

Country \_\_\_\_\_

Competitor# \_\_\_\_\_



## **16<sup>th</sup> International Biology Olympiad**

**Beijing  
July, 2005**

### **THEORY EXAMINATION**

#### **Part 2**

**Total time available: 2.5 hours (150 minutes)**

**Total points available: ~80**

**There is only one correct option for each question: No negative marking in place**

**Questions 85-92.** Sex determination in fruit flies and mammals are both XY type, that is, XX leads to female and XY leads to male.

85. Some organisms have abnormal sex chromosomes such as XO (only have one X chromosome) or XXY (extra X chromosome). The most likely cause of the abnormal sex chromosome is: (1 point)

- A. An error occurred in mitosis of the fertilized egg.
- B. Gene mutation
- C. An error occurred in meiosis during gamete formation.
- D. Sex chromosomes in gametes are either lost or doubled in fertilization.

86. In organisms with XXY chromosome type, there is an extra X chromosome. How do you most conveniently determine if this X chromosome is from sperm or egg? (1 point)

- A. Karyotype
- B. *In situ* hybridization
- C. RFLP (Restriction fragment length polymorphism)
- D. DNA sequencing

87. In mammals, XO leads to female and XXY leads to male. In fruit flies, XO leads to male and XXY leads to female. Which of the following is **NOT** correct? (1 point)

- A. The Y chromosome in mammals is necessary for formation of a male organism.
- B. The Y chromosome in mammals is required for the sex organ development.
- C. The Y chromosome in fruit flies is not functional.
- D. The number of X chromosomes in fruit flies impacts on sex determination.

88. In mammals with abnormal sex chromosomes, the number of individuals with XO chromosome type is far fewer than the number of individuals with the XXY chromosome type. It is therefore predicted that: (1 point)

- A. The individuals with the XO chromosome type are less capable of surviving than those with the XXY chromosome type.
- B. The individuals with XO chromosome type are less capable of reproducing than that with XXY chromosome type.
- C. The difference is related to gender of the individuals (XO leads to female and XXY leads to male).
- D. None of the above.

89. In both fruit flies and mammals, XX leads to female and XY leads to male. The gene products encoded by two X chromosomes of female individuals are nearly identical to those encoded by one X chromosome of male individuals. This is accomplished by gene dosage compensation. In mammals, it is accomplished by converting one X chromosome into a Barr body (X inactivation). Which of the following about the Barr body is/are correct? (1 point)

- (1) Only normal female individuals have Barr bodies.
- (2) Only normal male individuals don't have Barr bodies.
- (3) Barr bodies can always be used to determine gender of human beings.
- (4) The maximum number of Barr bodies is one
- (5) The number of Barr bodies equals the number of X chromosomes minus one.

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

90. No Barr body can be observed in normal female fruit flies because (1 point)

- A. The X chromosome of fruit flies is too small
- B. There is no mechanism of dosage compensation in fruit flies
- C. There is no X inactivation in fruit flies
- D. Heterochromatin is difficult to detect in fruit flies.

91. The fur color of cats is determined by genes on the X chromosome.  $X^A$  is the dominant allele for orange fur, while  $X^a$  is the recessive allele for black fur. Which of the following is true about the fur color of the offsprings from a  $X^A X^a$  female cat and  $X^A Y$  male cat? (1 point)

- A. They are all orange
- B. All the female are orange and half the male are orange
- C. Regardless of sex, half are orange, the other half have fur that is a mosaic of orange and black.
- D. Those with mosaic fur are all female.

92. One of the genes controlling sweat glands in humans is located on the X chromosome. Two twin sisters show different phenotypes of the sweat gland. One has no sweat glands on her left arm while the other has sweat glands on her left arm. Which of the following statements is/are **TRUE**? (1 point)

- (1) The twins cannot be identical.
- (2) They both are heterozygous for the gene.
- (3) The reason for the different phenotype is random X inactivation.
- (4) X inactivation must occur after the first division of the zygote.

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

93. Mycorrhizae are symbiotic associations of fungi and plant roots. Which of the following is/are **TRUE** about mycorrhizae? (1point)

- (1) They are often harmful to plant roots while beneficial to fungi.
- (2) They are often beneficial to plants but harmful to fungi
- (3) They are helpful for plants to absorb water and minerals.
- (4) They could even help the older root region above the root hair area to supply minerals to plants.

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

94. Complete the following sentence: Stomata of a plant open when guard cells (1point)

- A. accumulate water by active transport.
- B. sense an increase in  $\text{CO}_2$  in the air spaces of the leaf.
- C. become more turgid because of an influx of  $\text{K}^+$ , followed by the osmotic entry of water.
- D. sense that water content of the whole plant is low.

95. Which of the following processes of plants could be regulated by phytochrome?

(1point)

- (1) seed germination
  - (2) flowering
  - (3) shoot elongation
  - (4) open and closure of stomata
- A. 1, 2, 3, 4
  - B. 1, 2, 3
  - C. 1, 2
  - D. 1

96. If  $N$  represents population size,  $r$  represents the difference in per capita birth rates and death rates,  $K$  represents the carrying capacity,  $t$  represents time, which of the following equations best describes logarithmic growth of the population? (1point)

A.  $\frac{dN}{dt} = rN$

B.  $\frac{dN}{dt} = rNK$

C.  $\frac{dN}{dt} = r(K-N)$

D.  $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$

97. ~~Which of the following is usually the limiting process of phosphorous cycles? (1 point)~~

~~A. Decomposition~~

~~B. Utilization in primary production~~

~~C. Release from soil~~

~~D. Sedimentation~~

98. Which of the following ecosystems has the lowest primary production per square meter? (1 point)

A. a salt marsh

B. an open ocean

C. a grassland

D. a tropical rain forest



99. Which of the following is/are true about Archaea and Eubacteria? (1point)

- (1) They don't have a nuclear envelope
- (2) They both have branched chains in membrane lipids
- (3) They have one kind of RNA polymerase
- (4) They have circular chromosomes.

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

100. ~~Four major groups of fungi are recognized. They are chytrids, zygozote fungi, sac fungi and club fungi. Chytrids differ from other three groups in that (1point)~~

- ~~A. Chytrids don't have sexual reproduction~~
- ~~B. They are all aquatic.~~
- ~~C. They have cell walls made of cellulose~~
- ~~D. They have flagellated cells in their life cycles.~~

101. Chlorophyll a is involved in both light energy absorption and initial electron transfer of photosynthesis. Which of the following are true about the chlorophyll a? (1point)

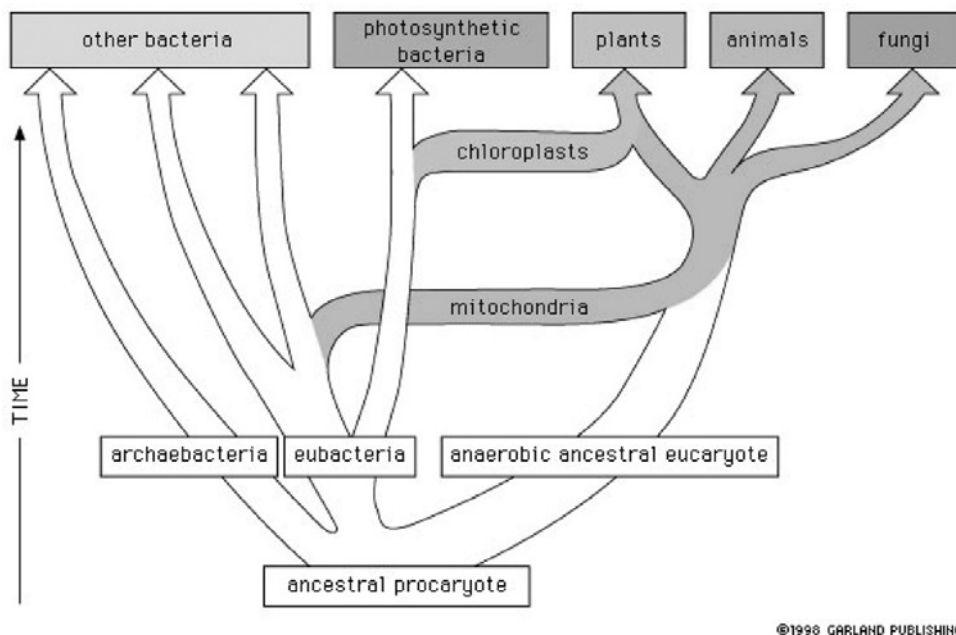
- (1) The position of chlorophyll a in photosystems has a strong influence on the function of chlorophyll a.
- (2) Chlorophyll a in the photosynthetic reaction center is chemically modified so that it performs initial electron transfer.
- (3) Part of chlorophyll a is structurally related to the heme group found in hemoglobin.
- (4) Part of chlorophyll a is structurally related to carotenoids.

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

102. In measurement of photosynthetic electron transfer, intact chloroplasts are isolated and used to estimate electron transfer rates under different conditions. Which of the following is **CORRECT**? (1point)

- A. Addition of an uncoupler leads to an increased rate of electron transfer.
- B. Cyclic electron transfer starts only when linear electron transfer is inhibited.
- C. ATP synthesis could only be observed with continuous light illumination.
- D. Oxygen evolution by chloroplast suspension is absolutely dependent upon the presence of CO<sub>2</sub>.

103. The figure shown below is a diagram of an evolutionary tree. Which of the following statements about evolution are true and deducible from the figure? (2 points)



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- (1) All eucaryotic cells contain mitochondria.
- (2) Symbiosis of the eucaryotic ancestor with autotrophic cells preceded the symbiosis with the cell taking advantage of the oxidative metabolism.
- (3) There is a common ancestor of eubacteria and eukaryota, archaebacteria are a group with unique and independent origin.
- (4) The ancestral eukaryote was anaerobic.
- (5) None of the recent photosynthetic bacteria are related to the chloroplasts.

**PTO**

- (6) Mitochondria and chloroplasts have similar genomes.
- (7) Mitochondria are present in the cells of the plants, animals and fungi.
- (8) Fungi lost chloroplasts during evolution.
- (9) Bacteria are a highly homogenous group of organisms which showed rapid diversification of their genomes and metabolisms during the last billion years.
- (10) Chloroplasts and mitochondria are results of independent endosymbiotic events.

- A. 1, 2, 5
- B. 3, 4, 7
- C. 4, 7, 10
- D. 6, 8, 10
- E. 4, 9, 10

104. ~~The figure shown below is an image of a DNA molecule. Structure of the DNA molecule can undergo dramatic and highly regulated changes during the cell cycle. Which of the following statements are true about the cross-like structure on the image. (2 points)~~



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- ~~(1) During the replication all four DNA strands in the double helix are covalently interconnected.~~
- ~~(2) In the prophase of the mitosis chromosomes highly condense and get interconnected via covalent bonds.~~
- ~~(3) During the prophase of the first meiotic division recombination between sister chromatids takes place and new covalent bonds are temporarily formed which results in the formation of the cross-like conformation of the DNA.~~
- ~~(4) Image is photomontage of the forbidden conformation of the DNA molecule.~~

- ~~(5) During the prophase of the first meiotic division recombination between homologous chromosomes takes place and new covalent bonds are temporarily formed which results in the cross-like conformation of the DNA.~~
- ~~(6) Cross-like structures of the DNA molecules could be observed in the nucleus of the B-cells and T-lymphocytes during their development.~~
- ~~(7) Figure shows situation in the cytosol of the bacterial cell where translation and transcription are not separated spatially.~~
- ~~(8) Some viruses use formation of the cross-like structures to integrate into the host chromosomes.~~
- ~~(9) In the apoptotic cells DNA is cleaved and finally forms unusual cross-like conformation—useful marker of the final stages of the programmed cell death.~~
- ~~(10) Figure shows unusual type of the replication in the Archaeobacteria when three double helixes are formed from one precursor DNA double helix.~~

~~A. 5, 6, 8~~

~~B. 1, 3, 8~~

~~C. 6, 8, 10~~

~~D. 2, 7, 9~~

~~E. 4, 6, 10~~

105. The Siamese cat is an example of an animal with melanin synthesized in both sexes mostly at the body extremities. That makes snout, ears, tail and feet much darker than the rest of the body. Explanation of this type of the body coloration is that:

(1 point)

- A. Only at the body extremities the enzyme tyrosinase (responsible for the synthesis of the melanin) is synthesized.
- B. The only places where one of the X chromosomes that have the dominant gene of the tyrosinase is NOT inactivated
- C. Melanin is synthesized only in the colder parts of the body because the Siamese cat has a temperature sensitive gene for the enzyme producing melanin.
- D. Melanocytes are localized only at the snout, ears, tail and feet – the rest of the body lacks melanocytes.
- E. The body extremities are more exposed to the UV-radiation which stimulates production of the melanin.

106. Retinoblastoma (Rb) and p53 genes are examples of anti-oncogenes (tumour suppressors). Which of the following statements is **TRUE**? (1 point)

- A. Mutation in the p53 gene (when p53 lost its regulatory function) can stop the cell cycle.
- B. Overproduction of the Rb protein in the retina can cause cancer.
- C. Cells with a mutated p53 gene are predisposed to malignancy.
- D. Cells with a mutated Rb gene are resistant to malignancy.
- E. Various viruses incorporated homologs of the p53 and Rb genes into their genomes and use these proteins for the transformation of the host cell.

107. The extracellular matrix is responsible for the mechanoelastical properties of the tissues. Which of the following molecules is **NOT** a component of the extracellular matrix: (1 point)

- A. elastin
- B. cytokeratin
- C. laminin
- D. collagen
- E. chondroitin sulphate



~~108. Prions are unique infectious agents formed only from protein called PrP. What are the true statements about prions? (1 point)~~

- ~~(1) prion protein has an exceptionally stable conformation~~
- ~~(2) mutated form of the PrP can predispose to Creutzfeldt-Jacob disease in human~~
- ~~(3) wt form of prion protein is expressed in the brains of the healthy animals~~
- ~~(4) spongiform encephalopathy is a typical phenotype of the prion-caused disease~~
- ~~(5) prion diseases are restricted only to man, cow and sheep because only these species express PrP~~
- ~~(6) prions are small viruses with symmetrical capsid without DNA or RNA~~
- ~~(7) prion disease is highly infectious and could be transmitted via body fluids~~
- ~~(8) prion disease could be transmitted via transplantation or cannibalism~~
- ~~(9) mouse with genetic knock-out for the PrP is resistant to the prion disease~~
- ~~(10) prion disease could be cured by bone marrow transplantation~~

~~A. 1, 4, 6, 7~~

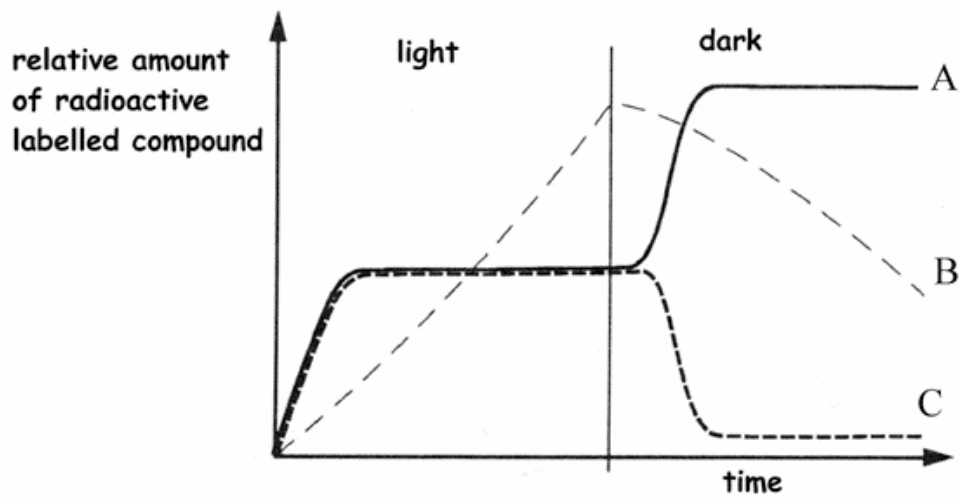
~~B. 2, 3, 4, 5~~

~~C. 2, 3, 8, 9~~

~~D. 4, 6, 8, 9~~

~~E. 1, 3, 9, 10~~

109. Algae were supplied with a radioactive isotope of Carbon,  $^{14}\text{C}$ , and allowed to photosynthesise. After a period of time, the light was switched off and the algae were left in the dark. The graph shows the relative amount of some radioactive labelled compounds over the period of the experiment. (1 point)

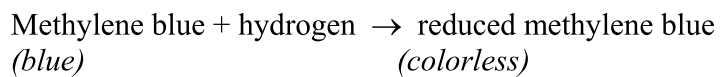


Which line represents the amount of glycerate 3-phosphate (3GP), ribulose biphosphate (RuBP) and sucrose formed? (1 point)

Fill out the correct letter of the line in the correct box.

Compound	Line
(1) 3GP	
(2) RuBP	
(3) Sucrose	

110. Methylene blue acts as a hydrogen acceptor. It is blue in its oxidised state, but goes colourless when it is reduced by accepting hydrogen atoms. (1 point)



A student wishes to investigate this reaction, he prepares four test tubes as shown below:

	Tube A	Tube B	Tube C	Tube D
Distilled water	-	2 ml	2 ml	2 ml
Glucose solution	2 ml	2 ml	-	2 ml
Methylene blue solution	1 ml	1 ml	1 ml	-
Yeast solution	2 ml	-	2 ml	2 ml

All tubes were incubated at a temperature of 30 °C. The colour was recorded at the start and after intervals of 5 and 15 minutes. The results are shown in the following table.

Colour of content	Tube A	Tube B	Tube C	Tube D
At start	Blue	Blue	Blue	colourless
After 5 minutes	colourless	Blue	Blue	colourless
After 15 minutes	colourless	Blue	Pale blue	colourless

Which test tube can be characterized as a control in this investigation and which test tube generates an irrelevant (useless) result? (1 point)

Fill out the correct letter below

	Tube
(1) Control	
(2) Useless	

111. Morgan crossed *Drosophila* of two known genotypes,  $BbVv \times bbvv$ , where  $B$ , the wild-type (grey) body, is dominant over  $b$  (black body) and  $V$  (wild-type wing) is dominant over  $v$  (vestigial, a very small wing). Morgan expected to see four phenotypes in a ratio 1:1:1:1. But he observed:

Wild type: 965

Black vestigial: 944

Grey vestigial: 206

Black normal: 185

These results were explained by assuming linkage of alleles together with genetic recombination (crossing over).

In this particular example the recombinant frequency (defined as the ratio of recombinants in relation to the total offspring) is: (1 point)

A. 0.205

B. 0.170

C. 0.108

D. 0.900

E. 0.080

112. 70% of the population of Beijing is able to taste phenylthiocarbamide. The ability to taste (T, taster) is dominant over the inability to taste (t, non-taster).

What percentage of the offspring of 'tasters' will be non-tasters? (2 points)

- A. 25%
- B. 15%
- C. 13%
- D. 20%
- E. 7.5%

**Questions 113-116.** Wild type individuals of *Drosophila* have red eyes and straw-coloured bodies. A recessive allele of a single gene in *Drosophila* causes *glass eye* and a recessive allele of a different gene causes *ebony body*.

A student crosses pure breeding wild type flies with pure breeding flies having glass eye and ebony body and the resulting F1 flies showed all the wild type phenotype for both features. On crossing the F1 flies among themselves the student expect a 9:3:3:1 ratio but the results are not like that. The actual offspring showed:

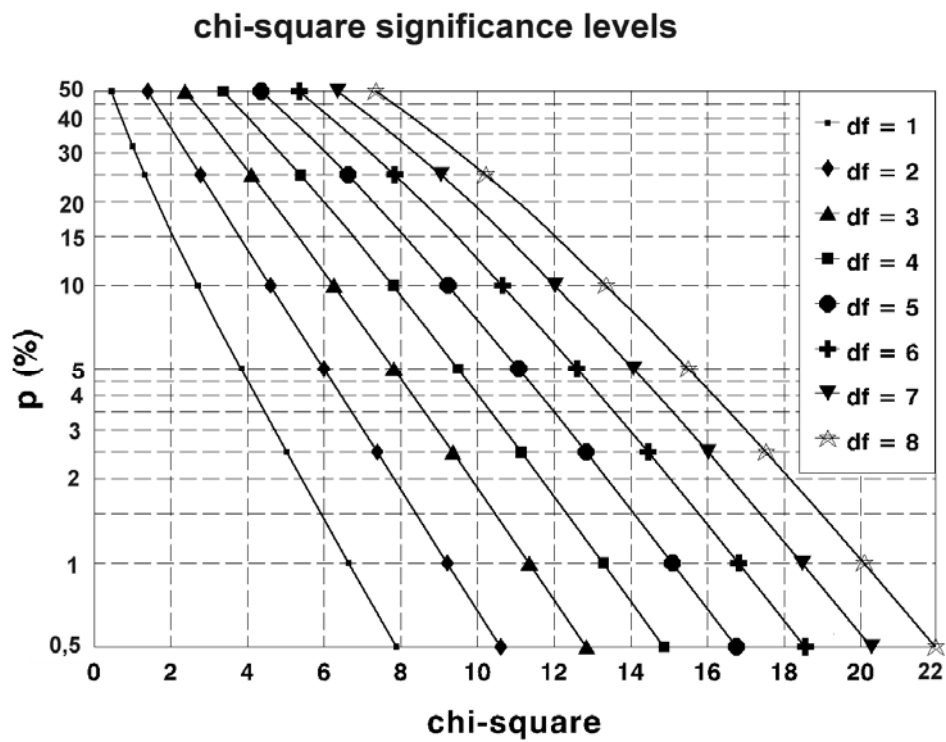
Eye	Body	Number of flies in F2
Wild	Wild	164
Wild	Ebony	37
Glass	Wild	59
Glass	Ebony	28

There are two possibilities:

- The differences from 9:3:3:1 are coincidental (null hypothesis accepted).
- The differences do not occur by coincidence (null hypothesis rejected).

You are required to check this applying the  $\chi^2$  (chi square) test.

For this situation, e.g. degree of freedom, the following diagram with  $\chi^2$  values should be used:



Question 113. The calculated  $\chi^2$  is? (3 points)

- A. 10.11
- B. 2.84
- C. 14.33
- D. 11.40

Question 114. Indicate the degree of freedom (df) for this test: (1 point)

- A. 2
- B. 3
- C. 4

Question 115. Determine the probability that the deviation of the observed results from expected results is due to chance alone. (1 point)

- A. About 1%
- B. About 2%
- C. About 5%
- D. About 8%

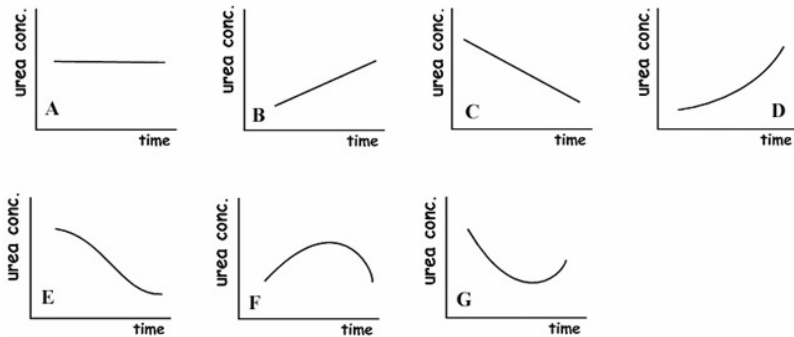
Question 116. To explain the observed deviation of the 9:3:3:1 ratio the student suggested some possibilities.

- (1) linkage of both the alleles
- (2) crossing over
- (3) incomplete dominance

Which combination of suggestions is the correct explanation? (1 point)

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

117. Which of the following diagram shows the correct representation of the urea content in the urine of a person on hunger strike, who then died. (1 point)





118. Wilhelm von Osten gave performances with his horse called *smart Hans*. He stated that he taught his horse to make calculations. But in fact this isn't true at all. He had taught the horse to respond to his hidden but triggering signals. As a result the horse made the desired movements: swinging the correct number of times with his foreleg. After that the horse got some reward.

What kind of learning behaviour is this? (1 point)

- A. adaptation
- B. conditioning
- C. habituation
- D. imitation
- E. imprinting
- F. insight
- G. Fixed action pattern

119. A snail crawling across a board will withdraw into its shell when you drop a marble on the board. Repetition of dropping marble will lead to a weaker withdraw action and in the end the snail will ignore the marble dropping. Which of the following terms do apply for the disappearance of the withdraw action? (1 point)

- (1) adaptation
- (2) conditioning
- (3) habituation
- (4) imprinting
- (5) insight
- (6) learned behaviour
- ~~(7) ritualisation~~
- ~~(8) trial and error~~

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

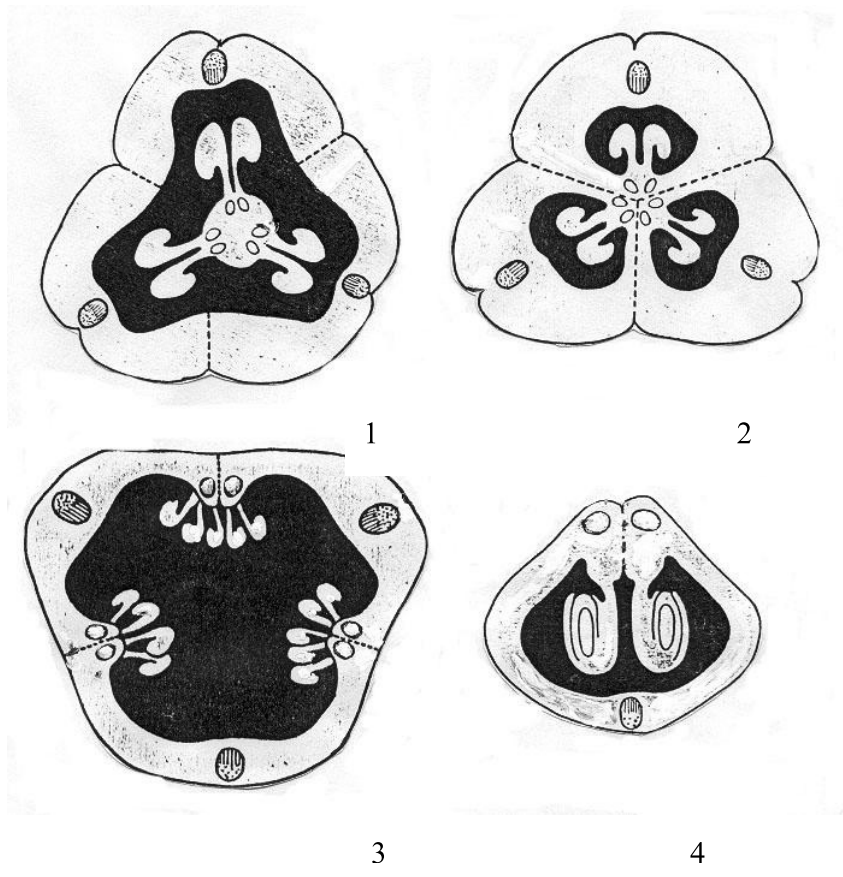
120. Bonsai trees need water with a very low lime content. Which types of water could be used to water them? (1 point)

- (1) Carbonated mineral water
- (2) Rain water
- (3) Tap water with high water hardness
- (4) Tap water with high water hardness treated by leaving it over night with a mix of peat and crushed stones and filtrating it before use
- (5) Molten snow

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

121. Observe the diagrams 1 to 4 representing cross sections of the ovaries of different flowers.

Match the numbers in front of the placentation type (A-D) with the corresponding diagram.

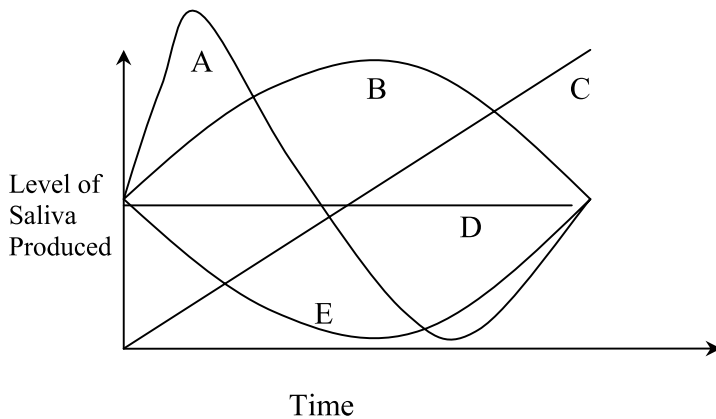


- A. Axile placentation.
- B. free central placentation.
- C. Marginal placentation.
- D. Parietal placentation.

Match the number with correct placenta type. (1 point)

type	Answer
1	
2	
3	
4	

122. Which curve shows the correct time course of the production of saliva in a human after the intake of citric acid? (1 point)



**Questions 123-125.** The behavior of eight Humboldt penguins (*Spheniscus humboldti*) is investigated in a larger group of penguins in a zoo enclosure. The animals can be distinguished by the marks or their individual pattern of black dots on their white thorax. To document the relationship between penguins, their nearest neighbor (closest animal in the enclosure) was recorded in short time intervals during day time in a period of several weeks. The table shows the relatively stable mean values for the frequency of neighbors for the four male (M1 – M4) and four female (F1 – F4) penguins.

	M1	M2	M3	M4	F1	F2	F3	F4	$\Sigma$
M1		2	5	1	0	3	7	77	95
M2	2		0	9	9	75	1	2	98
M3	5	0		0	0	0	78	6	89
M4	1	9	0		80	8	0	0	98
F1	0	9	0	80		7	0	0	96
F2	3	75	0	8	7		0	0	93
F3	7	1	78	0	0	0		7	93
F4	77	2	6	0	0	0	7		92
$\Sigma$	95	98	89	98	96	93	93	92	

Several months later the same animals were observed again yielding the following values.

	M1	M2	M3	M4	F1	F2	F3	F4	$\Sigma$
M1		4	8	2	1	4	11	60	90
M2	4		0	12	12	65	1	5	99
M3	8	0		0	0	1	62	9	80
M4	2	12	0		70	14	0	1	99
F1	1	12	0	70		10	0	1	94
F2	4	65	1	14	10		0	3	97
F3	11	1	62	0	0	0		10	84
F4	60	5	9	1	1	3	10		89
$\Sigma$	90	99	80	99	94	97	84	89	

During the following years these values tended to remain the same.

123. Analyze the tables and determine the mating system of the Humboldt penguins.

(1 point)

- A. promiscuity
- B. polyandry
- C. polygyny
- D. monogamy

124. Which is the most common polygamous relationship in these penguins? (1 point)

- A. promiscuity
- B. polyandry
- C. polygyny
- D. monogamy

125. Which group of animals do the penguins belong to? (1 point)

- A. Ratitae (birds with flat breast and weak breast muscles)
- B. Carinatae (birds with strong breast muscles)
- C. Neither, they are not birds

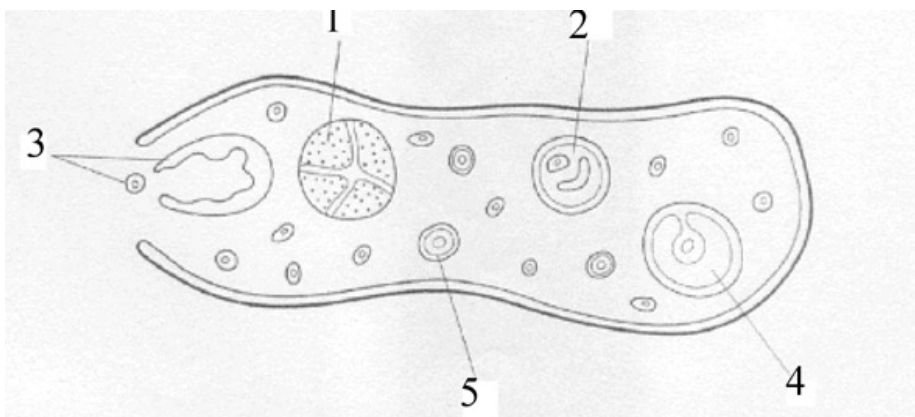
126. The substrate(s) of RUBISCO is (are): (1 point)

- (1) Phosphoenolpyruvate (PEP)
- (2) Ribulose-bis-phosphate (RuBP)
- (3) Oxaloacetic acid (OAA)
- (4) Phosphoglyceric acid (PGA)
- (5) Carbon dioxide (CO<sub>2</sub>)
- (6) Phosphoglyceraldehyde (GAP)
- (7) Oxygen (O<sub>2</sub>)

- A. 1, 2, 5
- B. 1, 5
- C. 2, 5
- D. 1, 2, 6
- E. 2, 5, 7

127. The diagram shows a section through a mammalian ovary. The numbers indicate different stages of development. (1 point)

Choose the correct sequence of numbers in which the structures develop.



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



**Questions 128-131.** PKU and albinism are two autosomal recessive disorders, unlinked in the human. If a normal couple produced a boy with both disorders and they want to have the second child:

128. What is the chance of the second child having PKU? (1 point)

- A.  $1/2$
- B.  $1/4$
- C.  $2/3$
- D.  $1/16$

129. What is the chance of the second child having both traits? (1 point)

- A.  $1/2$
- B.  $1/4$
- C.  $1/8$
- D.  $1/16$

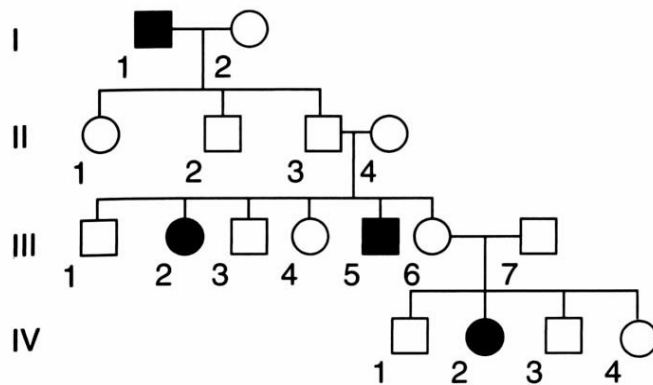
130. What is the chance of the second child having either PKU or albinism? (1 point)

- A.  $1/2$
- B.  $3/4$
- C.  $3/8$
- D.  $3/16$

131. What is the chance of their having a normal child? (1 point)

- A. 1/16
- B. 4/9
- C. 9/16
- D. 6/16

~~Questions 132-137. There is a patient who expressed a very rare phenotype. According to the medical source, this phenotype is seen in 1 in every 100,000 people. The family history of this patient is given below:~~



~~132. How is the trait inherited? (1 point)~~

- ~~A. autosomal recessive~~
- ~~B. autosomal dominant~~
- ~~C. sex-linked recessive~~
- ~~D. sex-linked dominant~~

~~133. If D = dominant, d = recessive, what is the genotype of II-3? (1 point)~~

- ~~A. DD~~
- ~~B. Dd~~
- ~~C. dd~~
- ~~D. X<sup>d</sup>Y~~
- ~~E. X<sup>D</sup>Y~~

~~134. What is the genotype of II-4? (1 point)~~

- ~~A. DD or X<sup>D</sup>X<sup>D</sup>~~
- ~~B. Dd or X<sup>D</sup>X<sup>d</sup>~~
- ~~C. dd or X<sup>d</sup>X<sup>d</sup>~~

~~135. If IV-2 married to a man from an unrelated family, what is the chance to get a normal child? (1 point)~~

- ~~A. 1/2~~
- ~~B. 2/3~~
- ~~C. 100%~~
- ~~D. Cannot be determined~~

~~136. For the alleles D and d, which individual should be homozygous? (1 point)~~

- ~~A. III-1~~
- ~~B. III-2~~
- ~~C. III-4~~

~~D. III-5~~

~~E. III-7~~

~~137. If this trait is instead quite common in the population, then what is the chance that~~

~~IV-4 is heterozygous? (1 point)~~

~~A. 1/2~~

~~B. 1/4~~

~~C. 2/3~~

~~D. 100%~~

138. There are several types of human blood cells such as erythrocytes and monocytes.

They all come from stem cells. Which of the following is/are correct about the stem cells of blood cells? (1 point)

- (1) B cells come from lymphoid stem cells.
- (2) T cells come from lymphoid stem cells.
- (3) Erythropoietin stimulates production of erythrocytes from myeloid stem cells.
- (4) Neutrophils and basophils are derived from the same stem cells.
- (5) Lymphoid stem cells come from myeloid stem cells.

A. 1, 2, 3, 4, 5

B. 1, 2, 3, 4

C. 1, 3

D. 1, 2, 4

139. Which of the following role(s) do platelets play in the clotting process? (1 point)

- (1) They help to form a plug for protection against blood loss.
- (2) They release chemical signals for fibrin formation.
- (3) They release chemical signals for reducing blood pressure.

A. 1, 2

B. 1, 2, 3

C. 2, 3

D. 1, 3

140. Which of the following is **NOT** involved in allergic response in human? (1 point)

- A. Histamine.
- B. Mast cell.
- C. Plasma cell
- D. Platelets.

141. There are several sensory receptors in human skin. Which of the following is located deepest in the skin? (1 point)

- A. Sensory receptor for pain.
- B. Sensory receptor for cold.
- C. Sensory receptor for heat.
- D. Sensory receptor for strong pressure.

142. A mutant zebra fish has a reduced number of hair cells in the neuromast of its lateral line system. Which of the following will happen? (1 point)

- (1) The mutant fish will not be able to detect depth of water.
- (2) The mutant fish will swim slowly.
- (3) The mutant fish could not detect the sound of its prey.
- (4) The mutant fish will show impaired detection of water movement around its body.

A. 1, 2

B. 3, 4

C. 4

D. 2, 4

143. Hemoglobin is responsible for transporting oxygen from the lungs to the tissues.

The Bohr shift is one of the most important properties of hemoglobin. Which of the following is **NOT** true about Bohr shift? (1 point)

- A. Additional oxygen is bound by hemoglobin in the lungs when pH decreases.
- B. Additional oxygen is released from hemoglobin at a lower pH.
- C. CO<sub>2</sub> is involved in Bohr shift.
- D. Bohr shift helps tissues to obtain more oxygen during exercise.

144. Which of the following is/are NOT true about the difference in the digestive tracts of carnivores and herbivores? (1 point)

- (1) Carnivores usually have a bigger stomach.
- (2) Carnivores usually have a shorter colon.
- (3) Herbivores usually have a longer caecum.

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

**Questions 145-148.** Hemophilia and color blindness are X-linked recessive traits. When a color-blind woman is married to a hemophiliac man,

145. What is the chance of their having a normal son? (1 point)

- A. 50%
- B. 0%, all their sons will suffer from color-blind
- C. 0%, all their sons will suffer from hemophilia
- D. It depends on the recombinant frequency.

146. If their son was married to a woman whose mother was colour-blind and their father was not colour-blind, what is the chance for them to produce a normal daughter?

(1 point)

- A. 0%
- B. 50%
- C. 75%
- D. 100%

~~147. If their daughter was married to a normal man whose father was color blind, and produced 1 normal son, 4 normal daughters, 2 color blind sons, 2 hemophiliac sons and 1 color blind, hemophiliac son, the distance between the two genes is: (1 point)~~

- ~~A. 0.5~~
- ~~B. 0.33~~
- ~~C. 0.2~~
- ~~D. 0.1~~

~~148. If they have a color blind daughter, (1 point)~~

- ~~A. There must be a mutation in her father's germ line.~~
- ~~B. She must have abnormalities other than color blind.~~
- ~~C. The chance is less than 1/100,000~~
- ~~D. The chance is about 1/1000~~



**Questions 149-152.** Huntington disease is a rare fatal disease. People with this disease start to show symptoms in their 40's. Peter's father (John) has Huntington disease.

John's father (Peter's grandfather), who also had this disease, had 11 children (5 sons and 6 daughters). Among them, 6 (3 sons and 3 daughters) of them developed the disease and five died from it.

149. How is the trait inherited? (1 point)

- A. autosomal recessive
- B. autosomal dominant
- C. sex-linked recessive
- D. sex-linked dominant

150. What is the possibility that Peter will also develop the disease? (1 point)

- A. 50%
- B. 25%
- C. 75%
- D. 67%

151. Peter is married to a normal woman. What is the possibility that their first child will eventually develop the disease? (1 point)

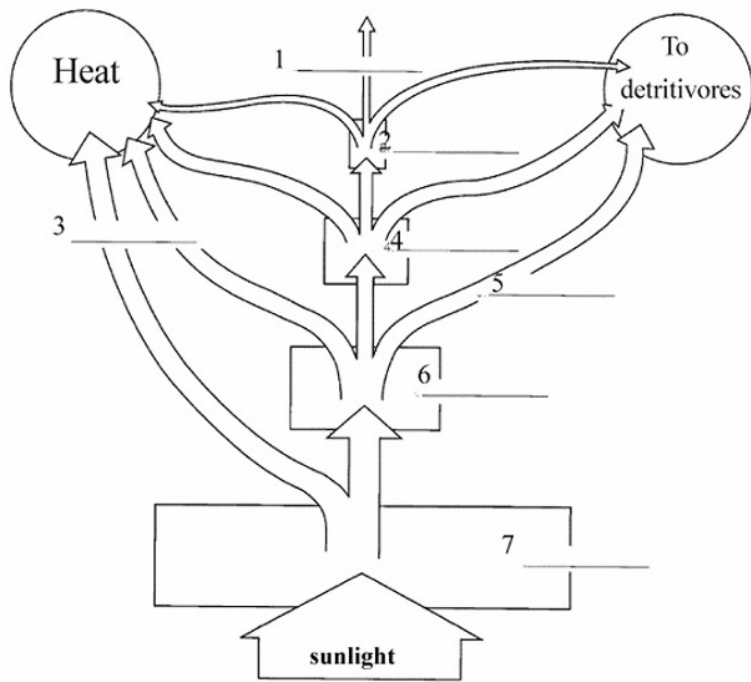
- A. 50%
- B. 25%
- C. 75%
- D. 67%
- E. 0

152. If Peter's mother-in-law died from the same disease, what is the possibility that their first child will eventually develop the disease? (1 point)

- A. 3/16
- B. 4/16
- C. 7/16
- D. 9/16
- E. 12/16

153. Trophic levels are indicated below with numbered lines in the flowchart. Write the appropriate trophic level name in the space provided next to its number. Write ONLY the letter of the trophic characteristic. (1 point)

**NOTE:** Left-hand circle in flowchart is *Heat*; right-hand circle in flowchart is *To detritivores*.



1. no answer required

5. \_\_\_\_\_

A. energy used in cellular respiration

2. \_\_\_\_\_

6. \_\_\_\_\_

B. secondary consumers

3. \_\_\_\_\_

7. \_\_\_\_\_

C. tertiary consumers

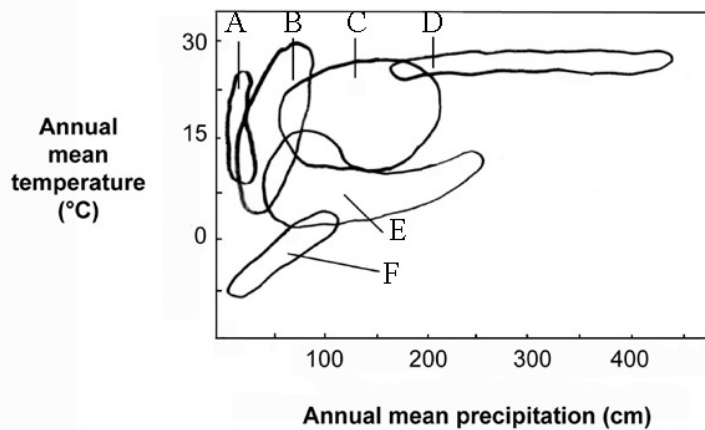
D. energy in wastes

E. primary producers

4. \_\_\_\_\_

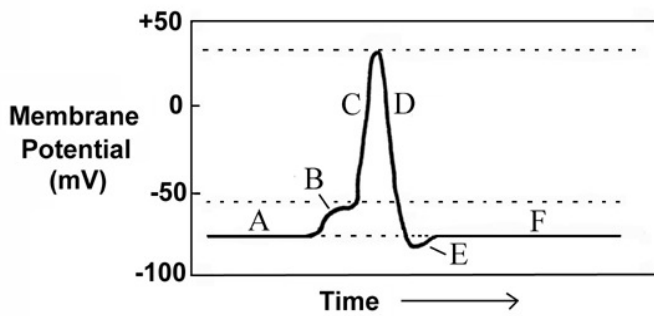
F. primary consumers

154. Match the biome in the figure below with the appropriate plotted area (a, b, c, d, e, and f) in the climograph. (1 point)



1. \_\_\_\_\_ arctic and alpine tundra
2. \_\_\_\_\_ coniferous forest
3. \_\_\_\_\_ desert
4. \_\_\_\_\_ grassland
5. \_\_\_\_\_ temperate forest
6. \_\_\_\_\_ tropical forest

155. Referring to the action potential graph below, write the letter (from the graph) that corresponds to the appropriate action potential action on the right of what is occurring at that stage of the action potential. (1 point) **Note, there could be more than one choice for each question.**



1. \_\_\_\_\_ The membrane is unable to respond to any further stimulation regardless of intensity

2. \_\_\_\_\_ Sodium gates close, and potassium gates re-open

3. \_\_\_\_\_ Both sodium and potassium voltage-gated channels are closed

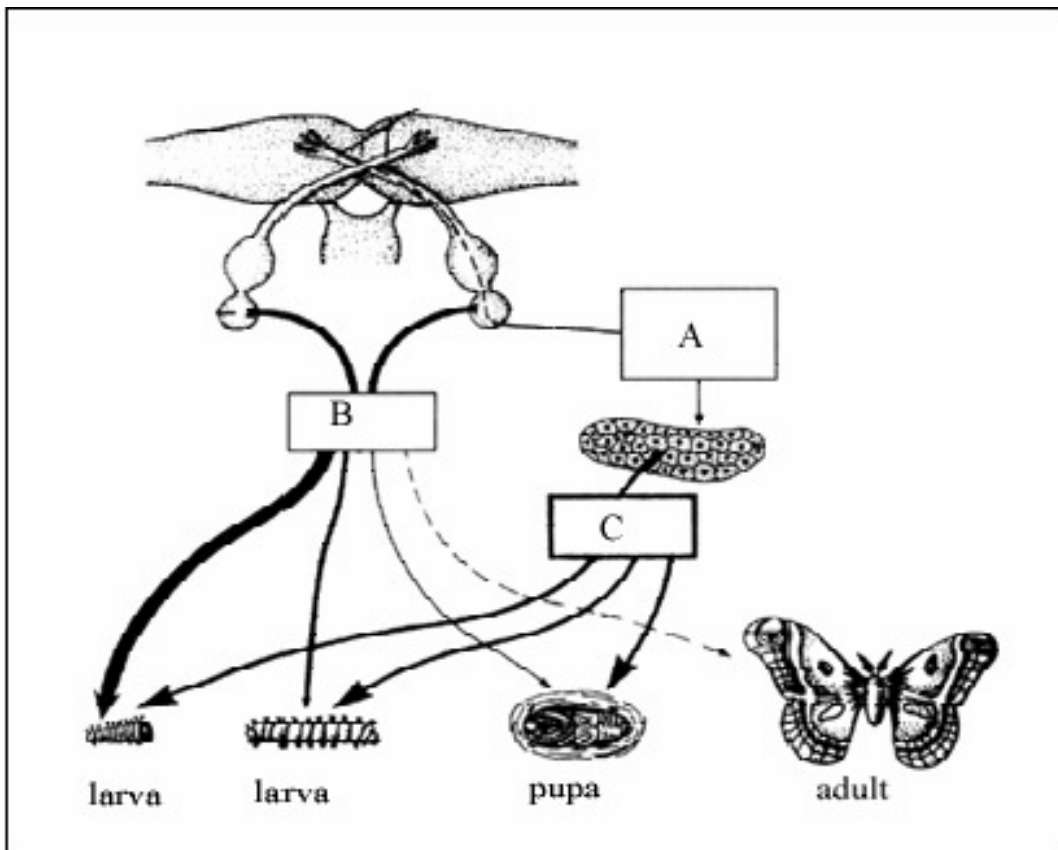
4. \_\_\_\_\_ Stimulus opening of some sodium channels

156. Molting is a process observed in insects. Which of the following statements is/are true? (1 point)

- (1) The exoskeleton of insects is largely made of protein and chitin.
- (2) The structure of chitin is similar to that of bacterial cell wall peptidoglycan.
- (3) No enzyme has been found to digest chitin.
- (4) Molting can be observed in all arthropods.
- (5) The only place that is not covered by exoskeleton is the joints between the body and walking legs.

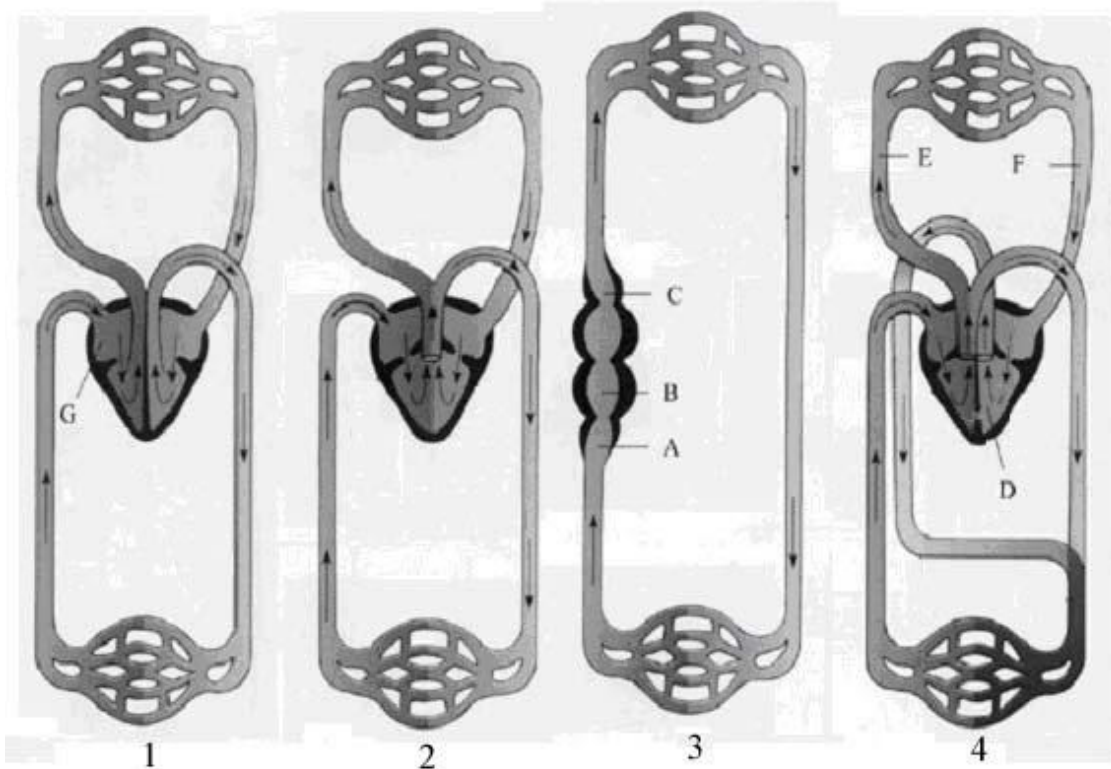
- A. 1, 2, 4, 5
- B. 1, 4
- C. 1, 3, 4, 5
- D. 1, 5

157. The mechanism of molting has largely been revealed. The figure below is a diagram of such a process. Boxes A, B and C represent 3 different growth hormones and molting hormones. Fill in the answer boxes by choosing the correct letter. (1 point)



	<b>Answer: A-C</b>
1. brain hormone (BH)	
2. juvenile hormone (JH)	
3. molting hormone (MH)	

158. The figure below shows 4 different circulation systems of vertebrates. From left to right, these are the circulation systems of (1 point)



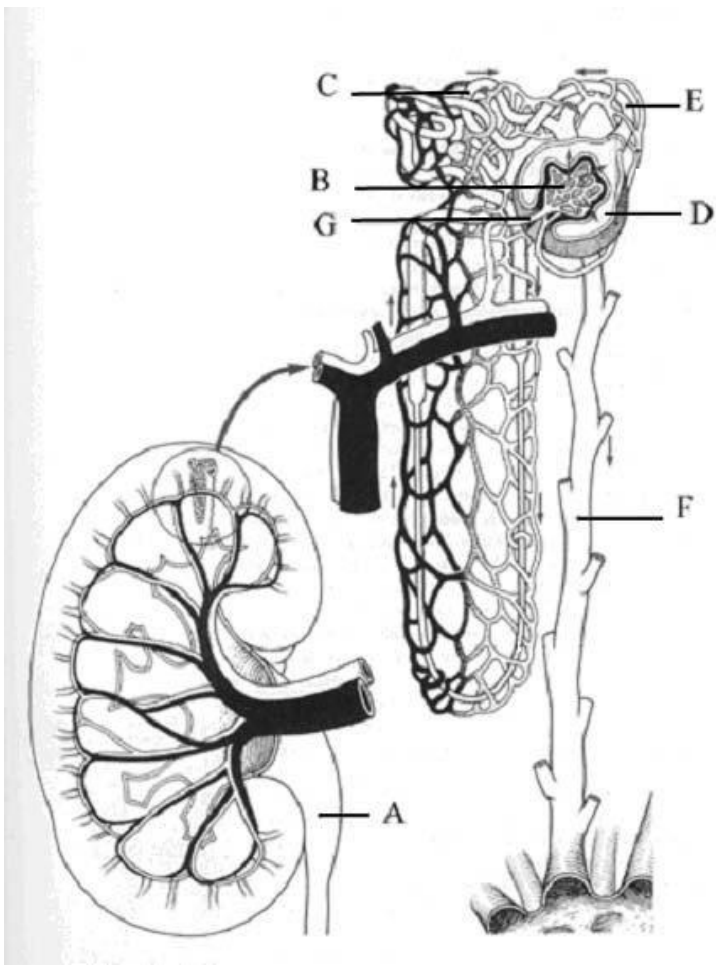
- A. mammals, reptiles, amphibians, and fish, respectively.
- B. fish, amphibians, reptiles, and mammals, respectively.
- C. mammals, amphibians, reptiles, and fish, respectively.
- D. mammals, amphibians, fish, and reptiles, respectively.

159. Match the numbers shown below with correct structures in the figure in question above (question158). (1 point)

	Answer A-G
1 Sinus venosus	
2. Atrium	
3 Pulmonary vein	
4 Pulmonary artery	
5 Conus arteriosus	
6 Right Atrium	
7 Left ventricle	



Questions 160-162. The structure of a mammalian kidney is shown below.



160. Match the following terms with the correct structures shown in the figure. (1 point)

1. collecting duct
2. glomerulus
3. distal tubule
4. Bowman`s capsule
5. proximal tubule
6. ureter
7. afferent arteriole

	Answer A-G
1	
2	
3	
4	
5	
6	
7	

161. The substances that are reabsorbed in the proximal tubule is/are: (1 point)

- (1)  $\text{Na}^+$
- (2)  $\text{Cl}^-$
- (3) Water
- (4) Glucose
- (5) Amino acids
- (6) Urea

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

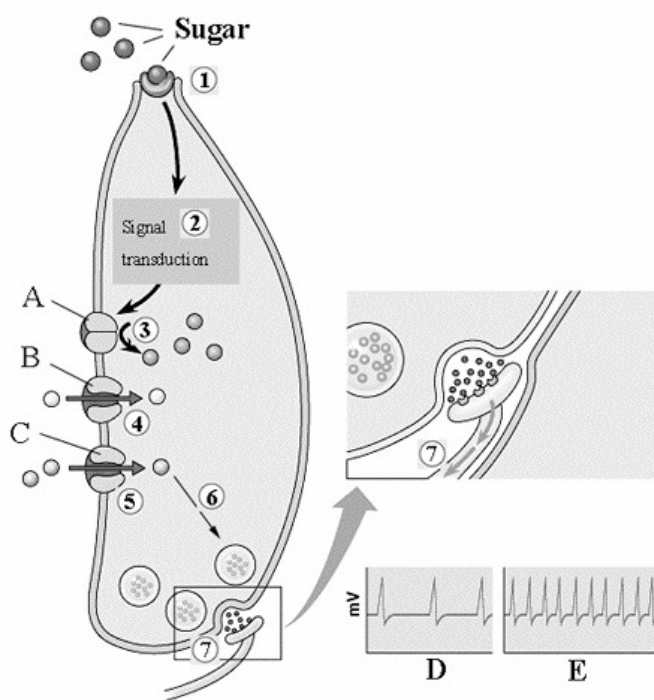
162. In the kidney, ultrafiltration occurs in which of the following structures? (1 point)

- (1) Nephrons
- (2) Bowman's capsule
- (3) Proximal tubule
- (4) Distal tubule
- (5) Collecting duct

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

**Questions 163-166.** Sensory transduction by a taste receptor is shown in the figure below.

The sequential events of the transduction is labeled by numbers 1 to 7. A portion of the cell is magnified. Structures A B and C are different channels



163. Structure A which is responsible for event 3 is a (1 point)

- A. Potassium channel
- B. Calcium channel
- C. Sodium channel
- D. Neurotransmitter channel
- E. Glycine channel

164. Structure C which is responsible for event 5 is a (1 point)

- A. Potassium channel
- B. Calcium channel
- C. Sodium channel
- D. Neurotransmitter channel
- E. Glycine channel

165. Event 4 by structure B (1 point)

- A. depolarizes membrane potential.
- B. increases membrane permeability
- C. transports more sugars molecules into the cell.
- D. transports signal molecules into the cell so that the cell starts to synthesize neurotransmitters.
- E. transports precursor molecules of neurotransmitters into the cell so that the cell can synthesize neurotransmitters.

166. Which of the following statements is/are true about the action potentials shown as D and E in the figure? (1 point)

- (1) They were both recorded after and before sugar molecules were present, respectively.
- (2) They were recorded before and after sugar molecules were present, respectively.
- (3) The action potential observed after sugar reception is triggered by an increase of calcium ions which stimulate neurotransmitter release.
- (4) The action potential observed after sugar reception is triggered by an increase of Potassium ions which stimulate neurotransmitter release.
- (5) The action potential is recorded from taste sensory receptor cells.

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

167. ~~Which of the following is NOT a mechanism of animal migration? (1 point)~~

- ~~=====~~ A. Cruising
- ~~=====~~ B. Piloting
- ~~=====~~ C. Navigation
- ~~=====~~ D. Orientation

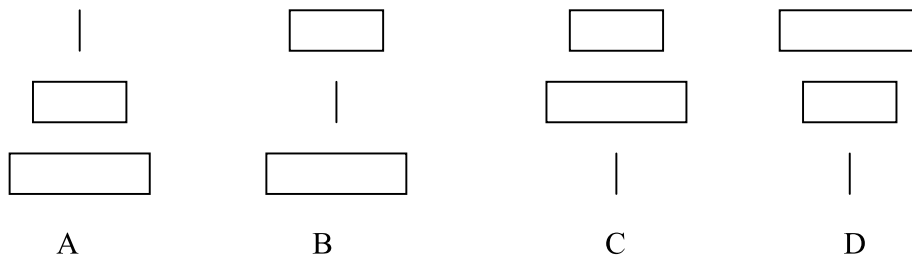
168. Both snake and weasel hibernate. Which of the following is correct? (1 point)

- A. They will die when temperature decreases below the critical temperature.
- B. Weasel will die when temperature decreases below the critical temperature.
- C. Snake will die and weasel will wake up when the temperature decreases below the critical temperature.
- D. Weasel keeps low body temperature and slow heart rate during the entire period of hibernation.

169. ~~It is possible to predict bird diversity based on forest types. Which of the following is most critical to bird diversity for a forest? (1 point)~~

- ~~A. Forest area~~
- ~~B. Vertical stratification~~
- ~~C. Species composition of plants~~
- ~~D. Coniferous or deciduous forests~~

170. Four quantity pyramids (total number of organisms) are shown below. Which is representative for plant-aphid-ladybug (ladybird)? (1 point)

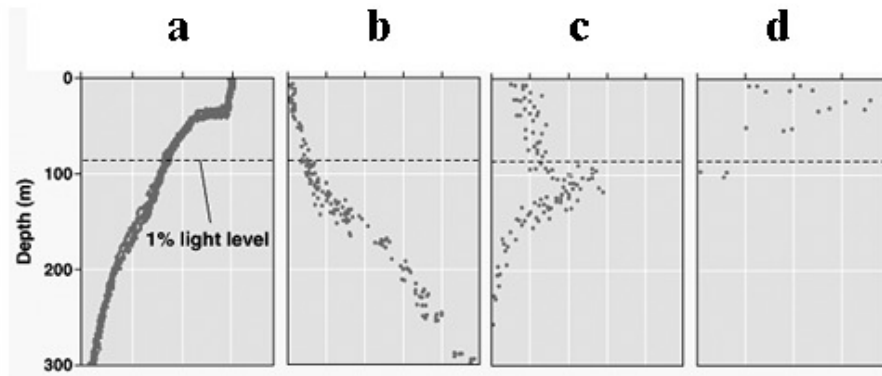


171. Which of the following ecosystems has the highest net primary productivity? (1 point)

- A. Tropical rain forest
- B. Open ocean
- C. Northern coniferous forest
- D. Farm lands

172. The figure below shows the vertical distribution of some parameters (Chlorophyll, Phosphate, Primary production and Temperature) in the North Pacific during summer.





From left to right, letter a through letter d represent: (1 point)

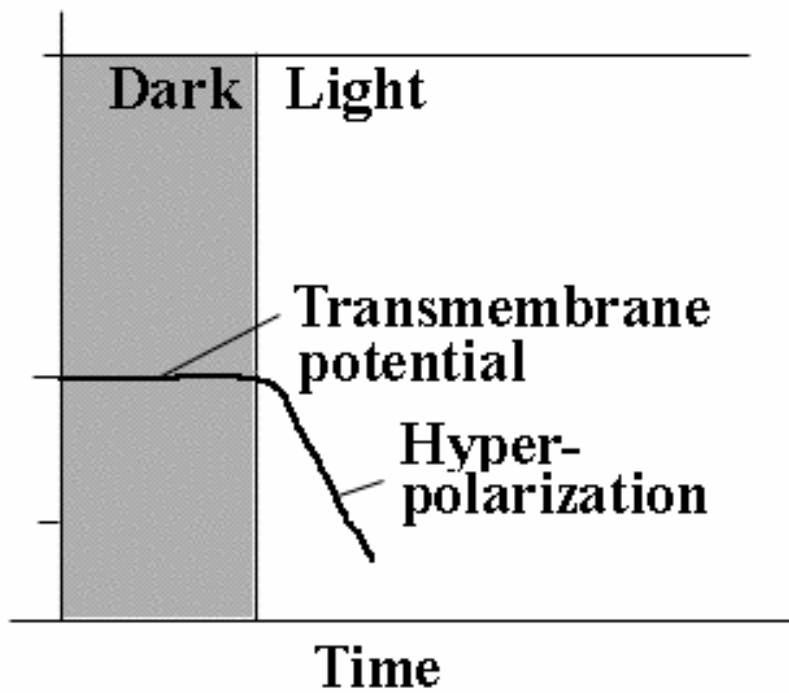
- A. Temperature, phosphate, chlorophyll and primary production
- B. Chlorophyll, phosphate, temperature and primary production
- C. Primary production, phosphate, temperature, chlorophyll
- D. Phosphate, temperature, primary production and chlorophyll.

173. The length of a food chain in a food web is often quite short. Usually, the length is shorter than 5 links. Which is mostly likely reason for the shortness of the food chain?

(1 point)

- A. The population of final predator is often too large.
- B. The primary producers can sometimes be indigestible.
- C. Only about 10% of energy in one link can be converted to organic matters in next trophic level.
- D. Wintertime is too long and low temperature limits primary productivity.

174. The figure below shows a membrane potential graph detected after a rod cell of human eyes sees light. Which of the following is the direct trigger for the hyperpolarization? (1 point)



~~A. Retinal switches from cis form to trans form.~~

~~B. Cyclic GMP is destroyed.~~

~~C. Transducin is activated.~~

~~D. Potassium channel is closed~~

~~E. Sodium channel is closed.~~