

Adrenaline Rush

SAMPLE

These sample problems will give you a glimpse of how Adrenaline Rush problems in the contest will be structured.

All the best for SBL 2024!



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AR Problem 1 [Ecology, Ethology, Biosystematics]

(Easy)

SimpBiosis

Remora fish have a disk on their heads, allowing them to attach to larger animals like sharks and whales. When the larger animal feeds, the remora fish detaches itself to eat the extra food. The larger animal does not feed on nor lose any significant energy due to this relationship.

What kind of ecological relationship is exemplified by remora fish and larger animals?

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



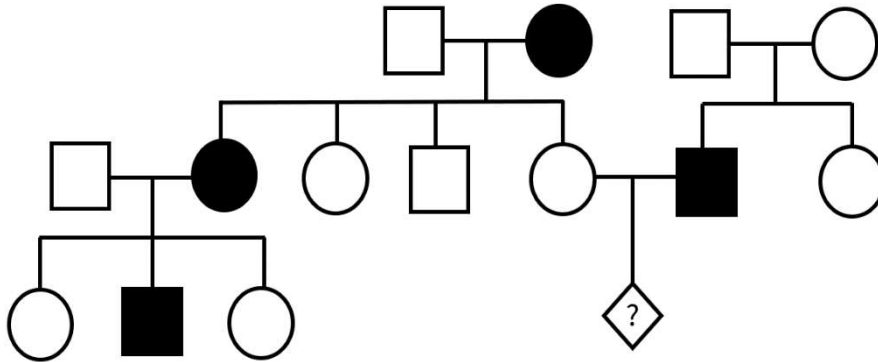
Answer: **A**

Explanation: In ecological relationships, the two important things to take note of are the effects on both organisms. In this case, the remora fish benefits from this symbiosis as it is able to consume more food than it would have been able to, but the larger animal is unaffected as there is no competition for food. The food is “extra” food implying that there is no competition for food. Hence the relationship between them is commensalism.

AR Problem 2 [Genetics and Evolution] (Easy)

Beta

Sickle-cell anaemia (SCA) is an autosomal recessive condition caused by a point mutation in the haemoglobin beta gene (HBB) found on chromosome 11p15. The diagram below shows the inheritance of SCA in a family.



What is the probability that the child marked with a question mark will be a boy affected with SCA?

- A. $\frac{1}{2}$
- B. $\frac{1}{3}$
- C. $\frac{1}{4}$
- D. $\frac{1}{6}$

Answer: **C**

Explanation: Let A/a be the gene involved. I-1 is a heterozygote because II-2 is affected, so each parent (I-1 and I-2) must have a recessive allele. I-1 is unaffected so he must be a heterozygote. Thus, a cross of Aa x aa will yield 1 Aa : 1 aa ratio. Since II-5 is unaffected, she cannot be homozygous recessive as she would then be affected. Hence, II-5 is definitely heterozygous. Hence this is a simple cross between Aa x aa, so the probability of being affected is $\frac{1}{2}$. The probability of the child being a boy is $\frac{1}{2}$, so the probability of an affected son is $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$.

AR Problem 3 [Animal Anatomy and Physiology]

(Easy)

My Heart will beat for you

What is the approximate cardiac output of a lady at rest who has a heart rate of 80 bpm and in each ventricular contraction 60 mL of blood is pumped into the aorta?

- A. 2L/min
- B. 3L/min
- C. 4L/min
- D. 5L/min



Answer: **D**

Explanation: The cardiac output can be calculated by the formula:

$$\text{Cardiac output (CO)} = \text{Heart Rate (HR)} \times \text{Stroke Volume (SV)}$$

SV refers to the amount of blood pumped out of the ventricles with each contraction.

Thus, the *CO* can be calculated as:

$$CO = 80\text{bpm} \times 0.060\text{L} = 4.8\text{L}/\text{min} = 5\text{L}/\text{min} \text{ (1 s. f.)}$$

Thus, the answer is $5\text{L}/\text{min}$. Remember to convert 60mL to 0.06L as the units of the answer is in litres (L).

AR Problem 4 [Molecular Biology, Biochemistry, Cell Biology] (Medium)

Purple Leaves

Some plants have variegated leaves, which are leaves that contain different pigments. *Coleus scutellarioides* is a plant with variegated leaves. Each leaf contains a purple region along the midrib and a green region. The plant was supplied with radioactive carbon dioxide, $^{14}\text{CO}_2$ and was kept in a dark cupboard for 24 hours and then illuminated for the next 24 hours. The level of radioactivity of the variegated leaves was measured in both the absence and presence of light. The results are shown in the table below.

	Radioactivity (Bq)	
	Purple Region	Green region
Absence of Light	10	10
Presence of Light	60	700

Which of the following statements most accurately explains the results?

- A. The purple region does not photosynthesise. The radioactive products move by diffusion from the green region to the purple region.
- B. Anthocyanins contain less chlorophyll so they have a lower photosynthetic rate.
- C. Anthocyanins do not contribute to the excitation of electrons in the photosystems and thus no photosynthesis occurs in the purple regions.
- D. Anthocyanins shield the chlorophyll from photons.

Answer: **D**

Explanation: In the absence of light, both regions have the same levels of radioactivity. This is because the lack of light causes the light-dependent reactions to halt, preventing the formation of ATP and NADPH for the Calvin Cycle. Even though the Calvin Cycle is not dependent on light, the lack of ATP and NADPH causes the Calvin Cycle to stop too. Thus only a small amount of radioactive carbon dioxide is fixed with RuBP to form 3-phosphoglycerate (PGA), so the radioactivity levels are low and similar.

However, in the presence of light, the radioactivity levels of the green region of the leaf is higher. The green colour is contributed by chlorophyll, while the purple colour is contributed by anthocyanins. Anthocyanins are stored in vacuoles and protect the plant against excess light (which would trigger photoinhibition) by absorbing photons. Since energy absorbed by the vacuole cannot be transferred to the chloroplasts, the presence of anthocyanins lowers the photosynthetic efficiency of the leaf by decreasing the amount of photons and thus energy collected and passed to the photosystems. Hence, the light-dependent reactions proceed at a slower rate and carbon fixation drops, explaining the lower radioactivity levels. Additionally, differential gene expression in purple regions causes more anthocyanin and less chlorophyll to be produced, so there would be less photosynthesis due to lower levels of chlorophyll.

Let's now examine each statement.

- A. *The purple region does not photosynthesise. The radioactive products move by diffusion from the green region to the purple region.*

[Explanation] The purple region still contains chlorophyll and is able to photosynthesise, allowing for carbon fixation and hence production of radioactive compounds.

- B. *Anthocyanins contain less chlorophyll so they have a lower photosynthetic rate.*

[Explanation] It is wrong to say anthocyanins contain less chlorophyll as they are different pigments. It is the purple regions that contains less chlorophyll.

- C. *Anthocyanins do not contribute to the excitation of electrons in the photosystems and thus no photosynthesis occurs in the purple regions.*

[Explanation] Anthocyanins absorb photons to prevent photoinhibition, but the energy is not transferred to the electrons in the photosystems for photoexcitation. However, that does not mean no photosynthesis occurs in the purple regions, as chlorophyll is still present, just in low quantities, for photosynthesis. This is why radiation is still detected in the purple region; if no photosynthesis occurred, no radiation would be detected.

- D. *Anthocyanins shield the chlorophyll from photons.*



[Explanation] Anthocyanin-containing cells absorb photons to prevent photoinhibition. This reduces the amount of photons that reach the chlorophyll pigments, causing less energy to be transferred for photoexcitation, so there would be lower rates of photosynthesis.

Hence the answer is D.

AR Problem 5 [Plant Anatomy and Physiology]

(Hard)

Me so Fine; Me so Droopy

Mesophytes are plants only requiring a moderate amount of water, while halophytes are plants that are salt-tolerant. A mesophyte was planted in soil with high salinity and irrigated. The mesophyte subsequently wilted.

How many of the following measures could be taken to reverse the wilting in this plant?

- I. Flush the soil with water to remove excess salts.
 - II. Increasing humidity of the environment.
 - III. Apply Vaseline on the bottom surface of the leaves to reduce transpiration.
 - IV. Adding more auxin to the plant.
 - V. Placing the plant in an area with high sunlight.
 - VI. Plant a halophyte beside the mesophyte.
 - VII. Placing the plant near a fan.
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- A. 0 or 1
 - B. 2 or 3
 - C. 4 or 5
 - D. 6 or 7

Answer: **A**

Explanation: The plant is wilting due to the high salinity of the soil. This causes excessive exosmosis and causes the plant to lose water. Thus, cell turgor is lost, causing the plant to droop and wilt.

To reverse this effect, water concentration of the cell sap must be increased by decreasing exosmosis and increasing endosmosis. Let's analyse each measure individually.

- I. Flush the soil with water to remove excess salts.
[Explanation] This can be done as removing the excess salts increases the water potential of the soil allowing water to enter the cells via osmosis, reversing the wilting.
- II. Increasing humidity of the environment.
[Explanation] While this decreases the transpiration rate and hence loss of water via transpiration, it is insufficient to reverse wilting because the main problem of excessive exosmosis is not corrected. Water is already in a very low amount in the plant so what measure II does is only to slow down the rate of loss of water.
- III. Apply Vaseline on the bottom surface of the leaves to reduce transpiration.
[Explanation] Similar to measure II, reducing transpiration is insufficient to correct the loss of water from the cell sap and hence turgor pressure of the cells.
- IV. Adding more auxin to the plant.
[Explanation] Auxin is primarily involved in cell elongation, root formation, and apical dominance, and has little significant effect on reversing wilting.
- V. Placing the plant in an area with high sunlight.
[Explanation] This increases water loss by transpiration which worsens the wilting effect.
- VI. Plant a halophyte beside the mesophyte. [Explanation] While halophytes do sequester salts intracellularly and excrete salt via salt glands, this effect is insignificant compared to the large amounts of salt of the soil. Hence, there is no significant effect.
- VII. Placing the plant near a fan.
[Explanation] Increased wind will only worsen the wilting as the rate of transpiration is increased. Wind blows away any water vapour around the stomata causing more water to evaporate out of the leaves. Thus, water loss is exacerbated.

Since only Measure I can reverse the wilting, the answer is A.

All the best for SBL 2024!





Credits

All figures are original work.