

KVPY-SX 2017 (BIOLOGY)

B

PART-I

- Interferons combat viral infection by
 - Inhibiting viral packaging directly.
 - Increasing the binding of antibodies to viruses.
 - Binding to the virus and agglutinating them.
 - Restricting viral spread to the neighboring cells.
- Leydig cells synthesize
 - Insulin
 - Growth hormone
 - Testosterone
 - Estrogen
- Glucagon increases the blood glucose concentration by
 - Promoting glycogenolysis.
 - Increasing the concentration of fructose 2,–6-bisphosphate.
 - Increasing the concentration of pyruvate kinase.
 - Inhibiting gluconeogenesis.
- Which ONE of the following is NOT essential for Polymerase Chain Reaction (PCR)?
 - Restriction enzyme
 - Denaturation of DNA
 - Primers
 - DNA polymerase
- CO₂ acts as a greenhouse gas because
 - It is transparent to heat but traps sunlight.
 - It is transparent to sunlight but traps heat.
 - It is transparent to both sunlight and heat.
 - It traps both sunlight and heat.
- A graph of species richness vs area on log-log axes is
 - Linear
 - sigmoidal
 - Oscillatory
 - parabolic

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7. Concentration of Na^+ ions outside a nerve cell is ~ 100 times more than inside. The concentration of K^+ ions is more inside the cells. The levels of Na^+ ions and K^+ ions are maintained by
- (A) Free diffusion of Na^+ ions and pumping of K^+ ions across the membrane.
 - (B) Na^+ and K^+ pumps in the membrane.
 - (C) Free diffusion of K^+ ions and pumping of Na^+ ions across the membrane.
 - (D) Water channels formed by lipids in the membrane.
8. In a chemical reaction, enzymes catalyze the reaction by
- (A) Lowering the activation energy.
 - (B) Increasing the activation energy.
 - (C) Decreasing the free energy change between reactants and products.
 - (D) Increasing the free energy change between reactants and products
9. The rigidity of cellulose is due to
- (A) Coiled structure of glucose polymer
 - (B) $\beta(1 \rightarrow 4)$ glycosidic linkage
 - (C) Hydrogen bonding with adjacent glucose polymer
 - (D) Cross-linking between glucose and peptides
10. Antigen-antibody reactions
- (A) Always result in precipitation of the complex
 - (B) Depend only on covalent interactions.
 - (C) Are irreversible.
 - (D) Depend on ionic and hydrophobic interactions.
11. Which ONE of the following combinations of molecular masses of polypeptides are obtained from purified human IgM when analysed on sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) under reducing conditions?
- (A) 55 kDa, 15 kDa
 - (B) 70 kDa, 25 kDa, 15 kDa
 - (C) 55 kDa, 25 kDa
 - (D) 155 kDa

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12. For a particular gene that determines the coat color in a diploid organism, there are three different alleles that are codominant. How many different skin colors are possible in such an organism?
(A) 9 (B) 6 (C) 4 (D) 3
13. Two genetic loci controlling two different traits are linked. During the inheritance of these traits, the Mendelian laws that would be affected is/are
(A) Law of dominance, law of segregation and law of independent assortment
(B) Law of segregation and Law of independent assortment
(C) Only Law of independent assortment
(D) Only Law of segregation
14. Which ONE of the following statements is INCORRECT?
(A) Alleles are different forms of the same gene.
(B) Alleles are present at the same locus.
(C) Alleles code for different isoforms of a protein.
(D) Alleles are non-heritable
15. Which ONE of the following statements is INCORRECT about restriction endonucleases?
(A) They serve as primitive form of immune system in bacteria.
(B) They digest the DNA non-randomly.
(C) They digest the DNA at specific location.
(D) They digest the DNA from free ends
16. The number of net ATP molecules produced from 1 glucose molecule during glycolysis is
(A) 1 (B) 2 (C) 3 (D) 4
17. Which ONE of the following coenzymes is required for the conversion of L-alanine to a racemic mixture of D-and L-alanine?
(A) Pyridoxal-6-phosphate (B) Thiamine pyrophosphate
(C) Coenzyme A (D) Flavin adenine dinucleotide

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18. The cyclic electron flow during photosynthesis generates
(A) NADPH alone. (B) ATP and NADPH.
(C) ATP alone. (D) ATP, NADPH and O₂.
19. Match the type of cells given in Column I with organisms given in Column II. Choose the appropriate combination from the options below.
- | Column-I | Column-II |
|--------------------|----------------|
| (P) Flame cells | (i) Sponges |
| (Q) Collar cells | (ii) Hydra |
| (R) Stinging cells | (iii) Planaria |
- (A) P-iii, Q-i, R-ii (B) P-iii, Q-ii, R-I (C) P-i, Q-ii, R-iii (D) P-ii, Q-iii, R-i
20. Compared to the atmospheric air, the alveolar air has
(A) More pO_2 and less pCO_2 (B) Less pO_2 and more pCO_2
(C) More pO_2 and more pCO_2 (D) Less pO_2 and less pCO_2

PART-II

21. The genetic distance between genes A and B is 10 cm. An organism with Ab combination of the alleles is crossed with the organism with aB combination of alleles. What will be the percentage of the gametes with AB allele combination by an F₁ individual?
(A) 1 (B) 5 (C) 10 (D) 50
22. Proteins P, Q, and R are associated with intact organellar membrane in a cell. If the intact organelle is treated with a high ionic strength buffer, only protein R remained associated with the membrane fraction. Based on this, one could conclude that
(A) P and Q are peripheral membrane proteins.
(B) R is a peripheral membrane protein.
(C) P and Q are integral membrane bound proteins.
(D) P is peripheral and Q is integral membrane protein.

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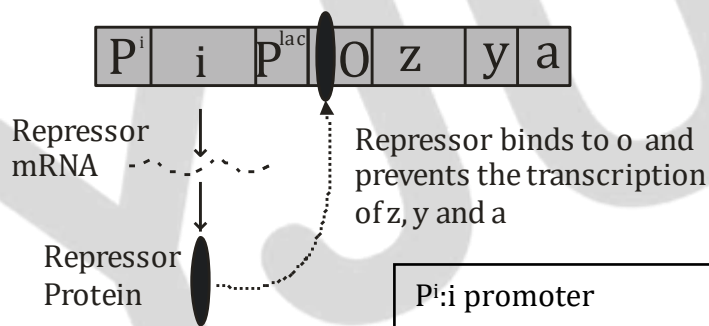
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23. In photosynthesis, oxygen is produced by
(A) Photosystem I from carbon dioxide.
(B) Photosystem II from carbon dioxide
(C) Photosystem I from water
(D) Photosystem II from water
24. How many different proteins consisting of 100 amino acids can be formed from 20 different amino acids?
(A) 20^{100} (B) 100^{20} (C) 2^{20} (D) 20×100
25. Molecular weight of *E. Coli* DNA is 3.1×10^9 g/mol. Average molecular weight of nucleotide pair is 660 g/mol and each nucleotide pair contributes to 0.34 nm to the length of DNA. The length of *E. coli* DNA molecule will be approximately
(A) 0.8 nm (B) 1.6 nm (C) 1.6 μ m (D) 1.6 mm
26. Which ONE of the following options is TRUE with respect to Emigration?
(A) It is the difference between the births and deaths in a population.
(B) It is the difference between individuals who have come to a habitat and who have left the habitat.
(C) It involves individuals of different species coming to a habitat from elsewhere during the period under consideration
(D) It involves individuals of a population leaving a habitat during the time period under consideration.
27. Choose the CORRECT combination of statements given below related to cysteine residue in proteins.
i. Cysteine can be linked to tyrosine by S-O bond.
ii. Cysteine can be linked to another cysteine by S-S bond.
iii. Cysteine can complex with Zn^{2+} .
iv. Cysteine can be linked to methionine by S-S bond
(A) i and ii (B) ii and iii (C) iii and iv (D) i and iv

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28. The minimum number of plants to be screened to obtain a plant of the genotype $AabbCcDd$ from a cross between plants of genotypes $AaBbCcDd$ and $AABbCCDd$ is
(A) 8 (B) 16 (C) 32 (D) 64
29. When a pure bred, red flower-producing plant of genotype RR is crossed with a pure bred, white flower-producing plant of genotype rr , all the F_1 plants produced pink flowers. If all the plants in each generation from F_1 to F_6 are selfed, what will be the percentage of plants with red and white flowers in the final population consisting of a large number of individuals? (Consider that flower colour has no effect on reproduction and survival.)
(A) 3 – 4 (B) 12 – 13 (C) 49 – 51 (D) 97 – 100
30. The schematic below describes the status of *lac* operon in the absence of lactose. Which ONE of the following happens when lactose is present in the cell?



P^i : i promoter
 i : lac repressor gene
 P^{lac} : lac promoter
 O : lac operator
 Z , y , a ; three lac genes

- (A) Lactose binds to P^i and stops the transcription of i .
- (B) Lactose is converted to allolactose, which binds to P^{lac} and results in the displacements of the repressor from O .
- (C) Lactose is converted to allolactose, which binds to the repressor protein and prevents its interaction with O .
- (D) Lactose has no effect on the status of the *lac* operon.

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ANSWER KEY

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

SOLUTIONS

PART-I

1. (D)

Interferons are biological response modifiers which activate the immune system and helps in destroying the tumour. They act as a barrier in virus replication and restrict the viral spread to the neighbouring cells.

2. (C)

In male reproductive system, the regions outside the seminiferous tubules called interstitial spaces, contain small blood vessels and interstitial cells called Leydig cells. Leydig cells synthesise and secrete testicular hormones called androgens. The testosterone is a male androgen and is produced in the testes.

3. (A)

Glucagon is a pancreatic hormone produced by cells of the islets of Langerhans. Glucagon raises the concentration of glucose in the blood by promoting glycogenolysis, which is the breakdown of glycogen (the form in which glucose is stored in the liver), and by stimulating gluconeogenesis, which is the production of glucose from amino acids and glycerol in the liver.

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4. (A)

Polymerase chain reaction, or PCR, is a technique to make many copies of a specific DNA region in vitro (in a test tube rather than an organism). PCR relies on a thermostable DNA polymerase enzyme, Taq polymerase to make new strands of DNA, and requires DNA primers. Taq polymerase can only make DNA if it's given a primer, a short sequence of nucleotides that provides a starting point for DNA synthesis.

The basic steps of PCR are: denaturation, annealing and extension. RE is not required in PCR

5. (B)

Greenhouse gases effectively absorb thermal infrared radiation, emitted by the Earth's surface. Greenhouse gases (GHG) include carbon dioxide, water vapour, methane, ozone, nitrous oxide and fluorinated gases.

CO₂ acts as a greenhouse gas because it is transparent to sunlight but traps heat. Greenhouse effect increases earth's temperature by trapping heat.

6. (A)

The great German naturalist and geographer Alexander von Humboldt observed that within a region species richness increased with increasing explored area, but only up to a limit. In fact, the relation between species richness and area for a wide variety of taxa (angiosperm plants, birds, bats, freshwater fishes) turns out to be a rectangular hyperbola.

On a logarithmic scale, the relationship is a straight line or linear described by the equation

$$\log S = \log C + Z \log A$$

Where S=Species richness, A=Area, Z = slope of the line (regression coefficient),
C = Y-intercept.

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7. (B)

When a neuron is not conducting any impulse, i.e., resting, the axonal membrane is comparatively more permeable to potassium ions (K^+) and nearly impermeable to sodium ions (Na^+). Similarly, the membrane is impermeable to negatively charged proteins present in the axoplasm. Consequently, the axoplasm inside the axon contains high concentration of K^+ and negatively charged proteins. In contrast, the fluid outside the axon contains a high concentration of Na^+ and thus form a concentration gradient. These ionic gradients across the resting membrane are maintained by the active transport of ions by the sodium-potassium pump which transports 3 Na^+ outwards for 2 K^+ into the cell.

8. (A)

Enzymes are biological catalysts. Catalysts lower the activation energy for reactions. The lower is the activation energy for a reaction, the faster is the rate. Thus enzymes are the catalysts which speed up reactions by lowering the activation energy.

The chemical which is converted into a product is called a 'substrate'. Hence enzymes, i.e. proteins with three dimensional structures including an 'active site', convert a substrate (S) into a product (P).

9. (C)

Cellulose is an unbranched polymer of beta-glucose. The linkages are called beta-1,4-glycosidic bonds, formed between adjacent D-glucose monomers which undergoes condensation reactions.

This polymer forms long, straight chains giving it a rigid structure. Because hydrogen bonds are formed between parallel chains so cellulose are rigid in nature.

10. (D)

Antigen-antibody reactions have non covalent interaction that includes hydrogen bonds, ionic bonds, hydrophobic interaction and Vanderwall's interaction.

In antigen antibody reaction, the antibody attaches with the antigen and the part of antigen which combines with antibody is called epitope.

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11. (B)

Different types of antibodies are produced in our body. IgA, IgM, IgE, IgG are some of them. Because these antibodies are found in the blood, the response is also called as humoral immune response.

IgM is the major antibody of humoral immune response and it exists as part of the B-cell antigen receptor on the surface of B cells, and as a secreted glycoprotein.

Polypeptides obtained from purified human IgM when analysed on sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) under reducing conditions is 70 kDa, 25 kDa, 15 kDa

12. (B)

In case of co-dominance the F₁ generation resembles both parents and each gene has multiple alleles instead of the fact that in an individual only two alleles can be present on a gene.

Because humans are diploid organisms, each person possesses any two of the three gene alleles.

Human skin color is a good example of polygenic (multiple gene) inheritance. Assume that three "dominant" capital letter genes (A, B and C) control dark pigmentation because more melanin is produced. The "recessive" alleles of these three genes (a, b & c) control light pigmentation because lower amounts of melanin are produced.

A genotype with all "dominant" capital genes (AABBCC) has the maximum amount of melanin and very dark skin. A genotype with all "recessive" small case genes (aabbcc) has the lowest amount of melanin and very light skin.

A genotype with three "dominant" capital genes and three small case "recessive" genes (AaBbCc) has a medium amount of melanin and an intermediate skin color. This latter genotype would be characteristic of a mulatto.

So to find the number of possible skin colour is:

$n + (n+1)/2 = 3 + (3+1)/2 = 6$ where n is number of alleles

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13. (C)

According to Mendel's Law of Independent Assortment 'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'.

Consider the segregation of one pair of genes R and r. Fifty per cent of the gametes have the gene R and the other 50 per cent have r. Now besides each gamete having either R or r, it should also have the allele Y or y.

But segregation of 50 per cent R and 50 per cent r is independent from the segregation of 50 per cent Y and 50 per cent y.

Linkage is an exception of law of independent assortment. Morgan observed that the two genes did not segregate independently of each other and the F₂ ratio deviated very significantly from the 9:3:3:1 ratio (expected when the two genes are independent). Morgan attributed this due to the physical association or linkage of the two genes and coined the term linkage.

14. (D)

Alleles are different forms of the same gene or are two alternative forms of same gene. Mendel studied seven traits in pea plants that each had two alleles, one dominant and one recessive. So Alleles code for different isoforms of a protein. Generally, the dominant allele is represented by a capital letter, and a recessive allele is represented by the same but small letter.

Alleles are present at the same locus (position) on a chromosome.

Humans are called diploid organisms because they have two alleles at each genetic locus, with one allele inherited from each parent. So alleles are heritable.

15. (D)

The two enzymes are responsible for restricting the growth of bacteriophage in Escherichia coli. One of these added methyl groups to DNA, while the other cut DNA. The later is known as restriction endonuclease.

Restriction endonucleases always cut DNA molecules at a particular point by recognizing a specific sequence of six base pairs. This specific base sequence is known as the recognition sequence. They do not cut DNA from free ends.

They digest the DNA into fragments non-randomly and serves as a primitive form of immune system in bacteria as it prevents against invading viruses.

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16. (B)

Glycolysis occurs in the cytoplasm of the cell and is present in all living organisms. In this process, glucose undergoes partial oxidation to form two molecules of pyruvic acid.

In glycolysis, a chain of ten reactions, under the control of different enzymes, takes place to produce pyruvate from glucose.

ATP is utilized at two steps: first in the conversion of glucose into glucose 6-phosphate and second in the conversion of fructose 6-phosphate to fructose 1,6-diphosphate. The conversion of DPGA to 3-phosphoglyceric acid (PGA), is an energy yielding process.

Hence during glycolysis, 4 molecules of ATP are produced per glucose molecule. However, 2 ATP molecules are consumed in the process of glycolysis so net ATP molecules is 2.

In glycolysis net ATP produced = $4 - 2 = 2$ ATP

17. (A)

Pyridoxal-6-phosphate is the active form of vitamin B₆, is a coenzyme in a variety of enzymatic reactions. PLP acts as a coenzyme in all transamination reactions, and in certain decarboxylation, deamination, and racemization reactions of amino acids.

Another function of PLP as coenzyme is the conversion of L-alanine to a racemic mixture of D- and L-alanine which is catalyzed by enzyme alanine racemase.

18. (C)

When only PS I is functional, the electron is circulated within the photosystem and the phosphorylation occurs due to cyclic flow of electrons known as cyclic photophosphorylation.

Cyclic photophosphorylation also occurs when only light of wavelengths beyond 680 nm are available for excitation.

When stroma lamellae membranes lack PS II as well as NADP reductase enzyme the excited electron does not pass on to NADP⁺ but is cycled back to the PS I complex through the electron transport chain. The cyclic flow hence, results only in the synthesis of ATP, but not of NADPH + H⁺.

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19. (A)

Specialized cells called flame cells help in osmoregulation and excretion. They are found in animals of Phylum – Platyhelminthes. Platyhelminthes includes animals which have dorso-ventrally flattened body, hence are called flatworms. Some members are Planaria, Taenia and Fasciola.

Members of the phylum Porifera are commonly known as sponges. Sponges have a water transport or canal system. Water enters through minute pores (ostia) in the body wall into a central cavity, spongocoel, from where it goes out through the osculum. Choanocytes or collar cells line the spongocoel and the canals.

The name Cnidaria is derived from the cnidoblasts or cnidocytes (which contains the stinging capsules or nematocytes) present on the tentacles and the body. Cnidarians exhibit two basic body forms called polyp and medusa. The former is a sessile and cylindrical form like Hydra, Adamsia, etc. whereas, the latter is umbrella-shaped and free-swimming like Aurelia or jelly fish.

20. (B)

Pressure contributed by an individual gas in a mixture of gases is called partial pressure and is represented as pO_2 for oxygen and pCO_2 for carbon dioxide.

Alveolar air has pCO_2 40 mm of Hg and pO_2 104 mm of Hg whereas atmospheric air has pCO_2 0.3 mm of Hg and pO_2 159 mm of Hg.

So alveolar air has more pCO_2 and less pO_2

PART-B

21. (B)

When cross is done between genotype having allele Ab and genotype with allele aB then we get AaBb in F_1 generation.

The gametes formed from AaBb will be AB, Ab, aB and ab.

Out of which Ab and aB are parental type (90%) while AB and ab are recombinant type (10%).

Now the genetic distance between genes A and B is 10 cm it means its recombination frequency is 10%. So AB and ab are two recombinant type so 5% for AB and 5% for ab.

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22. (A)

Peripheral proteins lie on the surface of membrane while the integral proteins are partially or totally buried in the membrane.

Peripheral membrane proteins are attached to surface of membrane by electrostatic, hydrogen-bonding or hydrophobic interactions which are weak. So when intact organelle are treated with a high ionic strength buffer, the Peripheral membrane proteins dissociate from the membrane while integral membrane proteins remains associated with the membrane as they are inside the membrane.

As only protein R remained associated with the membrane fraction this means it is an integral protein while P and Q gets dissociated so are peripheral membrane proteins.

23. (B)

The splitting of water is associated with the PS II; water is split into H^+ , $[O]$ and electrons. This creates oxygen, one of the net products of photosynthesis. The electrons needed to replace those removed from photosystem I are provided by photosystem II. The water splitting complex is associated with the PS II, which itself is physically located on the inner side of the membrane of the thylakoid.



24. (A)

Amino acids are the monomers that make up proteins. Protein is made up of one or more linear chains of amino acids, each of which is called a polypeptide. There are 20 types of amino acids commonly found in proteins.

So if we consider that proteins are composed of unit sequences of n amino acids, then number of different proteins is calculated by formula 20^n

So total number of proteins = 20^{100}

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25. (C)

Molecular weight of DNA = Number of base pairs \times average molecular weight of nucleotide pair.

So, number of base pairs = molecular weight of DNA / average molecular weight of nucleotide pair

$$= 3.1 \times 10^9 / 660 = 4.70 \times 10^6$$

Each nucleotide pair contributes to 0.34 nm to the length of DNA so

4.70×10^6 pair will contribute to

$$4.70 \times 10^6 \times 0.34 = 1.6 \times 10^6 \text{ nm} = 1.6 \text{ mm}$$

26. (D)

Emigration is the number of individuals of the population who left the habitat and gone elsewhere during the time period under consideration.

The difference between the births and deaths in a population is called population density.

The difference between individuals who have come to a habitat and who have left the habitat affects the population growth.

Immigration involves individuals of same not different species coming to a habitat from elsewhere during the period under consideration.

27. (B)

There are 21 types of amino acids (e.g., alanine, cysteine, proline, tryptophan, lysine, etc.), a protein is a heteropolymer and not a homopolymer.

Cysteine is one of the few amino acids that contains sulfur. This allows cysteine to bond in a special way and maintain the structure of proteins in the body.

The sulfur atoms of two cysteine molecules are bonded to each other to make cystine, another amino acid. The bonded sulfur atoms form a disulfide bridge, a principal factor in the shape and function of skeletal and connective tissue proteins and in the great stability of structural proteins such as keratin.

Many metal co factors like zinc, iron, and copper can make complex with the substituent of cysteine residues.

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28. (A)

Number of plants with particular genotype can be calculated by the formula 2^n , where n is the number of heterozygous gene in the desired genotype.

So given genotype is AabbCcDd and heterozygous pair will be 3

Hence $2^3 = 8$

29. (D)

When a pure bred, red flower-producing plant of genotype RR is crossed with a pure bred, white flower-producing plant of genotype rr, all the F1 plants produced pink(Rr)flowers is an example of incomplete dominance.

When the F1 will be self-pollinated the F2 will results in the following ratio

1 (RR) Red: 2 (Rr) Pink: 1 (rr) White

F2 generation

	R	r
R	RR	Rr
r	Rr	rr

So, if all the plants in each generation from F1 to F6 are selfed, the percentage of plants with red and white flowers in the final population will be calculated by calculating the percentage of homozygous individuals as only homozygous plant show characters of parents.

There is relationship between F1 and F6 generation phenotypic character that F6 generation resembles the F1 generation because pink flowers on fertilisation will produce red, pink, white flowers in the ratio 1:2:1

1 red flower plant (RR) and 1 white flower plant (rr) forms total 4 plants

	R	R
r	Rr	Rr
r	Rr	Rr

So the percentage of red and white flowers in F6 generation will be

$$2/4 \times 100 = 50 \%$$

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30. (C)

The lac operon consists of one regulatory gene (the *i* gene which is derived from the word inhibitor) and three structural genes (*z*, *y*, and *a*). The *i* gene codes for the repressor of the lac operon.

The *z* gene codes for beta-galactosidase (β -gal), which is primarily responsible for the hydrolysis of the disaccharide, lactose into its monomeric units, galactose and glucose.

The *y* gene codes for permease, which increases permeability of the cell to β -galactosides.

The *a* gene encodes a transacetylase. Hence, all the three gene products in lac operon are required for metabolism of lactose.

When lactose is present in the cell then the lactose is transported into the cells through the action of permease. In the presence of an inducer, lactose first lactose converts into allolactose, which binds to P^{lac} and results in the displacements of the repressor from *O*.

The repressor is inactivated by interaction with the inducer. This allows RNA polymerase access to the promoter and transcription proceeds.

