

USABO SEMIFINAL EXAMINATION  
March 16 to 25, 2011

2011 USABO Semifinal Exam DRAFT

Part A

Cell and Molecular Biology (20%)	12 questions 1-12
Plant Anatomy and Physiology (15%)	9 questions 13-21
Animal Anatomy and Physiology (25%)	15 questions 22-36
Ethology (5%)	3 questions 37-39
Genetics and Evolution (20%)	12 questions 40-51
Ecology (10%)	6 questions 52-57
Biosystematics (5%)	3 questions 58-60

**Part A**

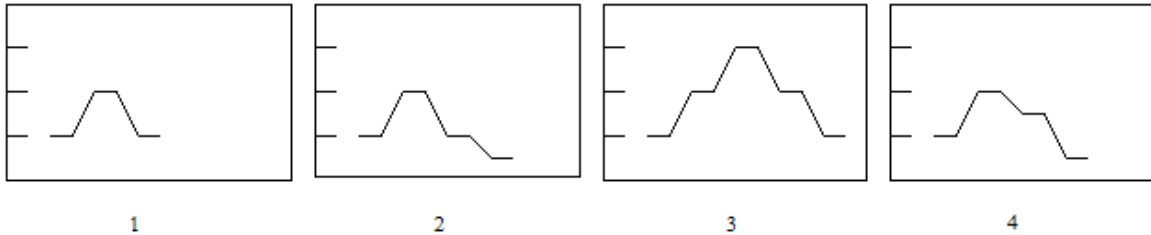
**CELL AND MOLECULAR QUESTIONS 1 to 12**

1. If you extract the genetic material of the Bacteriophage ( $\Phi$ X174), you will find that its composition is 25% A, 33% T, 24% G, and 18% C. How would you interpret these results?
- A. The experiment's results must be erroneous; something went wrong
  - B. We could admit that the %A approximately equals that of T, and the same is true for C and G. Consequently, Chargaff's rules are followed and the DNA is double stranded
  - C. Because the %A does not equal the %T, nor does the %G equal the %C, the DNA is single-stranded; it is replicated by special enzymes, following a particular replication pattern, with the single-stranded chain as a template
  - D. Because the %A does not equal the %T, nor does the %G equal the %C, the DNA must be single-stranded; It replicates by synthesizing a complementary strand and uses the double stranded form as a template
  - E. Bacteriophage ( $\Phi$ X174) is an RNA virus

**Answer D**

2. The diagrams below refer to variation in the amount of DNA (y-axis) as a function of time (x-axis) during cell division. (The units are arbitrary.) Which of these diagrams depict what happens during meiosis and mitosis, respectively?

- A. 1 and 2
- B. 1 and 3
- C. 2 and 3
- D. 3 and 4
- E. 4 and 1



**Answer E**

3. Which of the following cellular proteins make *direct* contact with chromosomes?

- A. Centrosomes and microtubule-associated proteins
- B. Kinesins, myosins, and actin microfilaments
- C. Histones, condensins, and synaptonemal complexes
- D. All of the above
- E. None of the above

**Answer C**

4. Your colleague's PCR reaction failed to amplify the human rhodopsin gene. Her lab notebook indicates that she added dNTPs, the Rhodopsin template gene, complementary DNA primers, buffer, and an *E. Coli* DNA polymerase and ran the reaction under the proper conditions. How would you advise her to fix the reaction?

- A. Add a bacterial promoter to the Rhodopsin template
- B. Add extra ATP so there is enough energy to catalyze the reaction
- C. Add dNTPs to facilitate elongation
- D. Use a different polymerase
- E. Use RNA primers instead

**Answer: D**

5. For a constant concentration of an enzyme, which of the following is true of a noncompetitive inhibitor?

- A.  $k_m$  is lowered;  $v_{max}$  remains constant
- B.  $k_m$  is increased;  $v_{max}$  remains constant
- C.  $k_m$  remains constant;  $v_{max}$  is lowered
- D.  $k_m$  remains constant;  $v_{max}$  is increased

E.  $k_m$  remains constant;  $v_{max}$  remains constant

**Answer C**

6. The mitochondrion has more than three stop codons. Which biological principle does this violate?

- A. Central dogma
- B. Endosymbiotic theory
- C. Conservation DNA replication
- D. Complementary base-pairing
- E. Universal genetic code

**Answer: E**

7. Which of the following structures and processes can exist in eukaryotic cells and in all prokaryotic cells?

- I. Nuclear envelope
- II. Ribosomes
- III. Introns
- IV. ATP synthesis
- V. rRNA 18S
- VI. Cell membrane
- VII. DNA polymerase
- VIII. Cytoskeletal elements

- A. I, II, III and VIII
- B. II, IV, VI and VIII
- C. I, III, V and VII
- D. II, IV, V and VI
- E. II, III, VI and VIII

**Answer: D**

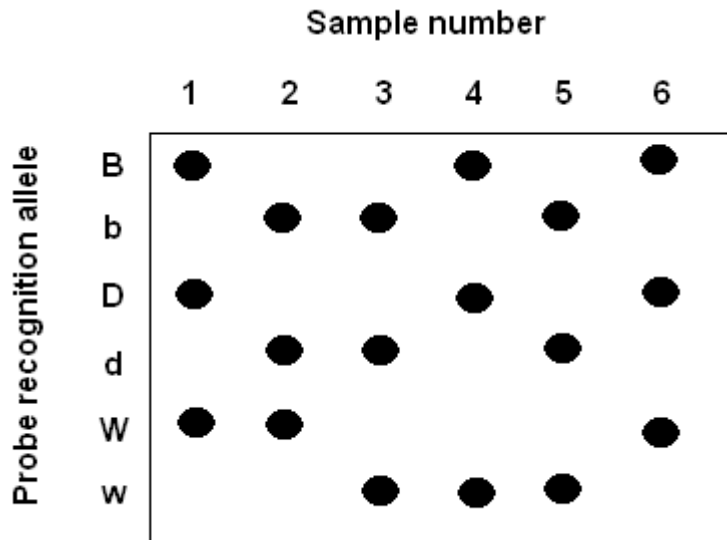
8. Comparing the effect of an inhibitor with an uncoupler of oxidative phosphorylation, the:

- A. inhibitor would allow electrons to pass through the electron transport chain
- B. inhibitor would increase the pumping of protons by the electron transport chain
- C. uncoupler would increase heat production by the mitochondria
- D. uncoupler would inhibit the reduction of oxygen by the electron transport chain
- E. uncoupler would stop the oxidation of NADH by the electron transport chain

**Answer: C**

9. Three different genes (B, D, and W) are found on a small region of chromosome 1. Each gene has two alleles. In order to determine the recombination frequency between these three genes, sperm were isolated from a male heterozygous for all three genes. The male had all dominant alleles on his maternal copy of chromosome 1, but only recessive alleles on his paternal copy of chromosome 1. Each sperm was isolated individually and PCR amplified in the BDW region.

The amplified products were spotted on a nitrocellulose membrane and radioactive allele specific probes were hybridized with the samples. The resulting autoradiograph is shown below where a dark spot indicates successful hybridization of the probe with the membrane.



What is the recombination frequency between B and W?

- A. 1:2
- B. 1:3
- C. 1:4
- D. 5:6
- E. 1:1

**Answer: B**

10. You order a degenerate probe designed from the following hemoglobin protein sequence:

Trp –	Gly –	Lys –	Val –	Asn
TGG	GGC	AAA	GTC	AAT
	T	G	T	C
	A		A	
	G		G	

How many different probe sequences would be returned to you? How many would be specific to your gene of interest?

- A. 25 total, 1 specific to gene
- B. 25 total, 5 specific to gene
- C. 32 total, 1 specific to gene
- D. 64 total, 1 specific to gene
- E. 64 total, 5 specific to gene

**Answer: D**

11. A yeast extract contains all the enzymes required for alcohol production. The extract is incubated under anaerobic conditions in 1 liter of media containing: 200 mM glucose, 20 mM ADP, 40 mM ATP, 2 mM NADH, 2 mM NAD<sup>+</sup> and 20 mM Pi (inorganic phosphates). What is the maximum amount of ethanol that can be produced in these conditions?

- A: 2 mM
- B. 20 mM
- C. 40 mM
- D. 200 mM
- E. 400 mM

**Answer: B**

12. The concentration of ions inside an amoeba is expressed below as ion-units per milliliter. The composition of the extra-cellular environment (ECE) is given for comparison. Assume the amoeba has been in the environment for some time.

	Na <sup>+</sup>	K <sup>+</sup>	Cl <sup>-</sup>	HCO <sub>3</sub> <sup>-</sup>
Amoeba	1	42	3	119
ECE	21	16	41	119

Simple diffusion alone could account for which ionic concentration inside the amoeba: [Assume the membrane is permeable in some degree to all of the above ions.]

- A. Na<sup>+</sup>
- B. HCO<sub>3</sub><sup>-</sup>
- C. Na<sup>+</sup>, K<sup>+</sup>, Cl<sup>-</sup> and HCO<sub>3</sub><sup>-</sup>
- D. Na<sup>+</sup>, Cl<sup>-</sup> and HCO<sub>3</sub><sup>-</sup>
- E. K<sup>+</sup>

**Answer B**

## PLANT ANATOMY AND PHYSIOLOGY

13. You find a plant that appears to have parallel veined leaves. Examination of its root indicates a single layered pericycle, primary xylem in the center of the root, and an active vascular cambium. The plant most likely belongs to which of the following groups?

- A. Conifer
- B. Dicot
- C. Fern
- D. Gnetum
- E. Monocot

**Answer: B**

14. “Year after year, men cruising timber or hunting deer in the Blue Mountains of eastern Oregon had come back with the same story. Near the little hamlet of Kamela, they had heard a faraway tinkling, a ghostly bell ringing. No one was able to track down the strange sound. It would fade away in the sighs of the wind through the big pines. Skeptics accused the men of hearing things. Last week, while slashing a right-of-way for a power line from *Bonneville* Dam, lumberjacks brought down a ponderosa pine. Tied by a shriveled leather thong, high in the treetop, was the answer to the mystery of Kamela; a bronze cattle bell inscribed with the date 1878. The people of Kamela guessed that a pioneer had tied it to a sapling that had grown to a towering pine.” (*Time Magazine*, 1937) Which of the following is the best appraisal of the concluding sentence of the above report?

- A. Logical because this tree could have attained great height since 1878.
- B. Logical because a tree trunk elongates from the base up.
- C. Illogical because no one knows with certainty when the bell was tied to the sapling.
- D. Illogical because elongation of a tree trunk occurs from the apical meristem up.
- E. There is no basis for appraising the concluding sentence of the report.

**Answer: D**

15. Arrange the following five events in an order that explains the bulk flow of substances in the phloem.

1. Sugar moves down the stem
2. Leaf cells produce sugar by photosynthesis
3. Sugar is transported from cell to cell via the apoplast and/or symplast
4. Solutes are actively transported into sieve elements
5. Water diffuses into the sieve tube elements

- A. 2,1,4,3,4
- B. 1,2,3,4,5
- C. 2,4,3,1,5
- D. 4,2,1,3,5
- E. 2,4,1,3,5

**Answer: C**

16. A field of a common grain crop, *Zea mays* (corn, maize), was being cultivated for genetic plant-studies. Over the years it was noted that rabbits were eating the fallen kernels (corn seed) that were left in the field. The botanists were quick to notice that the rabbits did not eat the most starchy portion of the seed (taking mostly the protein) when environmental conditions were good. As conditions became more stressful, the rabbits came back to eat the most starchy portions of the seeds remaining. These behaviors lead the botanists to an interesting collaborative study with a team of zoologists and nutritionists.

**What part of the corn seed was eaten last by the rabbits under more stressful conditions?**

- A. Cotyledon
- B. Hypocotyl
- C. Scutellum
- D. Endosperm
- E. Coleoptile

**Answer: D**

**17. Which of the following statement(s) about the regulation of the stomatal opening is true?**

- A. The concentration of abscisic acid in the guard cells increases
- B. Higher  $K^+$  concentrations decrease guard cell's more negative water potential
- C. The Level of carbon dioxide in the spaces inside the leaf increases
- D. Lower  $K^+$  concentrations give guard cells a more negative water potential
- E. Potassium ions diffuse passively out of the guard cells

**Answer: B**

**18. When an oak seedling is one year old, a small marker is inserted into its primary phloem tissue. Two years later, where would you expect to find this marker?**

- A. External to the cork cambium
- B. Between the secondary phloem and the cork cambium
- C. Between the vascular cambium and the secondary phloem
- D. Between the vascular cambium and the primary xylem
- E. Internal to the primary xylem

**Answer: B**

**19. Plant hormones react on target tissues to activate a receptor. Thus, for a response to occur the following five events must take place:**

1. the binding of the hormone/receptor should initiate a change in the receptor (amplification). Calcium is often involved and its interaction is mediated by the protein calmodulin
2. the target tissue recognizes the hormone (i.e., there must be a receptor to which the hormone can bind)
3. the target tissue must be sensitive (sensitized) to the hormone
4. the hormone must be present in an appropriate quantity
5. the activated receptor initiates a physiological response

**What is the appropriate order of these events?**

- A. 1, 2, 3, 4, 5
- B. 2, 4, 3, 1, 5
- C. 4, 3, 2, 1, 5

- D. 3, 4, 2,1,5  
E. 4, 3,1, 2, 5

**Answer: C**

**20. Which of the following combinations have only primary walls in a mature plant?**

A	Collenchyma cells	Fibers	Sieve tube member
B	Meristematic cells	Tracheary elements	Collenchyma cells
C	Sclereids	Collenchyma cells	Sieve cells
D	Sieve elements	Meristematic cells	Collenchyma cells
E	Vessels members	Meristematic cells	Parenchyma cells

**Answer: D**

**21. Blue light plays a variety of roles in guard cell action. Which of the following is NOT a role of blue light in guard cell action?**

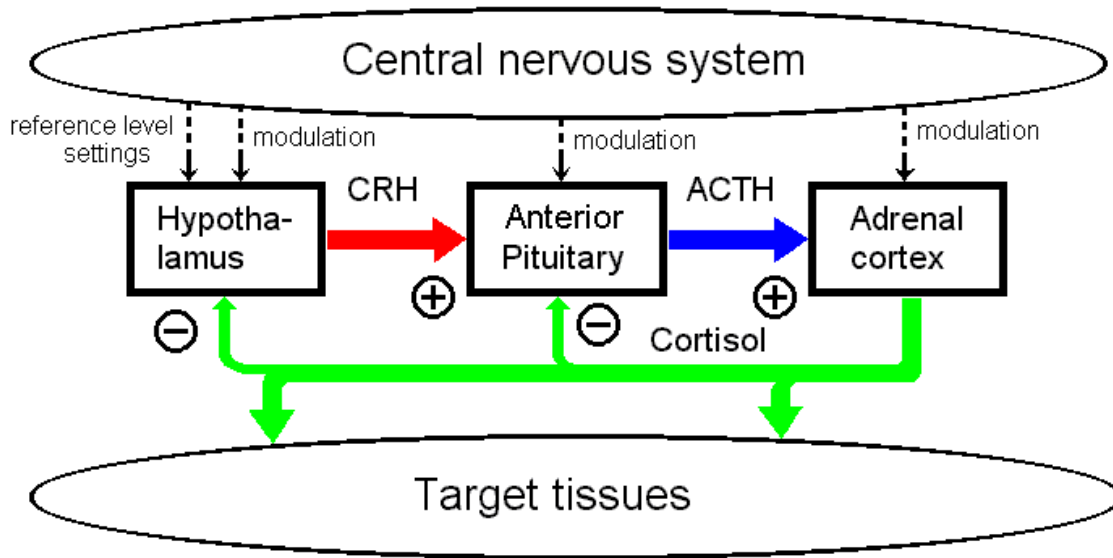
- A. Activates a calcium transporter
- B. Activates a membrane bound proton ATPase
- C. Stimulates potassium uptake
- D. Stimulates malate synthesis
- E. Stimulates starch hydrolysis

**Answer: E**

## **ANIMAL ANATOMY AND PHYSIOLOGY**

Questions 22 and 23 refer to the diagram shown below. The diagram illustrates feedback loops. Increased or decreased stimulation is indicated by + or —.





**Fig 1. Structure diagram of the HPA axis**

22. Which of the following would lead to a **DECREASE** in activity of the anterior pituitary gland?

- A. A lack of receptors for cortisol on the hypothalamus
- B. A lack of receptors for cortisol on the anterior pituitary
- C. An intravenous injection of a large amount of ACTH
- D. A tumor in the hypothalamus causing it to secrete excess corticotropin- releasing hormone
- E. An increased sensitivity of the anterior pituitary to corticotropin-releasing hormone

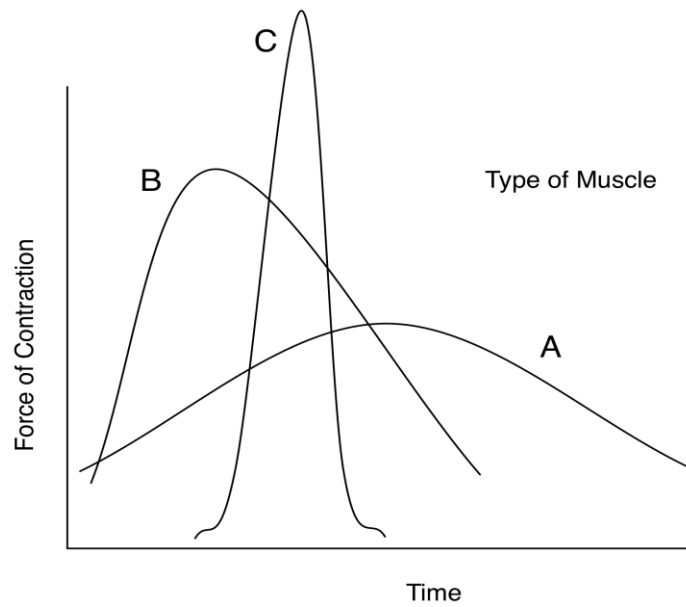
**Answer: C**

23. What would happen if the adrenal cortex was artificially stimulated to produce large amounts of cortisol?

- A. Less corticotropin-releasing hormone would be released
- B. More ACTH would be released
- C. The activity of the hypothalamus would increase
- D. The activity of the anterior pituitary would increase
- E. The hypothalamus would become insensitive to cortisol

**Answer: A**

24. The graph below represents the contraction patterns for three different kinds of muscles. Find the correct sequence of patterns for smooth muscle, skeletal muscle and cardiac muscle.



- A. ABC
- B. ACB
- C. BAC
- D. BCA
- E. CBA

**Answer B**

25. The numbers in the first column correspond to human, elephant, bat, mouse, and carp. Which number below indicates each organism?

Number	Body Temp (°C)	Heart Rate (beats/min)	Maximal speed of locomotion (m/s)
1	1-30	30-40	1.5
2	38	450-550	3.5
3	31	500-660	14
4	36.2	22-28	11
5	36.6	60-90	10

	1	2	3	4	5
A.	Human	Elephant	Bat	Mouse	Carp
B.	Mouse	Bat	Elephant	Human	Carp
C.	Carp	Mouse	Bat	Elephant	Human
D.	Carp	Mouse	Elephant	Bat	Human
E.	Bat	Mouse	Carp	Human	Elephant

**Answer C**

26. Why does the stomach use both pepsin and HCl to break down proteins in food?

- A. HCl denatures the tertiary and quaternary structure of proteins, while pepsin breaks the primary structure
- B. HCl removes the tertiary structure of proteins, while pepsin breaks the primary and quaternary structure
- C. HCl removes the quaternary structure of proteins, while pepsin breaks the primary and tertiary structure
- D. pepsin removes the tertiary and quaternary structure of proteins, while HCl breaks the primary structure
- E. pepsin removes the tertiary structure of proteins, while HCl breaks the primary and quaternary structure

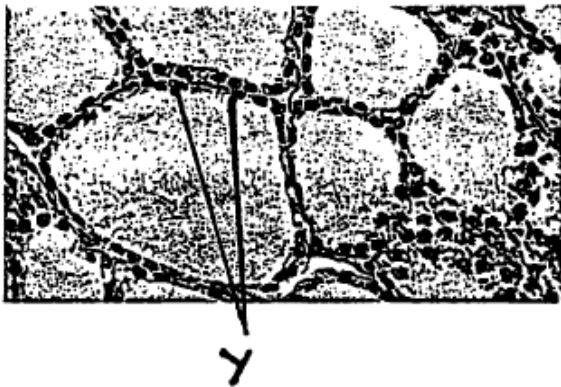
**Answer: A**

**27. A patient is diagnosed with a disorder in which the pituitary gland overproduces anti-diuretic hormone (ADH). Which of the following combinations of symptoms would you expect to be associated with this disorder?**

- A. Reduced urine volume and low blood osmolarity
- B. Reduced urine volume and high blood osmolarity
- C. Increased urine volume and low blood osmolarity
- D. Increased urine volume and high blood osmolarity
- E. Increased urine volume with no change in blood osmolarity

**Answer: A**

**28. In the diagram below, the cells indicated by “y” are most likely responsible for which of the followingss?**



- A. Estrous cycle
- B. Growth
- C. Glucose metabolism
- D. Increasing blood calcium concentration
- E. Regulating the rate of oxygen use by cells

**Answer: E**

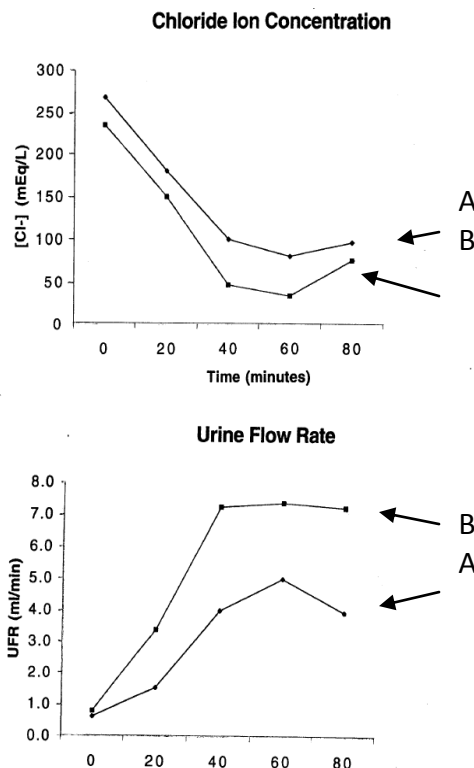
**29. The pathology associated with *Vibrio cholerae* is due to cholera toxin (CT) leads to which of the following?**

1. Active pumping of  $\text{Ca}^{2+}$  out of the cell
2. Increased concentration of intracellular cAMP
3. Increased osmolarity of the intestine and diarrhea
4. Ribosylation and activation of Gi protein
5. Ribosylation and activation of Gs protein

- A. 1, 2, 4
- B. 1, 3, 5
- C. 2, 3, 4
- D. 2, 3, 5
- E. 3, 4, 5

**Answer: D**

30. Students conducted a renal function experiment. Before the experiment began, students in one group consumed their usual volume of fluids, while students in the other group limited their fluid intake. At time  $t = 0$ , both groups drank 750 mL of water.



According to the data in the figures to the left, which of the following statements is **TRUE**?

- A. Group A students' blood level of aldosterone was probably highest at  $t = 60$  minutes
- B. Group B excreted approximately 140 mL of urine from  $t = 20$  to 40 minutes
- C. Group B probably represents the fluid-deprived groups
- D. Group B students' collecting ducts were less permeable to water than those of Group A students at  $t = 60$  minutes
- E. None are correct

**Answer: D**

31. What observations would you **NOT** make when the body responds to a rapid increase of organic acids?

- A. Decreased blood pH

- B. Decreased respiration rate
- C. Increased alveolar ventilation
- D. Increased blood pressure
- E. Increased heart rate

**Answer: B**

**32. A preadolescent boy suffers an injury to the anterior pituitary. Although FSH is no longer produced, ICSH (LH) levels are normal. At 25 years of age, one would expect that he would**

- A. Be impotent
- B. Be sterile
- C. Have impaired interstitial cell function
- D. Not develop secondary sex characteristics
- E. Produce large amounts of inhibin

**Answer B**

**33. If adenyl cyclase, the enzyme that converts ATP to cAMP is blocked, the:**

- A. Activity of progesterone at the endometrium would increase
- B. Endometrial cells would not respond to estradiol
- C. Corpus luteum would not respond to HCG
- D. Level of progesterone produced by the ovary during the luteal phase would increase
- E. Mammary glands would not respond to progesterone

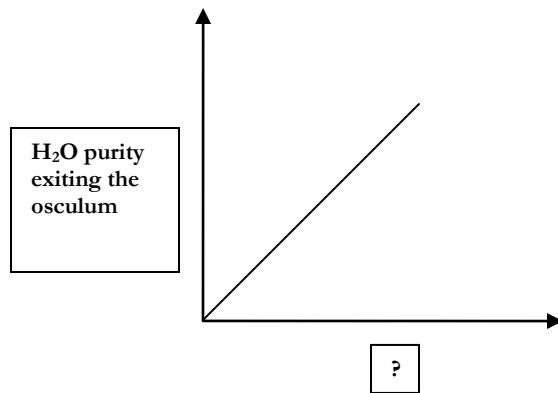
**Answer: C**

**34. All of the following would result from severing the sensory fibers of the vagus nerve from the lung, EXCEPT**

- A. Atelectasis
- B. Disappearance of the Hering-Breuer reflexes
- C. Less inhibition of the inspiratory center during forced breathing
- D. Less stimulation of the expiratory center during forced breathing
- E. Potential damage o the lungs due to overinflation

**Answer: A**

**35. In the graph below, what factors would account most directly for the shape of the plot?**



- A. Number of amoebocytes per sponge
- B. Number of choanocytes per sponge
- C. Number of spicules per sponge
- D. Rate of cribrostatin synthesis (molecules/time unit)
- E. Spongin concentration (g/volume unit)

**Answer: B**

36. \_\_\_\_\_ are to termites as \_\_\_\_\_ are to plants.

- A. Cellulose molecules, water molecules
- B. Gut microbes, mycorrhizal fungi
- C. Gut microbes, water molecules
- D. Hours of darkness, hours of light
- E. Predators, prey

**Answer: B**

### Ethology

37. Which one of the following statements is **NOT** a general precondition necessary for the evolution of reciprocal altruism?

- A. Benefits of receiving aid must exceed the cost of donating
- B. Donors must be able to recognize partners, remember their previous actions and refuse to cooperate with individuals that did not reciprocate
- C. Interacting organisms must have a high coefficient of relatedness
- D. Repeated pair-wise interactions are needed to permit role exchanges between donor and beneficiary
- E. All of the above are necessary pre-conditions

**Answer C**

38. What is the proximate cause of the cuteness response?

- A. Individuals who didn't find babies cute were more likely to destroy their own genes
- B. Infants who did not look cute were more likely to be killed
- C. Infants have relatively large eyes located in the middle of the face

- D. A and B are both proximate causes
- E. B and C are both proximate causes

**Answer: C**

**39. Which of the following is a model of parental care paired with its correct description?**

- A. Association model – strength of the pair-bond between parents is directly associated with the amount of parental care
- B. Conflict model – females who compete against other females for resources provide less care
- C. Parental provision model – males are most likely to provide for offspring in species with internal fertilization
- D. Symbiosis model – Bidirectional exchange of resources between parent(s) and offspring
- E. Parental provision model – biological parents recruit alloparents to care for offspring

**Answer: D**

## Genetics and Evolution

**40. Genes A and B are linked 12 map units apart. A heterozygous individual whose parents were Aabb and aaBB would be expected to produce gametes in the following frequencies:**

- |    |        |        |        |        |
|----|--------|--------|--------|--------|
| A. | 44% AB | 6% Ab  | 6% aB  | 44% ab |
| B. | 6% AB  | 44% Ab | 44% aB | 6% ab  |
| C. | 12% AB | 38% Ab | 38% aB | 12% ab |
| D. | 6% AB  | 6% Ab  | 44% aB | 44% ab |
| E. | 38% AB | 12% Ab | 12% aB | 38% ab |

**Answer: B**

**41. A particular plant is variegated, that is all parts of some branches are green and other branches are white. An investigator wishes to find how this character is inherited. She removes mature anthers from a white flower and pollinates a pigmented flower. All the offspring produce pigmented flowers. However, before jumping to conclusions about the pattern of inheritance she decides she needs to make a reciprocal cross. Therefore she removes mature anthers from a pigmented flower and pollinates a white flower. All the offspring produce white flowers. What was her conclusion about the pattern of inheritance?**

- A. a Mendelian trait with white being recessive to colored.
- B. a Mendelian trait with colored being recessive to white
- C. a sex-linked (X-linked) recessive gene was involved
- D. cytoplasmic inheritance was involved
- E. incomplete dominance was involved

**Answer: D**

42. For a dominant trait that is **FAVORED** by natural selection, the frequency of the relevant allele in a population will change fastest when the allele

- A. Frequency is initially low
- B. Frequency is initially intermediate
- C. Frequency is initially high
- D. Frequency is fixed at zero or one
- E. Frequency will not change; it will remain constant

**Answer: A**

43. Which of the following is true?

- A. Gametes have a homologous pair of each chromosome
- B. Gametes have two copies of each autosome
- C. After anaphase II of meiosis each chromosome consists of two sister chromatids
- D. After anaphase I of meiosis a chromosome consists of one sister chromatid
- E. Immediately after S phase a chromosome consists of two sister chromatids

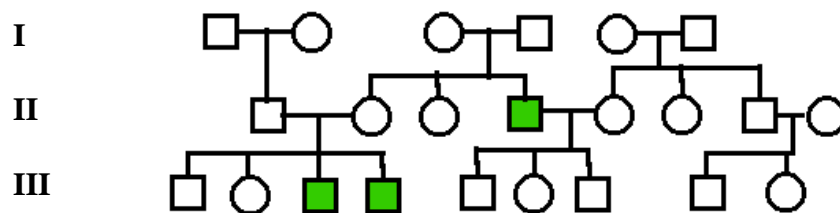
**Answer: E**

44. An individual has the following genotype 49XXXXY. Which description below best describes this individual?

- A. Genetic female with two Barr bodies
- B. Genetic male with two Barr bodies
- C. Genetic female with three Barr bodies
- D. Genetic male with three Barr bodies
- E. More than one answer above is possible description of this individual

**Answer: D**

For Questions 45 and 46, use the pedigree below that illustrates a relatively rare trait that is non-lethal.



45. Which of the following best describes the inheritance pattern?

- A. Autosomal dominant
- B. Autosomal recessive
- C. X-linked, dominant
- D. X-linked, recessive
- E. Mitochondrial



**Answer: D**

46. Using the sequence of I-4, II-2, II-4, and III-6 for the individuals in the diagram above, which of the following best describes their genotypes?

- A.  $XX^a$ ,  $X^aY$ ,  $XX^a$ ,  $XY$
- B.  $XX^a$ ,  $XY$ ,  $XX^a$ ,  $X^aY$
- C.  $XY$ ,  $XX^a$ ,  $X^aY$ ,  $XX^a$
- D.  $X^aY$ ,  $XX^a$ ,  $XY$ ,  $XX^a$

**Answer: C**

47. Which of the following statements is FALSE concerning Fox's proteinoid microspheres?

- A. Movement within the microspheres resembles cytoplasmic streaming
- B. They swell in hypertonic medium and shrink in hypotonic medium
- C. Chemical reactions can occur within the microspheres
- D. They possess a defined internal structure
- E. They incorporate and adsorb various materials from the medium

**Answer: B**

48. Suppose that the traits below occurred just once in evolution. What traits were most likely possessed by the most recent ancestor of Deuterostomia, Ecdysozoa, and Lophotrochozoa?

- 1. Cephalization
  - 2. Exoskeleton
  - 3. Indeterminate development
  - 4. Segmentation
  - 5. Triploblastic
- A. 1, 2, 5
  - B. 1, 4, 5
  - C. 2, 3
  - D. 2, 3, 4
  - E. 3, 4

**Answer: B**

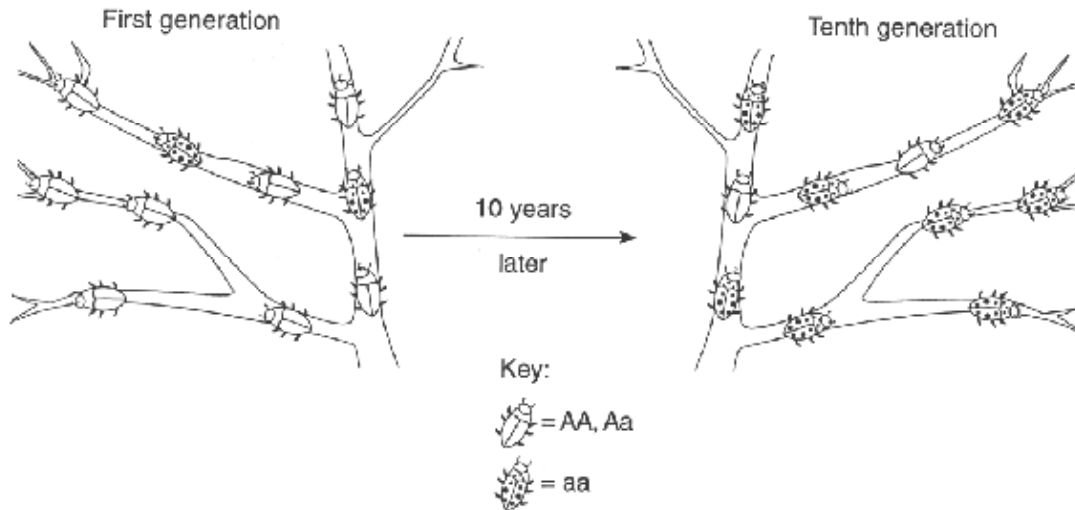
49. The presence of a vertebral column is with respect to all vertebrates [first term], but with respect to all chordates [second term].

- A. homologous; analogous

- B. primitive; derived
- C. adaptive; maladaptive
- D. analogous; homologous
- E. analogous; derived

**Answer: B**

50. Population genetics shows us that certain traits of a species will become more abundant if they benefit the species. The diagram below illustrates the change that occurred in the frequency of phenotypes in an insect population over 10 generations. A probable explanation for this change would be that over time there was:



- A. A decrease in the population of this insect
- B. An increase in the population of this insect
- C. A decrease in the adaptive value of gene *a*
- D. An increase in the adaptive value of gene *a*
- E. A decrease in the mutation rate of gene *A*

**Answer: D**

51. In foxes, there are 9 coat colors: red, standard silver, Alaskan silver, double-black, smoky red, cross-red, blended-cross, substandard silver, and sub-Alaskan silver. A red fox was crossed with a double-black fox and their offspring were then crossed with each other. The  $F_2$  phenotypes were; 10 red : 18 smoky red : 20 cross-red : 39 blended-cross : 9 standard silver : 19 substandard silver : 12 Alaskan silver : 22 sub-Alaskan silver : 8 double-black. How many genes are involved in this cross?

- A. 18 genes
- B. 4 pairs of genes

- C. 9 genes
- D. 9 pairs of genes
- E. 4 genes

**Answer: B**

## Ecology Questions 52 to 57

**52. For populations that exhibit \_\_\_\_\_ population growth, maximum harvesting yield is achieved when \_\_\_\_\_.**

- A. exponential, population growth rate is highest
- B. logistic, the population reaches its carrying capacity
- C. logistic, population growth rate is highest
- D. logistic, population growth rate is not changing with population size
- E. exponential, the population reaches its carrying capacity

**Answer: C**

**53. The best description of the relationships between fundamental niches (FN) and realized niches (RN) of two competing species that coexist is:**

- A.  $FN_A = RN_A$ ;  $FN_B = RN_B$
- B.  $FN_A > RN_A$ ;  $FN_B = RN_B$
- C.  $FN_A < RN_A$ ;  $FN_B < RN_B$
- D.  $FN_A > RN_A$ ;  $FN_B > RN_B$
- E.  $FN_A = RN_A$ ;  $FN_S > RN_S$

**Answer: D**

**54. Which of the following is a description of protostomes?**

- A. Radial and determinate cleavage, blastopore becomes mouth, schizocoelous development
- B. Radial and determinate cleavage, enterocoelous development, blastopore becomes anus
- C. Spiral and determinate cleavage, blastopore becomes mouth, schizocoelous development
- D. Spiral and determinate cleavage, enterocoelous development
- E. Spiral and indeterminate cleavage, coelom forms as split in solid mass of mesoderm

**Answer: C**

**55. All of the major body plans seen today appeared in the fossil record over 500 million years ago at the beginning of the:**

- A. Burgess period
- B. Cambrian period
- C. Carboniferous period
- D. Cretaceous period

E. Ediacaran period

**Answer: B**

56. You have been asked to begin to develop some genetic testing molecular markers to determine diversity of two equally sized groups of humans. Group A lives in remote regions of Borneo without outside contact and is highly inbred, while group B lives in New York with wide genetic origins and divergent populations that freely interbreed with others. What is the most accurate statement concerning a strategy for developing DNA markers for these species:

- A. Each group will require a balance between conserved and polymorphic DNA markers
- B. Group B will require greater numbers of conserved DNA markers than group A
- C. Group B will have greater numbers of polymorphic DNA markers than group A
- D. Group B will have fewer numbers of polymorphic DNA markers than group A
- E. The same DNA markers for each group regardless of their polymorphic nature

**Answer: C**

57. A man with the blood type A and Rh<sup>+</sup> marries a woman with A and Rh<sup>-</sup> blood-type. They have two boys who both have O<sup>-</sup> blood. Assuming simple Mendelian inheritance of blood type and Rh, what is the probability that their next two children will be male and will have O<sup>-</sup> blood, too?

- A. 1/8
- B. 1/16
- C. 1/32
- D. 1/64
- E. 1/256

**Answer: C**

## Biosystematics Questions 58 to 60

58. For which of the following fungi does one mitotic division follow the meiotic division that occurs after karyogamy?

- I. Ascomycota
- II. Basidiomycota
- III. Zygomycota

- A. I only
- B. II only
- C. III only
- D. I and II
- E. I, II, and III

**Answer: B**

59. Which of the following characteristics is unique to the protist phylum Ciliophora?

- A. Autotrophic nutrition
- B. Concentration of organelles at one end of the cell
- C. Differentiation of macro- and micronuclei
- D. Paramylon storage molecule
- E. Use of rhizopoda for movement

**Answer: C**

**60. Heterospory first arose in the:**

- A. Bryophytes
- B. Ferns
- C. Lycophytes
- D. Psilophytes
- E. Sphenophytes

**Answer: C**

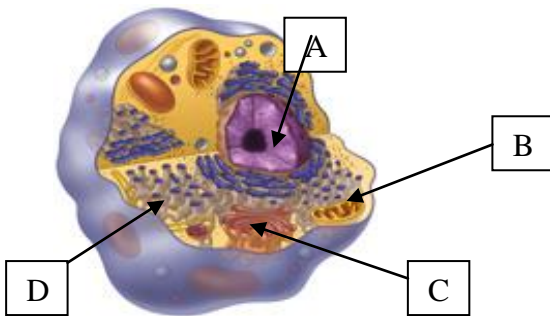
## **PART B**

Cell and Molecular Biology (20%)	12 questions 61-73
Plant Anatomy and Physiology (15%)	9 questions 74-82
Animal Anatomy and Physiology (25%)	15 questions 83-97
Ethology (5%)	3 questions 98-100
Genetics and Evolution (20%)	12 questions 101-112
Ecology (10%)	6 questions 113-118
Biosystematics (5%)	3 questions 119-120

### **Cell and Molecular Questions 61 to 73**

Use the labels in the diagram below to answer the questions 61 to 65. (8 points)

Using the labels of the picture to answer the questions below:



You are a scientist hunting for enzymes involved in various aspects of cellular metabolisms. Which organelle would you want to isolate and analyze if you are looking for (fill in the relevant organelle label in the sentences below):

- 61. Enzyme that is involved in DNA replication \_\_\_\_\_
- 62. Enzyme involved in producing large amounts of ATP \_\_\_\_\_
- 63. Enzyme attaching sugar molecules to proteins \_\_\_\_\_
- 64. Enzyme involved in protein synthesis \_\_\_\_\_
- 65. DNA \_\_\_\_\_

**Answer: 61, A & B, 62, b, 63, C, 64, blank, 65 A& B**

66. How do polypeptides find their way from the site of synthesis on the cytoplasmic ribosome to the place of their destination in the peroxisome?

- A. Without signals
- B. By specific transport along the cytoskeleton
- C. By specific carboxy-terminal targeting signals
- D. By specific vesicular transport
- E. By transport within the ER

**Answer C**

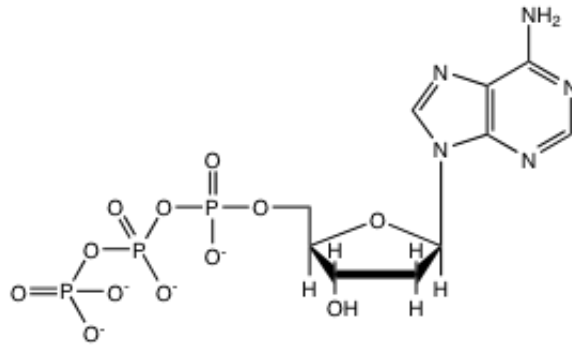
67. In the lab, you are running an SDS-PAGE, but you realize that you forgot to add DTT, a reducing agent, when you were loading the gel. Which amino acid residue will this affect?

- A. Cysteine
- B. Serine
- C. Glutamate
- D. Lysine
- E. Methionine

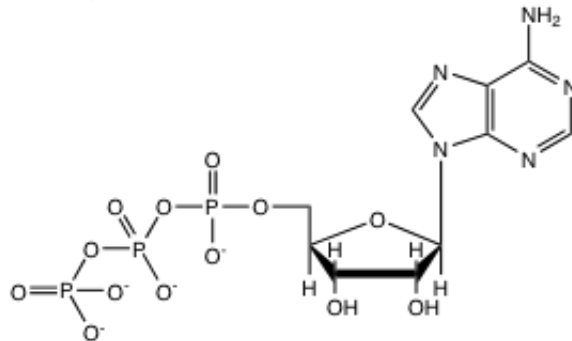
**Answer: A**

68. Sequencing reactions involve many of the same reagents as PCR, with one major exception: a modified version of dNTPs is used. Which of the following should be included in a sequencing reaction but not a PCR?

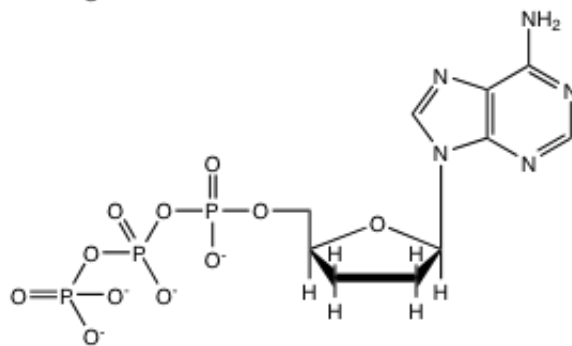
A.



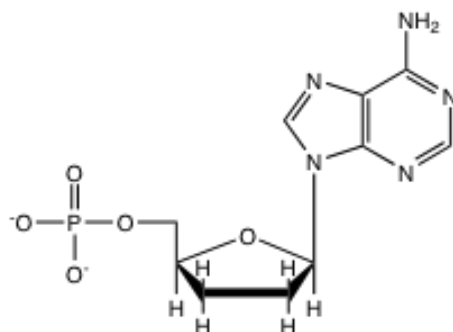
B.



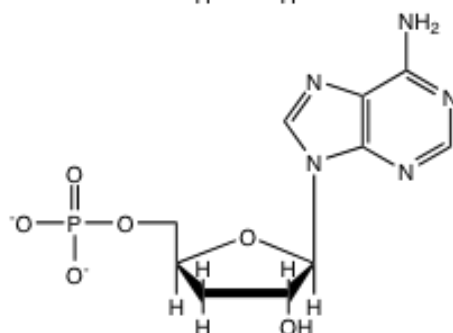
C.



D.



E.



**Answer: C**

69. A human liver cell and a plant cell from the cortex of a root are placed in a beaker of distilled water. What will most likely occur?

- A. Both cells will be in osmotic balance with the water and neither will swell or shrink
- B. The liver cell will shrivel, while the plant cell will become flaccid and the plasma membrane will pull away from the cell wall
- C. The liver cell will shrivel, while the plant cell will become very turgid
- D. The plant cell will become flaccid and the plasma membrane will pull away from the cell wall, while the liver cell will swell and may even burst
- E. The plant cell will become very turgid, while the liver cell will swell and may even burst

**Answer: E**

70. You are given an unknown organism to study. Upon examination, you find that it does not have a nuclear membrane or mitochondria, which structure(s) below would it possess?

- A. Chloroplast
- B. Endoplasmic reticulum
- C. Ribosomes
- D. Lysosome
- E. 9+2 Cilia

**Answer: C**

71. The velocity of carrier-mediated diffusion across cellular membranes:



- A. Can increase up to a maximum value
- B. Does not depend on saturation of the carrier
- C. Is always proportional to substrate concentration
- D. Is greater in uniporters than symporters
- E. Varies with substrate concentration in the same way as that observed for simple diffusion

**Answer: A**

**72. Why can glycolysis proceed under anaerobic or aerobic conditions while the citric acid cycle is strictly aerobic?**

- A. Enzyme catalysis during the citric acid cycle is regulated by allosteric effectors which include oxygen
- B. Enzymes of glycolysis do not use oxygen as cofactors, while enzymes of the citric acid cycle require oxygen for proper folding
- C. NAD<sup>+</sup> for glycolysis can be regenerated through the conversion of pyruvate into lactate under anaerobic conditions
- D. NAD<sup>+</sup> is produced during three steps of glycolysis and only one step of the citric acid cycle
- E. Oxygen is a byproduct of the conversion of the glycolytic intermediate glucose-6-phosphate to fructose-6-phosphate

**Answer: C**

**73. Which of the following are likely to cause cellular changes when injected directly into the appropriate cells cytoplasm?**

- I. Triiodothyronine (T<sub>3</sub>)
- II. Cortisol
- III. Insulin
- IV. Epidermal growth factor

- A. I, II
- B. I, IV
- C. II, III
- D. II, IV
- E. III, IV

**Answer: A**

## **Plant and Anatomy Questions 74 to 82**

**74. The tissues in bryophytes which are analogous to the xylem and phloem, respectively, are made of:**

- A. Tracheids, leptoids

- B. Hydroids, leptoids
- C. Tracheids, albuminous cells
- D. Sieve cells
- E. None of the above

**Answer: A & B**

**75. The water potential ( $\Psi$ ) of cells in a plant's root are typically around -0.2 MPa. If a plant is placed in solution with a water potential ( $\Psi$ ) of -0.05 MPa, the plant roots will**

- A. Become turgid from water moving into the roots
- B. Become flaccid from water moving out of the roots into the water
- C. Be largely unaffected due to the minor difference in water potential
- D. Be unaffected as water potential has nothing to do with water flow

**Answer: A**

**76. The table below shows data from an experiment with two groups of plants. For two weeks, Group I was not fertilized and Groups II was fertilized. The growth in millimeters of each plant was measured for the each group. Based on the results in the chart below, which statement is true?**

**Growth (mm)**

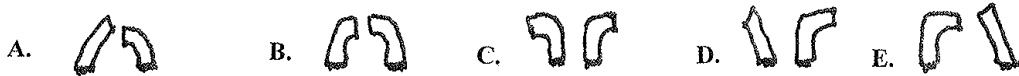
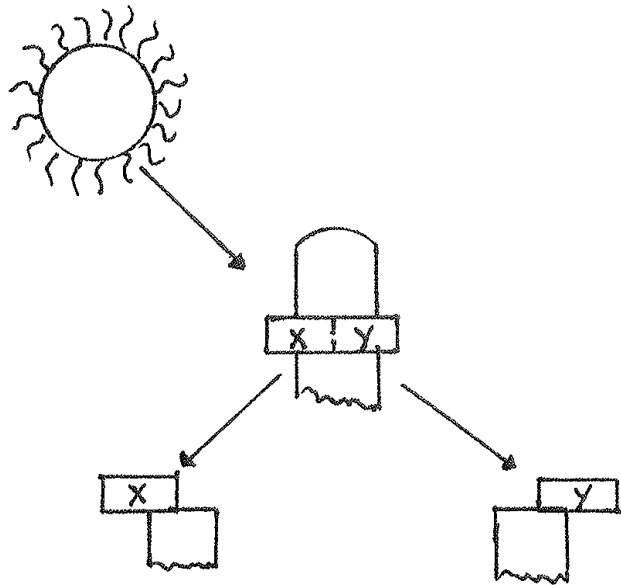
Group I	Group II
3.2	6.7
3.5	10.4
4.0	8.7
2.9	9.8
4.1	11.5

- A. Experimental populations contained different sample sizes
- B. After two weeks the mean size of fertilized and unfertilized plants was similar
- C. The unfertilized group has a larger standard deviation than the fertilized
- D. In order to observe any differences the experiment should have been run for longer than two weeks
- E. The fertilized group has a larger standard error than the unfertilized

**Answer: E**

**77. The diagram below shows an agar block inserted beneath the tip of a growing grass seedling that is exposed to light from the left. After exposure to light, the block is removed and cut into two halves as shown by the dotted line. These halves are then placed onto a pair of new, straight grass seedlings whose tips have been removed. These seedlings are then grown in the dark. If**

the agar blocks are placed on these two plants as indicated, which of the diagrams below shows the expected result?



**Answer: A**

78. All but which of the following statements are true about photosynthesis except:

- A. A plant that could carry out cyclic photophosphorylation but could not perform any other aspects of photosynthesis would release  $O_2$  as a by-product of its metabolism
- B. ATP is synthesized as high energy electrons that are passed along a chain of electron acceptor molecules
- C. Light energy to drive photophosphorylation may first be trapped by the chlorophyll pigments in Photosystem I and then passed to a molecule of P700, which traps it
- D. There are two light events in noncyclic photophosphorylation

**Answer: A**

79. There is a large difference in pH across the thylakoid membrane between the thylakoid compartment and the stroma. From the list given below, choose those that are appropriate in explaining the difference. (Choose A, B, C, or D)

- i. The transport of protons into the thylakoid compartment by the electron transfer system
- ii. The transport of protons out of the thylakoid compartment into the stroma by the electron transfer system
- iii. Protons splitting from water remaining in the thylakoid compartment

- iv. Protons splitting from water exiting the thylakoid compartment
- v. The removal of hydrogen from the stroma during the reduction of NADP to NADPH
- vi. The retention of hydrogen in the stroma during the reduction of NADP to NADPH

- A. i, iv, and vi only
- B. ii, iv and vi only
- C. I, ii, iii only
- D. i, iv and v only
- E. i, iii and v only

**Answer: E**

**80. Chloroplasts and mitochondria share similarities. From the following characteristics, use A, B, C, D, or E to select those to both chloroplasts and mitochondria.**

- i. both contain ribosomes
- ii. both are single-membrane bounded structures
- iii. both are double-membrane bounded structures
- iv. both undergo reactions that are primarily oxidative in nature
- v. both undergo chemiosmosis
- vi. both have similar, although not identical, electron transfer systems
- vii. both undergo reactions that are primarily reductive in nature
- viii. both contain DNA and RNA

- A. i, iii, vi, vii, and viii only
- B. i iv, vi, vii and viii only
- C. ii iv, v, vii and viii only
- D. ii, iii, vi , vii, and viii only
- E. ii, iv, vi, vi, and viii only

**Answer: A**

**81. Plant cells have large vacuoles that comprise as much as 90% of mature cell volume, in contrast to animal cells that typically have vesicles comprising less than 10% cell volume. Which of the following explains this characteristic difference in plant vs animal cells?**

- A. Most plants do not have well-developed excretory systems and use vacuoles as waste dumps
- B. Vacuoles are an energetically inexpensive way to increase cell size and therefore surface area to intercept light for photosynthesis
- C. Vacuoles accumulate ions and water, contributing to turgor pressure which keeps the plants rigid, despite their lack of skeletons
- D. All of the above
- E. None of the above

**Answer: D**

82. The group of plants that is sister to the euphyllophytes is

- A. Bryophytes
- B. Lycophytes
- C. Ferns
- D. Charales
- E. Green algae

**Answer: B**

**Animal Anatomy and Physiology 83-97**

83. A patient previously diagnosed with Graves disease (an antibody-mediated autoimmune disorder) comes to your clinic for a routine follow-up exam. Your patient complains of nervousness, fatigue, and diarrhea all of which are worse when they forget to take their medications for Graves. Upon finding a goiter of the thyroid gland, you draw a complete blood screen and assay iodine uptake by the thyroid gland. You expect to find the following:

- A. Decreased iodine uptake by the thyroid gland, decreased serum cholesterol
- B. Decreased serum TSH, decreased  $T_3$ , increased  $T_4$
- C. Decreased  $T_3$  and  $T_4$ , increased serum cholesterol
- D. Increased serum TSH, decreased triiodothyronine ( $T_3$ ) and thyroxine ( $T_4$ ) levels, increased iodine uptake by the thyroid gland
- E. Increased calcium, increased serum TSH

**Answer: C**

Questions 84 to 88 are based on a virtual experiment. A confluent layer of macrophage cells are grown in two (2), 25 cm<sup>2</sup> tissue culture flasks with appropriate medium containing 10% plasma serum. For the experiment, all medium is removed from the flask and the cells are washed with appropriate buffers to remove all traces of serum and media. *E. coli* bacteria, suspended in serum free media, are then added or “fed” to the macrophages. The process of *E. coli* death from phagocytosis was then studied.

84. It is necessary in a phagocytosis study to remove the serum because:

- A. The complement proteins would have independently killed the bacteria.
- B. The B cells would have independently killed the bacteria.
- C. The natural killer cells would have independently phagocitized the bacteria.
- D. Serum proteins would have inhibited the membrane attack complex (MAC).
- E. Serum proteins would have inhibited the MHC complex.

**Answer: A**

After 30 minutes the cells in flasks in tissue culture flask one (1) and two (2) are washed with appropriate buffers to remove all *E. coli*. Serum free media is added and the flasks incubated.

85. The macrophage cell notifies other cells of an immunological invader by:

- i. Up-regulating expression of MHC I molecules upon activation.
- ii. Up-regulating expression of MHC II molecules upon activation.
- iii. Interacting with the complement system.
- iv. Acting as an antigen presenting cell.
- v. Inactivating viruses once they enter the macrophage.
- vi. Decreasing enzymatic production
- vii. Increasing enzymatic production

- A. i, iii, iv, vi
- B. iv, v, vii
- C. ii, iii, iv, vii
- D. ii, iii, iv, v
- E. i, ii, iv, vi

**Answer: C**

86. During incubation the macrophage and microbe are at war. Which statement is true.

- A. The macrophage digests the *E. coli* through the oxidative burst.
- B. The *E. coli* protects itself through the oxidative burst.
- C. The oxidative burst is characterized by an increased production of hydrogen peroxide.
- D. A and B
- E. A and C

**Answer E**

The macrophages are then lysed by adding ice cold water. The lysed macrophages and water are then centrifuged and the bacteria isolated from the macrophage debris. The bacteria were suspended, diluted and plated on agar. After 90 minutes, the same procedure was followed for tissue culture Flask 2 and the bacteria were again plated. Bacterial Plates 1 and 2 were incubated for 24 hours.

87. Why were the macrophages lysed with a brief exposure to ice cold water and not the *E. coli*?

- A. Rapid cold-shock results in osmotic lysis.
- B. Gram positive bacteria are impervious to osmotic insult.
- C. The membrane lipid bilayer is impermeable to water.
- D. Lysis occurs only with eukaryotic cells.
- E. Cell walls limit osmotic lysis.

**Answer: E**

88. When you compare bacteria plate 1, (45 minutes) and bacteria plate 2 (90 minutes) you would predict (3 points):

- A. Equal colonies on Plates 1 and 2
- B. No colonies on Plate 1
- C. No colonies on Plate 2
- D. More colonies on Plate 1 than Plate 2
- E. More colonies on Plate 2 than Plate 1

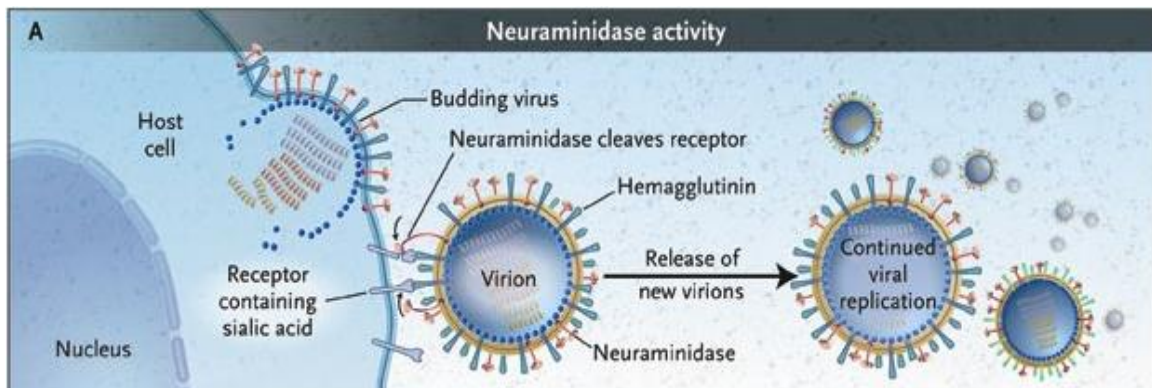
**Answer: D**

89. Why do adults usually die when their body temperature exceeds 105°F, but young children may survive that temperature, at least for a longer period of time?

- A. Children have a larger relative surface area to volume ratio than adults
- B. Children perspire more profusely than adults
- C. At a higher temperature children's hemoglobin carries more oxygen than adult hemoglobin
- D. Children's proteins are denatured at higher temperatures than adults
- E. Adults lose their ability to sense warmth as they age

**Answer: A**

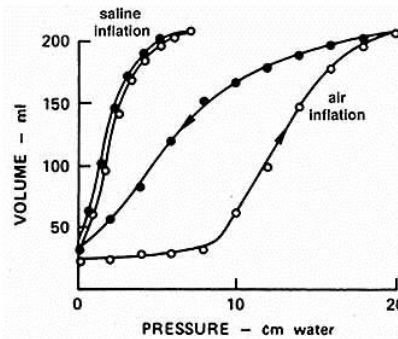
90. When someone already has the flu, they can be given the drug Tamiflu to prevent further spread of the virus. Tamiflu inhibits neuraminidase, an enzyme on the surface of the influenza virus. Below is a diagram of the activity of neuraminidase. How would inhibiting neuraminidase preventing further spreading of influenza?



- A. Influenza particles will no longer be able to attach to host cells
- B. Receptors containing sialic acid will not be cleaved. These receptors are needed to make influenza virulent.
- C. Receptors containing sialic acid will not be cleaved. Thus, new virions will not be released and no new infections can occur.
- D. If neuraminidase is not active, hemagglutinin can not function. This would render the virus non-virulent.

**Answer: C**

91. The following graph shows the pressure-volume curve of a mammalian lung when it is removed from the body and filled under two conditions. One condition is when the lung is inflated with air and the second is when it is inflated with saline solution (the entire lung is filled with saline). In both instances the excised lungs retained the thin film of liquid that lines the respiratory alveoli.



Based on the data presented in the graph, which of the following statements is true?

- A. The lung cannot increase its volume if it is filled with saline instead of air.
- B. Surface tension created by the air-liquid interface on the alveolar surface increases the work needed to inflate the lung.
- C. Resistance to flow of fluids through the respiratory passageways is greater than is the resistance to flow of air, so more work is needed to inflate the lung with saline than with air.
- D. Lung compliance is independent of infusion media.
- E. The work required to inflate the lungs with air at small volumes is less than the work required to inflate the lung at large volumes.

**Answer: B**

92. Polarity in the developing *Drosophila* embryo is determined by a(n):

- A. Expression of the gap protein hunchback throughout the embryo
- B. Protein gradient of the segmentation protein *engrailed*
- C. Protein gradient of the *bicoid* protein expressed from maternal mRNA
- D. Protein gradient of the gap protein *hunchback*
- E. Expression of the segmentation protein *engrailed* throughout the embryo

**Answer: C**

93. An extremely high dose of HMG-CoA reductase inhibitor would severely disrupt which of the following processes?

- I. Synthesis of bile salts
- II. Formation of bilirubin
- III. Production of surfactant
- IV. Aldosterone synthesis
- V. Vitamin D synthesis



- A. I, II, and IV
- B. I, III, and IV
- C. I, IV, and V
- D. II and IV
- E. III, IV, and V

**Answer: C**

**94. A child is born with erythroblastosis fetalis. Which of the following is an acceptable explanation for the observed pathology?**

- A. The child must be the first conceptus of the mother
- B. The mother was treated with the carcinogen *Rhogam* during pregnancy
- C. Anti-D antibodies were generated into the mother by a previous pregnancy
- D. The father must be Rh-negative
- E. Erythroblastosis fetalis leads to decreased red blood cell synthesis

**Answer: C**

**95. Substances that excite  $\beta_2$  adrenergic receptors ( $\beta$ -agonists) are used to treat asthma and COPD (Chronic Obstructive Pulmonary Disease). These drugs can have significant side effects including:**

- A. Decreased sensitivity to inflammation, inhibition of uterine contraction, hypotension
- B. Hypotension, increased blood pressure, decreased plasma potassium
- C. Hypertension, dizziness, vasoconstriction
- D. Bronchial-dilation, increased uterine contraction, increased serum angiotensin
- E. Dizziness, bronchial-constriction, decreased sensitivity to inflammation

**Answer: A**

**96. The 4 layers of the digestive tract from the inside out are:**

- A. Serosa, muscular layer, mucosa, submucosa
- B. Serosa, muscular layer, submucosa, mucosa
- C. Mucosa, submucosa, muscular layer, serosa
- D. Submucosa, mucosa, serosa, muscular layer
- E. Muscular layer, serosa, mucosa, submucosa

**Answer: C**

**97. Trace the flow of filtrate through the nephron as it enters the kidney through the renal artery.**

1. Proximal convoluted tubule
2. Collecting duct
3. Descending limb of loop of Henle
4. Bowman's capsule
5. Distal convoluted tube
6. Ascending limb of loop of Henle

- A. 4,1,3,6,5,2
- B. 4,1,6,3,5

- C. 4,5,6,3,1
- D. 4,5,3,6,1,2
- E. 4,6,3,1,5,2

**Answer: A**

### **Ethology 98-100**

**98. Which of the following may represent advantage(s) of a dominance hierarchy?**

- A. Suppression of aggression among conspecifics
- B. Ensures food access for high ranking individuals
- C. Reduction of the effects of lethal combat
- D. A and B only
- E. A, B, and C

**Answer: E**

**99. Select the mating system that best describes the following exemplary species/characteristics:**

- Very large testes relative to body size
- No male parental care
- Females advertise oestrus

- A. Dispersed
- B. Promiscuity
- C. Monogamy
- D. Polyandry
- E. Polygyny

**Answer: B**

**100. For certain fishes that maintain feeding territories that they must patrol against intruders, the most successful individuals will be those maintaining:**

- A. Very large territories compared to their size
- B. Very small territories compared to their size
- C. Intermediate sized territories compared to their size
- D. Cooperation with individuals of the same species
- E. Groups of females to capture prey

**Answer: C**

### **Genetics and Evolution 101-112**

**101. Two cultivars of the 4-o' clock plant (*Mirabilis jalapa*) are reciprocally crossed. When pollen from cultivar A pollinates cultivar B, all the offspring are nonvariegated (all green). When pollen from cultivar B pollinates cultivar A, some of the offspring**

are variegated (having green and white patches), some are green, and some are white but die as seedlings.

Which of the following statements are true?

1. Cultivar A is variegated
  2. Cultivar B is variegated
  3. A portion of chloroplasts in variety A carry a mutation for chlorophyll synthesis
  4. The pollen's genotype determines variegation in this cross
  5. Variegation is a lethal recessive phenotype
- A. 2, 4 only  
B. 2, 4, 5 only  
C. 1, 3 only  
D. 1, 2, 5 only  
E. 1, 2, 3, 4, 5

**Answer: C**

102. In bacteria, the elongation factor EF-Tu binds aminoacyl-tRNAs and transports them to the A site of the ribosomal large subunit after translation has been initiated. Which amino acid's aminoacyl-tRNA does not need EF-Tu to enter the ribosome?

- A. Phenylalanine  
B. Proline  
C. Lysine  
D. Glycine  
E. Formylmethionine

**Answer: E**

103. The Telome Theory describes the evolution of

- A. Euphyllophyte leaves  
B. Lycopphyte leaves  
C. Plant meristems  
D. Roots from shoots  
E. Vascular tissues

**Answer: A**

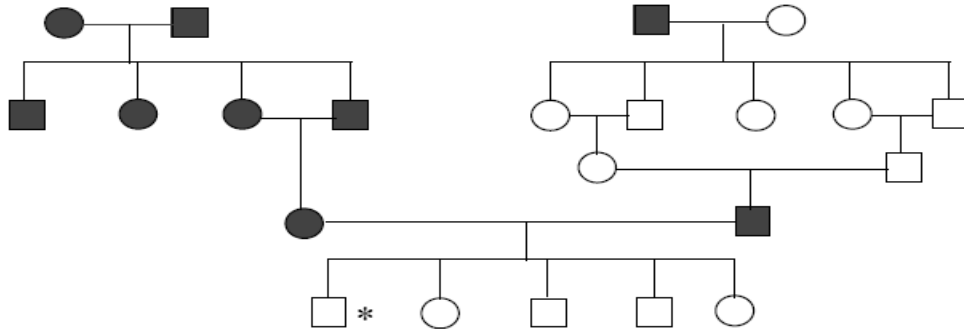
104. Plesiomorphy refers to a character that is

- A. Ancestral  
B. Derived  
C. Distributed among taxa  
D. No longer found in extant taxa

E. Unique to a given taxon

**Answer: C**

105. A recessive phenotype was discovered in two unrelated families. A man from one family marries a woman from the other family. They have five children [see the pedigree below]. Assume the recessive phenotype is completely penetrant. If so, what is the genotype of the starred individual?



- A.  $D^1D^2$
- B.  $D^1d^2$
- C.  $d^1D^2$
- D.  $d^1d^2$

**Answer: D**

106. Which statement is true according to Darwin's theory of evolution through natural selection?

- A. Species adapt until reaching an optimal form
- B. Individuals evolve as a function of their environment
- C. Species producing many offspring are more adapted than those producing few
- D. The number of offspring produced by an individual is related to both the traits of the parents and the environment
- E. In a population undergoing natural selection most mutations lead to new species

**Answer: D**

For Questions 107 to 110, use the following information: You are studying a population of penguins found on an island near Antarctica, and discover that some have blue feet, while others have orange.

107. You count 16 blue-footed penguins and 84 orange-footed penguins. Assuming that foot color is determined by two different alleles of one gene, where the orange foot allele is dominant to the blue foot allele, and that the population is

in Hardy-Weinberg equilibrium, what is the allele frequency of the orange foot allele?

- A. 0.40
- B. 0.50
- C. 0.60
- D. 0.75
- E. 0.84

**Answer: C**

108. Under the same assumptions as above, what is the frequency of heterozygotes for the foot color gene in this population of penguins?

- A. 0.0
- B. 0.24
- C. 0.4
- D. 0.48
- E. 0.6

**Answer: D**

109. Upon further investigation, it is discovered that 20 of the orange-footed penguins have a small black spot on the bottom of their feet, and that these individuals are the heterozygotes for the foot color gene. Assuming random mating over many generations, one would expect the frequency of blue-footed penguins to approach

- A. 0
- B. 0.04
- C. 0.07
- D. 0.1
- E. Cannot be determined

**Answer: C**

110. Assume the black-spotted orange feet are caused by another gene epistatic to the foot color gene. With random mating over many generations, one would expect the frequency of blue-footed penguins to approach

- A. 0
- B. 0.04
- C. 0.06
- D. 0.07
- E. Cannot be determined

**Answer: E**

111. In *Lycopersicon esculentum* (tomato), plants that were homozygous tall with smooth fruit were crossed with plants that were homozygous recessive dwarf with hairy fruit. The F1 plants were test-crossed with the following results:

Tall, smooth fruits	36
Dwarf, hairy fruits	39
Tall, hairy fruits	12
Dwarf, smooth fruits	13

These data indicate that the genes for:

- A. Height and fruit surface are on different chromosomes
- B. Height and fruit surface are completely linked
- C. Height and fruit surface are linked and 12.5 units apart
- D. Height and fruit surface are linked and 25 units apart
- E. Height and fruit surface are linked and 33 units apart

**Answer: C**

112. A woman with blood type A,  $RH^+$  gives birth to a child with type O,  $Rh^-$  blood. There are five men who may be the father. The blood types of all five are determined in order to identify the father. Regrettably, only one of the men can be removed from consideration. Of the blood types below, which man can definitely be removed?

- A. A,  $Rh^+$
- B. O,  $Rh^+$
- C. B,  $Rh^+$
- D. B,  $Rh^-$
- E. AB,  $Rh^-$

**Answer: E**

Ecology 113-117

113. Which of the following factors are believed to influence the global latitudinal gradient of species richness? Choose all that apply.

1. Stability of tropical biomes over time
2. Actual evapotranspiration
3. Potential evapotranspiration

- A. 1
- B. 2
- C. 1, 2
- D. 1, 3
- E. 1, 2, 3

**Answer: E**

114. The region of the world with the greatest biodiversity of marine taxa (in total and per area) is the:

- A. Abyssal plain of the Atlantic Ocean

- B. Southern Ocean (the ocean surrounding Antarctica)
- C. Seas between Southeast Asia and northern Australia
- D. Caribbean Sea
- E. Pelagic zone of the North Pacific

**Answer: C**

**115. Which of the following threaten coral reefs worldwide?**

1. Pollution
  2. Destruction of mangrove and seagrass communities, which trap and filter pollution from runoff
  3. Destructive forms of fishing, such as fishing with dynamite
  4. Ocean acidification due to increasing atmospheric CO<sub>2</sub> concentration
  5. Diseases of corals
- A. 1, 2, 5
  - B. 1, 3, 4
  - C. 3, 4, 5
  - D. 1, 2, 3, 5
  - E. 1, 2, 3, 4, 5

**Answer: E**

**Questions 116 to 117 refer to the following paragraph. In Argentina at 32° S latitude there are deserts east of the Andes Mountains. In Chile at 18° S latitude there are deserts west of the mountains in. Select from the following list of explanations those that best explain these two situations (6 Points/3 each).**

- i. Easterly winds
- ii. Westerly winds
- iii. Descending dry air masses
- iv. Ascending dry air masses
- v. Rain shadow on east side of mountain
- vi. Rain shadow on west side of mountain

**116. The Argentina deserts mentioned above are most likely the result of:**

- A. i, ii, and iii only
- B. i, iv and v only
- C. i, iii, and vi only
- D. iii, and v only
- E. ii, iv and vi only

**Answer: C**

**117. Chile deserts mentioned above are most likely the result of:**

- A. i and ii only
- B. i and v only
- C. i and iv only

- D. ii and v only
- E. ii and iv only

**Answer: A**

**Biosystematics 118-120**

**118. The Kingdom of Tonga is an archipelago consisting of 176 islands in the South Pacific. Only 51 of these islands are inhabited by man. A plant population that reproduces annually was found on one of the remote uninhabited islands of Tonga. Two flower-color variants were present, yellow and orange. Flower color is known to be a monogenic trait. The frequencies of the two flower colors were observed annually over a ten-year period. It was noted the proportion of plants with orange flowers steadily declined each year. From these data, it may reasonably be concluded that:**

- A. The increased frequency of yellow-flowered plants was a result of genetic drift.
- B. Migration of yellow-flowered plants into the population was the most likely cause of the observed change.
- C. Mutation occurred more frequently in yellow-flowered plants than in orange-flowered plants.
- D. Orange-flowered plants had a lower genetic fitness than the yellow-flowered plants.
- E. Yellow-flowered plants were capable of crossing with other yellow-flowered plants or with orange-flowered plants but orange-flowered plants could only cross with other orange-flowered plants.

**Answer: D**

**119. The region of the world with the greatest biodiversity of marine taxa (in total and per area) is:**

- A. Abyssal plain of the Atlantic Ocean
- B. Southern Ocean (the ocean surrounding Antarctica)
- C. Seas between Southeast Asia and northern Australia
- D. Caribbean Sea
- E. Pelagic zone of the North Pacific

**Answer: C**

**120. Some populations are characterized by the presence of balanced polymorphism. This condition may be maintained by all of the following EXCEPT:**

- A. Balancing selection
- B. Directional selection
- C. Disruptive selection
- D. Frequency-dependent selection
- E. Natural selection

**Answer: B**



***PART C***

1. Match the animals and their characteristics. Mark the appropriate box with an “X” in the space provided (Points Possible 20. Incorrect answers will be subtracted from correct answers for Total Points)

	Freshwater fish	Bird	Marine fish	Lizard	Marine mammal	Terrestrial mammal
Drinks water regularly						
Does not drink water						
Wastes are discarded as ammonia						
Wastes are discarded as urea						
Wastes are discarded as uric acid						
Actively secretes salt						
Actively absorbs salt						
Excretes hypotonic urine relative to the body fluids						
Excretes isotonic urine relative to the body fluids						
Excretes hypertonic urine relative to the body fluids						

**Answer**

	<b>Fresh water fish</b>	<b>Bird</b>	<b>Marine fish</b>	<b>Lizard</b>	<b>Marine mammal</b>	<b>Terrestrial mammal</b>
<b>Drinks water regularly</b>		<b>X</b>	<b>X</b>			<b>X</b>
<b>Does not drink water</b>	<b>X</b>			<b>X</b>	<b>X</b>	
<b>Wastes are discarded as ammonia</b>	<b>X</b>		<b>X</b>			
<b>Wastes are discarded as urea</b>					<b>X</b>	<b>X</b>
<b>Wastes are discarded as uric acid</b>		<b>X</b>		<b>X</b>		
<b>Actively secretes salt</b>			<b>X</b>			
<b>Actively absorbs salt</b>	<b>X</b>					
<b>Excretes hypotonic urine relative to the body fluids</b>	<b>X</b>					
<b>Excretes isotonic urine relative to the body fluids</b>			<b>X</b>			
<b>Excretes hypertonic urine relative to the body fluids</b>		<b>X</b>		<b>X</b>	<b>X</b>	<b>X</b>

2. Movement from an aquatic environment to the land presented a number of challenges for plant reproductions. Describe these challenges and explain how the angiosperms have adapted to survive and reproduce on land. Include a diagram of the angiosperm life cycle and describe with some detail the process of sexual reproduction in plants (Total 20 points).

**Answer**

**Primary problems:**

**1. Lack of water for flagellated sperm (2)**

**2. Zygote and embryo in danger of desiccation (2)**

**(extreme fluctuation in temperature, humidity, wind, light... can affect embryo)**

**Life cycle altered to avoid necessity of flagellated sperm swimming to egg and to roved protection fro embryo.**

**3. Insert Life Cycle sketch (10 points)**

**Haploid (2)**

**Gametes, spores, multicellular haploid (Total 3)**

**Diploid (2)**

**Zygote, multicellular diploid (2)**

**Meiosis (1)**

**Fertilization (1)**

**4. Details (6)**

**Any six of the following:**

- **Gametophytes are much reduced in angiosperms**
- **Major advance is evolution of pollen**
- **Pollen grain falls on stigma and pollen tube grows down style and delvers 2 sperm directly to embryo sac—no need for flagellated sperm**
- **Double fertilization gives rise to zygote and triploid endosperm (provides food source to maintain embryo and early growth)**
- **Seed coat protects zygote and embryo**
- **Ovary wall will ripen into fruit that often provides means of dispersal.**

**Congratulations on being a Semi-finalist!**

**We hope to see you as a Finalist!!**