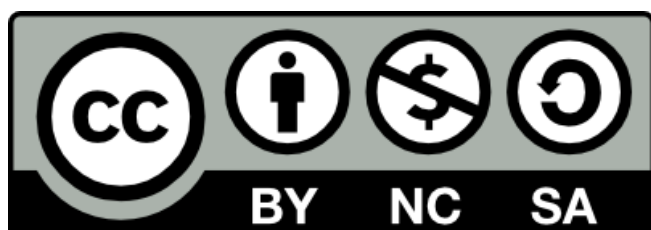




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Country _____

Competitor# _____



16th International Biology Olympiad

**Beijing
July, 2005**

THEORY EXAMINATION

Part 1

Total time available: 2.5 hours (150 minutes)

Total points available: ~80

GENERAL INSTRUCTIONS

Please check that you have the appropriate examination papers and answer sheets.

It is recommended that you manage your time in proportion to the points allocated for each question.

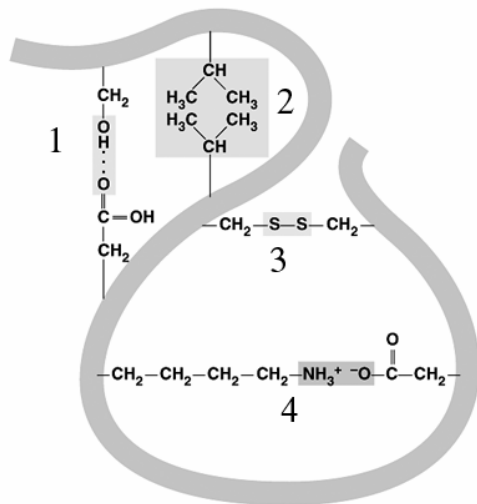
IMPORTANT

Use the answer sheets provided to record your answers.

Ensure your name and three digit code numbers are written on the top of each page of the answer sheets.

Use the 2B pencil provided to fill in the correct answers on the answer sheet.

1. Various forces are important in the interactions contributing to the tertiary structure of a protein. The figure below is a diagram showing several possible interactions. Please match the numbered interactions with their correct names. (1 point)



- A. Hydrogen bond
- B. Hydrophobic interaction
- C. Peptide bond
- D. Disulphide bond
- E. Ionic bond

Interactions	Answer: A-E
1	
2	
3	
4	

2. Which of the following statements about cytokinesis in plant cells is/are **NOT** correct ?

(1 point)

- (1) Plant cells form cell plates
- (2) Cytokinesis can start during mitosis
- (3) Plant cells have a contracting ring
- (4) Membrane fusion connects cell plate and the cytoplasmic membrane of the mother cell.
- (5) Golgi apparatus does not participate in cytokinesis of a plant cell until two daughter cells are formed.

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

3. DNA ligase is an important enzyme that connects DNA fragments. Which of the following is/are **TRUE** about DNA ligase? (1 point)

- 1) It is important to the DNA replication process
- 2) It is important in molecular cloning
- 3) It requires DNA fragments having sticky ends
- 4) It could cut DNA molecules in the presence of ATP and Mg^{2+} .
- 5) It requires ATP for its function because the 3'-hydroxyl group of a DNA fragment needs to be phosphorylated before the DNA molecules could be ligated.

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

Questions 4-6: Checkpoints in the cell cycle are very important in regulation of cell cycle. The following three questions are about the cells cycles and checkpoints.

4. Two animal cells at different phases in the cell cycle can be induced to fuse to form a single cell with two nuclei. This system provides a very useful tool for studying the cell cycle.

Which of the following is correct? (1 point)

- A. When a cell in M phase is fused with a cell in G_1 phase, the nucleus in M phase stops the mitotic process.
- B. When a cell in M phase is fused with a cell in G_2 phase, the nucleus in G_2 phase starts the mitotic process.
- C. When a cell in G_2 phase is fused with a cell in G_1 phase, both nuclei start the mitotic process.
- D. When a cell in M phase is fused with a cell in G_1 phase, the nucleus in G_1 phase starts DNA synthesis.
- ~~E. When a cell in M phase is fused with a cell in G_1 phase, the nucleus in M phase stops the mitotic process.~~

5. Which of the following are true about checkpoints in the cell cycle? (1 point)

- (1) If a cell in the G_1 phase does not receive a signal at the G_1 checkpoint, the cell usually goes into the G_0 phase.
- (2) A cell must receive a signal at the G_2 checkpoint to go into mitosis.
- (3) A cell must receive a signal at the M checkpoint to go into mitosis.
- (4) The protein factors that control checkpoints in cell cycle are mostly present in nuclei.
- (5) The cell cycle in unicellular organisms does not have checkpoints.

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

6. In cloning the first mammal, researchers used a mammary cell as the nuclear donor and fused it with an enucleated egg (cell with nucleus removed). Which of the following is **CORRECT**? (1 point)

- A. The mammary cell was in G_1 phase
- B. The mammary cell was in G_2 phase
- C. The mammary cell was in S phase
- D. The mammary cell was in M phase
- E. The mammary cell was in G_0 phase

7. Cyanobacteria (blue-green algae) are a group of very important bacteria that perform photosynthesis. Which of the following is/are **TRUE** about cyanobacteria. (1 point)

(1) They are gram-negative bacteria

(2) They produce oxygen in photosynthesis

(3) All cyanobacteria can fix nitrogen

(4) Some cyanobacteria can live with fungi symbiotically

(5) The blue-green color of cyanobacteria comes solely from chlorophyll

A. All are correct (1, 2, 3, 4, 5)

B. 1, 2, 3, 4

C. 1, 2, 3

D. 1, 2, 4

E. 1, 2

Questions 8-9 are about biotechnology of transgenic organisms or genetically modified organisms (GMO).

8. In creating “golden rice” that produces betacarotenes in rice kernels, the genes responsible for betacarotene synthesis are transformed. Which of the following is/are true? (1 point)

- (1) The researcher used normal rice for transformation
- (2) The researcher used Ti plasmid for transformation
- (3) The researcher used a dicot plant for transformation first followed by crossing between the dicot plant and the rice plant
- (4) Golden rice has a higher nutritional value than normal rice
- (5) Beside *Agrobacterium*, the researcher also used another bacterium, *Escherichia coli* in construction of transforming vectors.

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

~~9. When a DNA fragment under control of a promoter was transformed into tobacco plants with Ti plasmid, the transgenic plants showed a lower activity of CO₂ fixation. Biochemical examination found that the transgenic plant had a lower amount of Rubisco, a key enzyme for Calvin cycle. Which of the following is/are likely to be the reason(s) for the phenotype? (1 point)~~

- ~~(1) The DNA fragment was transformed into chloroplasts and resulted in interference with chloroplast transcription.~~
- ~~(2) Genetic exchange between the transformed DNA fragment and host chromosomal DNA resulted in insertion of Ti plasmid into chromosome, leading to a lower expression of Rubisco genes~~

~~(3) The transformed DNA fragment interfered normal transcription of the gene encoding large subunit of Rubisco~~

~~(4) The transformed DNA fragment interfered normal transcription of the gene encoding small subunit of Rubisco~~

~~A. 1, 2, 5~~

~~B. 1, 3, 4~~

~~C. 1, 4,~~

~~D. 4,~~

~~E. 3~~

10. Which of the following is/are true about endosymbiosis? (1 point)

- (1) Both plastid and lysosome are products of endosymbiosis
- (2) Eukaryotic cells could engulf other eukaryotic cells to establish a symbiotic relationship
- (3) Cyanobacteria are ancestors of plastids and mitochondria
- (4) Cyanobacteria lost their chlorophyll b gene in endosymbiosis.
- (5) Flagella of some eukaryotic cells are derived from cyanobacteria

A. 1, 3, 5

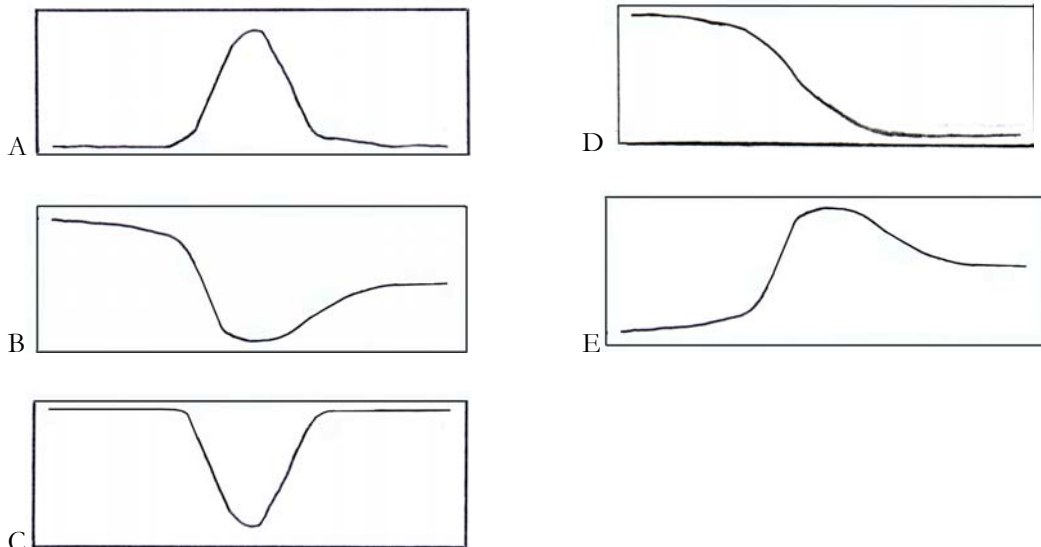
B. 1, 2

C. 2, 4

D. 2

E. 4

11. Which of the following graphs correctly displays the relationship of blood flow velocity in humans as the blood flows from the aorta → arteries → arterioles → capillaries → venules → veins → venae cavae: (1 point)



12. Lowering the level of a hedge with a hedge trimmer stimulates the hedge to become bushy because: (1 point)

- A. It stimulates the production of ethylene gas.
- B. Removing the apical meristems makes more auxin, which stimulates lateral branch buds to grow.
- C. Removing the apical meristems makes less ethylene, which stimulates lateral branches to grow
- D. Removing the apical meristems results in less auxin, which then allows lateral branches to grow.
- E. Removing the lateral buds results in apical dominance under the influence of cytokinins

13. Which of the following is/are true about telomeres? (1 point)

- (1) Telomeres are present in all DNA in eukaryotic cells
- (2) Telomeres are present in bacterial plasmids
- (3) Telomeres are required for replication fork formation
- (4) Telomeres are specific sequences present in eukaryotic chromosomes
- (5) Telomeres are required for maintaining chromosomal length

A. 1, 3, 5,

B. 3, 4, 5

C. 4, 5

D. 2

E. 3

14. For terrestrial and most aquatic environments, neither animal nor plant life could exist without the metabolic "services" provided by: (1 point)

- A. chemoheterotrophs
- B. extremophile archaeans
- C. Fungi
- D. *Homo sapiens*
- E. Fertilizer

15. The inner ear of humans, and most other mammals, is sensitive to body position and balance. What organ(s) is/are responsible for this? (1 point)

- A. cochlea
- B. cochlea and basilar membrane
- C. semicircular canals
- D. semicircular canals and cochlea
- E. semicircular canals, utricle, and saccule

16. Flukes are often parasites in or on another animals. They could cause diseases in human beings. Blood fluke (*Schistosoma mansoni*) is a parasitic trematode that infects men. Which one of the following is **NOT** true about its life cycles. (1 point)

- A. There are two types of larvae in the fluke
- B. It reproduce asexually in the human host
- C. The larvae need water to swim
- D. Its infection of human being is through skin
- E. An intermediate host is often required for completion of their life cycle.

17. In animal behavior a sign stimulus could trigger a fixed action pattern (FAP). Which of the following is **NOT** an example of sign stimulus-FAP? (1 point)

- A. Some moths fold their wings and drop to the ground when they detect an ultrasonic signal from bats.
- B. A wasp finds its nest according to the surrounding objects.
- C. A newly hatched bird cheeping loudly in begging for food when its parent returns to nest.
- D. Breeding mayflies lay eggs when they detect water.

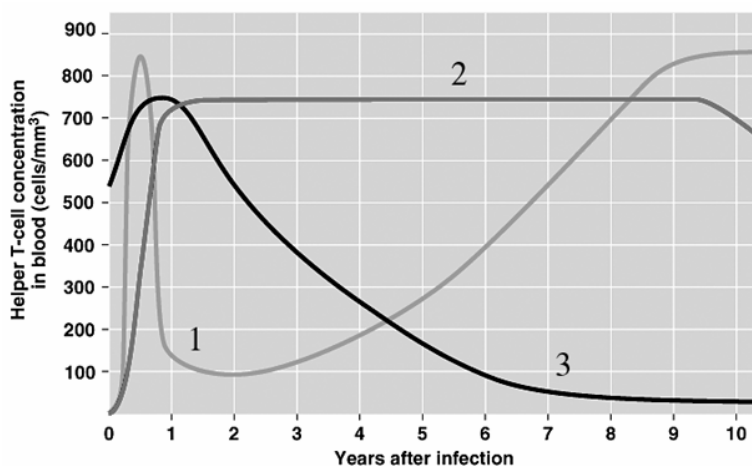
18. Some birds (eg Gulls) feed on mollusks. The birds grasp the prey and fly upwards to a certain height before they drop the prey onto a rock to break the shells. If the shell was not broken by the first drop, the birds will pick it up and drop it again until it is broken. In one experiment, researchers found the following relationship between the drop heights and the number of times it was dropped before the shell broke. (1 point)

Height of drop (m)	Number of drops required to break shell
1	67
2	46
3	18
4	6
5	5
6	4
12	3

According to the optimal foraging theory, which of the following is the most likely height that the birds would fly to drop the shells?

- A. 6.5 m
- B. 4.5 m
- C. 2.5 m
- D. 3.5 m
- E. 12.5 m

19. The figure below shows cytological and biochemical changes of a human infected by HIV. There are three curves in the figure labeled as 1 through 3. Which of the following is **CORRECT**? (1 point)



- A. Curve 1 represents viral numbers
Curve 2 represents concentration of antibodies against HIV
Curve 3 represents T-cell mediated immunity
- B. Curve 1 represents T-cell mediated immunity
Curve 2 represents concentration of antibodies against HIV
Curve 3 represents viral numbers

C. Curve 1 represents T-cell mediated immunity

Curve 2 represents viral numbers

Curve 3 represents concentration of antibodies against HIV

D. Curve 1 represents concentration of antibodies against HIV

Curve 2 represents T-cell mediated immunity

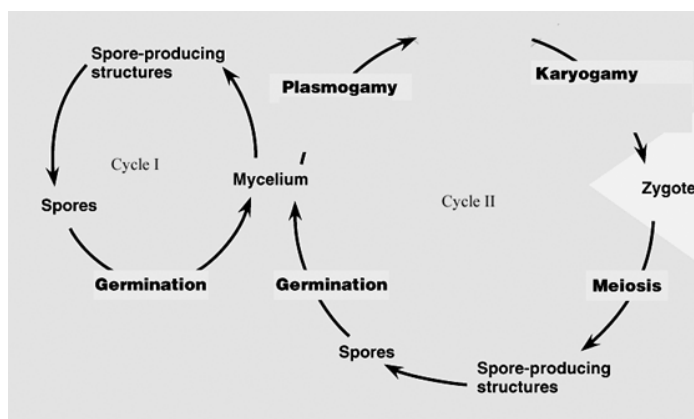
Curve 3 represents viral numbers

E. Curve 1 represents viral numbers

Curve 2 represents T-cell mediated immunity

Curve 3 represents concentration of antibodies against HIV

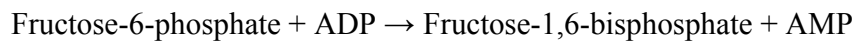
20. The figure below shows a generalized life cycle of fungi. Which of the following is/are **TRUE**? (1 point)



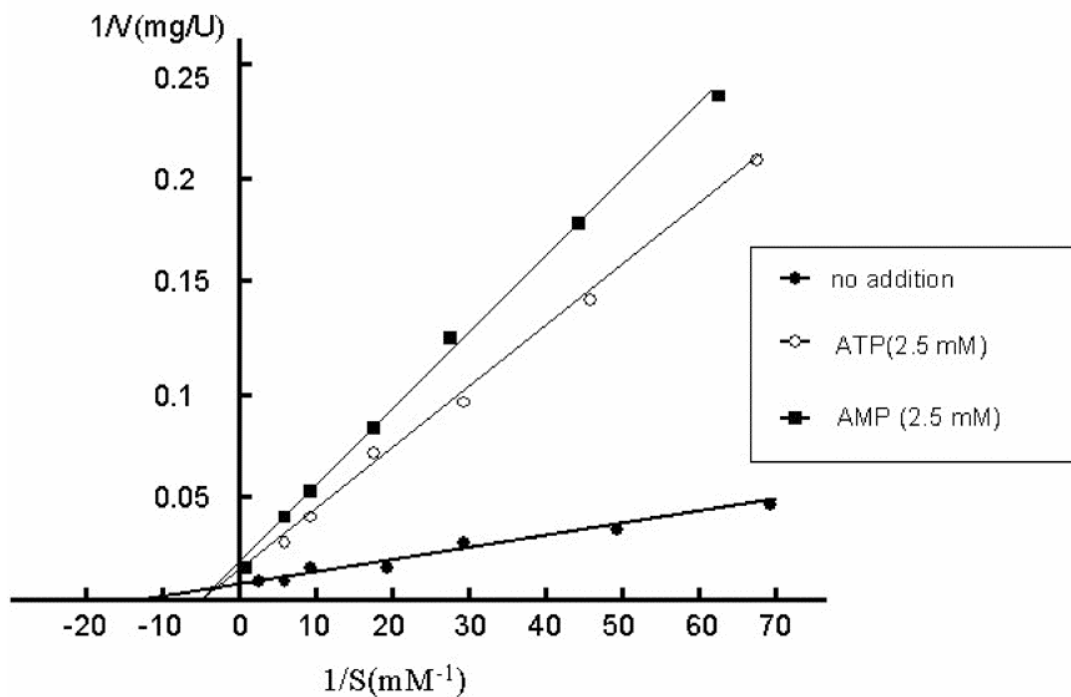
- (1) Spores are generally haploid
- (2) Cycle I is a sexual life cycle and cycle II is an asexual life cycle
- (3) Diploid fungi are formed after plasmogamy
- (4) There are two types of mycelia that mate even though they may look alike.

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

Questions 21-24. The hyperthermophilic archeon, *Pyrococcus furiosus*, has an unusual phosphofructokinase. It catalyzes the following reaction:



It was found that the addition of glucose, pyruvate, phosphoenolpyruvate, citrate and fructose-2,6-bisphosphate did not show any effect on the reaction rate. The effects of ATP and AMP addition were shown as Lineweaver-Burk plots:



Answer the following questions:

21. Which of the following statements is **TRUE** ? (1 point)

- A. The reaction is ATP-dependent.
- B. The reaction is ADP-dependent.
- C. The reaction is AMP-dependent
- D. None of the above answers are true.

22. What is the effect of ATP or AMP on the reaction rate? (1 point)

- A. Only allosteric Stimulation
- B. Only allosteric inhibition
- C. Only competitive inhibition
- D. Only uncompetitive inhibition
- E. Mixed inhibition

23. Does this phosphofructokinase play an important role in the regulation of glycolysis in *Pyrococcus furiosus*? (1 point)

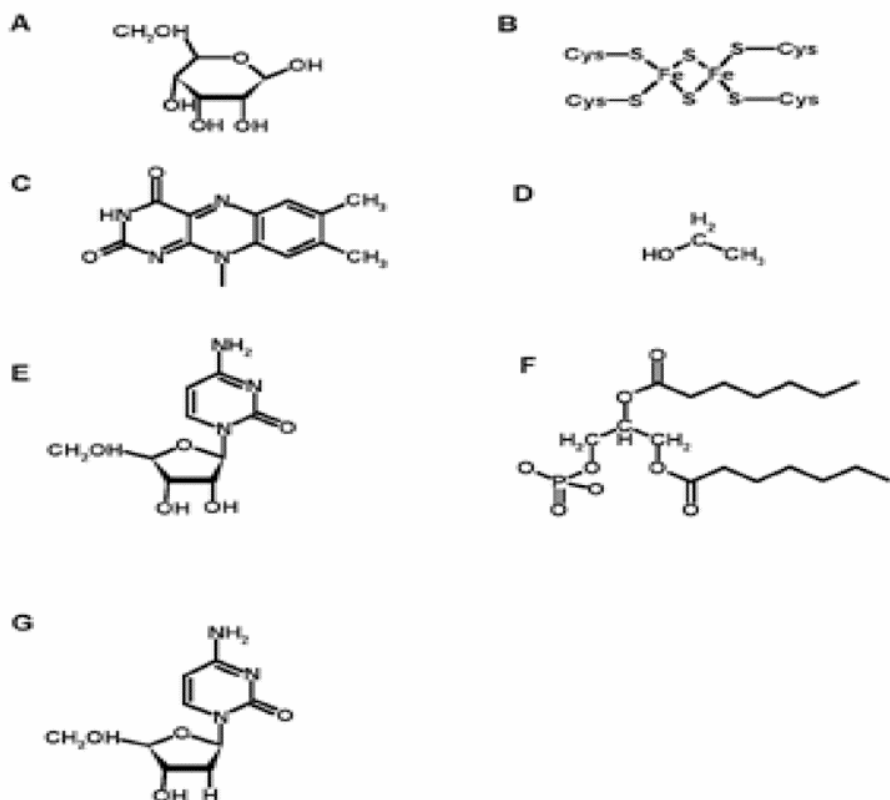
- A. Yes
- B. No
- C. The conclusion cannot be drawn.

24. *Pyrococcus furiosus* phosphofructokinase was purified and gave a single band at 52 kDa on SDS-polyacrylamide gel electrophoresis. Its native molecular mass was determined by gel filtration chromatography to be approximately 190 kDa. The protein is: (1 point)

- A. monomer
- B. dimer
- C. trimer
- D. tetramer
- E. hexamer

25. Match the following names or descriptions to the right biochemical compounds listed.

(2 points)



1. Nucleoside found in DNA
2. Phospholipid
3. A yeast fermentation product
4. Monosaccharide
5. Iron-sulfur center

Answer [A-G]
1.
2.
3.
4.
5.

~~26. Antibiotics are antimicrobial substances produced by some organisms to prevent growth of other organisms. Match the following antibiotics as inhibitors to their cellular targets: (1 point)~~

~~A. Cell wall synthesis~~

~~B. Plasma membrane formation~~

~~C. DNA replication~~

~~D. RNA transcription~~

~~E. Protein translation~~

	Answer (A-E)
1. Polymyxins	
2. Tetracycline	
3. Rifampin	
4. Penicillin	
5. Mitomycin	

~~27. Glucose labeled with ^{14}C at C-1 is incubated with the glycolytic enzymes and necessary cofactors. What is the distribution of ^{14}C in the pyruvate that is formed? (1 point)~~

~~A. The label is in the methyl carbon atom of pyruvate.~~

~~B. The label is in the carboxyl carbon atom of pyruvate.~~

~~C. The label is in both the methyl and carboxyl carbon atoms of pyruvate.~~

~~D. The label is in the middle carbonyl carbon atom of pyruvate.~~

28. A common component of NADP, NAD, FMN, FAD, and coenzyme A is: (1 point)

- A. A pyrimidine ring
- B. A three ring structure
- C. An ADP
- D. Deoxyribose
- E. A triphosphate group

29. Which of the following statements is/are **CORRECT**? (1 point)

- (1) The citric acid cycle (Krebs/TCA cycle) does not exist as such in plants and bacteria, because its functions are performed by the glyoxylate cycle.
- (2) The citric acid cycle oxidizes the acetyl CoA derived from fatty acid degradation.
- (3) The citric acid cycle produces most of the CO₂ in anaerobic organisms.
- (4) The citric acid cycle provides succinyl CoA for the synthesis of carbohydrates.
- (5) The citric acid cycle provides carbon skeletons for amino acid synthesis.

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

30. Key enzymatic differences between liver, kidney, muscle and brain account for their differences in the utilization of metabolic fuels. Which of the following does **NOT** represent such a biochemical difference? (1 point)

- A. The liver contains glucose 6-phosphatase, whereas muscle and the brain do not. Hence muscle and the brain, in contrast with the liver, do not release glucose into the blood.
- B. The liver has little of the transferase needed to activate acetoacetate to acetoacetyl CoA. Consequently, acetoacetate and 3-hydroxybutyrate are exported by the liver and be used by heart muscle, skeletal muscle and the brain.
- C. Under conditions of prolonged starvation, the fatty acids stored in the adipose tissues will be converted into ketone bodies there before being transported to the brain and muscle for complete oxidation.
- D. Lactate dehydrogenase does not appear to exist in the heart muscle. As a result, the heart depends on aerobic oxidation to obtain the energy for its continuous pumping.

31. An organelle in eukaryotic cell is spherical or ovoid with a diameter of 0.1 to 1.5 μm and consists of a single membrane. It participates in a variety of metabolic processes, including H_2O_2 -based respiration and lipid metabolism. This organelle is most likely to be? (1 point)

- A. Mitochondrion
- B. Peroxisome
- C. Endoplasmic reticulum
- D. Lysosome
- E. Endosome

32. A red alga has two major kinds of photosynthetic pigments: phycobilisomes (phycobilins) that absorb green light and chlorophylls that absorb red and blue light. A student performed an experiment and obtained measurement data as shown in table. Note: light intensity remained constant during the experiment.

Light quality	Photosynthetic oxygen evolution rate
Blue light only	28
Green light only	65
Red light only	47
Blue and green	150
Blue and red	73
Green and red	146

Which of the following is/are **NOT** correct? (2 points)

- (1) Blue light absorption was less efficient in photosynthetic electron transfer because the blue light is mostly absorbed by chlorophyll b.
- (2) Red light is more efficiently absorbed by chlorophyll than blue light.
- (3) An enhancement effect, caused by the simultaneous excitation of the two photosystems, is observed in this experiment.
- (4) It is predicted that more overlapping is present in the long wavelength region than in the short wavelength region between phycobilisome absorption spectrum and chlorophyll absorption spectrum.

A. 1, 2, 4

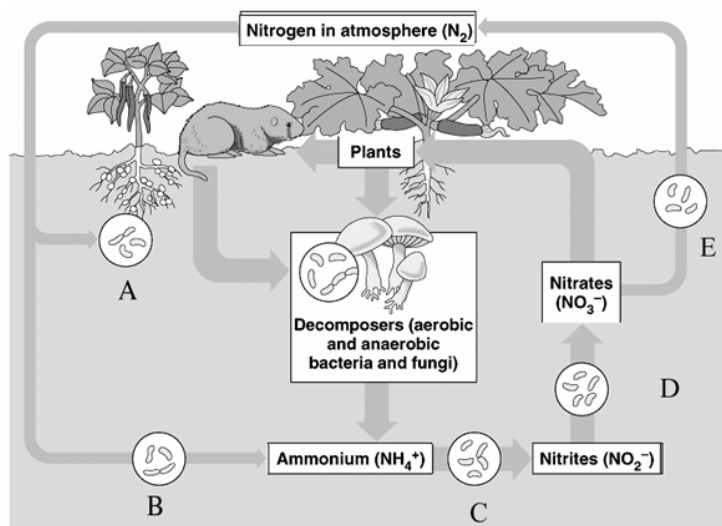
B. 1, 3, 4

C. 3, 4

D. 1, 2

E. 1

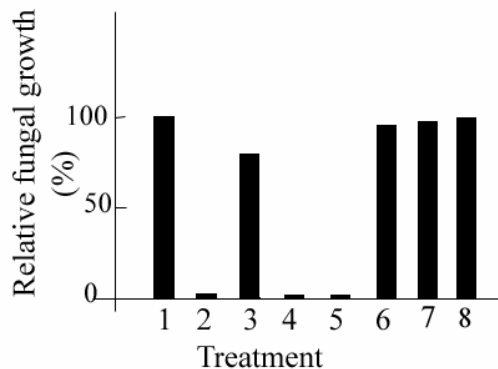
33. The figure below shows the nitrogen cycle. Complete the table below according to the information provided. (1 point)



Bacteria:	Answer: A through E. Note: there could be more than one correct answer
(1) Able to form nodules with plants	
(2) Able to denitrify	
(3) Able to nitrify	
(4) Able to use ammonium as energy source	
(5) Able to fix nitrogen from air	

34. A researcher found that seeds from a plant could inhibit the growth of some fungi.

He isolated some substances from the seeds and performed analyses. The figure below is the result. He also ran a regular SDS-gel electrophoresis that separated molecular standard proteins from 14 kDa to 100 kDa.



Treatment 1: no addition of the substance.

Treatment 2: addition of the substance.

Treatment 3: addition of the substance that was treated with β -mercaptoethanol (BME)

Treatment 4: same as treatment 3 except that BME was removed before addition of the substance to the fungal culture.

Treatment 5: the substance was treated at 80°C for 20 min before the addition to the fungal culture.

Treatment 6: the substance was treated at 80°C for 20 min in the presence of BME before the addition to the fungal culture.

Treatment 7: the substance was treated with trypsin.

Treatment 8: only trypsin was added to the fungal culture.

He found no protein could be detected in this molecular mass range with Coomassie stain (a protein stain) even though the substance(s) showed Coomassie binding in solution.

The substance(s) is colourless, but had a strong absorption in the UV region. Which of the following is/are correct? (2 point)

- (1) The substance(s) contains protein
- (2) The substance(s) has a disulphide bond that is important to its function
- (3) The substance(s) is stained poorly with Coomassie blue
- (4) The substance(s) is a protein with molecular mass smaller than 14 kDa.
- (5) The substance(s) is not resistant to trypsin treatment.

A. 1, 2, 3, 4, 5

B. 1, 2, 4

C. 1, 3, 4

D. 1, 4

E. 1, 5

35. Calculate the pI (isoelectric point) value of aspartic acid. Its pK_1 is 2.09, pK_2 is 3.86, pK_3 is 9.82. (1 point)

A. 5.26

B. 2.98

C. 5.96

D. 6.84

36. When we refer to a plant as a “short-day plant”, the exact meaning is: (1 point)

- A. The plant flowers in winter
- B. The plant flowers when day is shorter than 12 hours
- C. The plant flowers only in the equator area
- D. The plant flowers when night is longer than its own critical night length
- E. A and D

37. Which of the following is the photoreceptor that responds to day-length? (1 point)

- A. Chlorophyll
- B. Carotenoids
- C. Cytochrome
- D. Phytochrome
- E. Retinal

38. Which of the following statements is correct? (1 point)

- A. A flower is a reproductive organ
- B. A flower lacking any of sepal, petal, stamen or carpel is an imperfect flower
- C. Most grasses have imperfect flowers
- D. Floral parts in all angiosperms are arranged as four whorls
- E. Floral parts are sequentially initiated at the floral meristem

39. One of the means to prevent self-fertilization in plants is self-incompatibility. Which of the following statements is/are **TRUE** about self-incompatibility? (1 point)

- (1) The plants that show self-incompatibility have a unique stigma structure.
- (2) The flowers of the plants that show self-incompatibility only produce pollen when stigmas fail to develop.
- (3) Self-incompatibility is analogous to the animal immune response in that both have the ability to distinguish the cells of “self” from those of “nonself”.
- (4) Pollen from one plant will only develop a pollen tube on its own stigma if a pollen from another plant is present on the stigma.
- (5) Pollen from one plant will develop a pollen tube on its own stigma, but will not be able to fertilize the egg.

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

40. Where do you find cells that undergo meiosis in plants? (1 point)

- A. In the shoot apical meristem
- B. In the pollen
- C. In embryo sacs
- D. In the corolla
- E. In the ovule

41. Which of the following structures of plants consists of haploid cells? (1 point)

- A. Sporophytes
- B. Sporocytes
- C. Sporangia
- ~~D. Tapetum~~
- E. Gametophyte

Questions 42-45. Algae play very important roles in ecosystems. They are also diverse in pigmentation.

42. Red algae differ from green algae and brown algae in that (1 point)

- A. Red algae produce agar
- B. Red algae do not produce chlorophyll a
- C. Red algae do not have sexual reproduction
- D. No unicellular red alga has been found
- E. Red algae do not produce flagellated cells in their life cycle.

43. Dinoflagellates are a group of algae. Their pigments are similar to brown algae.

Therefore, the pigments of a typical dinoflagellate are similar to: (1 point)

- A. Pigments of Chlamydomonas
- B. Pigments of Volvox
- C. Pigments of a diatom
- D. Pigments of a red alga
- E. Pigments of blue-green algae

44. According to their pigmentation, which algal group would be most likely to perform photosynthesis in deepest water? (1 point)

- A. Red algae
- B. Green Algae
- C. Brown algae
- D. Golden algae

45. Seaweeds are large marine algae and they play very important role in marine ecosystems. Which of the following is/are **NOT** true about seaweeds? (1 point)

- (1) Most seaweeds are brown algae.
- (2) Diatoms can sometimes be large enough to be included as seaweeds.
- (3) Seaweeds have complicated structures such as leaves.
- (4) Seaweeds live in deep water
- (5) They use their holdfast to absorb nutrients

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

46. Apoptosis was first described in nematodes and was later found to be present in many organisms. Which of the following is **NOT** true about apoptosis? (1 point)

- A. It was discovered by cell lineage analysis of nematodes
- B. It is a critical process in animal development.
- C. It is controlled by a single gene
- D. It is found in insects
- E. Proteases and nucleases participate in apoptosis.

47. After synthesis, proteins are transported either by non-vesicular transport or by vesicular transport. Answer A for vesicular or B for Non-vesicular to indicate how each of the proteins indicated in the table is transported. (0.2x9, 1.8 points)

Proteins:	Answer A or B
1. cytoskeletal proteins	
2. Mitochondrial proteins	
3. Lysosomal proteins	
4. Nuclear proteins	
5. Cytoplasmic enzymes	
6. integral plasma membrane (cell surface) proteins	
7. secreted proteins	
8. Chloroplast proteins	
9. Peroxisomal protein	

48. An action potential in neurons is characterized by all of the following except that (1 point)
- A. It is initiated by opening of voltage-gated potassium channels
 - B. It is regarded as a regenerative response
 - C. It is regarded as an all-or-nothing response
 - D. It does not reduce in magnitude with space or time
 - E. It is characteristic of transmembrane potential changes that occur in most axons.

49. The resting potential in most neurons is primarily due to the membrane permeability of (1 point)

- A. Calcium
- B. Chloride
- C. Sodium
- D. Potassium
- E. Magnesium

50. Which of the following cell cycle phases is usually the shortest in duration? (1 point)

- A. G_1
- B. G_0
- C. G_2
- D. S
- E. M

51. Which of the following is/are often used for protein purification? (1 point)

- (1) Gel filtration chromatography
- (2) Ion exchange chromatography
- (3) Salt precipitation
- (4) SDS-electrophoresis
- (5) Substrate affinity chromatography

A. all of the above

B. 1, 2, 3, 4,

C. 1, 2, 4, 5

D. 1, 2, 3, 5

E. 2, 3, 4, 5

52. Which of the following is/are important in ATP synthesis? (1 point)

- (1) P700
- (2) P680
- (3) P450

A. 1

B. 2

C. 3

D. 1, 2

E. 1, 2, 3

53. Which of the following statements about mRNA is correct? (1 point)

- (1) All mRNA has a cap at its 5' end
- (2) All mRNA has a poly A tail at its 3' end
- (3) Its synthesis is performed by RNA polymerase
- (4) The stability of mRNA regulates abundance of the protein it encodes.
- (5) The codons on mRNA pair with anti-codons of tRNA through A-T, G-C hydrogen bonds

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

54. Which of the following about tRNA is/are correct? (1 point)

- (1) There are stem-loop structures
- (2) It consumes ATP in synthesis of aminoacyl tRNA
- (3) tRNA is synthesized by RNA polymerase III
- (4) tRNA is synthesized as a precursor and was processed before it is functional.
- (5) Although the theoretical number of tRNA molecules is 61, the actually number of tRNA molecules in most of the cell is smaller, partially because some anticodons can recognize more than one codon.

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

55. Which of the following is/are **NOT** true about the Freeze-fracture method in electron microscopy? (1 point)

- (1) Low temperature is used to weaken hydrogen bonding.
- (2) It is often used to observe structures within membrane.
- (3) Particles observed on fractured faces are often liposomes
- (4) Both eukaryotic and prokaryotic cells can be observed with this method
- (5) This method actually observes a replica of the specimen.

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

Questions 56-57. Yeast is one of the ideal organisms for the study of cellular, developmental and genetic processes. It can grow either on fermentable or non-fermentable carbon sources. With this property, people can isolate and analyze different yeast mutants associated with certain functions of subcellular organelles.

56. When the yeast mutant cannot grow on oleate (a long chain fatty acid), the mutant has a defect in which organelle? (1 point)

- A. Mitochondria
- B. Lysosome
- C. Peroxisome
- D. Nucleus
- E. Endoplasmic reticulum

57. When a yeast mutant cannot grow on glycerol, the mutant has a defect in which organelle? (1 point)

- A. Mitochondria
- B. Lysosome
- C. Peroxisome
- D. Nucleus
- E. Endoplasmic reticulum

58. Which of the following is **NOT** a factor influencing membrane fluidity? (1 point)

- A. Number of double bonds in the lipids
- B. Temperature
- C. Flip-flop movement of lipids
- D. Cholesterol

Questions 59-61 are about food digestion in the mammalian digestive system.

59. Which of the following is **NOT** involved directly in protein digestion? (1 point)

- A. Trypsin
- B. Dipeptidase
- C. Aminopeptidase
- D. Carboxypeptidase
- E. Enteropeptidase

60. Which of the following enzymes is **NOT** functionally present in small intestine? (1 point)

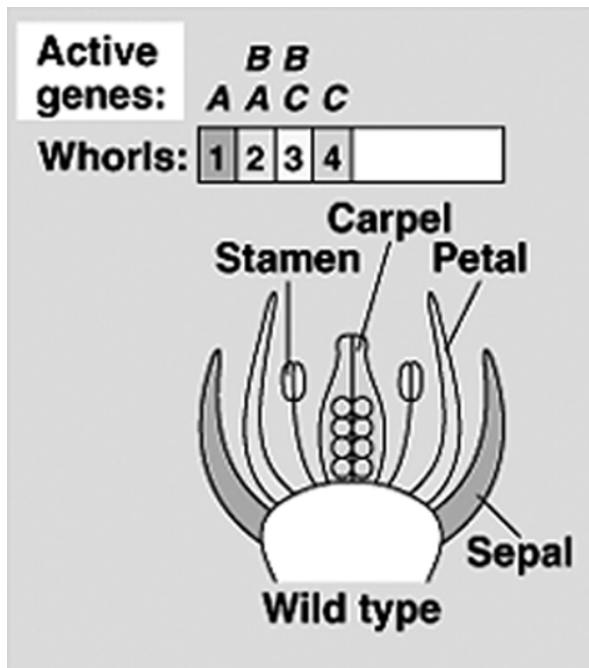
- A. Nucleases
- B. Lipase
- C. Chymotrypsin
- D. Pancreatic amylases
- E. Pepsin

61. Many hormones are involved in food digestion and absorption. Please match the functions to the appropriate hormones. (1 point)

- A. Regulation of blood sugar
- B. Stimulation of bicarbonate release
- C. Stimulation of the gallbladder to contract and release bile
- D. Stimulation of secretion of gastric juice.

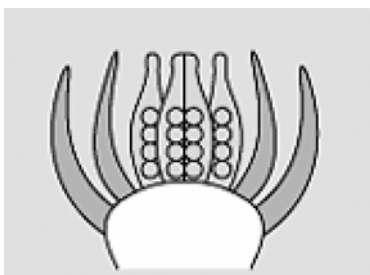
Hormones	Fill your answer
1. Cholecystokinin (CCK)	
2. Gastrin	
3. Secretin	
4. Insulin	

Questions 62-63. Flowering is one of the most sophisticated processes in plants. By analysis of flowering mutants and through other studies, researchers proposed an ABC model (hypothesis) to explain gene regulation of flower structures. Three classes of genes are involved: class A, class B and class C.



In this model, a sepal is produced when gene A is active, a petal is produced when genes A and B are active; Stamen is produced when genes B and C are active and a carpel is produced when gene C is active. When gene A is missing, gene C takes its place and when gene C is missing, gene A takes gene C's place.

62. According to the ABC model, which of the following mutants will produce the phenotype shown below? (1 point)



- A. A mutant lacking gene A
- B. A mutant lacking gene B
- C. A mutant lacking gene C
- D. A mutant lacking genes A and B
- E. A mutant lacking genes B and C

63. It has been demonstrated that Genes A, B and C encode transcription factors. Which of the following is **NOT** a property of transcription factors? (1 point)

- A. DNA-binding
- B. Interaction with other proteins
- C. Degradation by protease
- D. RNA binding
- E. Participation of other gene regulation

64. PCR (polymerase chain reaction) is one of the most powerful methods in molecular biology. Which of the following is/are **NOT** true about PCR? (1 point)

- (1) Primers are needed in PCR
- (2) A DNA polymerase that can tolerate high temperature is needed in PCR
- (3) ATP is needed in PCR
- (4) A DNA template is needed in PCR

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

65. Nitrogenous wastes of animals are released to their environments in different forms. Which of the following statements is/are true about animal nitrogenous wastes?
(1 point)

- (1) Urea is excreted by many marine fishes.
- (2) Ammonia is so toxic that it is rarely excreted as nitrogenous waste by any animals
- (3) The animals in dry environments could excrete uric acid
- (4) The form of nitrogenous waste is often an adaptation to animal habitats.

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

66. Among the nitrogenous wastes, urea, uric acid and ammonia the order of toxicity is: (1 point)

- A. Ammonia > uric acid > urea
- B. Urea > ammonia > uric acid
- C. Uric acid > urea > ammonia
- D. Ammonia > urea > uric acid
- ~~E. Urea > ammonia > uric acid~~
- ~~F. Uric acid > urea > ammonia~~

Question 67-69. Equilibrium dialysis is a method often used to determine the dissociation constant K_D for a ligand-binding protein. In this method, a protein at a known concentration is put into several dialysis tubes and each dialysis tube containing the protein is dialyzed against solutions containing the ligand at various ligand concentrations. Because the protein cannot move across the dialysis tube membrane while the ligand can, the ligand is “trapped” by the protein inside the dialysis tube and it creates a higher concentration of the ligand in the dialysis tube than that outside the dialysis tube. The dissociation constant of the ligand can thus be determined according to the following formula:

$$K_D = \frac{[M][L]}{[ML]}$$

Where $[M]$ is the concentration of free protein (no bound ligand) in the dialysis tube, $[L]$ is the concentration of the ligand and $[ML]$ is the concentration of the protein with bound ligand. Therefore, K_D is the ligand concentration when $[M]$ equals $[ML]$. $[M_T] = [M] + [ML]$.

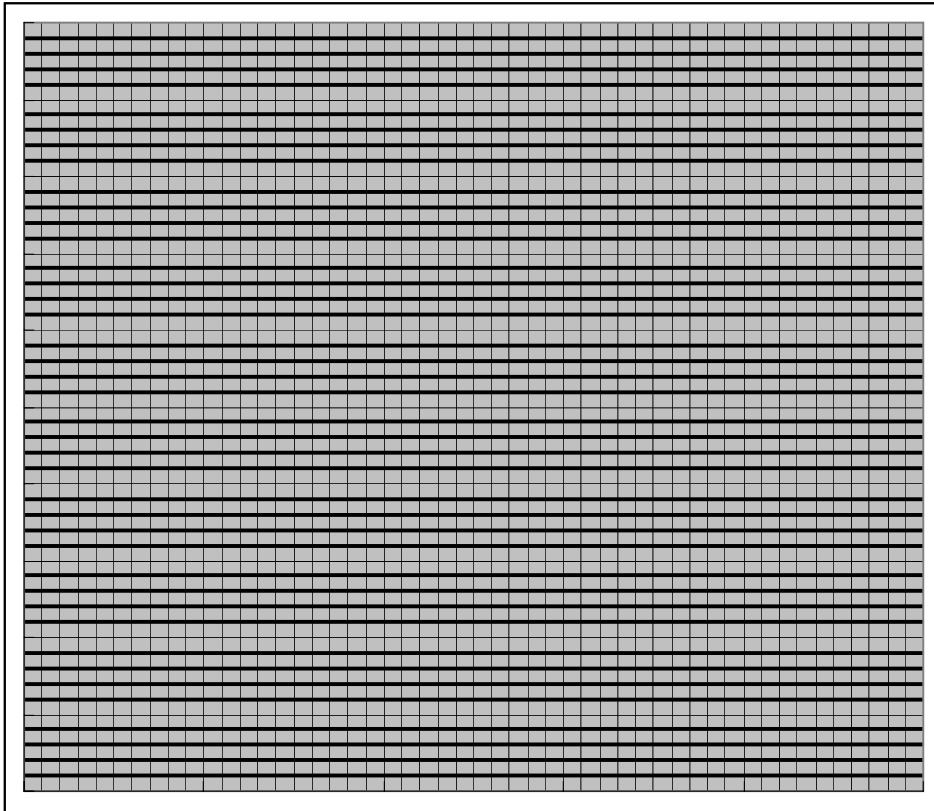
Where $[M_T]$ is the total concentration of the protein

The table below shows the measurement results of a calcium-binding protein.

The protein has a molecular mass of 20 kDa and the concentration of the protein in equilibrium dialysis is 1 mg.ml^{-1} .

Calcium concentration in dialysis solution (μM)	Calcium concentration in dialysis tube (μM)	$[\text{M}]/[\text{M}_\text{T}]$
20	30	
50	68	
100	129	
200	237	
400	442	
600	647	
1000	1050	
1500	1548	
2000	2049	

Please calculate the values of $[\text{M}]/[\text{M}_\text{T}]$ at each concentration and plot the data (Calcium concentration in solution vs $[\text{M}]/[\text{M}_\text{T}]$) on the plotting (graph) paper shown below.



67. How many calcium ions does one protein molecule bind? (1 point)

- A. 1
- B. 2
- C. 3
- D. 4
- E. It cannot be determined

68. What is the K_D of the protein? (3 point)

- A. 30 μM
- B. 78 μM
- C. 95 μM
- D. 104 μM
- E. 200 μM

69. There are two calcium-binding proteins, Protein X and Protein Y. If Protein X has a K_D of 250 nM and Protein Y has a K_D of 400 nM, which of the following is/are **NOT** correct? (2 point)

- (1) Protein X binds calcium more tightly than Protein Y.
- (2) Half of Protein Y will have bound calcium at the concentration of 400 nM.
- (3) It is more difficult to release the bound calcium from Protein Y.
- (4) When Protein X and Protein Y are mixed at equal molar concentration, more Protein X will have bound calcium than Protein Y at a calcium concentration of 250 nM.
- (5) When Protein X and Protein Y are mixed at equal molar concentration, equal amounts of Protein X and Protein Y will have bound calcium at a calcium concentration of 400 nM.

A. 1, 2, 5

B. 2, 4,

C. 3, 4

D. 4, 5

E. 3, 5

70. Which of the following are amniotes? (1 point)

(1) Bony fishes (Osteichthyes)

(2) Reptiles (Reptilia)

(3) Cartilaginous fish (Chondrichthyes)

(4) Jawless fish (Agnatha)

(5) Mammals (Mammalia)

(6) Amphibians (Amphibia)

(7) Birds (Aves)

A. 1, 4, 6, 7

B. 2, 3, 5

C. 2, 5, 7

D. 2, 4, 5, 6

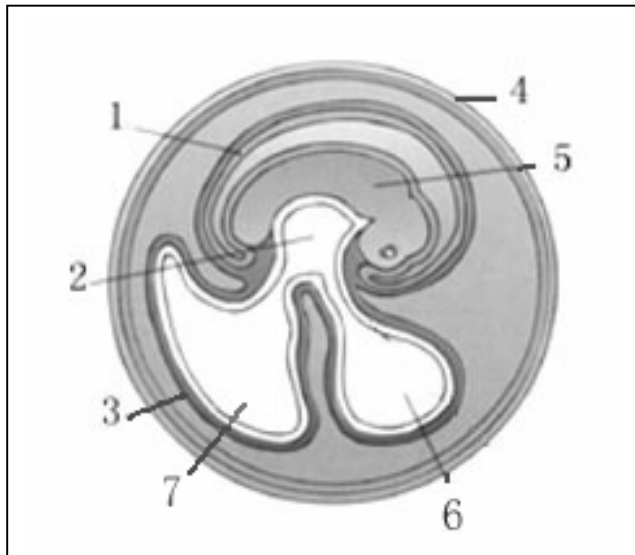
E. 2, 5, 6, 7

F. 4, 5, 6, 7

G. 5, 6, 7

71. The figure below shows schematic structures of an amniotic egg. Please name the structures labelled by numbers 1 through 7. (1 point)

A. amnion B. embryo C. allantois D. chorion. E. yolk sac. F. gut G. allantois cavity



1
2
3
4
5
6
7

Answer A-G

72. Fill in the appropriate answers based on the functions of the structures shown in the figure above (question 71). (1 point)

Main Function	Answer: A-G
(1) It protects the embryo in a fluid-filled cavity that prevents dehydration.	
(2) It provides nutrients for the embryo	
(3) It functions as a disposal cavity for metabolic wastes	
(4) It is rich in blood vessels and it forms a sac for collecting waste	

Questions 73-74. Compare 4 different invertebrates:

- (1) Spider
- (2) Grasshopper
- (3) Millipedes
- (4) Shrimp

73. Fill in the appropriate answers according to the following descriptions. (1 point)

- A. 1 pair of antennae, 3 pairs of legs
- B. 1 pair of antennae, more than 4 pairs of legs
- C. 2 pairs of antennae, 4 pairs of legs
- D. 2 pairs of antennae, more than 4 pairs of legs
- E. No antennae, 3 pairs of legs
- F. No antennae, more than 3 pairs of legs

Answer: A-F	
(1)	
(2)	
(3)	
(4)	

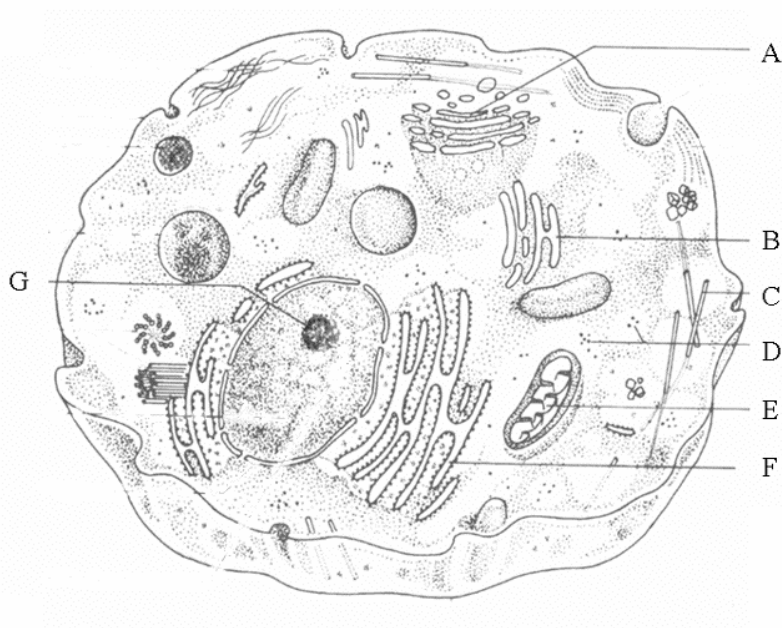
~~74. Fill in appropriate answers according to organs of excretion and gas exchange.~~

~~(1 point)~~

- ~~A. Excretion with Malpighian tubules and gas exchange with tracheal system.~~
- ~~B. Excretion with Malpighian tubules and coxal gland, gas exchange with tracheal system.~~
- ~~C. Excretion with maxillary gland and gas exchange with gill and tracheal system.~~
- ~~D. Excretion with Malpighian tubules and coxal gland, gas exchange with book lung~~
- ~~E. Excretion with Malpighian tubules and coxal gland, gas exchange with book lung and tracheal system~~
- ~~F. Excretion with maxillary gland and gas exchange with gill.~~

Answer A-F	
(1)	
(2)	
(3)	
(4)	

Questions 75-84. The figure below is a diagram of the ultra-structure of a cell..



75. If you are provided with two electron microscopic pictures, one from pancreas gland cells and the other from endothelial cells from the proximal tubule of a kidney nephron. Which of the structure shown in the figure will be more developed in the pancreas gland cell? (1 point)

Answer: choose one from A through G.

76. As the cells grow, the surface area of each cell increases. Which structure is the location where the lipids are synthesized for plasma membrane (cell surface) synthesis? (1 point)

Answer: choose one from A through G.

77. If you treat the cells for a short period of time with ^3H -Uracil followed by detecting the labelled cellular structure with autoradiography, which structure will have the highest concentration of silver grains (strongest labelling)? (1 point)

Answer: choose one from A through G.

78. Which structure is assembled in the nucleus and then transported to cytoplasm? (1 point)

Answer: choose one from A through G.

79. Erythropoietin (EPO) is hormone that stimulates production of erythrocytes. EPO is a highly glycosylated protein which can be secreted. Which structure would be responsible for the initial synthesis of EPO? (1 point)

Answer: choose one from A through G.

80. Which structure would be the site for initial glycosylation of EPO? (1 point)

Answer: choose one from A through G.

81. Which structure would be the site for final glycosylation of EPO? (1 point)

Answer: choose one from A through G.

82. Which structure is essential for the transport of EPO inside the cell? (1 point)

Answer: choose one from A through G.

83. The receptor for EPO is a membrane bound protein. Which structure is responsible for EPO's receptor synthesis? (1 point)

Answer: choose one from A through G.

84. Which structure has the ability to synthesize some proteins that are not encoded by nucleus. (1 point)

Answer: choose one from A through G.

END of PART I

Country _____

Competitor# _____



16th 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 CO_2 in the air spaces of the leaf.
- C. become more turgid because of an influx of 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, zygoete 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)

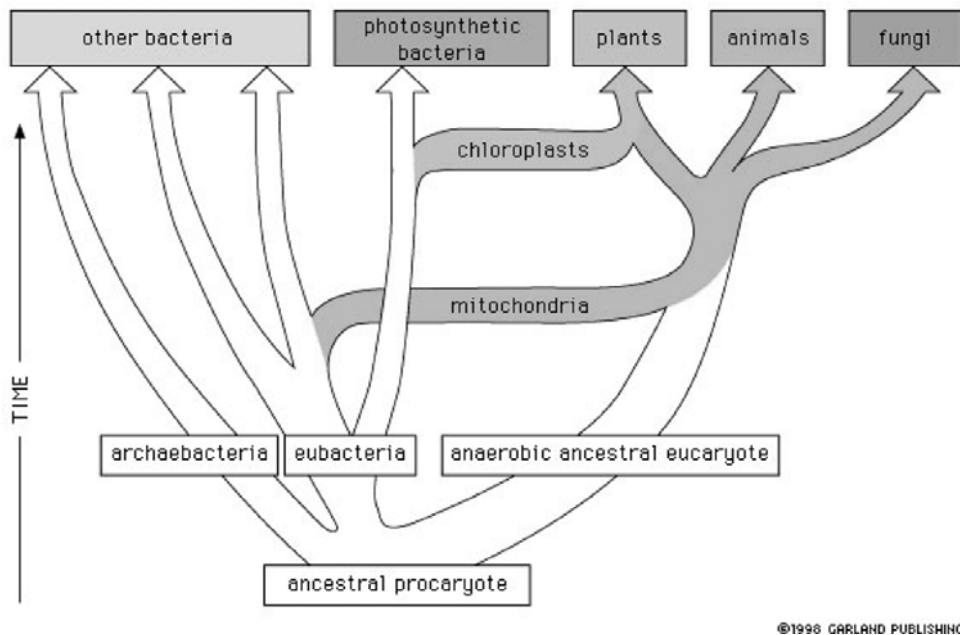
- (1) The position of chlorophyll a in photosystems has a strong influence on the function of chlorophyll a.
- (2) Chlorophyll a in the photosynthetic reaction center is chemically modified so that it performs initial electron transfer.
- (3) Part of chlorophyll a is structurally related to the heme 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 CO₂.

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)



- (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 an typical phenotype of the prion caused disease~~
- ~~(5) prion disease are restricted only 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 the bone marrow transplantation~~

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

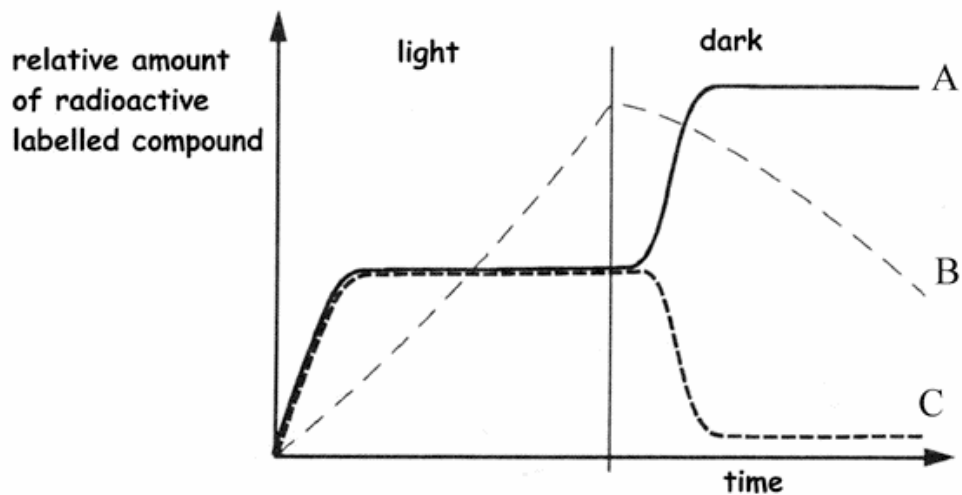
~~B. 2, 3, 4, 5~~

~~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}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)

Methylene blue + hydrogen → reduced methylene blue
(blue) *(colorless)*

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:

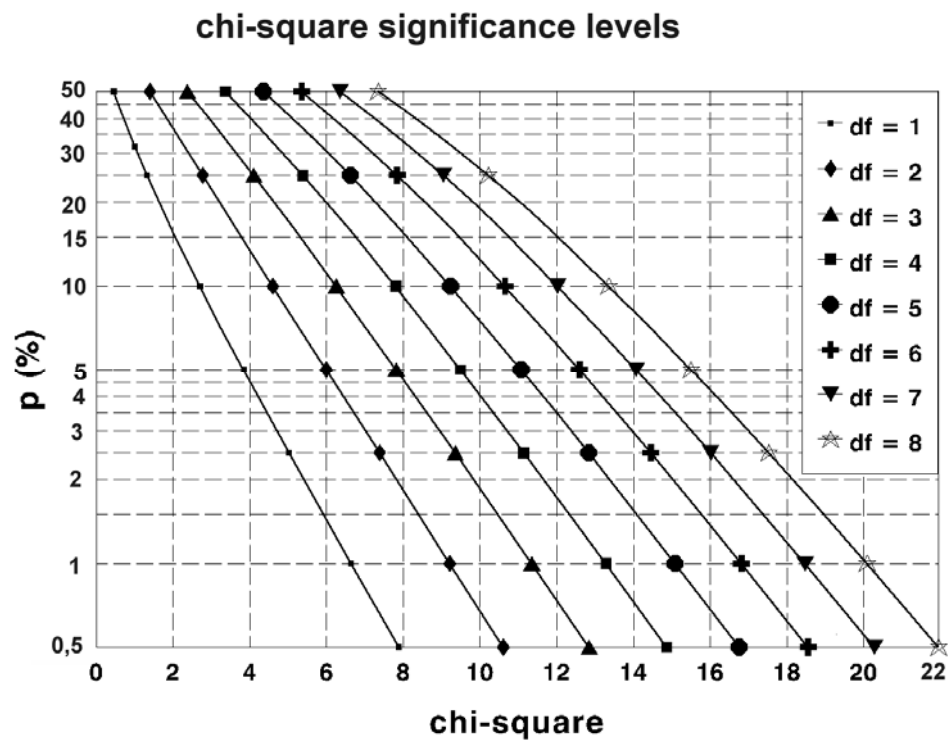
Eye	Body	Number of flies in F2
Wild	Wild	164
Wild	Ebony	37
Glass	Wild	59
Glass	Ebony	28

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 χ^2 (chi square) test.

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



Question 113. The calculated χ^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%

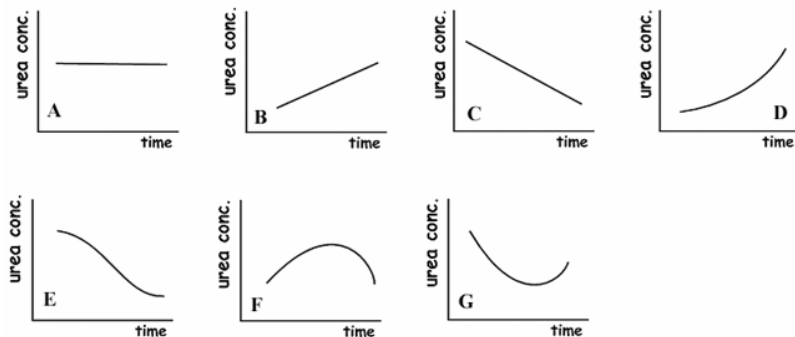
Question 116. To explain the observed deviation of the 9:3:3:1 ratio the student suggested some possibilities.

- (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

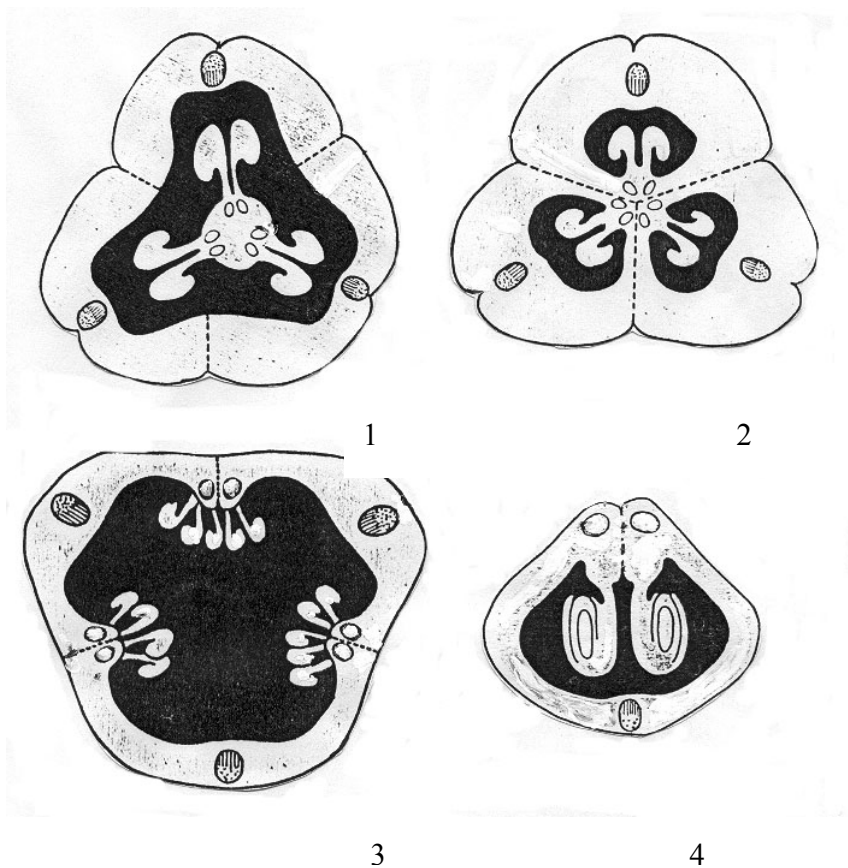
120. Bonsai trees need water with a very low lime content. Which types of water could be used to water them? (1 point)

- (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.

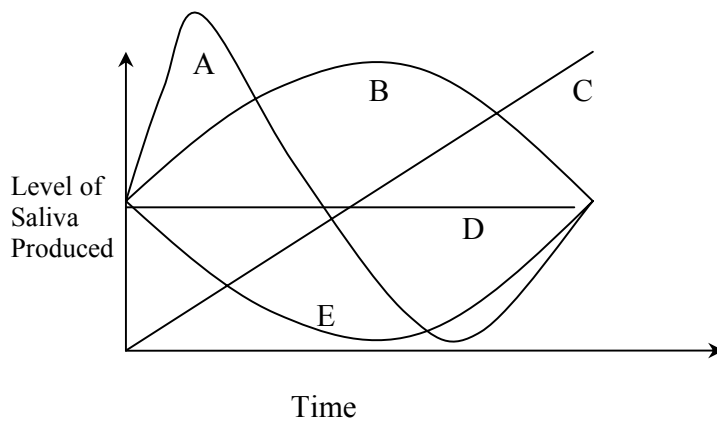


- A. Axile placentation.
- B. free central placentation.
- C. Marginal placentation.
- D. Parietal placentation.

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	Σ
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
Σ	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	Σ
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
Σ	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

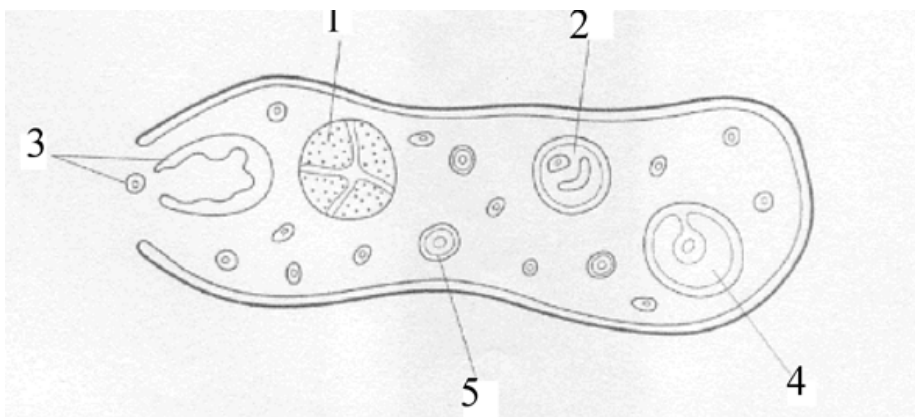
126. The substrate(s) of RUBISCO is (are): (1 point)

- (1) Phosphoenolpyruvate (PEP)
- (2) Ribulose-bis-phosphate (RuBP)
- (3) Oxaloacetic acid (OAA)
- (4) Phosphoglyceric acid (PGA)
- (5) Carbon dioxide (CO₂)
- (6) Phosphoglyceraldehyde (GAP)
- (7) Oxygen (O₂)

- 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. $1/16$

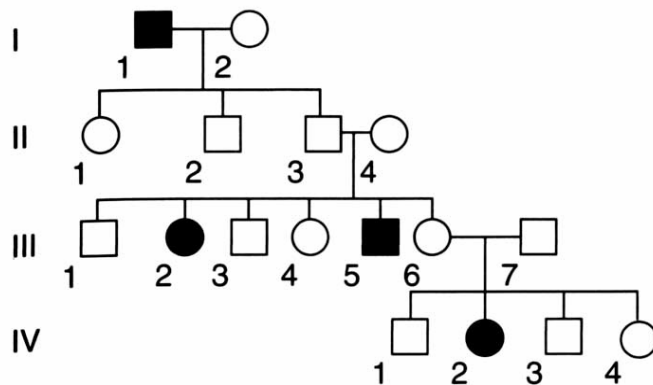
130. What is the chance of the second child having either PKU or albinism? (1 point)

- 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^dY~~

~~E. $X^D Y$~~

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

~~A. DD or $X^D X^D$~~

~~B. Dd or $X^D X^d$~~

~~C. dd or $X^d X^d$~~

~~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. CO₂ 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)

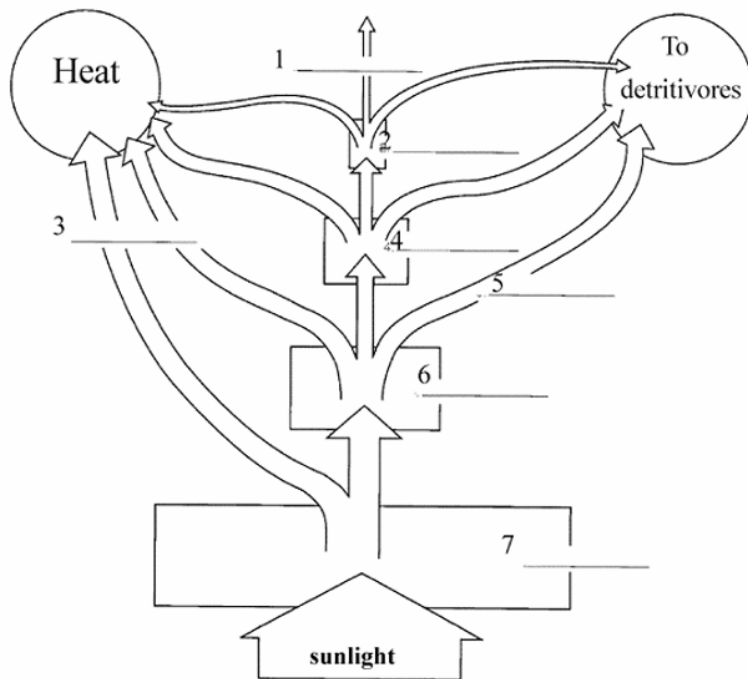
- A. 50%
- B. 25%
- C. 75%
- D. 67%
- E. 0

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. _____

2. _____ 6. _____

3. _____ 7. _____

4. _____

A. energy used in cellular respiration

B. secondary consumers

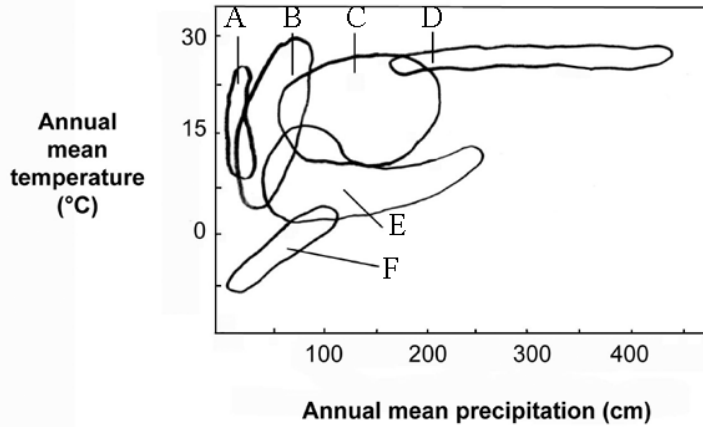
C. tertiary consumers

D. energy in wastes

E. primary producers

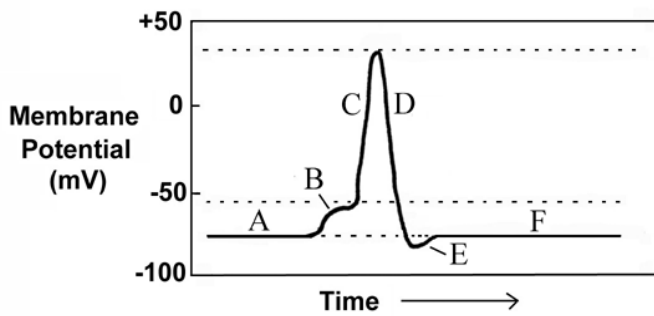
F. primary consumers

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.

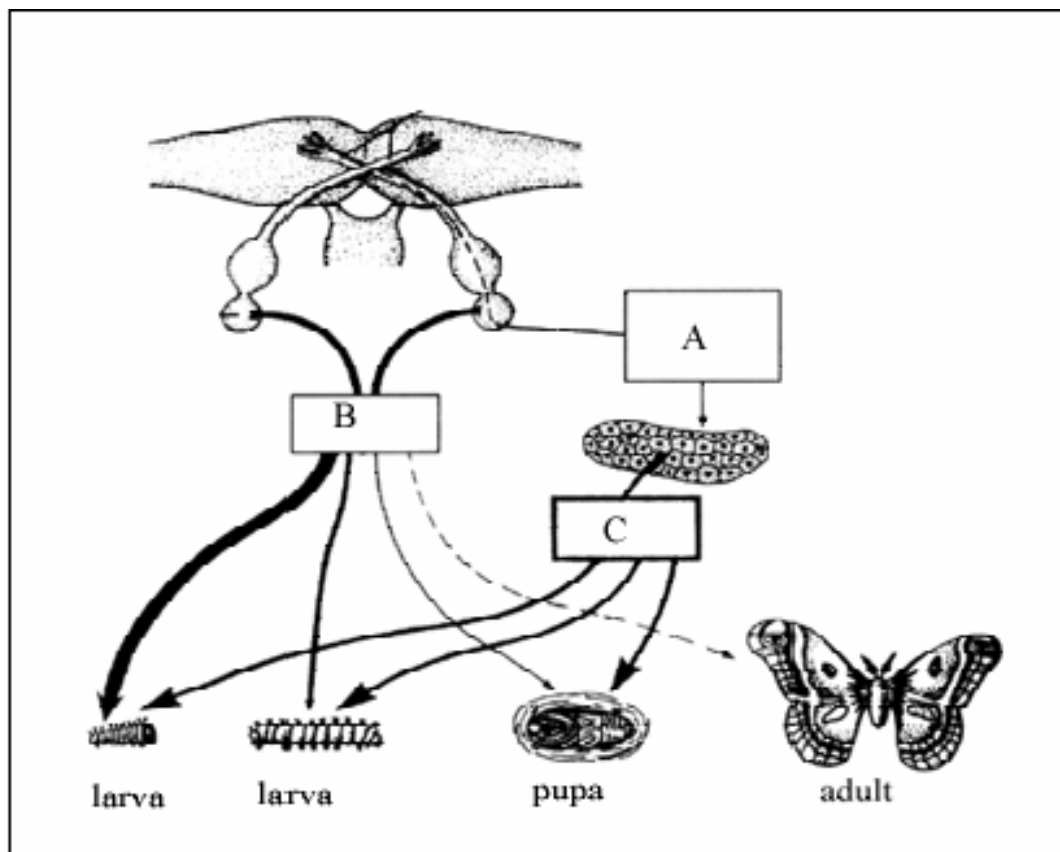
A. 1, 2, 4, 5

B. 1, 4

C. 1, 3, 4, 5

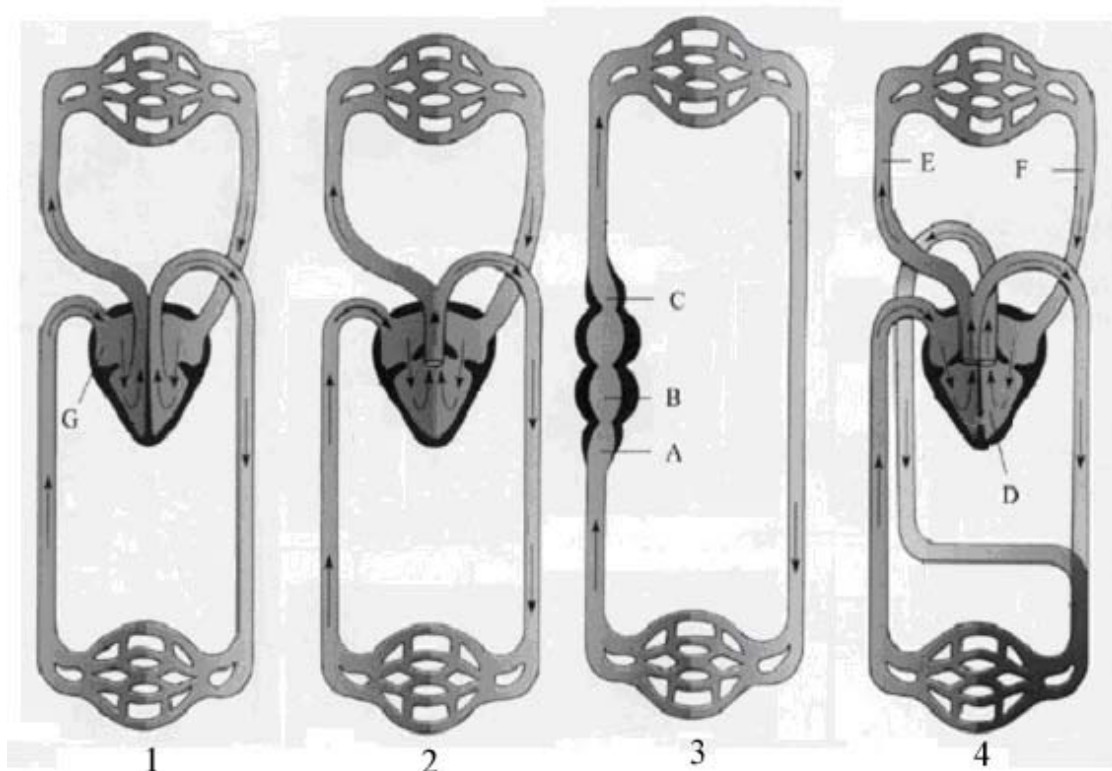
D. 1, 5

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)



	Answer: A-C
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)

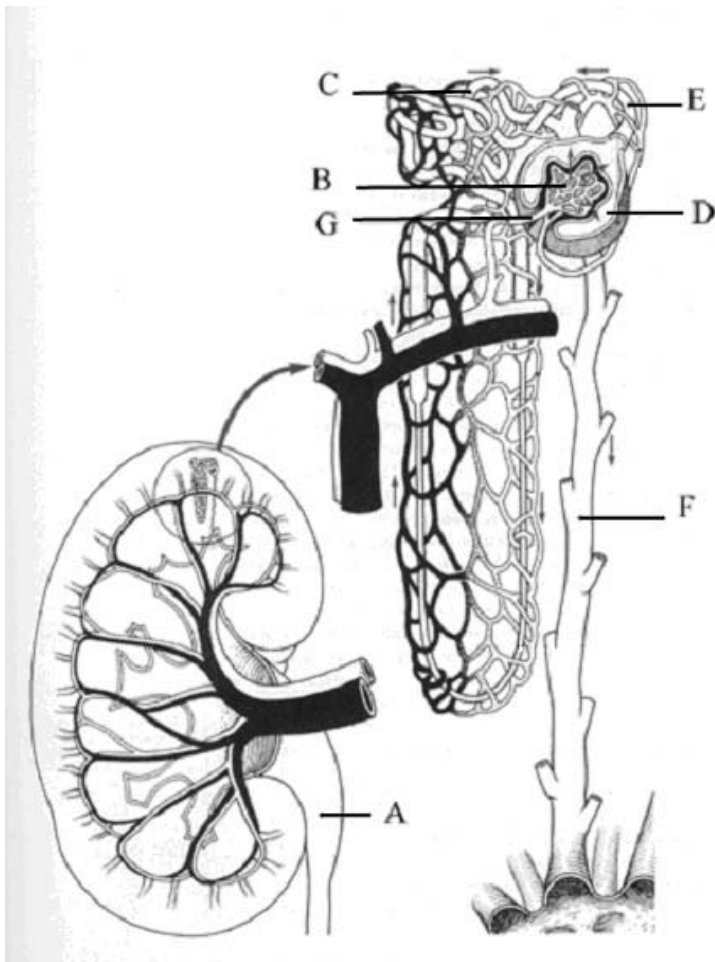


- A. mammals, reptiles, amphibians, and fish, respectively.
- B. fish, amphibians, reptiles, and mammals, respectively.
- C. mammals, amphibians, reptiles, and fish, respectively.
- D. mammals, amphibians, fish, and reptiles, respectively.

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) Na^+
- (2) 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

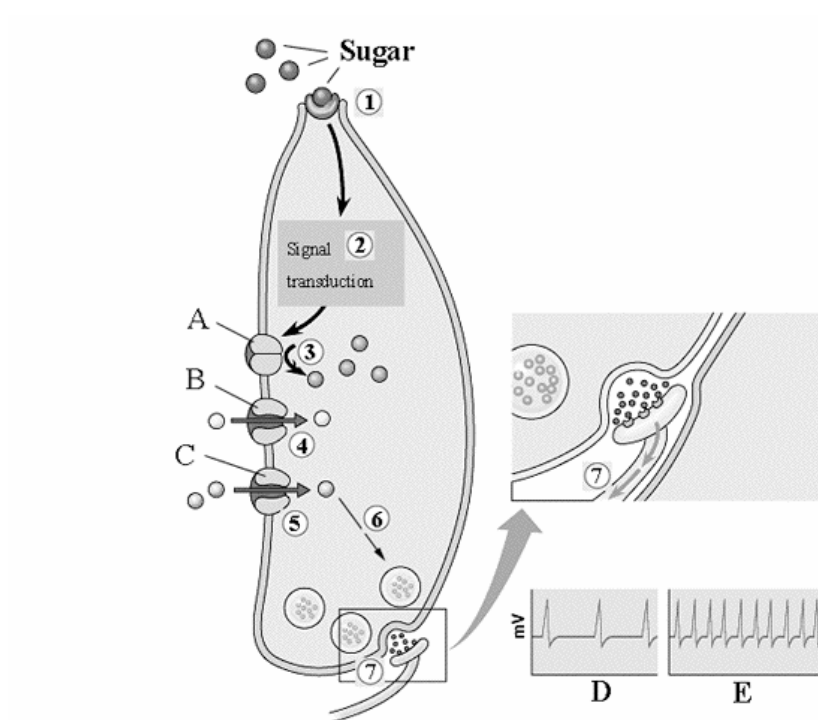
162. In the kidney, ultrafiltration occurs in which of the following structures? (1 point)

- (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~~

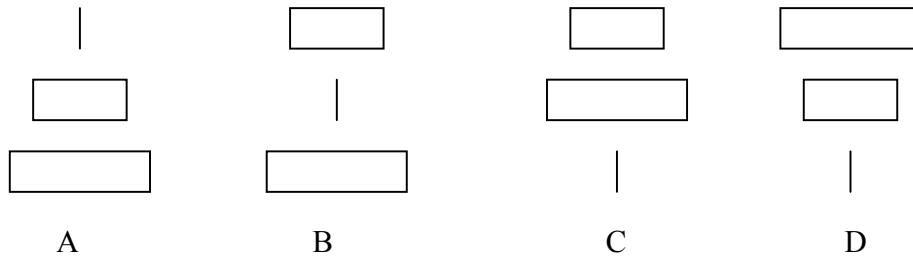
168. Both snake and weasel hibernate. Which of the following is correct? (1 point)

- 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~~

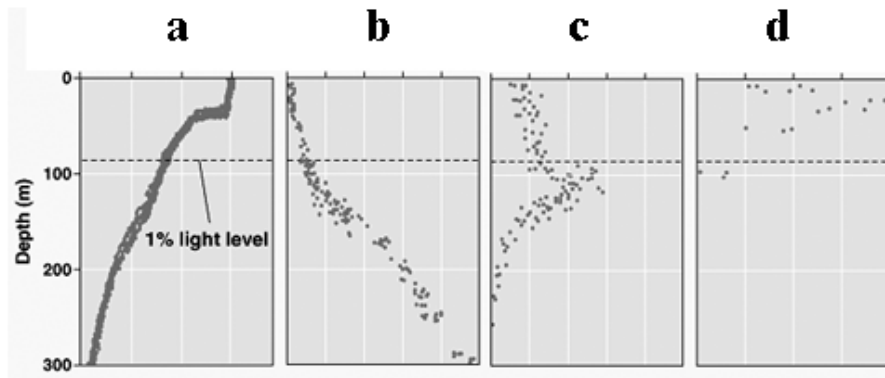
170. Four quantity pyramids (total number of organisms) are shown below. Which is representative for plant-aphid-ladybug (ladybird)? (1 point)



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.



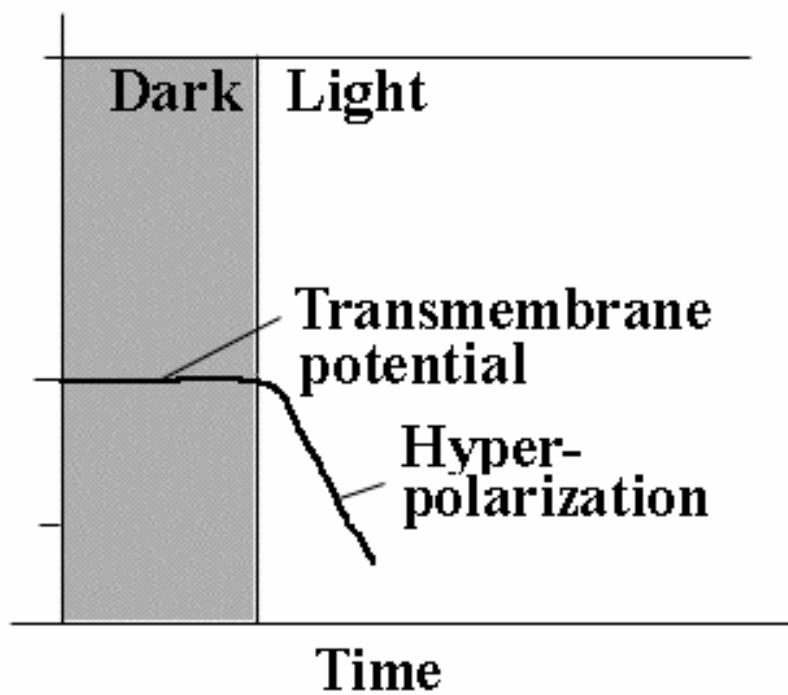
From left to right, letter a through letter d represent: (1 point)

- 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.~~