetric structure i.e. the two sides of membrane are structurally and functionally different. Since, lipids such as phospholipids do rotate, the absolute asymmetry of the lipids is not retained (as in the case of proteins) but rather changes over time.

5. (a)

Around 50% of the total radiation from sunlight falls under photosynthetically active radiation and supports the process of photosynthesis. It constitutes the light of 400-700 nm wavelengths which is absorbed by chlorophyll pigment. Out of which only 2 - 10% are captured by plants. Roughly 20% of it is consumed in respiration.

6. (c)

Pollen grain has a two-layered wall i.e., exine and intine. The hard-outer layer of pollens, named exine, is made of sporopollenin. It is one of the most resistant organic materials known. It can withstand high temperature and strong acids and alkali. No enzyme that degrades sporopollenin is so far known. This also helps in fossilization of pollen grains. It is hard so that the pollen grains are well protected from the hazardous environment when they are pollinated by biotic/abiotic agents.

7. (b)

Insectivorous plants trap and digest insects and other small animals to obtain the nitrogen that is required for their growth. Most plants absorb enough nitrogen from nitrates in the soil but as the insectivorous plants live in nitrate-deficient bogs, they need to fulfil their nitrogen demand by digesting the prey instead.

8. (c)

The nucleosome consists of DNA and proteins. It is present in eukaryotes. In eukaryotes, the organization of DNA is complex and is carried out by a set of positively charged basic proteins called histones. Histones are rich in the basic amino acid residues lysins and arginines with charged side chains. There are five types of histone proteins i.e., H_1, H_2A, H_2B, H_3 and H_4. Four of them occur in pairs to produce histone octamer or nu-body (two copies of each H_2 A, H_2 B, H_3 and H_4). The negatively charged DNA is wrapped around the positively charged histone octamer to form a structure called nucleosome. Nucleosome is the smallest unit of DNA packaging containing 200 nitrogen bases.

9. (a)

Gap junctions are aggregates of intercellular channels that permit direct cell–cell transfer of ions and small molecules. They directly connect the cytoplasm of two cells, which allows various molecules, ions and electrical impulses to directly pass through a regulated gate between cells. Gap junctions are found in many places throughout the body. This includes epithelia, which are the coverings of body surfaces, as well as nerves, cardiac (heart) muscle, and smooth muscle (such as that of the intestines).

10. (b)

Glandular epithelium is a type of epithelial tissue which covers the glands (both exocrine and endocrine) of our body. Their main function is secretion. Both endocrine and exocrine glands produce their secretions through the glandular epithelium via special cells called goblet cells. They are mainly of two types: unicellular, consisting of isolated glandular cells (goblet cells of the alimentary canal), and multicellular, consisting of cluster of cells (salivary gland).

11. (a)

The voltage across a membrane is called the membrane potential. The membrane potential is the basis for the conduction of nerve impulses along the cell membranes of neurons. Ions that are important in the formation of a nerve impulse include sodium (Na^+) and potassium (K^+). The arrival of the threshold stimulus is responsible for changing the permeability of the membrane of the axon to the sodium ions. The influx of the Na + ions causes depolarization of the membrane that causes generation of the impulse. The depolarization is followed by the repolarization due to efflux of the K^+.

12. (b)

Atrial natriuretic factor (ANF) is a 28 amino acid polypeptide hormone secreted mainly by the heart atria in response to atrial stretch. ANF acts on the kidney to increase sodium excretion and GFR, to antagonize renal vasoconstriction, and to inhibit renin secretion. When blood sodium levels and pressure are increased, ANP is secreted from the heart. It binds to its receptor in the kidney and blood vessels, and promotes salt excretion, lowers blood volume and relaxes the vessel.

13. (a)

Paraventricular nuclei of Hypothalamus synthesize mainly Oxytocin and a small amount of ADH (Antidiuretic Hormone)/vasopressin.

Supraoptic nuclei of Hypothalamus synthesize mainly vasopressin and a small amount of oxytocin.

Both the hormones are stored and secreted into the bloodstream from the posterior pituitary gland but synthesized in the Hypothalamus.

14. (b)

If we exhale multiple times into a conical flask containing lime water through a single intel fixed through a stop cork, lime water will turn milky because of CO_2. We inhale O_2 during respiration and exhale carbon dioxide. Lime water turns milky after exhalation because of the CO_2 gas. Lime water is calcium oxide ($Ca(OH)_2$) which when reacts with CO_2, forms calcium carbonate ($CaCO_3$). It is insoluble in water, hence, turns water cloudy or milky.

$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3$

15. (d)

The nerve pathway followed by a reflex action is called a reflex arc. For example, a simple reflex arc happens if we accidentally touch something hot.

1. Receptor in the skin detects a stimulus (the change in temperature).
2. Sensory neuron sends electrical impulses to a relay neuron, which is located in the spinal cord of the CNS. Relay neurons connect sensory neurons to motor neurons.
3. Motor neuron sends electrical impulses to an effector.
4. Effector produces a response (muscle contracts to move hand away).

16. (a)

Lactose does not easily diffuse across the E. coli cell membrane and must be actively transported into the cell by enzyme permease. When glucose is utilized and lactose is added synthesis of all the three enzymes increases about thousand-fold within 2 to 3 times. So, with small amount of permease present in cell lactose is diffused across membrane.

17. (d)

Passive immunity is the transfer of active humoral immunity of ready-made antibodies. Passive immunity can occur naturally, when maternal antibodies are transferred to the fetus through the placenta, and it can also be induced artificially, when high levels of antibodies specific to a pathogen or toxin (obtained from humans, horses, or other animals) are transferred to non-immune persons through blood products that contain antibodies, such as in immunoglobulin therapy or antiserum therapy.

18. (c)

Secretin stimulates pancreas into secreting bicarbonate (HCO_3^-) into the duodenum. This anion neutralizes the hydrochloric acid just coming from the stomach, allowing duodenum pH to rise to the optimum values for the pancreatic enzymes (proteases, lipases, pancreatic amylase).

19. (d)

The first stable product of CO_2 fixation in C_3 plants is a three-carbon organic acid. The enzyme ribulose-1,5-bisphosphate carboxylase–oxygenase (RUBISCO) combines CO_2 with the phospho sugars ribulose 1,5-bisphosphate to form two molecules of 3-phosphoglyceric acid. When radioactive CO_2 combines with RUBP then first stable compound radioactive phosphoglyceric acid.

20. (b)

The flower with the world's largest bloom is the Rafflesia arnoldii. This rare flower is found in the rainforests of Indonesia. It can grow to be 3 feet across and weigh up to 15 pounds! It is a parasitic plant, with no visible leaves, roots, or stem. The flowers look and smell like rotting flesh, hence its local names which translate to "corpse flower" or "meat flower".

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PART-II

21. (a)

A crista (plural cristae) is a fold in the inner membrane of a mitochondrion. It gives the inner membrane its characteristic wrinkled shape, providing a large amount of surface area for chemical reactions to occur on.

The Golgi apparatus is a membrane-bound organelle found in eukaryotic cells that are made up of a series of flattened stacked pouches called cisternae. It is located in the cytoplasm next to the endoplasmic reticulum and near the cell nucleus.

Thylakoids are membrane-bound compartments inside chloroplasts and cyanobacteria. They are the site of the light-dependent reactions of photosynthesis. Chloroplast thylakoids frequently form stacks of disks referred to as grana.

The radial spoke is a multi-unit protein structure found in the axonemes of eukaryotic cilia and flagella.

22. (b)

Frequency = no. of individuals with allele distribution/total no. of individuals.

$t*2 = 40/200 = 1/5$

$t = 0.4472 = 0.45$

As we know, $T + t = 1$

$T = 1 - 0.45$

$T = 0.55$

23. (d)

The oxygen–haemoglobin dissociation curve, also called the oxyhaemoglobin dissociation curve or oxygen dissociation curve (ODC), is a curve that plots the proportion of haemoglobin in its saturated (oxygen-laden) form on the vertical axis against the prevailing oxygen tension on the horizontal axis. This curve is an important tool for understanding how our blood carries and releases oxygen. The curve is usually best described by a sigmoid plot.

24. (c)

During G_1 phase, the cell is metabolically active and continuously grows but does not replicate its DNA. S or synthesis phase marks the period during which DNA synthesis or replication takes place. During this time, the amount of DNA per cell doubles. If the initial amount of DNA is denoted as 2C then it increases to 4C. However, there is no increase in the chromosome number; if the cell had diploid or 2n number of chromosomes at G1, even after S phase the number of chromosomes remains the same, i.e., 2n.

25. (a)

The metabolic theory of ecology (MTE) is an extension of Metabolic Scaling Theory and Kleiber's law. It posits that the metabolic rate of organisms is the fundamental biological rate that governs most observed patterns in ecology. MTE is part of a larger set of theory known as metabolic scaling theory that attempts to provide a unified theory for the importance of metabolism in driving pattern and process in biology from the level of cells all the way to the biosphere.

MTE is based on an interpretation of the relationships between body size, body temperature, and metabolic rate across all organisms. Small-bodied organisms tend to have higher mass-specific metabolic rates than larger-bodied organisms.

26. (a)

Phenylketonuria - an autosomal recessive disorder causing absence of hydroxylase enzyme thus, there is an inability of conversion of phenylalanine to tyrosine causing phenyl pyruvic idiocy and arthritis.

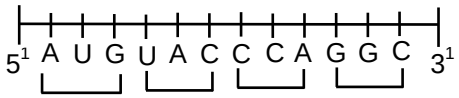
Albinism - an autosomal recessive condition causing tyrosinase deficiency. So, the melanin synthesis cannot take place.

Homocystinuria - a disorder of methionine metabolism causing abnormal deposition of homocysteine and its metabolites.

Argininemia - Autosomal recessive disorder. Due to deficiency of arginase enzyme, the arginine and ammonia get accumulated into the blood.

27. (d)

Template DNA



m-RNA (Complimentary To template DNA)

t–RNA ↓

UAC AUG GGU CCF — Same as template stand

(b) (a) (d) (c)

(1) Transcribed m-RNA has complimentary bases with the respect to DNA template.
(2) Anticodon on recognition loop is complimentary of codon present on m-RNA.

28. (c)

In DNA molecules, there are 2 strands of parents, the DNA number at the end of each cycle is increased in powers of 2.
Calculation:
DNA multiplies in exponents of 2 for 20 cycles each DNA yields 2 × 20 copies.
For 1000 DNA, $1000\times (2\times 20) = 10^9$.

29. (c)

Possible Gametes Produced by Black-haired, Brown-eyed Father

Possible Gametes Produced by Blonde-haired, Blue-eyed Father	**BE**	**Be**	**bE**	**be**
be	**BbEe**	**Bbee**	**bbEe**	**bbee**

Ratio of Brown haired and Brown eyed to Black haired and Brown eyed is 2: 2 or 1: 1.

30. (b)

Photoperiodism is the physiological reaction of organisms to the length of night or a dark period. It occurs in plants and animals. Photoperiodism can also be defined as the developmental responses of plants to the relative lengths of light and dark periods. They are classified under three groups according to the photoperiods: short-day plants, long-day plants, and day-neutral plants. In this experiment, plant flowers when dark period is above 8 hrs.
So, it is short day plant and actually measures night length to flower.