

## IJSO 2021 Biology MCQ Solution

**1.**

An ecologist found a small water body on an isolated island and observed the various organisms present in it. He classified the organisms based on different trophic levels as shown in the table:

Trophic level	Name of Trophic level	Organisms found	Description
Trophic level 1	Producers	Phytoplankton	Phytoplankton are autotrophs which produce their own organic nutrients
Trophic level 2	Primary consumers	Zooplankton	Zooplankton are herbivores. They feed on the phytoplankton for their energy source.
Trophic level 3	Secondary consumers	Small Planktivorous fish	These small fish are the primary carnivores. They feed on the zooplankton and derive their energy from it.

For studying the interactions between the organisms, the ecologist introduced a population of a carnivorous fish (which feed only on other small fish) in the waterbody.

Which one of the following statements is the correct statement regarding the long term consequence of this introduction?

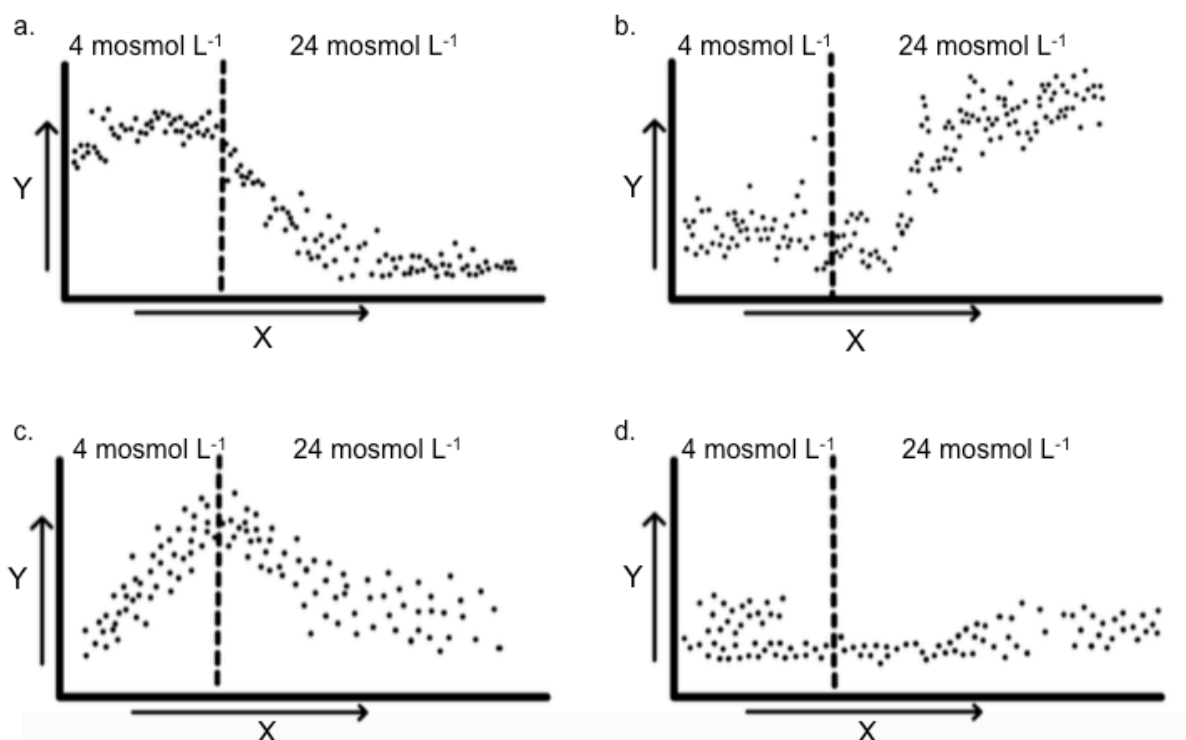
- a. There will be an increase in the biomass of autotrophs.
- b. There will be a decrease in the biomass of both autotrophs and herbivores.
- c. There will be an increase in the biomass of herbivores.
- d. There will be a decrease in the biomass of herbivores and increase in the biomass of autotrophs.

**Ans. c.** [Explanation: Food webs are defined by their biomass. Biomass is the energy in living organisms. Autotrophs, the producers in a food web, convert the sun's energy into biomass. Biomass decreases with each higher trophic level. Because biomass decreases with each trophic level, there are always more autotrophs than herbivores in a healthy food web. There are more herbivores than carnivores. As a population of carnivorous fish is introduced in the waterbody, the carnivorous fish will start feeding on the small fish (secondary consumers). This will lead to a decline in the population of the secondary consumers. As the population of secondary consumers declines, it will result in the population growth of the herbivores because now there will be fewer small fish to feed on them. With the increase of the herbivore population, the population of the autotrophs will decline because a greater number of herbivores will be available to feed on them. Thus, the longtime consequence of the introduction of tertiary consumer will lead to an increase in the Herbivore biomass and a decrease in the Autotroph biomass.]

2.

Paramecium lives in pond water that is hypotonic to its cellular contents. However, the Paramecium does not burst due to excess water uptake because of its contractile vacuole. The vacuole collects fluids from a system of canals present in the cytoplasm. When full, the vacuole and canals contract, expelling the fluid from the Paramecium.

In an experiment, the activity of contractile vacuole was monitored over time after placing the Paramecium in a growth medium having an osmotic concentration (osmolarity) of 4 mosmol L<sup>-1</sup> for 30 minutes and then shifted to a growth medium having an osmolarity of 24 mosmol L<sup>-1</sup>. Which one of the following graphs is a correct representation of the activity of contractile vacuole in these two media?



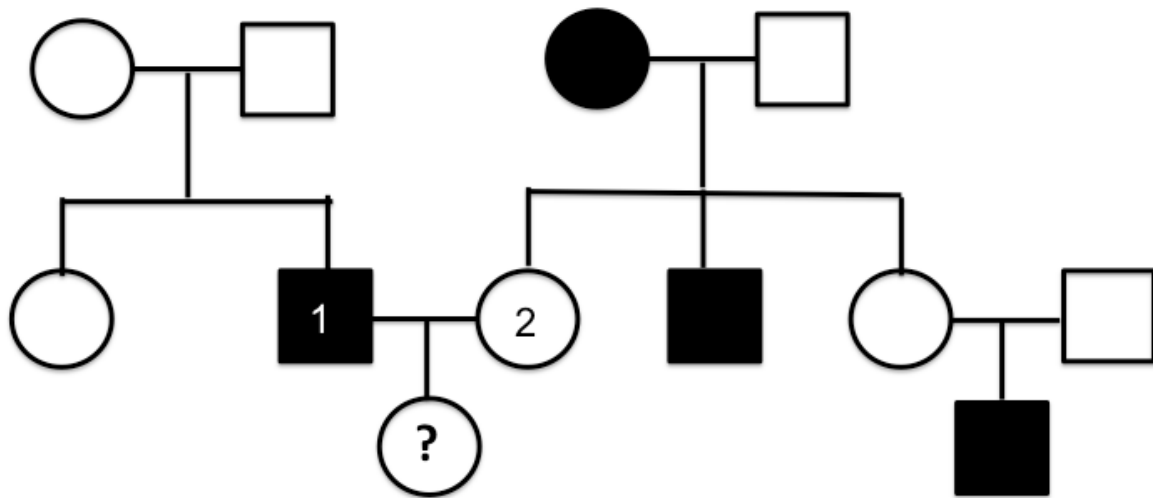
X = Time (min); Y = Activity

**Ans.: a** [Tests the understanding of osmolarity and interpretation of graphs. **Osmotic concentration** or **osmolarity** is the measure of solute concentration, defined as the number of osmoles (Osm) of solute per litre (L) of solution (osmol/L or Osm/L).

Water will move from the side with lower osmolarity to side with high osmolarity. The higher activity of the contractile vacuole indicates that the medium has lesser osmolarity than that of the cell. Thus a shift of paramecium from low to high osmolar solution would lead to decrease in the activity of the contractile vacuole.]

3.

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Female



Affected female



Male



Affected male



The pedigree above represents the inheritance of a genetic disorder. If the individuals marked 1 and 2 had a daughter, what is the probability that the daughter would show the disorder?

- a. 1
- b.  $1/2$
- c.  $2/3$
- d.  $1/4$

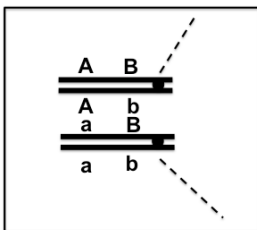
Ans.: b [The student has to first identify the mode of inheritance, which is X-linked recessive. Individual 1 has the genotype  $X^aY$ . Individual 2 is also a carrier  $X^aX$ . The daughter will get one X from the father that has the recessive allele and there is 50% chance of receiving the recessive allele from the mother.]

4.

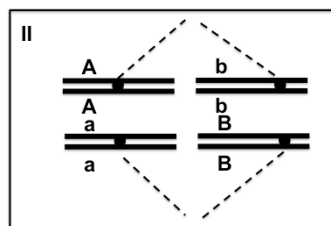
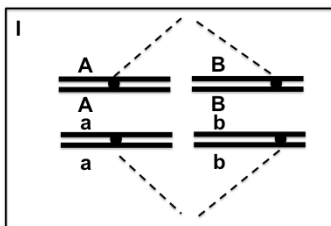
Given below are schematic representations of chromosomes at Metaphase I of meiosis. Which one of the following arrangement of chromosomes at the equatorial plane will definitely ensure independent assortment of the genes 'A' and 'B' under normal meiotic division?

The figures below depict the arrangement of alleles on the chromosomes and the alignment of chromosomes at the equatorial plane.

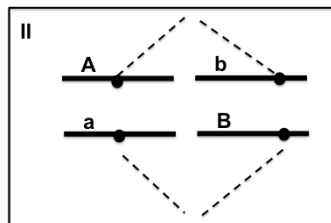
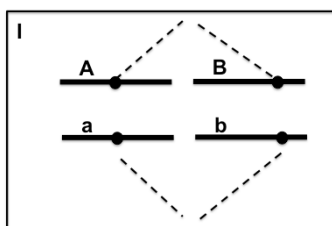
- a. When chromosomes are arranged as shown and there is crossing over between genes A and B.



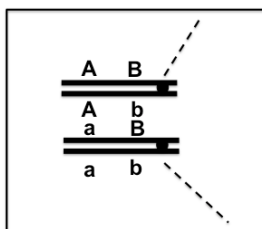
- b. When 50% of the cells in meiosis have orientation I and 50% have orientation II.



- c. When 50% of the cells in meiosis have orientation I and 50% have orientation II.



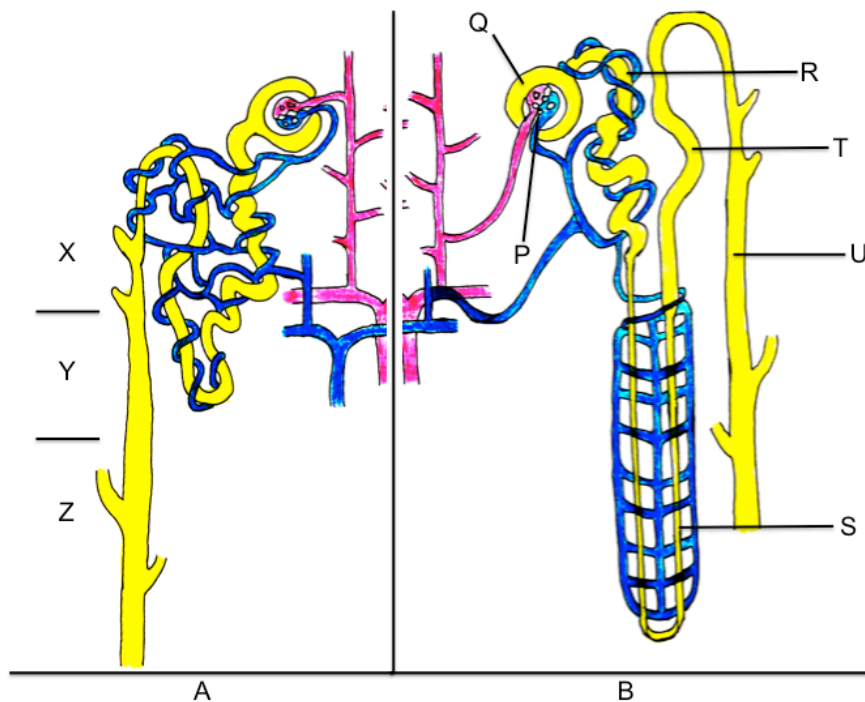
- d. When there is no crossing over between genes A and B.



**Answer: b** [If two genes are on different chromosomes they will always independently assort and that is because of the two possible orientations. Option 1 is incorrect, as although this will produce 4 kinds of gametes, all cells in meiosis will not undergo crossing over. Answer 3 is incorrect, as in metaphase I as there will be 2 chromatids per chromosomes. Answer 4 is incorrect, as sister chromatids should have the same alleles.]

5.

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A- Type A nephron; B- Type B nephron; P- Glomerulus; Q- Bowman's capsule; R- Proximal convoluted tubule; S- Loop of Henle; T- Distal convoluted tubule; U- Collecting duct; X- Cortex; Y- Outer medulla; Z- Inner medulla

The figure above represents two types of nephrons (labeled as A and B) observed in mammals. Which one of the following statements regarding the nephrons is correct?

- a. In comparison to type A nephron, the urine produced by type B nephron is likely to be more concentrated.
- b. Type B nephron is likely to absorb more potassium ions as compared to type A nephrons.
- c. In comparison to type B nephron, in type A nephron, reabsorption of NaCl leads to subsequent osmosis of water from loop of Henle into the blood.
- d. In comparison to type B nephron, type A nephron is likely to remove poisonous substances from the blood more efficiently.

**Ans. a** Explanation: The main difference in the two types of nephron is the long Loop of Henle in type B and its deeper extension into the renal medulla. The longer the loop and the deeper it extends into the renal medulla, the greater the concentrating power of the nephron. The loops of Henle are the longest and the urine is most hypertonic in desert dwellers such as the kangaroo rat.

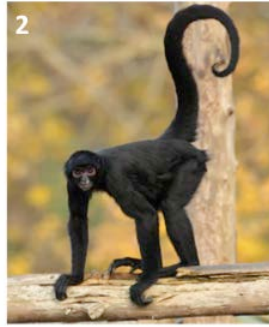
Statement b is incorrect as  $K^+$  ions are absorbed in the distal convoluted tubule

Statement c is incorrect as type B nephron will absorb more sodium chloride

Statement d is incorrect as secretion of poisonous substances from blood occurs in proximal convoluted tubule.

## 6

A small population of monkeys from Africa (Old World) are thought to have drifted to South America (New World) on natural rafts about 40 million years ago. There were no monkeys in the New World. On reaching South America, these monkeys bred and over time looked very different from the monkeys in Africa. They formed new species.



1 – Old world monkeys  
2- New world monkeys

Arrange the evolutionary processes that would lead to the formation of the new species.

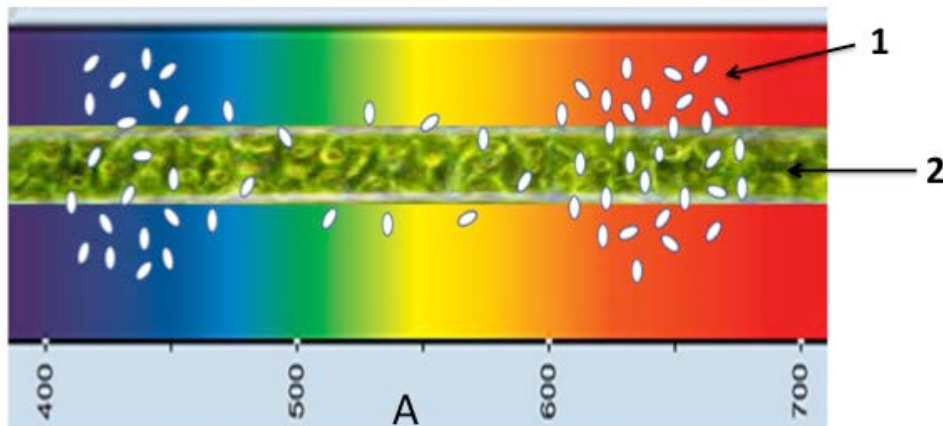
- a. Migration → Adaptation → Natural selection
- b. Genetic drift → Natural selection → Adaptation
- c. Natural selection → Adaptation → Genetic drift
- d. Adaptation → Genetic drift → Natural selection

**Ans. b** [Migration refers to gene flow from one population to another. The founding population of monkeys showed genetic drift and not migration, since no gene flow could occur because of the absence of monkey populations in S. America. Hence 1 is wrong. 2 is correct because the founding population formed by genetic drift, was acted upon by natural selection over generations, which led to their adaptation to the new habitat. Natural selection or adaptation will occur only after migration or genetic drift brings about an alteration in allelic / gene frequencies, hence 3 and 4 are wrong. Ref: <https://www.britannica.com/science/evolution-scientific-theory/Genetic-drift>]

7.

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In 1881, a scientist named Engelmann mounted a filamentous green alga, *Spirogyra*, on a slide and placed some motile bacteria in a nutrient medium around the algal filament. He illuminated the algal filament with a light spectrum (400-700nm) obtained using a prism and viewed the slide under a microscope.



1 – Bacteria    2- Algal filament    A- Wavelength (nm)

Based on the above, which one of the following statements is correct?

- a. The experiment was carried out to study respiration in algae.
- b. The bacteria used in this experiment are aerobic in nature.
- c. The bacteria are naturally attracted to red and blue light and not dependent on the algal filament.
- d. The distribution of bacteria is dependent on the specific structures present in the algal filament.

**Ans. b** [This experiment demonstrated the photosynthetic evolution of oxygen. The student should first identify the non-random distribution of the bacteria. This can then be correlated to the physiological activity. Looking at the spectrum they have to arrive at the conclusion that it is photosynthesis and this could involve oxygen liberation and thus the bacteria are aerobic]

**8.**

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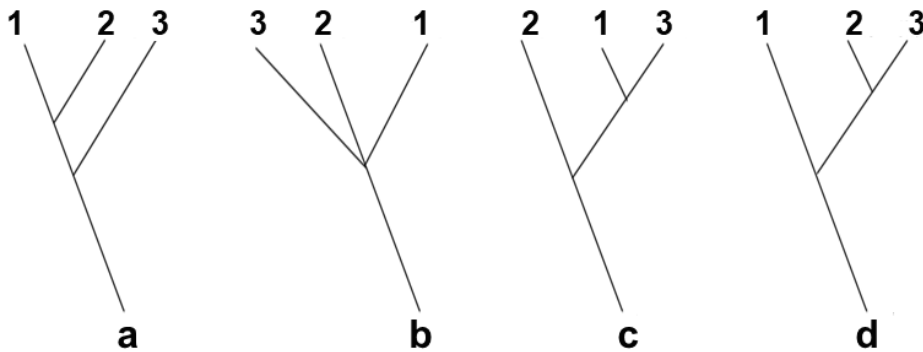
Filamentous cyanobacteria have special thick-walled structures called heterocysts that help in nitrogen fixation. Nitrogen from the atmosphere is fixed by the enzyme nitrogenase present in the heterocysts and converted to ammonia, using ATP as a source of energy. Nitrogenase is very sensitive to inactivation by oxygen. Which of the following modifications will allow heterocysts to effectively carry out nitrogen fixation?

- a. High chlorophyll content
- b. Lack of photosystem II activity
- c. Enhanced CO<sub>2</sub> fixation
- d. Low respiratory rate

**Ans: b** [Photosystem II is the site of oxygen evolution. Switching it off will reduce oxygen levels and enable nitrogen fixation by nitrogenase. Chlorophyll content and CO<sub>2</sub> fixation is reduced and respiratory rate is high in heterocysts, so a, c and d are wrong]. Ref: Cyanobacterial Heterocysts. Krithika Kumar et al. Cold Spring Harb Perspect Biol 2009;2:a000315)

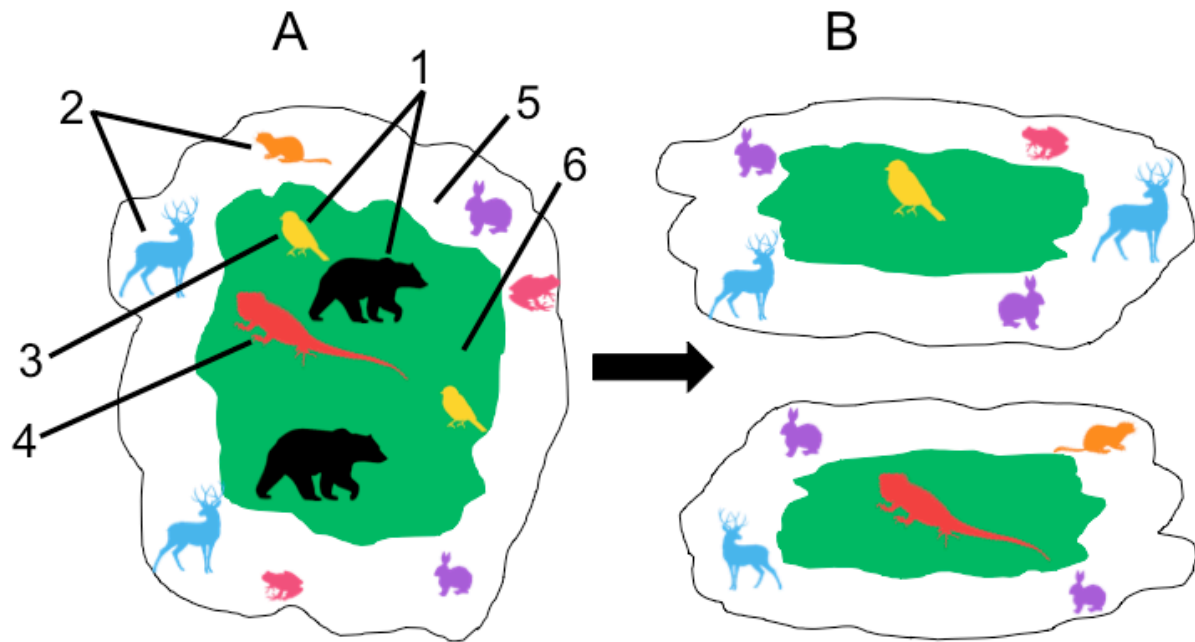


A phylogenetic tree is a diagram that depicts the lines of evolutionary descent of different species, from a common ancestor. In the phylogenetic trees shown below, the evolutionary descent of three organisms –Humans (1), Whale (2) and Sharks (3) has been depicted. Which of the following phylogenetic trees correctly represents the relatedness between these three organisms?



**Ans. a** [c and d are wrong because the shark is very different from whales or humans, since it is a fish while the latter two are mammals. b is wrong because it shows that all three - sharks, humans and whales have diversified from a common ancestor. a is correct because it shows that whales and humans share a more recent common ancestry than they do with sharks.]

10. \_\_\_\_\_



1- Interior species; 2- Edge species; 3- Sp-Y (bird); 4- Sp-X (reptile) 5- boundary zone; 6- deep forest.

The figure depicts a forest area depicting fauna living in deep forest or the boundary zone. The different species may reside in specific niches. An ecological niche is defined as the sum of its use of the biotic and abiotic resources in its environment.

Compare A and B and analyse the inferences given below:

- i. A and B are examples of ecological succession.
- ii. A and B are examples of habitat fragmentation.
- iii. In B, interior habitat has shrunk while number of edge species increased.
- iv. In B, there is an increase in both inner habitat and interior species.
- v. In A and B, sp-X and sp-Y occupy different niches.

Choose the option with correct combination of inferences cited above:

- a. i and iii only
- b. ii and iv only
- c. ii, iii and v
- d. i, iv and v

**Ans: c**