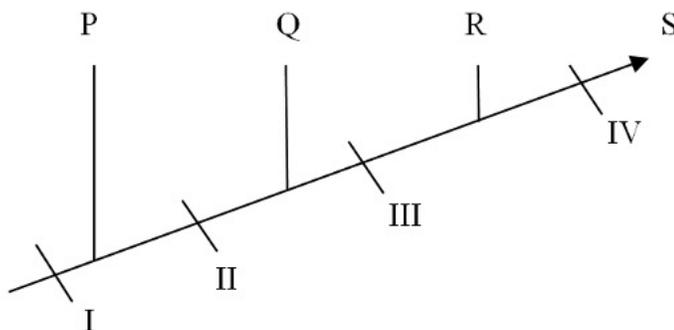


Biology Set I

Single Answered

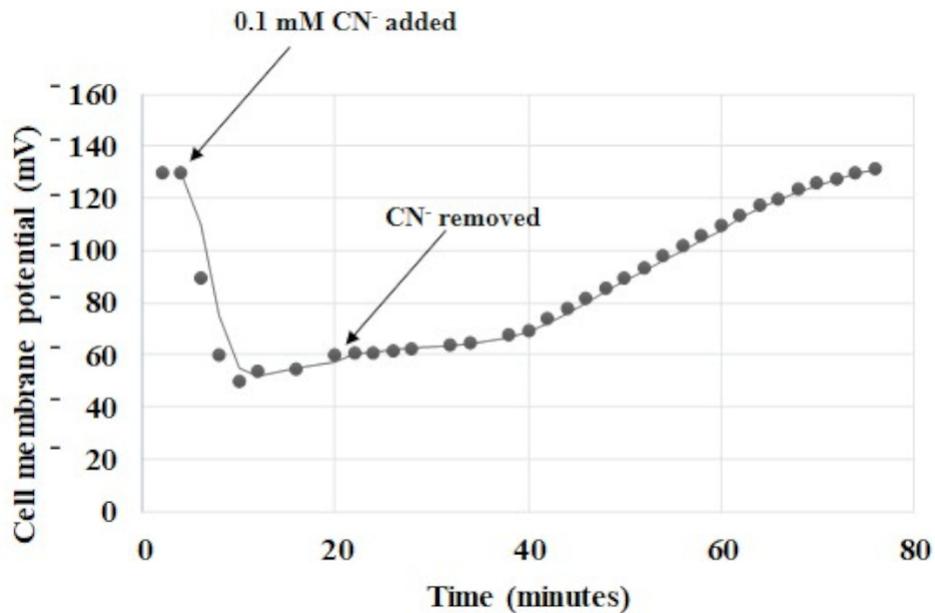
1. A cladogram representing the evolution of some animals (**P**, **Q**, **R** and **S**) is shown. **I** to **IV** in the cladogram represent different features that have evolved.



- The correct statement with respect to the given cladogram is
- (A) If **Q** is a bullfrog, **II** could be placenta.
 - (B) If features **III** and **IV** are mammary glands and hair, respectively, then **R** represents kangaroo and **S** represents humans.
 - (C) If **Q**, **R** and **S** represent bullfrog, koala and human, respectively, then feature **II** could be two pairs of limbs.
 - (D) If feature **I** is lungs, then **P** and **Q** are shark and bullfrog respectively.
2. A 1000 base pair double-stranded DNA (B form) has a melting temperature (T_m) of 58°C. If a duplex RNA (A form) of the same length and sequence is constructed, then the T_m of this new RNA duplex with respect to the DNA (B form) would be
- (A) higher due to greater stability of A form of RNA duplex.
 - (B) lower due to lower stability of A form of RNA duplex.
 - (C) lower because of unfavourable enthalpy of formation of RNA duplex.
 - (D) identical, as the number of hydrogen bonds remain the same.

3. A biochemist wants to purify a protein **X** (molecular weight = 30.2 kDa and pI = 7.5) from a solution containing proteins **X** and **Y** (molecular weight = 30.9 kDa and pI = 3.5) using ion exchange chromatography. In this technique, an anion exchange resin is positively charged and a cation exchange resin is negatively charged. The most appropriate resin where protein **X**, but not **Y** will remain bound is
- (A) cation exchanger at pH = 7.5.
 - (B) anion exchanger at pH = 2.5.
 - (C) cation exchanger at pH = 5.0.
 - (D) anion exchanger at pH = 7.5.
4. Bacterial endospores are highly resistant to environmental stressors such as heat, UV radiation, and oxidizing agents. They can remain dormant for a prolonged period. During the period of dormancy, they prevent the accumulation of potentially harmful mutations in their DNA. This is primarily due to
- (A) decreased water content and reduced enzyme activity.
 - (B) decreased salt concentration and enhanced enzyme activity.
 - (C) decreased respiration and decreased DNA supercoiling.
 - (D) increased enzyme activity and increased membrane permeability.

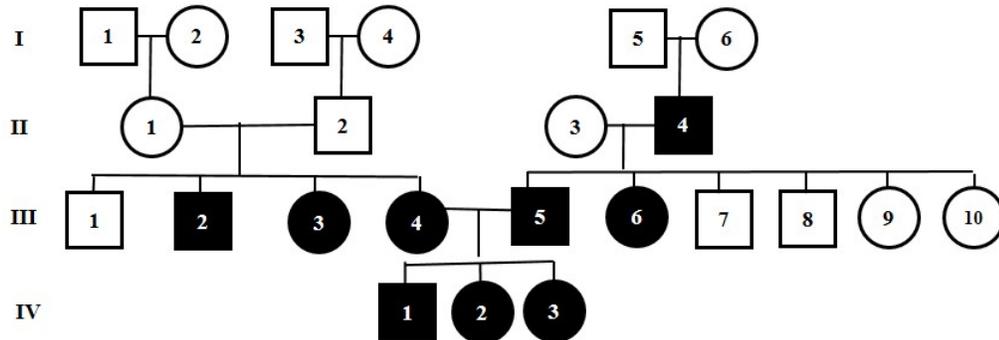
5. Pea seeds were allowed to germinate for 4 days and segments of the epicotyl around 1 cm were cut and placed in a nutrient solution having pH 7.0. These epicotyls were then treated with cyanide (CN^-) at a concentration of 0.1 mM and the membrane potential was recorded. Cyanide was washed out and the membrane potential was further recorded up to 78 minutes. A graph of cell membrane potential (mV) against time (minutes) was plotted as shown below.



Based on these experimental observations, the correct option is

- (A) addition of cyanide will decrease the membrane potential because of the depletion of ATP.
- (B) addition of cyanide will decrease the pH of the intermembrane space.
- (C) addition of excess oxygen will increase the membrane potential in presence of cyanide.
- (D) addition of cyanide will cause a rapid but irreversible depolarization of membrane potential.

6. In the given pedigree, circles represent females and squares represent males. Filled shapes indicate affected individuals while unfilled shapes indicate unaffected individuals. Based on the pedigree information provided, the correct inheritance pattern is



- (A) autosomal dominant.
 (B) autosomal recessive.
 (C) X-linked dominant.
 (D) X-linked recessive.
7. A population has a single locus with three alleles (**X1**, **X2**, and **X3**). The frequencies of these alleles are **p**, **q** and **r**, respectively, and if $p + q + r = 1$, then the correct statement is
- (A) the population is in Hardy-Weinberg equilibrium.
 (B) the population is not in Hardy-Weinberg equilibrium because it has three alleles.
 (C) this information is insufficient to state whether the population is in Hardy-Weinberg equilibrium.
 (D) the population will be in Hardy-Weinberg equilibrium if $r = 0$ and $p + q = 1$.

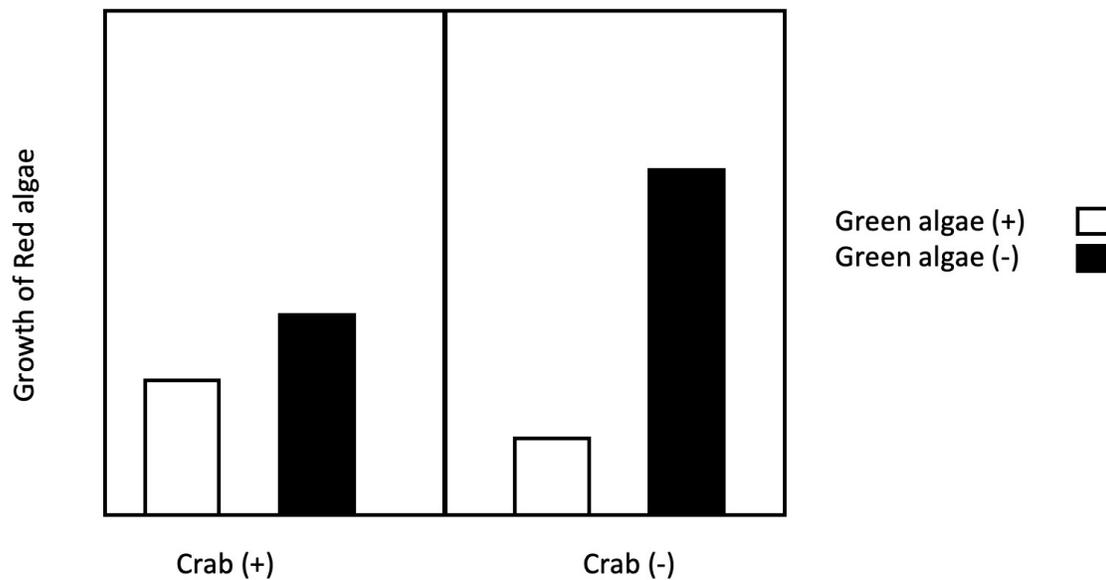
8. Mendelian theory of inheritance was crucial for Darwin-Wallace's theory of natural selection because

- (A) it explained how new variations will persist in a population over time despite their low frequency, which is essential for natural selection.
- (B) the Mendelian theory explained how characters acquired over an organism's lifetime can be passed on to the next generation, which is essential for natural selection to operate.
- (C) the Mendelian theory explained how variation appears in the biological system which is crucial for evolution by the process of natural selection.
- (D) the Mendelian theory first explained that linkage is essential for natural selection.

9. In a closed ecosystem, red algae, crabs and green algae are present and interact with each other. In order to understand the interactions between them, the following experimental treatments were imposed

- i. All crabs removed
- ii. All green algae removed
- iii. All crabs and green algae removed
- iv. All crabs, red and green algae are retained (Control)

The results of red algae growth from these experiments are shown in the graph. Plus (+) indicates presence and minus (-) indicates absence in this closed ecosystem. Red algae growth in all the treatments was significantly different from each other.



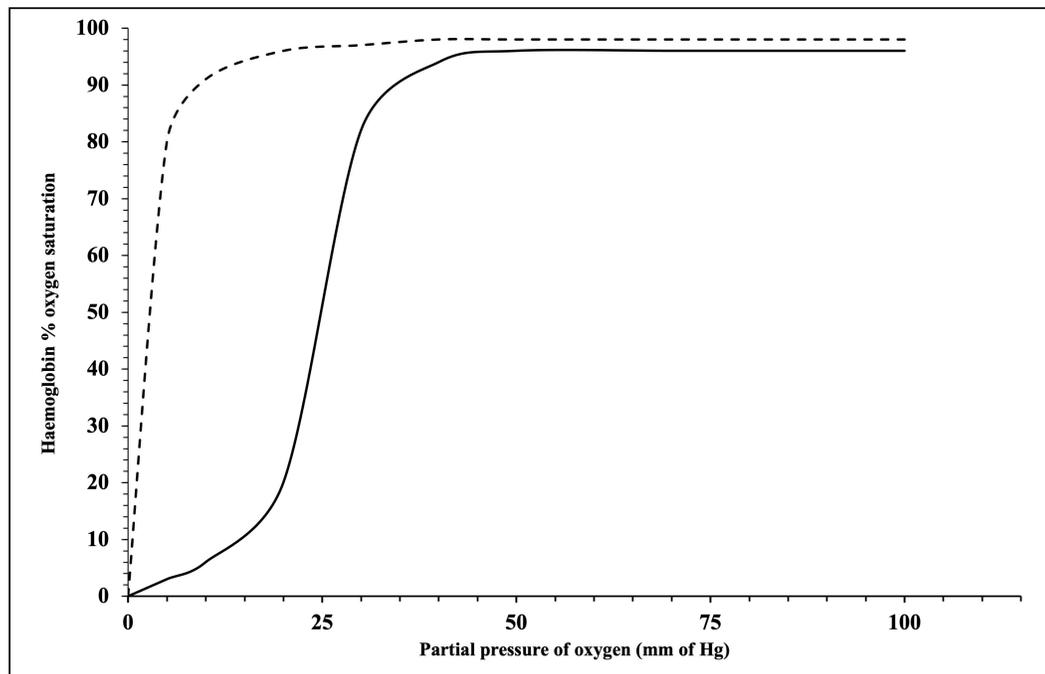
Based on these results, the correct option is

- (A) in the absence of crabs, green algae positively affected red algae growth.
- (B) in the presence of crabs, green algae positively affected red algae growth.
- (C) in the absence of green algae, crabs negatively affected red algae growth.
- (D) in the presence of green algae, crabs negatively affected red algae growth.

10. Synthesis of ATP takes place when protons flow back to the matrix side through an enzyme complex called ATP synthase. ATP synthase is made up of two operational units: a rotatory and a stationary component. Assume that the ATP synthase does ~ 100 rotations per second, and each rotation results in the generation of 3 ATP molecules. Suppose that a cell needs $\sim 3 \times 10^{10}$ molecules of ATP for one round of cell division that takes 30 minutes with the ATP synthase functioning at 50% efficiency. The minimum number of ATP synthase required for one round of cell division in this cell is
- (A) 222222
 - (B) 55555.5
 - (C) 111111
 - (D) 277777
11. The permeability of molecules across a lipid bilayer depends on their size and solubility in a nonpolar solvent relative to their solubility in water. For the species O_2 , H_2O , K^+ , glycerol and glucose, the order of their permeability across a lipid bilayer in the absence of any protein transporters is
- (A) $O_2 > H_2O > \text{Glycerol} > \text{Glucose} > K^+$
 - (B) $H_2O > O_2 > \text{Glycerol} > \text{Glucose} > K^+$
 - (C) $O_2 > H_2O > \text{Glucose} > \text{Glycerol} > K^+$
 - (D) $K^+ > O_2 > H_2O > \text{Glycerol} > \text{Glucose}$
12. A monoclonal (antibody specific for a given epitope of an antigen) IgG antibody (**M**) was produced in the laboratory that binds to a surface protein (**P**) of a virus (**V1**) and neutralizes 100% of **V1**. It was observed that **M** is also effective in neutralizing other viruses **V2**, **V3** and **V4** at 40%, 90% and 32% efficiency as compared to **V1**. If there are no other confounding factors, then the most accurate inference is
- (A) **V1**, **V2**, **V3**, and **V4** have identical surface protein **P**.
 - (B) the genome of **V1** and **V3** has to be 90% identical for the observed binding efficiency.
 - (C) the sequence of **P** is more similar in **V2** and **V4** than in **V1** and **V2**.
 - (D) a segment of sequence in **P** is highly conserved in **V1** and **V3** whereas the same segment is less conserved in **V2** and **V4**.

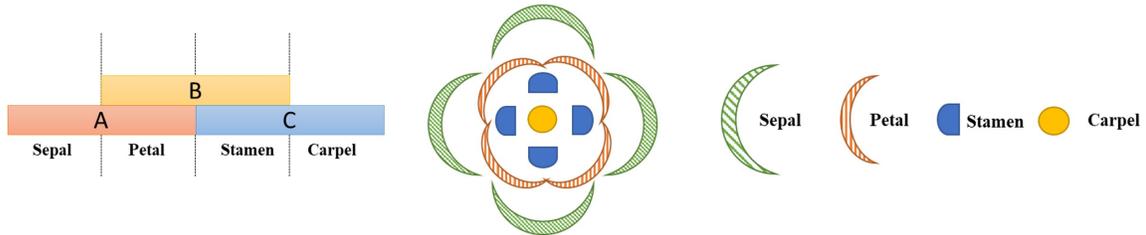
Multiple Answered

13. A genetic engineering experiment resulted in a new haemoglobin variant which exists primarily as $\alpha\beta$ dimers in solution. Based on the oxygen saturation curves of the variant (dashed line) and normal haemoglobin (solid line), it can be inferred that



- (A) the variant has a higher affinity to oxygen and shows non-cooperative behaviour.
(B) the variant has a higher affinity to oxygen and shows cooperative behaviour.
(C) the oxygen dissociation of the variant is less than 10% at 20 mm of Hg.
(D) at sea level (~ 150 mm of Hg), animals with this variant of haemoglobin can survive better than the ones with normal haemoglobin.
14. A hospital witnessed an outbreak of a nosocomial (hospital-acquired) infection caused by *Klebsiella pneumoniae*. It showed resistance to antibiotics generally used for its treatment. Under the given scenario, the antibiotic resistance of this organism can be attributed to
- (A) the presence of antibiotic resistance gene acquired through horizontal transfer from other prevalent strains in the hospital.
(B) silent mutations in target sites of antibiotics.
(C) neutralisation of antibiotics by enzymes that target and inactivate these antibiotics.
(D) reduced permeability of these antibiotics due to the formation of a protective barrier.

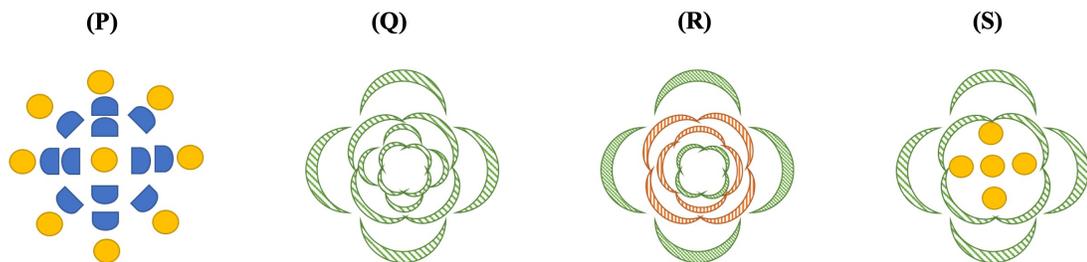
15. In the **ABC** model, the acquisition of floral organ identity is regulated by the floral homeotic genes namely **A**, **B** and **C**. A wild-type flower is depicted below.



Consider the following mutants

- i. loss of gene **C**
- ii. loss of gene **A**
- iii. loss of gene **B**
- iv. loss of genes **B** and **C**

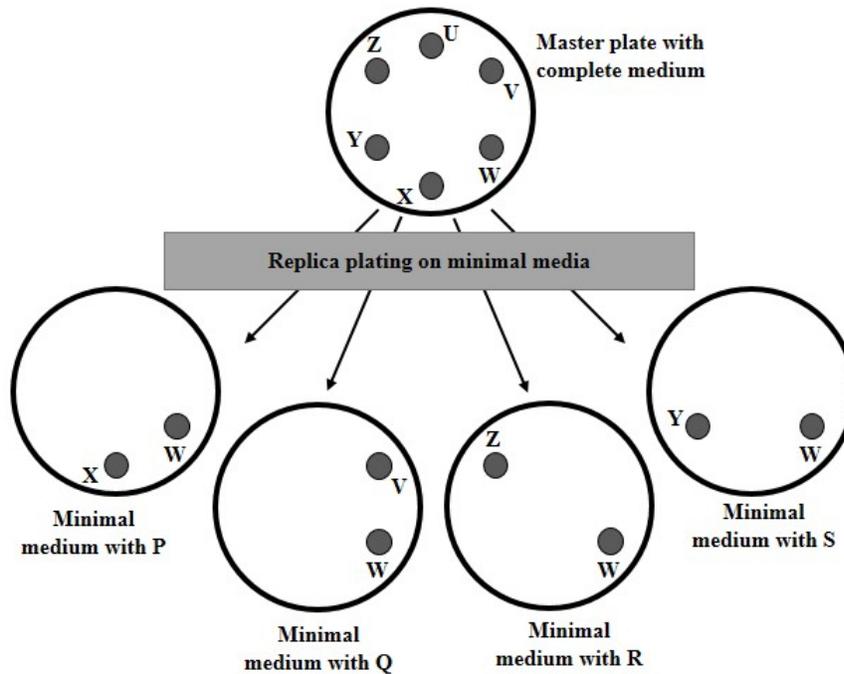
Possible floral phenotypes (**P-S**) resulting from these mutations are given below.



Based on this **ABC** model, the correct option(s) is(are)

- (A) (i) corresponds to **R** and (iv) corresponds to **Q**.
- (B) (i) corresponds to **S** and (ii) corresponds to **Q**.
- (C) (ii) corresponds to **P** and (iii) corresponds to **S**.
- (D) (iii) corresponds to **P** and (iv) corresponds to **R**.

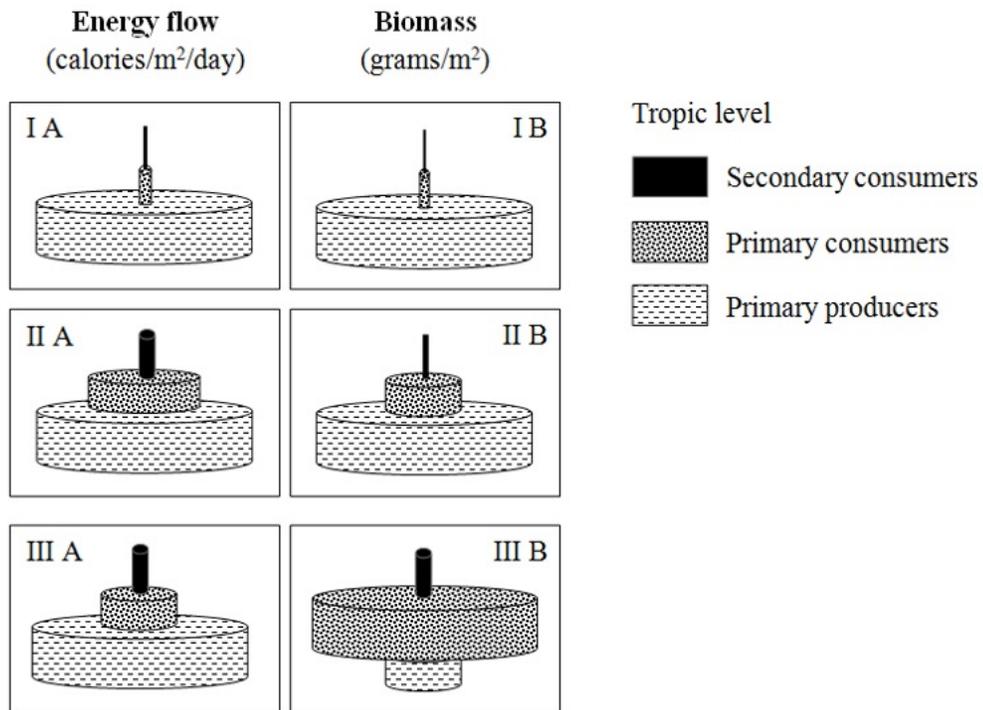
16. Auxotrophs are organisms with mutations that have lost the ability to synthesise essential organic compounds, and hence need supplements for growth in minimal media. Prototrophs are organisms that are able to synthesise essential compounds and hence can grow in minimal media without supplements. Colonies from six different strains of *E. coli* (**U**, **V**, **W**, **X**, **Y**, **Z**) are grown separately on a single master plate containing complete medium. No strain carries more than a single auxotrophic mutation. Replica plates are then made from this master plate. Each of this replica plate contains minimal medium to which a single supplement (either **P**, **Q**, **R**, or **S**) is added. In the diagram below, filled circles represent colonies that grew on the medium and absence denotes failure to grow.



Based on the scheme, the correct interpretation(s) is(are)

- (A) strain **W** is a prototrophic strain and strain **V** is auxotrophic for **Q**.
- (B) strain **Z** is auxotrophic for **R** and strain **Y** is auxotrophic for **S**.
- (C) strain **U** is a prototrophic strain and strain **X** is auxotrophic for **Q**.
- (D) strain **Y** is auxotrophic for **P** and strain **Z** is auxotrophic for **R**.

17. Energy diagrams allow ecologists to compare patterns of energy flow through the trophic levels of different ecosystems while biomass diagrams allow them to compare the amount of material present in living organisms at different trophic levels. The energy flow and biomass diagrams for a few ecosystems are given below.



Choose the correct statement(s).

- (A) **III B** cannot be the biomass pyramid of an open ocean since a biomass pyramid cannot be inverted at any level.
- (B) **I B** and **II B** are the biomass pyramids of a grassland and a forest ecosystem respectively, since most of the biomass in a grassland is found in the green parts and hence the efficiency of energy transfer from producers to primary consumers is higher in grassland as compared to a forest ecosystem.
- (C) **III A** could be the energy flow pyramid for an open ocean.
- (D) **I A** could be the energy flow pyramid for a forest ecosystem, since the majority of the biomass is tied up in wood and is not available to most herbivores.