



14-th International Biology Olympiad
Minsk - Belarus,
8th-16th July, 2003

THEORETICAL TEST

Dear competitors!

You will have 4.5 hours for answering all the tasks of parts A and B. Tasks for **part A** have **only one** correct answer. You have to mark it by filling in the circle opposite the test number on the **answer sheet**. Answers written in the question paper will not be taken into account.

Tasks for **part B** may have **several (more than one)** correct answers. You must fill them in the **answer sheet part B**. The marks for the questions of **part B** depend on the number and complexity of the questions.. The marks are shown in the text.

Be attentive while filling in the answer sheet. Make sure the correct circle corresponding to the appropriate question is filled in. Any corrections in **answer sheet** should be avoided!

Note there are some questions which are marked SKIPPED. **Do Not** answer these.

Please read all possible answers before attempting the question, as many questions continue over from one page to the next page.

PART A

Cell Biology (14 questions, 20 points).

A1. (1 point). List the following proteins in the order of decreasing evolutionary conservativeness of their primary structure:

1. Somatotropin.
2. Catalytic subunit of a DNA – polymerase.
3. Histone H1.
4. Prolamines (storage proteins of cereals).

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

A2. (1 point). What is the common feature of amino acids encoded by codons XUX, where X is any base, U is uracil?

- A. Hydrophobicity.
- B. Positive charge.
- C. Negative charge.
- D. Sulfur in the side chain.
- E. No common feature.

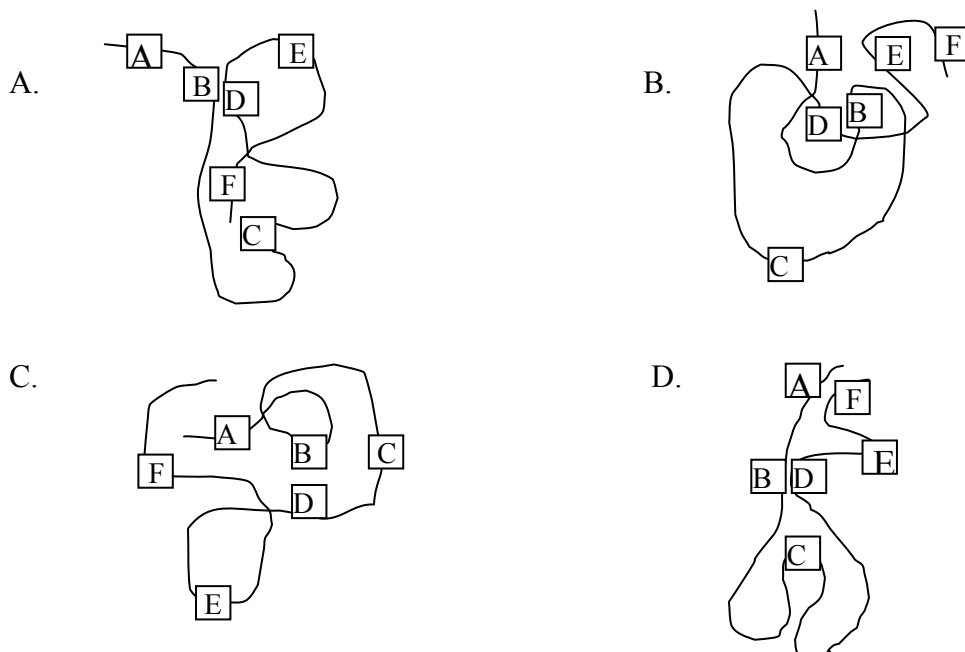
A3. (1 point). A denatured polypeptide chain containing amino acids of different chemical properties is shown in the figure.



Amino acid properties:

A and E: Have negatively charged side groups.	B: With many electropositive atoms.
C and F: Have hydrophobic side groups.	D: With many electronegative atoms.

If renatured, the most stable configuration of the above polypeptide in the cytoplasmic environment will be:



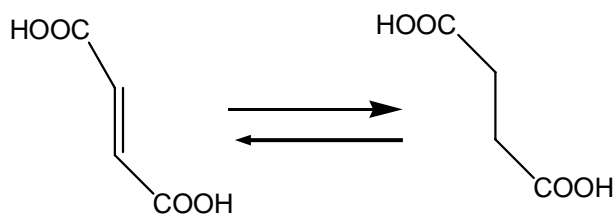
A4. (1 point). Nucleoside phosphates can be interphosphorylated enzymatically. Which one of the following reactions is impossible?

- A. $ADP + ADP = AMP + ATP$.
- B. $AMP + GTP = ADP + GDP$.
- C. $ATP + GDP = ADP + GTP$.
- D. $ATP + UMP = ADP + UDP$.
- E. $ADP + AMP = ATP + \text{adenosine}$.

A5. (1 point). Which nucleotides predominate in the genome of extremely thermophilic bacteria *Thermus aquaticus* in comparison to *E.coli*?

- A. A-T.
- B. C-T.
- C. G-A.
- D. G-C.
- E. T-G.

A6. (2 points). Define from reaction written below:



A6.1. (1 point). To which class does the enzyme catalyzing the reaction of formation of succinic acid (Succinate) from fumaric acid (Fumarate) belong?

- A. Isomerase.
- B. Dehydrogenase.(Oxidoreductases)
- C. Hydrolase.
- D. Synthase.
- E. Transferase.

A6. 2. (1 point). The coenzyme of this reaction is the derivative of which vitamin?

- A. B₁ - thiamine
- B. B₂. - riboflavin
- C. B₆. - pyridoxalphosphate
- D. B₁₂. - cyancobalamine
- E. B_c. – folic acid

A7. (1 point). It is known that cyanides (CN⁻) and carbon monoxide bind specifically to the reduced and oxidized form of cytochrome a₃ (cyt a₃) (part of complex IV of electron transport chain), respectively, in mitochondria. Which of the following statements are correct:

1. Cyanides and carbon monoxide are equally toxic to mitochondria.
2. Cyanides are far more toxic for mitochondria than carbon monoxide.
3. Carbon monoxide is more toxic for animals since it is capable of binding other iron-containing substances, e.g. hemoglobin.
4. Carbon monoxide is less toxic for animals since it is capable of binding other iron-containing substances, e.g. hemoglobin.
5. Cyanides are more toxic for animals since they are only capable of binding to cytochrome a₃.

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

A8. (1 point). *Lactobacilli* lack electron transport chain. However, under special circumstances, up to 50% of ATP is synthesized by membrane-linked H^+ - ATPase. What are the circumstances to generate a proton gradient to drive ATP formation mechanism.?

1. If the concentration of lactic acid is higher in the cell than it is in the medium.
2. If the concentration of lactic acid is lower in the cell than it is in the medium.
3. Uniport (unidirectional) of lactic acid.
4. Symport (both in or both out) of lactic acid with H^+ .
5. Antiport (one in and one out) of lactic acid with H^+ .

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

A9. (3 points). The lactose operon of *E.coli* consists of three genes:

lacZ encodes β -galactosidase,

lacY encodes galactosidepermease which carries out lactose transport to the cell,

lacA encodes galactoside-transacetylase.

Lac operon is under the control of LacI (repressor), which is inactive in the presence of lactose (inductor). There is a wide diversity of the chemical lactose analogs, for example:

Orthonitrophenyl- β -D-galactoside (ONPG) – is a substrate for β -galactosidase but not an inductor. The product of this reaction orthonitrophenol is toxic for a cell.

Isopropyl- β -D-thiogalactoside (IPTG) - is an inductor but not a substrate for β -galactosidase.

Phenyl- β -D-galactoside (PG) - is a substrate for β -galactosidase but not an inducer. The products of its hydrolysis are nontoxic for a cell.

A9.1. (1 point). Which cells will grow in the medium with PG as the only source of carbon and energy?

- A. $lacI^-$.
- B. $lacZ^-$.
- C. $lacy^-$.
- D. $lacZ^- lacy^-$.
- E. $lacI^- lacZ^-$.

A9.2. (1 point). Will these cells grow in the medium with ONPG?

- A. Yes.
- B. No.

A9.3. (1 point). Galactose is a toxic compound for the cells which have $galE^-$ mutation.

Which cells with this mutation will grow in the IPTG+PG medium (with arabinose as an additional source of carbon and energy available)?

- A. $lacI^-$.
- B. $lacZ^-$.
- C. $lacA^-$.
- D. $lacI^- lacA^-$.

A10. (2 points). A protein synthesis assay was carried out *in vitro*. A polyribonucleotide containing U and C in proportion 1:5 (positions of U and C are random) was used as a template. Which amino acids and in what proportions will be incorporated into the synthesized polypeptide molecules?

- A. $1Phe : 5Pro : 3Leu$.
- B. $1Leu : 1Pro : 1Ser : 1Phe$.
- C. $1Phe : 5Ser : 5Pro : 5Leu$.
- D. $1Phe : 25Pro : 5Ser : 5Leu$.
- E. $5Leu : 5Pro$.

For questions 11 and 12 use the table of genetic code at the beginning of the question paper.

A11. (3 points). The strand of DNA molecule isolated from *E. coli* bacteria has sequence: 5' – GTAGCCTACCCATAGG – 3'. Assume that an mRNA is transcribed from the corresponding double-stranded DNA, the template strand being complementary to the strand isolated.

A11.1. (1 point). What is the sequence of this mRNA?

- A. 3' – CAUCGGAUGGGUAUCC – 5'.
- B. 5' – GUAGCCUACCCAUAGG – 3'.
- C. 5' – GGAUACCCAUCCGAUG – 3'.
- D. 5' – CACAGAUACCCAGAUG – 3'.

A11.2. (1 point). Which peptide will be synthesized if its translation begins precisely at 5'– end of this mRNA? (Assume that start codon is not required).

- A. - Gly - Tyr - Pro - Ala – Asp.
- B. - His - Arg - Met - Gly – Ile.
- C. - Val - Ala - Tyr – Pro.
- D. - His - Arg - Tyr - Pro – Ala.

A11.3. (1 point). When tRNA^{Ala} separates from ribosome, which tRNA will bind next?

- A. tRNA^{Tyr}.
- B. tRNA^{Pro}.
- C. tRNA^{Val}.
- D. tRNA^{Arg}.
- E. tRNA^{His}.

A12. (1 point). The transcriptional activity of which kind of RNA polymerase in eukaryotes can be seen by using a light microscope (without any methods of colouration)?

- A. RNA-polymerase I.
- B. RNA-polymerase II.
- C. RNA-polymerase III.
- D. Primase.
- E. Impossible to determine.

A13. (1 point). Phalloidin, a very toxic compound isolated from the mushroom *Amanita phalloides*, has a very high affinity for actin polymers. Phalloidin can be marked by covalently linking it to a fluorescent molecule, like fluorescein, without affecting its affinity properties.

If a microscopic slide with methanol-fixed sperm is stained with a reagent containing fluorescein-marked phalloidin (excess reagent being washed away), which part of the

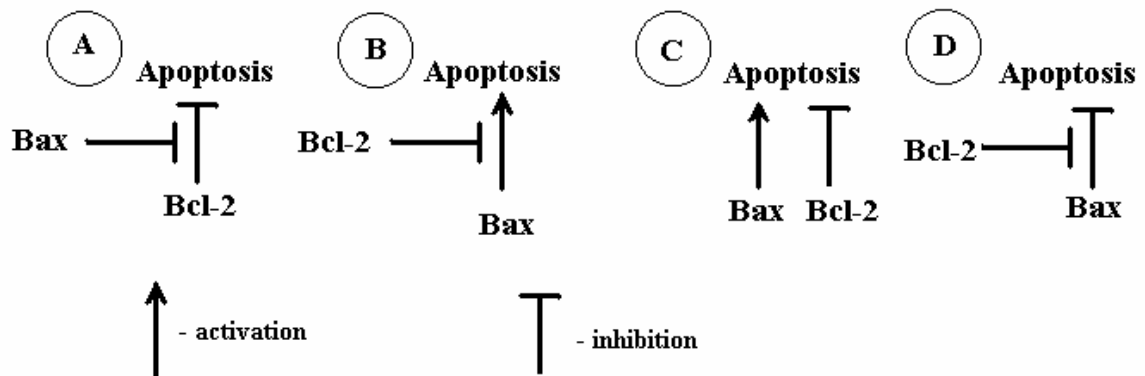
spermatozooids will be glowing under a fluorescence microscope?

- A. Acrosome.
- B. Flagellum.
- C. Head.
- D. Mitochondria.
- E. Whole spermatozoid.

A14. (2 points). On the basis of the following experimental facts, decide which of the four models (A, B, C or D) of Bax and Bcl-2 proteins' action in regulation of programmed cell death (apoptosis) is correct.

Experimental facts:

- Mice with inactivated bcl-2 gene had a high rate of apoptosis in various tissues, which could be corrected by the absence of Bax protein.
- Bax gene in a single genome copy was able to promote apoptosis in the absence of Bcl-2 protein.
- However, bcl-2 gene suppressed apoptosis in the absence of Bax protein.



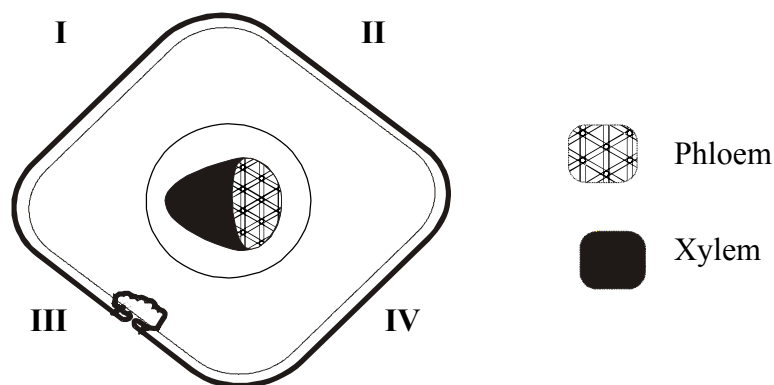
- A. Bax protein inhibits the action of Bcl-2 protein, which blocks apoptosis (look at A in the figure).
- B. Bcl-2 protein is an inhibitor of Bax protein, which promotes apoptosis (look at B in the figure).
- C. Bcl-2 and Bax proteins act independently, resulting in either survival or death, (look at C in the figure).
- D. Bcl-2 protein blocks inhibitory action of Bax protein on apoptosis (look at D in the figure).

Plant anatomy and physiology (10 questions, 12 points).

A15. (1 point). If the vascular system of a plant tendril is represented by the only one closed collateral (xylem & phloem are touching) bundle, the tendril is formed by the metamorphosis of which organ?

- A. Shoot.
- B. Leaf.
- C. Stem.
- D. Root.
- E. Impossible to determine.

A16. (1 point). A transverse microscopic section of a spruce needle leaf is shown in the diagram below. Which roman numerals indicates the upper surface of the leaf?



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

A17. (1 point). The endosperm in conifers develops from:

- A. The central nucleus resulting from double fertilization.
- B. The ovule after fertilization.
- C. The megaspore before fertilization.
- D. The megaspore after fertilization.
- E. The megasporangium cells before fertilization.

A18. (1 point). Which compounds are the main substrates for growth of xylophilous fungi (accomplishing decomposition of wood), which elicit white (1) and brown (2) rot?

1. 2.
A. Cellulose. Suberin.

- B. Cellulose. Lignin.
C. Lignin. Cellulose.

- D. Suberin. Cellulose.

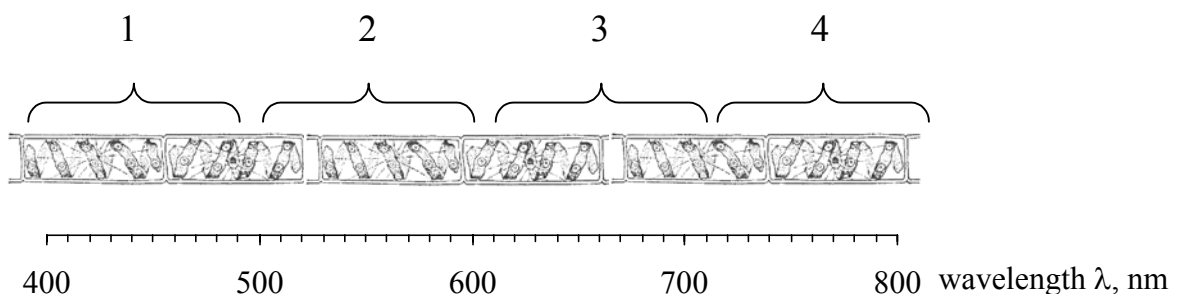
- E. Pectin. Hemicellulose.

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A19. (1 point). Which is the correct rank order of the pH value in cytosol (1), chloroplast stroma (2) the inside of thylakoids (3) in plant cells exposed to light:

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

A20. (1 point). Spirogyra filaments were placed in a medium, in which strict (obligate) aerobic bacteria were incubated without access to oxygen for some time. Then part of the spirogyra filament was illuminated with a narrow beam, which passed through a prism to obtain a spectrum (see figure below).



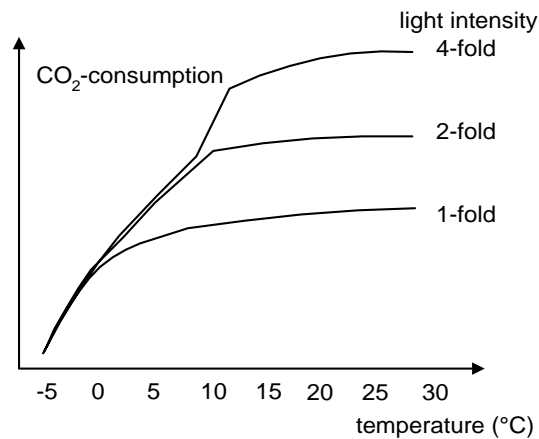
In which parts of the filament will the greatest concentration of bacteria be observed?

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

A21. (2 points). Plants of wild type corn whose Rubisco function was normal were compared with a mutant corn variety whose Rubisco is not able to catalyze an oxygenation reaction. Which of the following statements regarding the photosynthetic capacity of this mutant corn and the wild type is correct and why would it be correct? Assume the same temperature conditions.

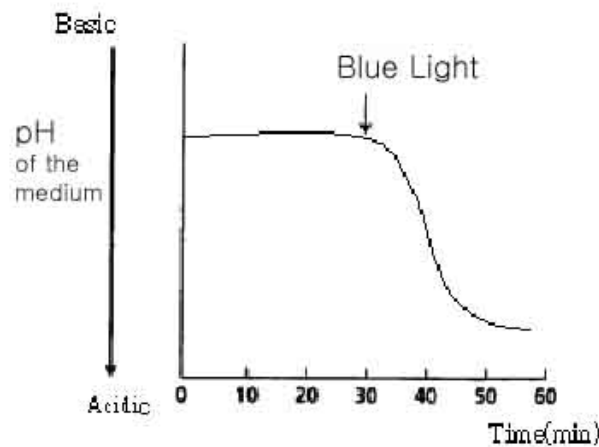
	Photosynthetic capacity of the mutant	Reason
A.	It would show much lower capacity compared to the wild type.	Rubisco in the bundle sheath cell loses its oxygen fixation capacity.
B.	It would show much lower capacity compared to the wild type.	Rubisco in the bundle sheath cell loses its carbon dioxide fixation capacity.
C.	It would show much higher capacity compared to the wild type.	Since mesophyll cells photorespire, photosynthetic capacity of the mutant would not be affected by this mutation.
D.	It would show the same capacity as the wild type.	Since mesophyll cells photorespire, photosynthetic capacity of the mutant would not be affected by this mutation.
E.	It would show the same capacity as the wild type.	Since CO ₂ concentration in the bundle sheath cells is high enough, both wild type and mutant corn do not photorespire.

A22. (2 points). Photosynthesis in plants is dependent on temperature (T) and light intensity (L). The following graphs show the results of measurements of CO₂ consumption for three plants of the same species under different light intensities. Which combination of statements concerning limiting factors in the temperature ranges (I) –5 °C to 0°C and (II) +20 °C to + 30°C is correct under the light intensity used?



	Temperature range from –5 to 0°C (I)	Temperature range from +20 to +30°C (II)
A.	T and L limiting factor.	T and L not limiting factor.
B.	T limiting, L not limiting.	T not limiting, L limiting.
C.	T limiting, L not limiting.	T limiting, L not limiting.
D.	T not limiting, L limiting.	T limiting, L not limiting.
E.	None of the above combinations is correct	

A23. (1 point). The result of an experiment which uses guard cell protoplasts of *Vicia faba* is given below. Protoplasts were incubated in a suspension medium with isotonic osmotic pressure. After 30 min under saturating red light they were irradiated with blue light for 30 sec. During the experiment in which the protoplasts were cultured the pH of the medium was monitored.



What would be the most plausible conclusion based on the above results?

- A. Blue light may help guard cells to take up protons from outside into the cell.
- B. Blue light may enhance the ability of guard cells to pump protons out of the cell.
- C. Blue light may be a very effective wavelength of light for the respiration of the guard cells.
- D. Blue light may activate all of the protoplasts to give away their energy.
- E. Not only blue light but also other wavelengths of light may help guard cells to transfer protons.

A24. (1 point). If an oat coleoptile deprived of its epidermis is placed in a physiological solution with pH = 5.0, relatively fast lengthening of the coleoptile occurs. The action of which hormone does this experiment imitate?

- A. Auxin.
- B. Gibberellic Acid
- C. Cytokinins.
- D. Ethylene.
- E. Abscisic Acid

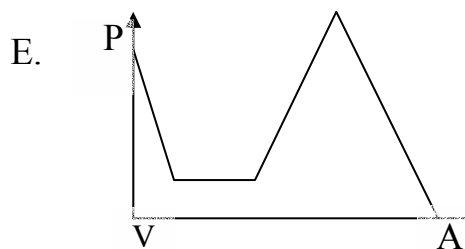
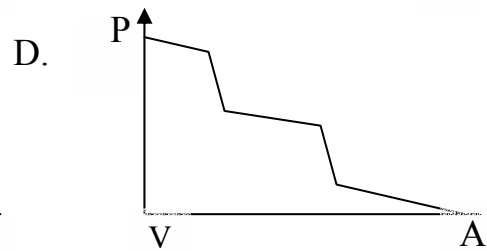
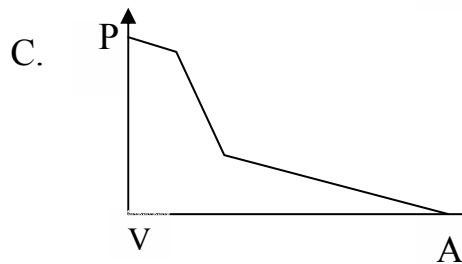
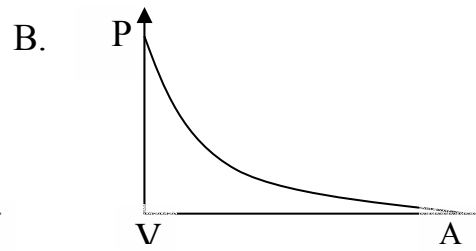
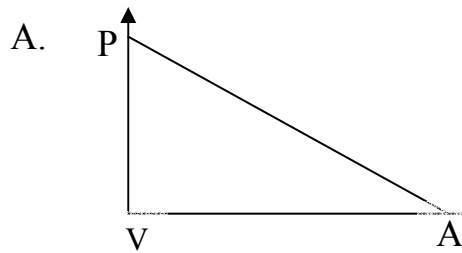
Animal Anatomy & Physiology (10 questions, 12 points).

A25. (1 point). In which animals is the volume of the lungs relatively constant during all the stages of ventilation (breathing)?

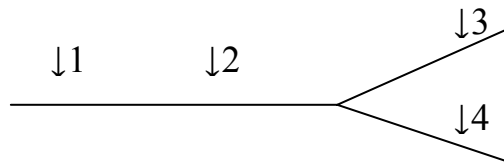
- A. In insects.
- B. In birds.
- C. In mammals.
- D. In reptiles.

A26. (1 point). During the blood flow from the ventricle to atrium in fishes, how does the pressure change?

- A - Atrium.
- V - Ventricle.
- P - Pressure.

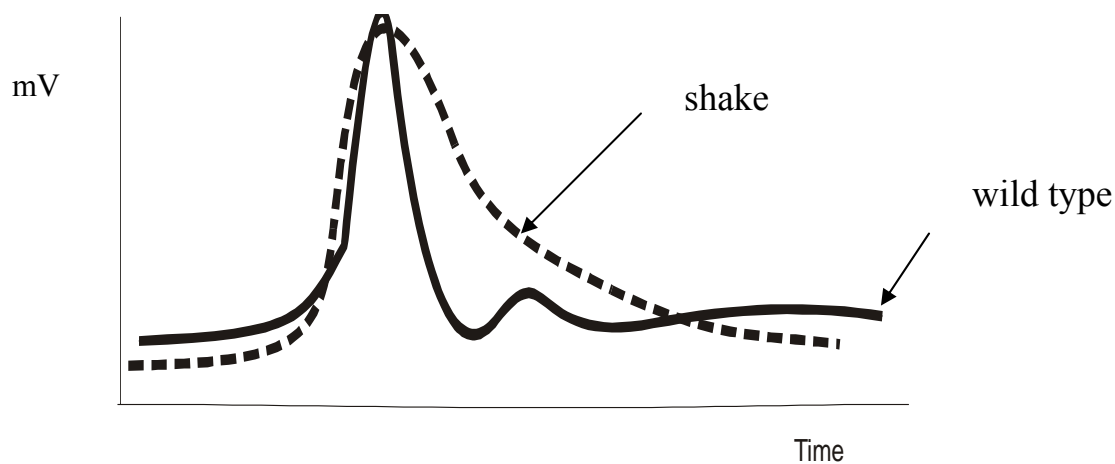


A27. (1 point). A branched axon is stimulated at the site '1' (see figure below). The excitation is transferred from site '1' to '2' and then to '3' and '4'. The excitation is measured at these sites. Which statement of impulse frequencies (I) measured at these sites is correct?



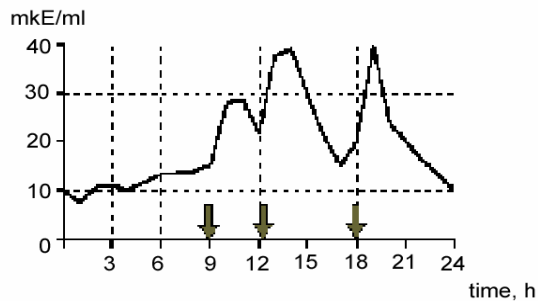
- A. $I(1) > I(2) > I(3)$, $I(3) = I(4)$, $I(3) + I(4) = I(2)$.
- B. $I(1) > I(2) > I(3)$, $I(3) = I(4)$, $I(3) \times I(4) = I(2)$.
- C. $I(1) < I(2) < I(3)$, $I(3) = I(4)$.
- D. $I(1) = I(2) > I(3)$, $I(3) = I(4)$, $I(3) + I(4) = I(2)$.
- E. $I(1) = I(2) = I(3) = I(4)$.

A28. (1 point). *Drosophila* flies homozygous for the *shake* mutation are extremely sensitive to diethyl ether that causes convulsions in homozygous individuals. Convulsions are caused by abnormalities in nerve impulse conduction. (see graph below). The function of which structures is impaired in the *shake* mutations?



- A. Na^+ -channels.
- B. K^+ -channels.
- C. Ca^{2+} -channels.
- D. K^+/Na^+ -ATPase.
- E. H^+ -pump.

A29. (1 point). Daily changes in the concentration of which hormone are represented by the following graph?



Arrows indicate the time of food consumption.

- A. Thyroxine
- B. Glucagon.
- C. Insulin.
- D. Cortisol.
- E. Parathormone.

A30. (1 point). Thyroiditis is an autoimmune disease, which is caused by the hyperactivity of the thyroid gland. In this disease the TSH (thyroid stimulation hormone) concentration in the blood is below normal. Antibody binding to hormone receptor sites may activate or block the receptor.

The cause of this disease is the binding of autoimmune antibodies to:

- A. Thyroxin receptors.
- B. Thyroxin.
- C. TSH receptors.
- D. TSH.
- E. Thyreoliberin receptors.

A31. (3 points). There are two recessive mutations ob^- and db^- in mice. These mutations cause the same phenotype: obesity, adipose tissue hypertrophy and predisposition to obesity related diseases (hypertension, physiological *diabetes insipidus* and so on). The mutations are not linked. Three experiments of parabiosis (surgically joining blood circulation systems of two mice with different genotypes) were carried out to define the roles of the products of these genes in weight regulation. Two weeks after the parabiosis, the weight of each mouse was determined (see table).

	$ob^-/ob^- + wt^+$		$db^-/db^- + wt^+$		$ob^-/ob^- + db^-/db^-$	
Weight	Loss of weight	Without changes	Without changes	Loss of weight	Loss of weight	Without changes

A31.1. (1 point). What is the consequence of the *ob* gene:

- A. Peptide hormone favouring obesity.
- B. Peptide hormone favouring loss of weight.
- C. Hormone receptor favouring obesity.
- D. Hormone receptor favouring loss of weight.
- E. Nonpeptide hormone favouring obesity.

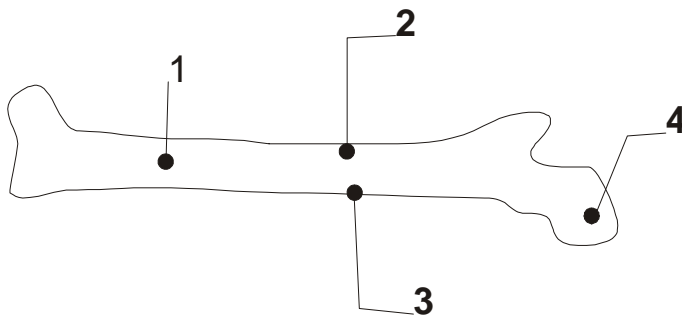
A31.2. (1 point). What is the consequence of the *db* gene:

- A. Peptide hormone favouring obesity.
- B. Peptide hormone favouring loss of weight.
- C. Hormone receptor favouring obesity.
- D. Hormone receptor favouring loss of weight.
- E. Nonpeptide hormone favouring obesity.

A31.3. (1 point). What segregation by phenotype will be seen in F_2 after interbreeding of individuals with the genotypes ob^- / ob^- and db^- / db^- ?

- A. 9:3:3:1.
- B. 9 :7.
- C. 15:1.
- D. 1:2:1.
- E. 3:1.

A32. (1 point). If four gold rods are implanted into a tibia-bone of a newborn rat (as shown in the figure), the distances between which of these rods will be maximally altered with growth?



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

A33. (1 point). Quick movement of the individuals of genus *Dryocopus* (wood-pecker) on tree trunks is enabled thanks to the fact that:

- A. All its leg fingers are directed forward.
- B. Two its leg fingers are directed forward and two its fingers are directed to the back.
- C. Three its leg fingers are directed forward and one leg finger is directed to the back.
- D. One its leg finger is directed forward and three leg fingers are directed to the back.

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A34. (1 point). The major difference between humoral immunity and cellular immunity is that:

- A. Humoral immunity is non-specific, whereas cellular immunity is specific for a particular antigen.
- B. Only humoral immunity is a function of lymphocytes
- C. Humoral immunity cannot function independently; it is always activated by cellular immunity.
- D. Humoral immunity acts against free-floating antigens, whereas cellular immunity works predominantly against pathogens that have entered body cells.
- E. Only humoral immunity displays immunological memory.

Ethology (2 questions, 2 points).

A35. (1 point). Which of the following cases result in optimal conditioning (Pavlovian)?

- A. Unconditional stimulus is delivered before conditional stimulus and unconditional stimulus is stronger than conditional stimulus.
- B. Unconditional stimulus delivered before conditional stimulus and unconditional stimulus is weaker than conditional stimulus.
- C. Conditional stimulus starts delivered unconditional stimulus and conditional stimulus is stronger than unconditional stimulus.
- D. Conditional stimulus starts delivered unconditional stimulus and conditional stimulus weaker than unconditional stimulus.

A36. (1 point). The cuckoo (*Cuculus canorus*) and its hosts is a well studied system of co-evolution as a long never ending process. A cuckoo lays its eggs in the nest of small passerines (*Passeriformes*). The cuckoo and its hosts have adopted different behaviours that result from the co-evolution between them.

Which combination of the following statements (1 – 6) are true?

1. The hosts lay their eggs in the afternoon.
2. The cuckoo eats ant eggs.
3. The host is aggressive towards a cuckoo.
4. The cuckoo eggs do not mimic the host's eggs.
5. The cuckoo is aggressive towards a host.
6. The cuckoo tries to avoid being seen in the host nest.

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

Genetics (10 questions, 12 points).

A37. (1 point). In birds, for instance chickens, sex is determined by a combination of sex chromosomes Z and W. At an early age it is difficult to determine their sex. However, it is commercially very important to distinguish males and females at this age. Using a genetic marker, it is possible to conduct such crosses so that sex will be determined by phenotypic expression of the marker gene. On which chromosome must the marker gene (I) be located and which crossing allows discrimination of the males from females (II)?

	Marker gene localization (I)	Crossing (II)
A.	On Z chromosome.	Female with recessive phenotype is crossed with a male homozygous for dominant allele.
B.	On W chromosome.	Female with recessive phenotype is crossed with a male homozygous for dominant allele.
C.	On Z chromosome.	Female with dominant phenotype is crossed with a male homozygous for recessive allele.
D.	On an autosome.	Female with recessive phenotype is crossed with a male heterozygote.
E.	On Y chromosome.	Female with dominant phenotype is crossed with a male heterozygote.

A38. (1 point). *abcde* genes are closely linked on the *E. coli* chromosome. Short deletions within this region lead to the loss of some genes. For example:

deletion 1 – *bde* genes

deletion 2 – *ac* genes

deletion 3 – *abd* genes

What is the gene order on the genetic map of the *E. coli* chromosome?

- A. b, c, d, e, a
- B. e, a, c, b, d
- C. a, b, c, d, e
- D. c, a, b, d, e
- E. a, b, c, d, e

A39. (2 points). According to the model proposed for floral organization, each whorl is determined by a unique combination of three genes, namely, A, B and C.

It has been shown that genes A and C mutually repress each other. The expression pattern of these genes in wild type flowers is shown below.

		S	P	St	C
gene activity	A				
	B				
	C				
		1	2	3	4
		whorls of flower			

S: sepal formation
P: petal formation
St: stamen formation
C: carpel formation

A39.1. (1 point). The morphology of flower that lacks the functional gene A will be:

- A. $\left[\begin{array}{cccc} - & - & \text{St} & \text{C} \\ 1 & 2 & 3 & 4 \end{array} \right]$
- B. $\left[\begin{array}{cccc} \text{C} & \text{St} & \text{St} & \text{C} \\ 1 & 2 & 3 & 4 \end{array} \right]$
- C. $\left[\begin{array}{cccc} \text{C} & \text{P} & \text{P} & \text{C} \\ 1 & 2 & 3 & 4 \end{array} \right]$
- D. $\left[\begin{array}{cccc} - & \text{P} & \text{St} & \text{C} \\ 1 & 2 & 3 & 4 \end{array} \right]$

A39.2. (1 point). The whorls of a flower that lacks the functional gene C will be:

A.
$$\begin{bmatrix} C & P & St & P \\ 1 & 2 & 3 & 4 \end{bmatrix}$$

B.
$$\begin{bmatrix} - & - & - & C \\ 1 & 2 & 3 & 4 \end{bmatrix}$$

C.
$$\begin{bmatrix} S & P & P & S \\ 1 & 2 & 3 & 4 \end{bmatrix}$$

D.
$$\begin{bmatrix} S & P & St & - \\ 1 & 2 & 3 & 4 \end{bmatrix}$$

A40. (2 points). Colour of the plant endosperm is determined by a single gene located in the centromere region. Expression of this gene takes place only in the cells of endosperm.

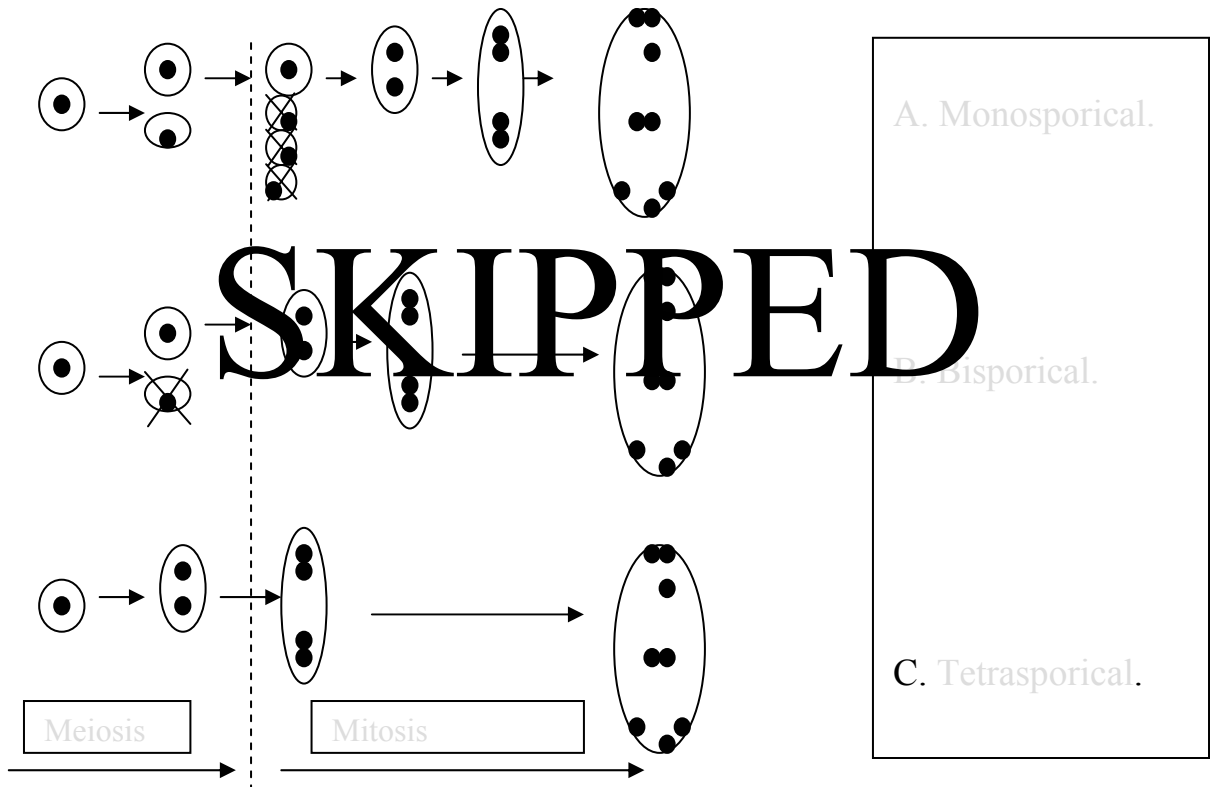
Experiment 1. Inbred plant line with coloured endosperm (CE) was pollinated by the pollen of inbred plant line with colourless endosperm (CLE). F₁ seeds were with coloured endosperm.

Experiment 2. After pollination of F₁ plants with pollen of CLE line all F₂ seeds were with coloured endosperm as well.

Experiment 3. After pollination of F₂ plants with pollen of CLE line 50% of plant gave seeds were with coloured and 50% with colourless endosperm.

A40.1. (1 points). According to the results of three experiments, determine which type of embryo sack is typical for this plant species?

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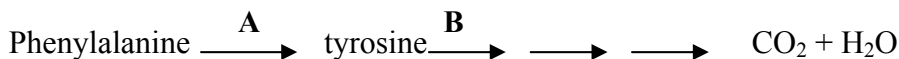


A40.2. (1 point). What ratio of seeds with coloured and colourless endosperm would be observed in experiment 2, if the gene of colouration of endosperm were located in >50 cM distance from centromere

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- A. 3:1.
- B. 1:3.
- C. 7:1.
- D. All with coloured endosperm.
- E. All with colourless endosperm.

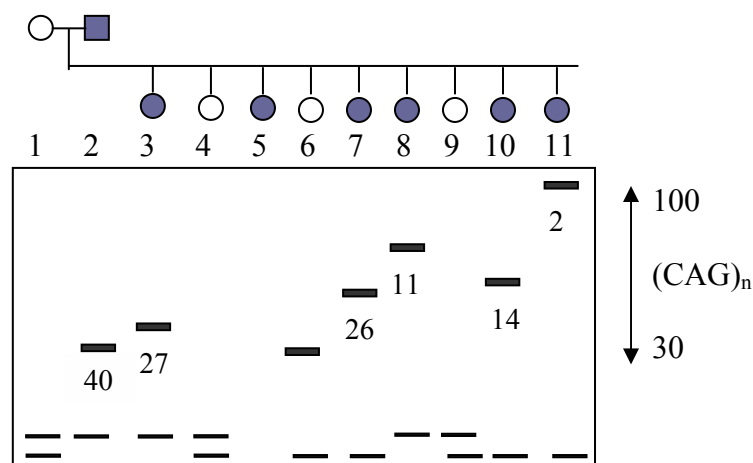
A41. (1 point). In humans PKU (phenylketonuria) is a disease caused by an enzyme dysfunction at step A in the following simplified reaction sequence, and AKU (alkaptonuria) is due to an enzyme inefficiency in one of the steps summarized as step B here:



A person with PKU marries a person with AKU. What are the expected phenotypes for their children? Note: both diseases (PKU and AKU) are not sex linked. Both parents are not heterozygous.

- A. All children will be ill.
- B. All children will be normal
- C. Half of their children will have PKU, but the other half will be normal.
- D. Half of their children will have AKU, but the other half will be normal.

A42. (1 point). The figure shows the results of electrophoresis of PCR-amplified DNA fragments obtained from members of a single family: mother (1), father (2) and 9 children. Father and 6 children (3, 5, 7, 8, 10, 11) in this family have symptoms of Huntington's disease (HD). Father first showed symptoms of the disease after he was 40 years old; the onset age of the disease in children is shown in the figure near corresponding DNA fragments. What is the probability of 4th, 6th and 9th child in this family falling ill with the disease?



- A. Child 4 and child 9 are healthy and will never develop Huntington's disease, whereas child 6 has high probability of developing the disease.
- B. Short PCR fragments correspond to appearance of HD at an early age.
- C. Child 4, child 6 and child 9 all have chances to develop HD at an older age.

D. There is no correlation between the age of children with disease symptoms and the rate of migration of PCR-amplified fragments.

E. Huntington disease is an infectious disease therefore most children of the family must be ill.

A43. (1 point). The long corolla of tobacco is inherited as a recessive monogenic characteristic.

If in a natural population 49% of plants have a long corolla, what is the probability that the result of test crossing plants with a short corolla from this population in F_1 will have uniformity of progeny?

- A. 82,4 %.
- B. 51 %.
- C. 30 %.
- D. 17,7 %.
- E. 42 %.

A44. (1 point). In a genetically balanced population involving alleles T and t. 51 % of the individuals show the dominant phenotype. Suddenly the living conditions change causing death of all recessive individuals before they reach maturity. After this, conditions return to normality. What will be the frequency of allele t after one generation?

- A. 0,41.
- B. 0,3.
- C. Impossible to determine.
- D. 0,7.
- E. 0,58.

A45. (1 point). On land the process of evolution proceeds faster than in the sea, because:

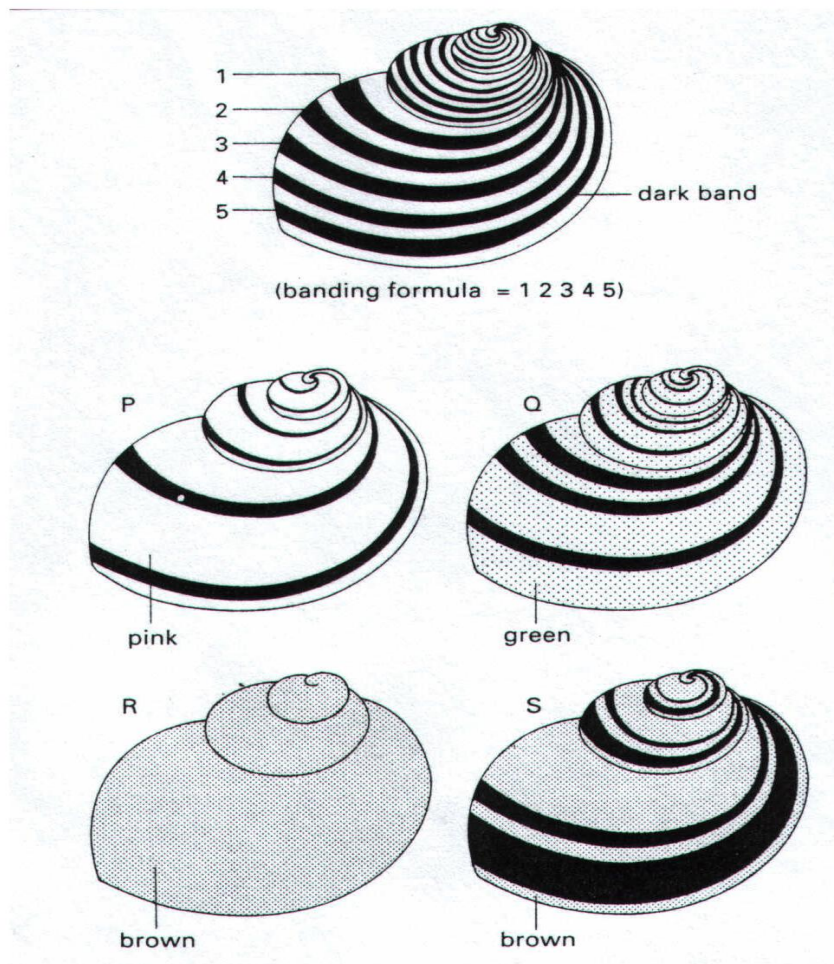
- A. Life started in the sea.
- B. Selection pressure is higher in the sea so surviving is more difficult.
- C. More fossils are found in depositions of the sea.
- D. Living conditions in the sea are more stable.

A46. (1 point). The phenomenon of reduction in organism complexity during the process of evolution is called:

- A. Ecological regress.
 - B. General degeneration.
 - C. Idioadaptation.
 - D. Aromorphosis.
 - E. Disjunction.
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Ecology (8 questions, 10 points).

A47. (3 points). The shell of the land snail shows variation in both colour and banding pattern. In order to construct a 5-figure banding formula, bands are numbered from the top of the largest whorl, as shown in the diagram. '0' is used to represent the absence of a band and square brackets indicate the fusion of two bands.



A47.1. (1 point). Using the appropriate letter, indicate the banding formula of shell S.

- A. 030[45].
- B. 03045.
- C. 02045.
- D. 003[45].

A47.2. (1 point). Thrushes (which have good colour vision) smash the shells of land snails against stones (anvils) in order to feed on the soft inner body. If snail types P, Q, R and S began in equal numbers in a habitat of grassland, which would be

the most popular among birds?

- A. P.
- B. Q.
- C. R.
- D. S.

A47.3. (1 point). A survey of broken shells collected from thrush anvils amongst dead beech leaves in a woodland area was carried out. Predict which of the following sets of results was obtained.

Options	Broken shells of each type (%)			
	P	Q	R	S
A.	13	33	1	5
B.	11	1	34	6
C.	5	1	14	32
D.	6	21	20	5

A48. (1 point). Which combination of the following statements, referring to the process of ecological succession, is correct?

1. Nutrient availability generally increases.
2. Species diversity decreases as the process proceeds.
3. A new group of plant species achieves dominance over time and ousts the previous species.
4. The height and biomass of the vegetation usually increases as the process proceeds.
5. Each group of species modifies the habitat making it more favourable for other species.

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

A49. (1 point). Which matching of factors influencing the growth of a population is correct?

	Factors depending on the population's density.	Factors independent of the population's density.
A.	Development of territories, cannibalism.	Wind, parasites, light.
B.	Migration, amount of food.	Temperature, crowding factor.
C.	Development of territories, temperature.	Humidity, wind, light.
D.	Overcrowding factor, light.	Wind, quality of the soil.
E.	Parasites, predators.	Quality of the soil, humidity.

A50. (1 point). A typical feature of the climax stage of an ecological succession is:

- A. The ecosystem is very stable
- B. The increase of biomass is at its maximum.
- C. The number of plant and animal species continues to increase.
- D. The net production of the ecosystem has remarkable but regular differences from year to year.

A51. (1 point). In ecological pyramids, normally each higher trophic level is smaller. Possible exceptions leading to inverted pyramids are:

- I. A pyramid of numbers with one big producer.
- II. A pyramid of mass when producers have a very short life cycle.
- III. A pyramid of energy in extremely hot ecosystems.

Which combination is correct?

- A. Only I and II.
- B. Only II and III.

C. Only I and III.

D. I, II and III.

E. None of these.

A52. (1 point). You and your family are stranded on a remote island with one cow and a large stock of wheat for cow food. To obtain the highest amount of energy and survive for the longest period of time, you should:

A. Feed the wheat to the cow, then drink the milk.

B. Eat the cow, then eat the wheat.

C. Feed the wheat to the cow, drink the milk, then eat the cow.

D. Drink the milk, eat the cow when milk production ceases, then eat the wheat.

A53. (1 point). If an area has a total energy, K , in the sunlight available, the net energy productivity of the fourth trophic level in the area is roughly:

A. $10^{-3} \times K$

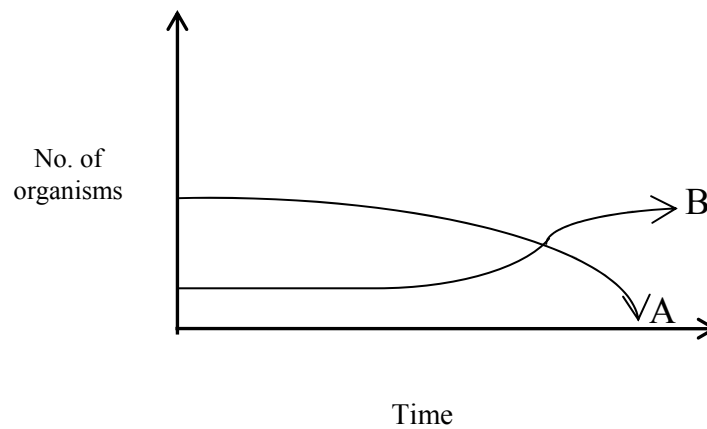
B. $10^{-5} \times K$

C. $10^{-7} \times K$

D. $10^{-4} \times K$

E. $10^{-6} \times K$

A54. (1 point). Assume first that the graph below shows the changes in two populations of herbivores in a grassy field. A possible reason for these changes is that:



- A. All of the plant population in this habitat decreased.
- B. Population B competed more successfully for food than did population A.
- C. Population A produced more offspring than population B did.
- D. Population A consumed the members of population B.
- E. Over time, both populations will have the same average number.

Biosystematics (6 questions, 6 points).

A55. (1 point). To assign ascidia to subphylum *Urochordata* it is necessary to know the features of the larval stage of ascidia. Which is the correct combination of statements I-IV ?

- I. They possess a notochord in the larval stage.
- II. They are highly specialised.
- III. They possess a hollow dorsal neural tube, which in metamorphosis is reduced.
- IV. They possess a propulsive tail, pharynx and branchial slits

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

A56. (1 point). Which are the characteristics of *Cnidaria* ?

- A. Oceanic/marine or freshwater, mainly predators.
- B. Only oceanic/marine, mainly predators.
- C. Oceanic/marine or freshwater, filter feeding.
- D. Only oceanic/marine, always filter feeding.
- E. Only freshwater, predators or parasites.

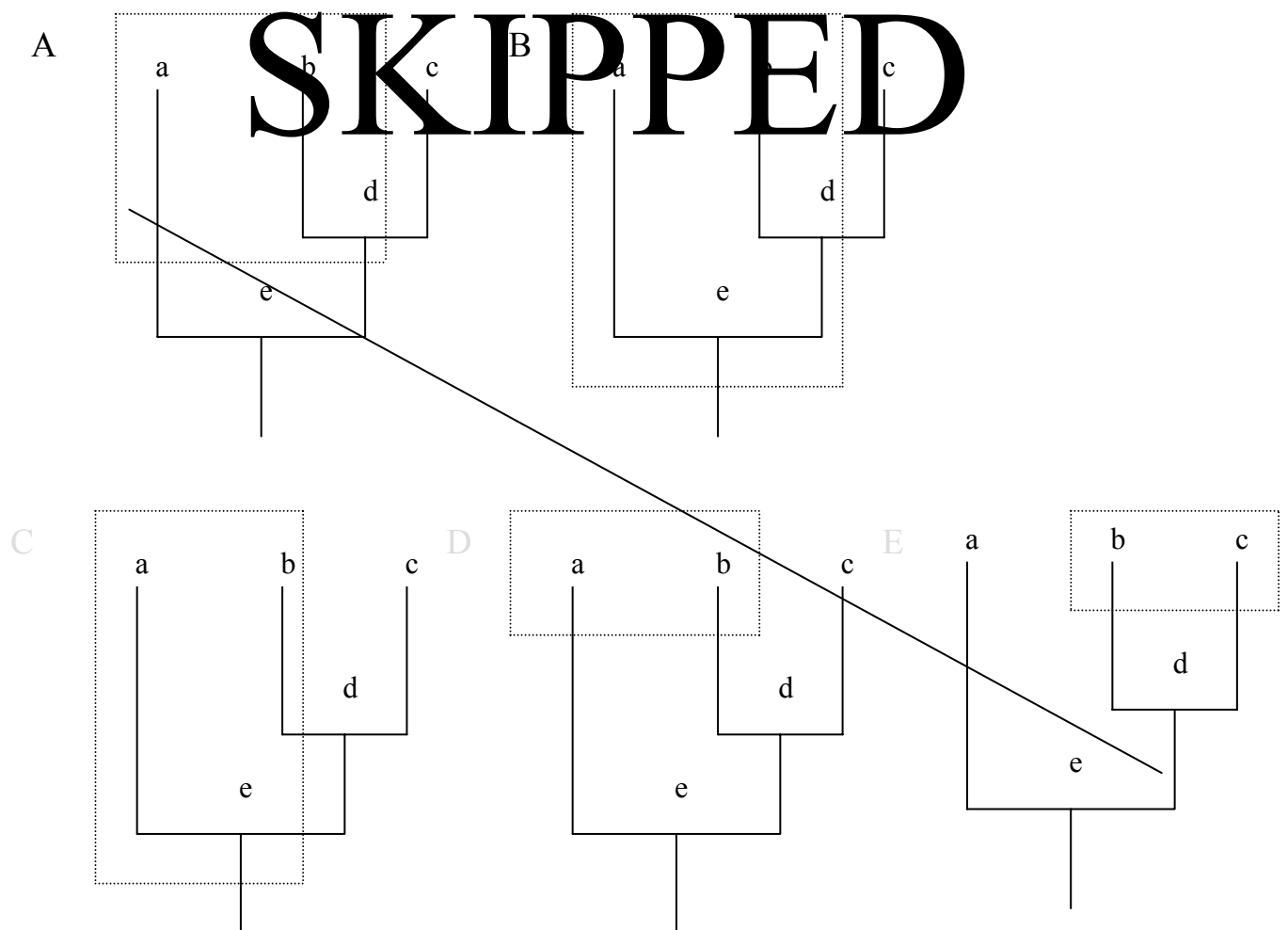
A57. (1 point). Which of the following statements can be used as evidence to prove the close evolutionary relationship between Phylum *Annelida* and Phylum *Mollusca*?

- A. Both of them have bodies with bilateral symmetry.
- B. Their digestive systems have similar parts.
- C. Their bodies consist of similar tegmata (segments).
- D. Both of them have a closed circulatory system.
- E. Many molluscs and marine annelids have a trochophore larva in their life cycle.

A58. (1 point). Zoologists place chordates and echinoderms on one major branch of the animal phylogenetic tree, and molluscs, annelids, and arthropods on another major branch. Which of the following is a basis for this separation?

- A. Whether or not the animals have skeletons.
- B. What type of symmetry they exhibit.
- C. Whether or not the animals have a body cavity.
- D. How the body cavity is formed.
- E. Whether or not the animals are segmented.

A59. (1 point). Phylogenetic connections between three extant (a, b, c) and two extinct (d, e) taxonomic groups are shown below in the cladogram. What kind of their association into a taxon of the highest rank (encircled with dotted line) would be in concord with principles of natural systematics (monophyletic or paraphyletic groups)?



A60. (1 point). There are five species (K, L, M, N, O) in a single family. They belong to the same genus. The table lists data concerning the presence or absence of six features in these species:

Species	Features					
	1	2	3	4	5	6
K.	+	-	+	+	+	-
L.	-	-	-	-	+	-
M.	+	-	-	-	-	-
N.	-	+	-	-	-	-
O.	+	-	+	+	-	-

Based on the assumption that the most probable scheme of phylogenetic development is that which required the least number of evolutionary changes, indicate the species that is the most probable ancestor of species O.

- A. K
- B. L
- C. M
- D. N