

PART B

Cell biology (10 questions, 51 points).

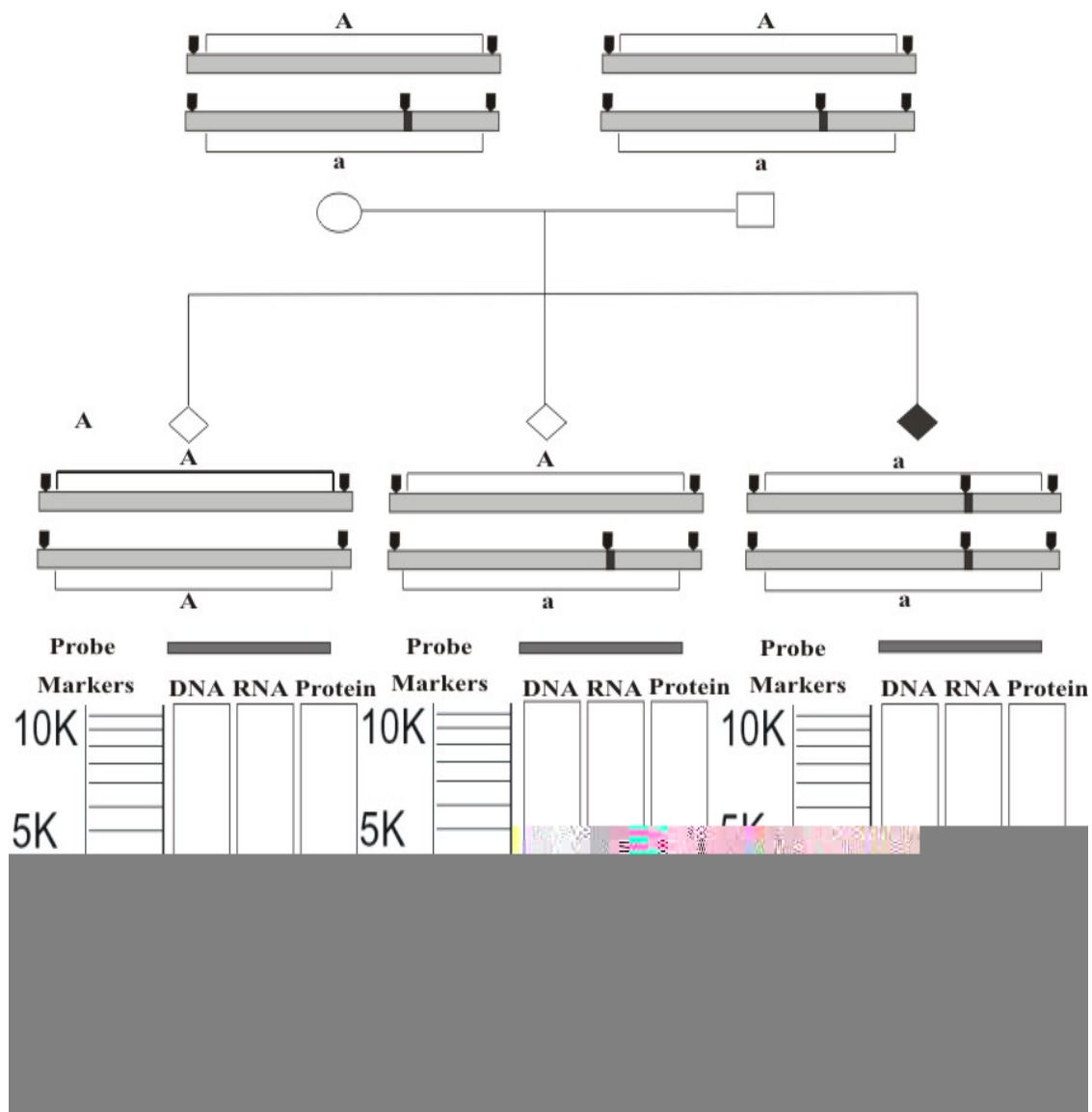
B1. (6 points). It is known that ribosomes of cytoplasm, ribosomes of endoplasmic reticulum (ER) and mitochondrial ribosomes take part in protein biosynthesis. Write the numbers of the proteins in the list below in the correct box, according to the site of their synthesis.

- | | | |
|-----------------|---------------------------|---------------------------|
| 1. Elastin | 5. Glycogen synthase | 9. Prothrombin |
| 2. Collagen | 6. Receptors for glucagon | 10. Keratin |
| 3. Somatotropin | 7. Casein | 11. Lactate dehydrogenase |
| 4. Actin | 8. Phosphofructokinase | 12. Tubulin |

Answers:

ER-bounded ribosomes	
Cytoplasmic ribosomes	
Mitochondrial ribosomes	

B2. (9 points). The Human condition albinism is inherited in the autosomal recessive manner (see figure). The cause of this condition is a mutation from wild type allele *A* to recessive allele *a*, which introduces a stop codon into the middle of the gene, resulting in a shortened polypeptide. The mutation also introduces a new target site for a restriction enzyme, which makes it possible to detect mutated genes by restriction mapping.



Task:

Depict the expected results of Southern-, Northern-, Western-blot hybridization analyses of all genotypes (aa , Aa , AA). Results of Southern-blot hybridization should be depicted according to the length of the largest restriction fragment (11 kb) and length markers shown to the left of each Southern-blot hybridization lane. Markers have to do only with the length of DNA fragments. Results of Northern- and Western-blot hybridization should be depicted without scale, but taking into account the respective positions of different restriction fragments for different genotypes.

B3. (3 points). Three human-mouse hybrid cell lines have been created (X, Y and Z). The table below summarizes their characteristics. Each cell line has several human chromosomes carrying genes coding for particular enzymes.

Human chromosome or enzyme	Line X	Line Y	Line Z
Chromosome 3	–	+	–
Chromosome 7	–	+	+
Chromosome 9	–	–	+
Chromosome 11	+	+	–
Chromosome 15	+	–	–
Chromosome 18	+	+	+

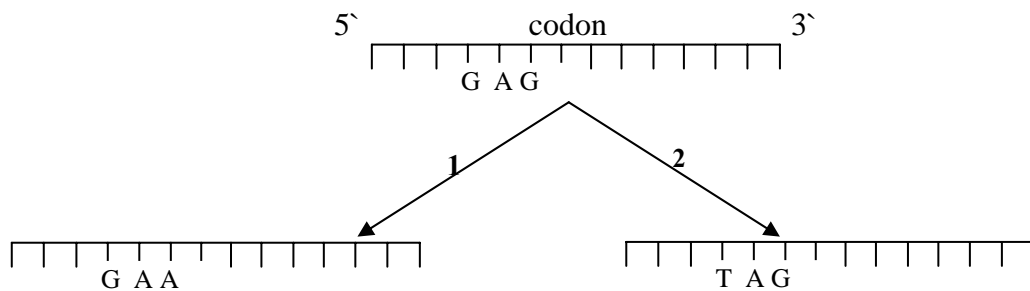
Chromosome 20	+	-	+
Glutathione reductase	+	+	-
Malate dehydrogenase	+	-	-
Galactokinase	-	+	+

Identify by giving the number, the human chromosome that carries the gene of each enzyme.

Answers:

Gene of Enzyme	Chromosome number
Glutathione reductase	
Malate dehydrogenase	
Galactokinase	

B4. (3 points). Two independent mutations event of a DNA segment lead to the following results. Mark the type(s) of mutations observed.
(See Genetic Codes in the front of Part A)



A. Point mutation.

E. Neutral mutation.

B. Transition.

F. Missense mutation.

C. Silent mutation.

G. Nonsense mutation.

D. Transversion.

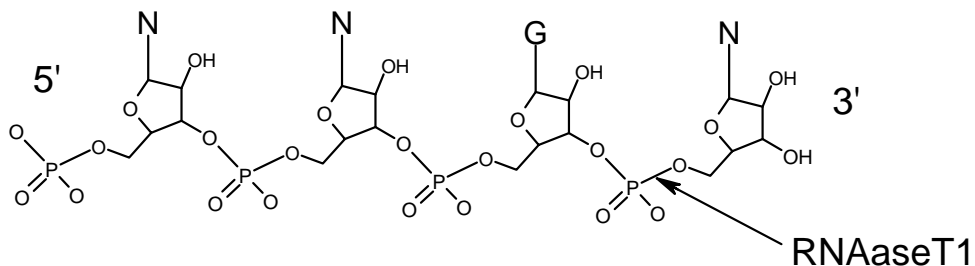
Answer

1: 2:

B5. (3 points). Mark the correct statements by '+' and the incorrect ones by '-' in the appropriate box.

- A. In any region of the DNA double helix only one chain of DNA that is usually used as a template for transcription.
- B. In bacteria the transcription of all classes of RNA is carried out by RNA polymerase of a single type, whereas in eukaryotic cells three types of RNA polymerase are used.
- C. Formation of the peptide bond is carried out by enzyme peptidyl transferase, which binds to large subunit of ribosome after the initiation of translation.
- D. Since the start codon for protein synthesis is AUG, methionine is only found in N termini of polypeptide chains.
- E. Many antibiotics used in medicine today selectively inhibit protein synthesis only in prokaryotes because of structural and functional differences between ribosomes of prokaryotes and eukaryotes.
- F. Modified nucleotides, which are in the composition of tRNA molecule, form as a result of covalent modification of standard nucleotides after their incorporation into RNA-transcripts.

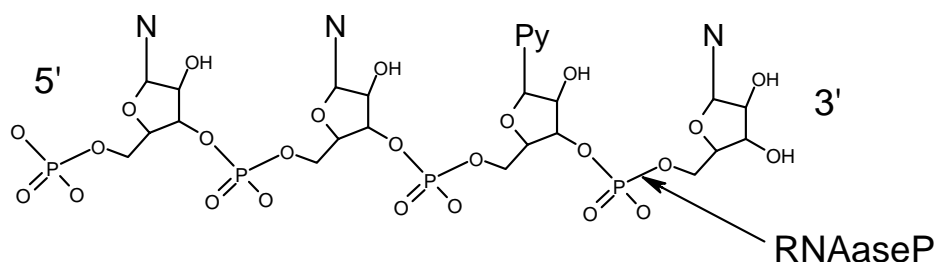
B6. (5 points). Oligoribonucleotide X was treated with phosphatase (for removal of 3' and 5' - terminal phosphates), then with RNAase T1, which cleaves all phosphodiester bonds located in a 3' position of guanosine in a 5'-specific manner.



As a result, oligonucleotides L, M and N were generated in equal amounts. Each of them was further treated with phosphatase and subjected to alkaline hydrolysis. Results are listed in the table below.

Oligoribonucleotide	Content, mole/mole of oligoribonucleotide
L	UMP (1), AMP (1), CMP (1), Guanosine (1)
M	AMP (1), Cytidine (1)
N	CMP (2) , Guanosine (1)

Then experiment was modified: oligoribonucleotide X after treatment with phosphatase was hydrolyzed with RNAaseP, which cleaves all phosphodiester bonds in a 3'-position of pyrimidines in a 5' - specific manner.



This hydrolysis yielded five products in approximately equimolar concentrations: uridine monophosphate, cytidine monophosphate and oligonucleotides P, Q and R. After resolution of the mixture and alkaline hydrolysis of these oligonucleotides data listed in the table below were obtained.

Oligoribonucleotide	Content, mole/mole of oligoribonucleotide
	CMP (1), GMP (1)
Q	GMP (1), AMP (1), Cytidine (1)
R	AMP (1), CMP (1)

Using the results given above, deduce the nucleotide sequence of oligoribonucleotide X.

Answer: _____

B7. (5 points). The amino acid cysteine (Cys) has three ionizable groups:

- α -amino group
- α -carboxyl group
- a side chain that can be negatively charged.

The pK values are 8.18, 1.71 and 10.28, respectively. In the answer table, enter the ionic charge of cysteine at pH 1, 5, 9 and 12.

Using an appropriate letter for each direction, show migration of cysteine in an electric field at different pH values.

- . To cathode (–)
- . To anode (+)
- . Does not migrate

Also in the table, circle the pH value nearest to the pI (isoelectric point) of this amino acid.

Answer:

pH	Ionic charge	Migrates toward
1		
5		
9		
12		

B8. (8 points). Listed in the two tables below are vitamins (A-K) and functions (1-12).

Designation	Vitamin
A.	B ₁ (thiamine)
B.	B ₂ (riboflavin)
C.	B ₆ (pyridoxine)
D.	Folic acid
E.	A (retinol)
F.	D (calciferol)
G.	E (tocoferol)
H.	(menaquinone)
I.	C (ascorbic acid)
J.	B ₁₂ (cobalamin)
K.	PP (nicotinic acid / niacin)

Number	Functions of vitamins or consequences of deficiency
1.	Antioxidant
2.	Regulation of calcium and phosphate metabolism
3.	Group transfer to or from amino acids
4.	Precursor of light absorbing group in visual pigments
5.	Blood coagulation
6.	Scurvy
7.	Beri beri

8.	Pellagra
9.	Anaemia
10.	-----leave this part blank-----
11.	Co-Enzymes of dehydrogenases
12.	Rickets

Match each of the vitamins with its appropriate biological functions and/or lack of deficiency of this vitamin or its derivatives. There may be more than one answer per question.

Answers:

Vitamin	Function
A.	
B.	
C.	
D.	
E.	
F.	

Vitamin	Function
G.	
H.	
I.	
J.	
K.	

B9. (4 points). The table below shows haploid or partial diploid *lac* operon of *E.coli*, where:

- Gene *lacI* codes for repressor.
- P and O are promoter and operator, respectively.
- *LacZ* and *lacY* represent genes encoding for β -galactosidase and β -galactoside permease, respectively.
- O^c is a constitutive mutation in the operator.
- I^s represents a mutation in the *lacI* gene, which causes mutant repressor protein not to be separated from the operator once it binds to it.

Assume that there is no glucose in the bacterial culture medium. In the following table write 'O' if β - galactosidase is synthesized, and 'X' if it is not.

Strain	Genotype	Lactose absent	Lactose present
1	$I^- O^c Z^+ Y^-$		
2	$I^+ O^c Z^- / I^+ O^+ Z^+$		
3	$I^- P^+ O^c Z^+ Y^+ / I^+ P^- O^+ Z^+ Y^-$		
4	$I^s P^+ O^+ Z^+ Y^- / I^- P^+ O^c Z^- Y^+$		

B10. (5 points). Match the number of the organism in the left column with the corresponding letter for the disease in the right column.

Organism

1. *Bacillus anthracis*
2. *Borrelia burgdorferi*
3. *Escherichia coli*
4. Filarial nematodes
5. *Plasmodium vivax*
6. *Streptococcus pyogenes*
7. *Trypanema pallidum*
8. *Trypanosoma gambiense*
9. *Vibrio cholerae*
10. *Yersinia pestis*

Disease

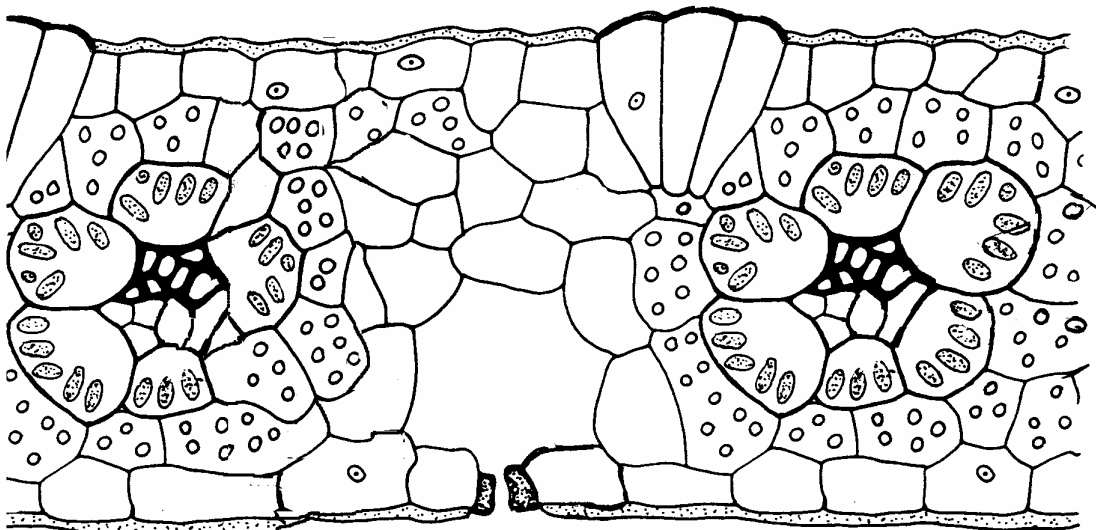
- A. African sleeping sickness
- B. Anthrax
- C. Cholera
- D. Elephantiasis
- E. Lyme disease
- F. Malaria
- G. Plague
- H. Tuberculosis
- I. Strep throat
- J. Syphilis
- K. Urinary tract infection

Answers:

1	2	3	4	5	6	7	8	9	10

Plant anatomy and physiology (6 questions, 29 points).

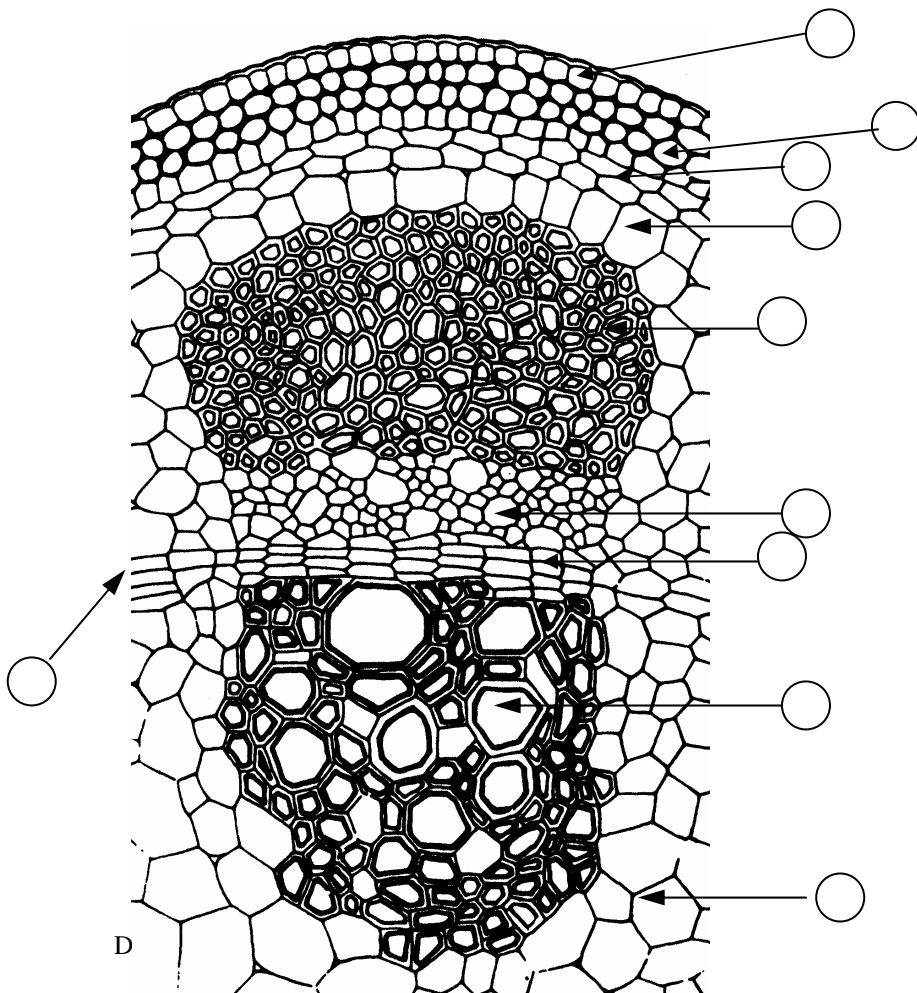
B11. (5 points). The figure shows a cross section of part of a plant leaf.



Indicate which of the following statements concerning this plant are true (+) and which are false (-).

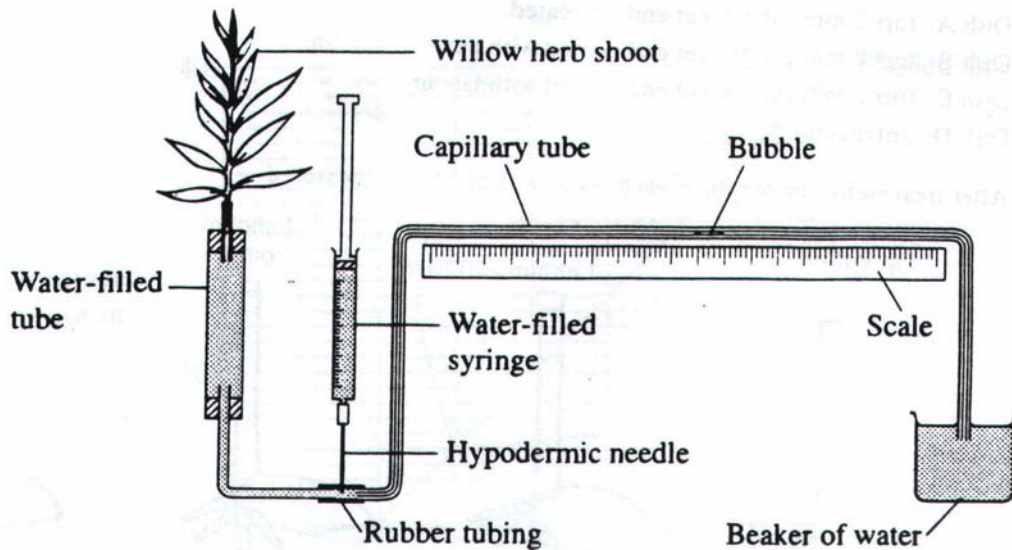
1. Aquatic (Hydrophytic) habitat.
2. C₄ -photosynthetic pathway.
3. "Kranz" anatomy
4. Mesophyll with isolateral organization.
5. Terrestrial Dry habitat (Xerophytic) and plants of tropics and subtropics.
6. C₃ photosynthetic pathway.
7. Pinnate venation.
8. Asteraceae(*Compositae*) Family.
9. Poaceae (*Gramineae*) Family.
10. Parallel venation.

B12. (5 points). Label the plant structures in the following diagram, by inserting the number in the appropriate circle on the answer sheet.



- | |
|-----------------------------|
| 1. Phloem. |
| 2. Xylem. |
| 3. Endodermis. |
| 4. Fascicular cambium. |
| 5. Epidermis. |
| 6. Parenchyma. |
| 7. Cortex parenchyma. |
| 8. Sclerenchyma. |
| 9. Interfascicular cambium. |
| 10. Collenchyma. |

B13. (5 points). The potometer can be used to measure transpiration in a cut shoot such as rose-bay willow plant, by measuring water uptake.



Indicate which of the following statements are true (+) and which are false (-).

- A. The potometer is usually assembled under water
- B. The water-filled syringe is used to suck water out of the apparatus when air bubbles appear.
- C. The shoot must be sealed over the cut point with vaseline immediately after it is cut from the plant.
- D. The hypodermic needle is used to introduce the air bubble into the potometer.
- E. Enclosing the shoot in a black plastic bag will reduce the transpiration
- F. The rate of transpiration will be high in still, humid air.
- G. The rate of transpiration will be highest in warm, dry moving air.
- H. The rate of water uptake and the rate of transpiration are not always equal.
- I. Low cohesive properties between the water molecules create problems for potometer experiments.
- J. Results from potometer experiments can never be quantitative.

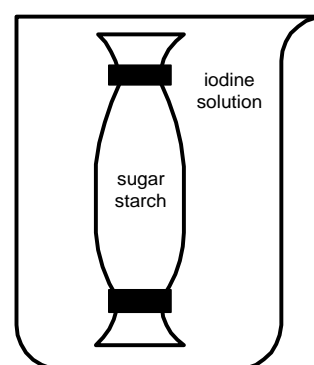
B14. (2,5 points). For a short-day plant, indicate which treatments, as listed below, would inhibit flowering. All the treatments were conducted at night. Mark correct statements with “+”, incorrect statements with “-”.

- . Exposure to red light and far-red light, consecutively.
- . Exposure to red light, far-red light, and red light, consecutively.
- . Exposure to red light, far-red light, and white light, consecutively.
- D. Exposure to white light and far-red light, consecutively.
- . Exposure to red light, far-red light, white light, red light, and white light, consecutively.

B15. (6,5 points). Diffusion and osmosis are important for the passive transport of molecules in the cell.

01. (2,0 points). The figure shows an experiment with a dialysis (visking) membrane filled with sugar and starch (colorless) suspended in a beaker with diluted iodine solution (orange – brown). Use ‘+’ to indicate which colour you would expect in the beaker and in the tube after several hours of dialysis.

	Solution in the beaker.	Solution in the dialysis tube.
Colorless		
Orange-brown		
Pink-red		
Greenish-yellow		
Blue-black		



02. (2.5 points). In a similar experiment, dialysis membranes are filled with solutions

with different concentrations of molecules and left in beakers with solutions with different molecule concentrations. The dialysis tubes all have the same mass at the beginning of the experiment. The size of the molecules is bigger than the pore size of the membrane. Mark with “+” the experimental settings in which the beaker contains a hypotonic solution compared to the dialysis tube, and mark with “-” the ones which do not.

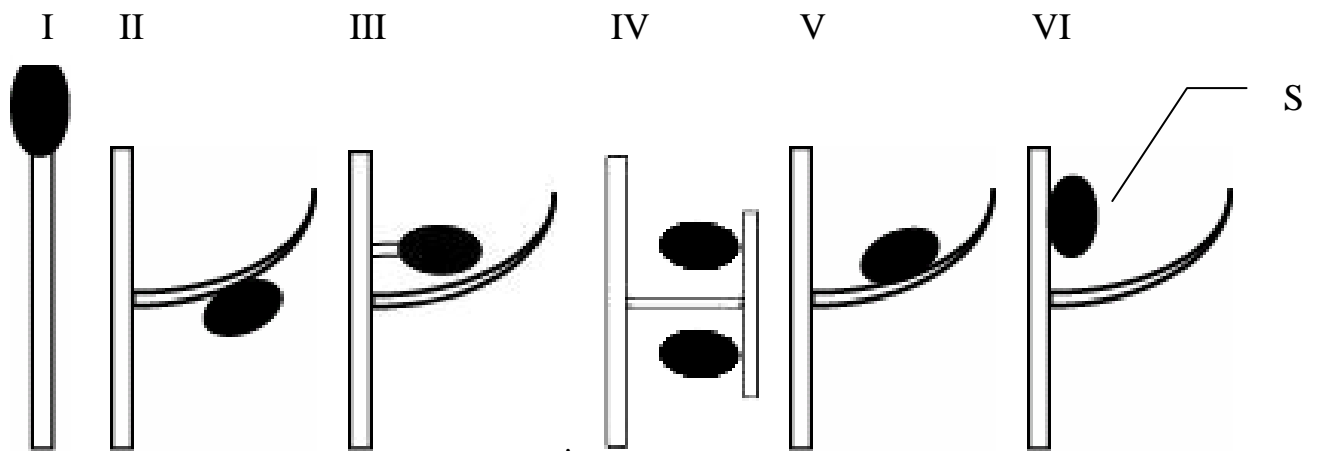
Experiment	A	B	C	D	E
Concentration in the dialysis tube (M).	0.1	0.8	0.4	0.2	0.4
Concentration in the beaker (M).	0.8	0.1	0.2	0.4	0.4
Hypotonic solution.					

03. (2 points). The tubes are weighed after several hours of dialysis. Their mass is compared to that before the dialysis. Write the letters of the experiments in the order of the final mass of the dialysis tube, beginning with the tube having the lowest mass.

Order of the tubes with regard to their mass:

Answers: _____

B16. (5 points). Which position of sporangia is characteristic of present day representatives of the higher plants phyla listed below?

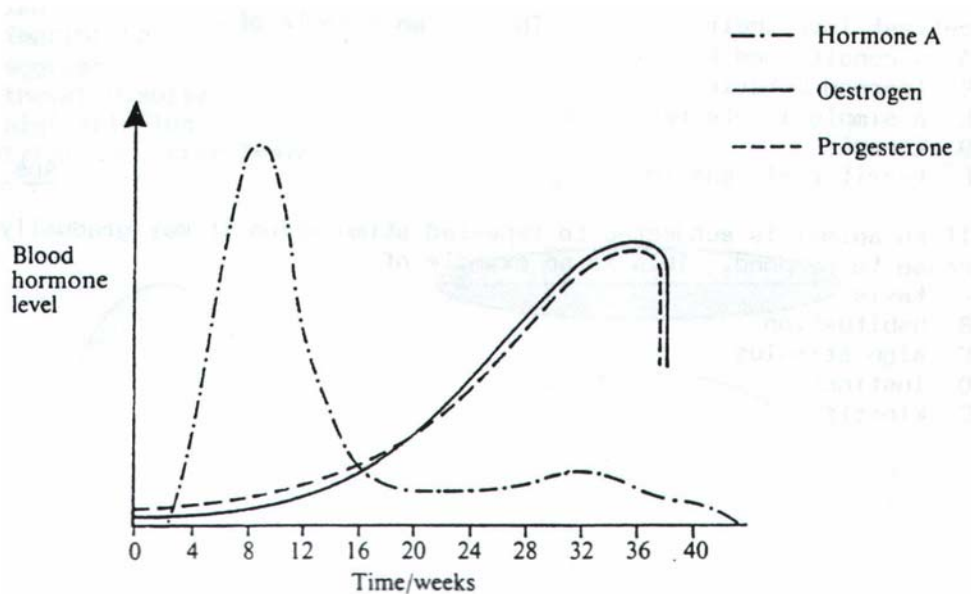


S- sporangium

Phylum	Plant number
<i>Bryophyta</i> (Liverworts and mosses)	
<i>Lycopodiophyta</i> (Club moss)	
<i>Equisetophyta</i> (Horse-tails)	
<i>Pterophyta</i> (<i>Polypodiophyta</i>) (Ferns)	

Animal Anatomy & Physiology (6 questions, 26 points).

B17. (5 points). The graph indicates the blood levels of three hormones produced in a pregnant woman.



01. (2 points). Using + (true) and – (false), indicate whether each of the following is true or false.

- A. Hormone A is produced by the ovary
- B. Hormone A is human chorionic gonadotrophin.
- C. Hormone A is prolactin.
- D. Hormone A is made by the chorion.

02. (1 point). Which hormone keeps the smooth muscle of the uterus relaxed during pregnancy? (mark with '+').

- A. Progesterone.
- B. Prolactin.
- C. Oxytocin.
- D. FSH.
- E. LH.

03. (2 points). Two other hormones, not shown on the graph, are also produced during pregnancy. These are prostaglandins and oxytocin. Indicate whether the following

statements are true (+) or false (-).

- A. These two hormones are produced by the ovaries.
- B. These two hormones are responsible for milk formation.
- C. These two hormones are responsible for contractions of the uterine wall.
- D. These two hormones are made by the endometrium and pituitary gland, respectively.

B18. (3 point). Name the germ layers of a metazoan embryo from which the following systems or organs developed:

- . Brain.
- . Hair.
- . Autonomic ganglia.
- D. Lungs.
- . Cardiac muscle.
- F. Cartilage.

- 1. **Ectoderm.**
- 2. **Endoderm.**
- 3. **Mesoderm.**

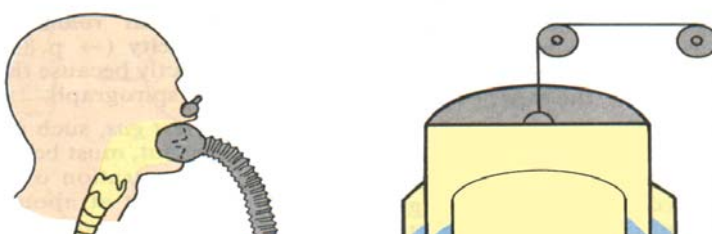
B19. (3 points). Match the protein (1 to 6) with its function (A to F):

- | | |
|-----------------|---|
| 1. Myoglobin. | A. Blood clotting. |
| 2. Prothrombin. | B. Regulation of water excretion. |
| 3. Ferritin. | C. Light-sensitive pigment of rod cells. |
| 4. Vasopressin. | D. Oxygen-storage in skeletal muscles. |
| 5. Collagen. | E. Iron storage in spleen, liver and bone marrow. |
| 6. Rhodopsin. | F. Major fibrous protein of connective tissue. |

Answers:

1	2	3	4	5	6

B20. (4 points). For the curve below, fill in the circles on the answer sheet using appropriate numbers from the upper figure. In the table, for every number put a correct letter corresponding to a term given below.



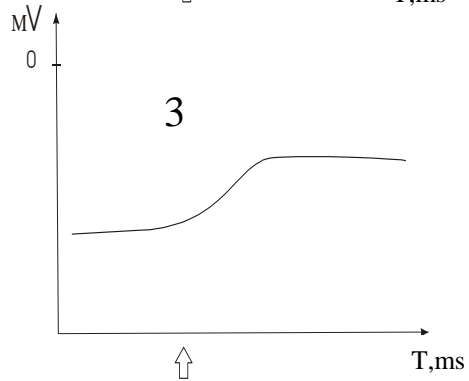
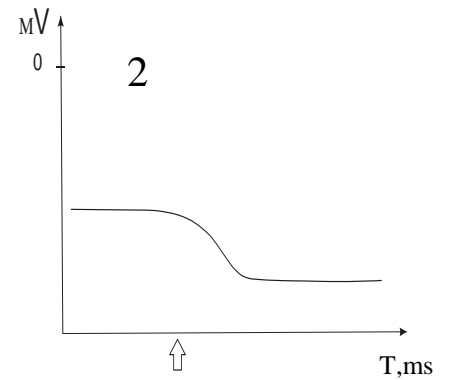
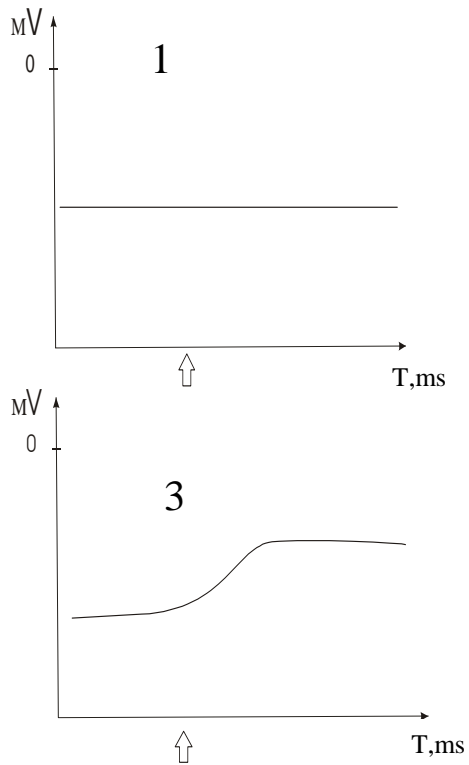
Respiratory volumes	
Number in the diagram and curve	Term letter
1.	
2.	
3.	
4.	

- A. Expiratory reserve volume.
- B. Tidal volume.
- C. Inspiratory reserve volume.
- D. Vital capacity.

B21. (7 points). How can the resting potential of a cell change after addition of the biologically active compounds listed below (compound addition is marked by an arrow \uparrow)?

01. (5 points). Determine which graph reflects the addition of which compound.

Fill the results in the table.



02. (2 points). What is the change of transmembrane potential, in graphs 2 and 3 called?

- A. Hyperpolarisation.
- B. Depolarisation.
- C. Repolarisation.

Nistatin (Na^+ -ionophore):

Tetrodotoxin (inhibitor of Na^+ -channels):

Valinomycin (K^+ -ionophore):

- D. Action potential.
- E. Overshoot.

Answers:

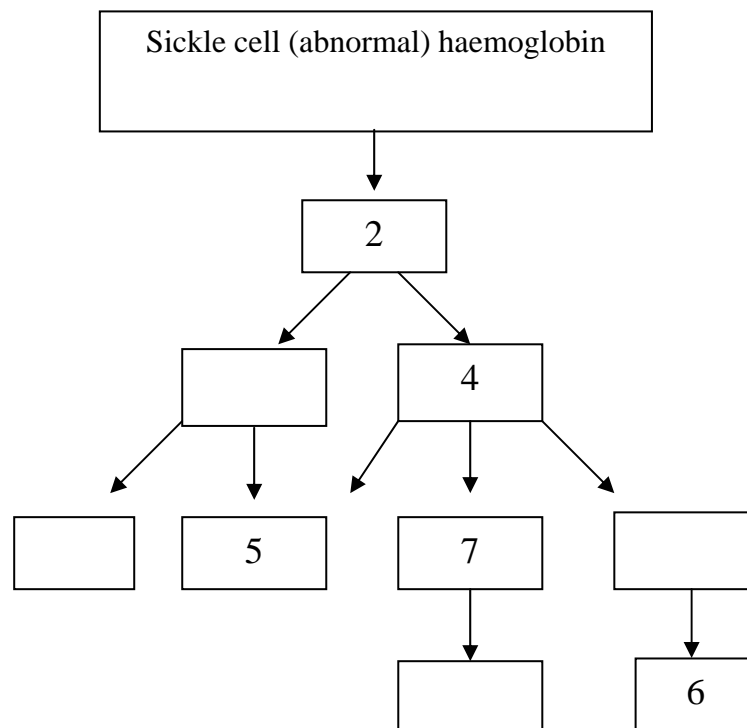
2 – _____

3 – _____

B22. (4 points). A mutation in the haemoglobin gene (*HbS*) causes sickle cell disease that produces a cascade of symptoms such as:

1. Anaemia.
2. Sickle shaped red blood cells.
3. Breakdown of red blood cells.
4. Clumping of cells and clogging of small blood vessels.
5. Heart failure.
6. Kidney failure.
7. Brain damage.
8. Damage to other organ.
9. Paralysis.

In the following diagram, the symptom in the box on top of the arrow causes the symptom in the box below the arrow. Fill the empty boxes with the number of the appropriate symptoms.



Ethology (2 questions, 12 points).

B23. (3 points). Guppies are often called ‘millionaire fishes’ because of their abundant progeny.

In 1966, Professor C.M. Breder, then director of the New York aquarium, decided to perform an experiment, in order to learn more about fish reproduction. He put pair of Guppies (one adult male and one adult female) into a small aquarium, with 27.5 liters of water capacity supplied with enough food and oxygen to maintain up to 300 fish. During the 6 following months and in an interval of 4 weeks between each breeding (these

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fishes are ovoviviparous), the female produced 102, 87, 94, 51 and 89 offspring, it means a total of 443 guppies. A later recount showed that only 9 were alive: 6 females and 3 males.

The rest had been eaten by their own mothers.

In another aquarium with the same size and conditions, the researcher placed 8 adult males, 8 adult females and 8 young fishes, a total of 24 guppies. Females got abundant progeny, too. Data of proliferation during the course of the following 6 months from the introduction of the original group of 24 guppies in the aquarium, are shown in the following tables.

FEMALE 1						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	29	24	31	30	33
	Females	58	48	64	58	68
	Total	87	72	95	88	101
Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 2						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	32	26	33	28	29
	Females	65	50	66	56	58
	Total	97	76	99	84	87
Number of offspring	Males	0	0			0

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counted some hours after hatching	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 3						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	32	29	25	34	28
	Females	64	56	51	69	55
	Total	96	85	76	103	83
Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 4						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	28	25	35	30	29
	Females	57	49	69	61	60
	Total	85	74	104	91	89

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Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 5						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	33	30	30	23	30
	Females	67	59	64	47	60
	Total	100	89	94	70	90
Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 6						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	30	29	26	35	25
	Females	62	57	53	70	52
	Total	92	86	79	105	77

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Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 7						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	29	24	33	28	29
	Females	60	50	71	57	62
	Total	89	74	104	85	91
Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0
Observation: The just hatched guppies were devoured by their own mother						

FEMALE 8						
		Week 4	Week 8	Week 12	Week 16	Week 20
Number of offspring after each hatching	Males	26	32	33	28	28
	Females	52	65	64	58	57
	Total	78	97	97	86	85

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Number of offspring counted some hours after hatching	Males	0	0	0	0	0
	Females	0	0	0	0	0
	Total	0	0	0	0	0

Observation: The just hatched guppies were devoured by their own mother

ORIGINAL NUMBER OF FISH			
	ADULTS		YOUNGS
	Males	Females	
Initial number of guppies in the aquarium	8	8	8
N° of guppies recounted one year later	3	6	0

Observations: The young of the original establishment were devoured by the adults.
Some adults of the original establishment died by unknown causes.

Which of the following statements arise from the analysis of the previous data? Mark with 'X' correct statements.

I. Guppies eat their own offspring ('infanticide' behaviour).

II. Guppies show 'indiscriminate' cannibalism, eating all individuals belonging to its

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- species.
- III. Guppies show 'selective' cannibalism, eating the individuals belonging to its species which are shorter than threshold level.
- IV. Guppies show 'selective' cannibalism eating only foreign progeny.

B24. (8 points). Two young men (Hans and Henri), behaviour researchers of more or less the same age and appearance, are going to do some investigations about sexual preferences of human females. For this purpose they select six nice outdoor cafés popular with young women and hire two similar bikes of which one is provided with an extra child saddle (see diagram).



Hans and Henri expect that a man having a bike with a child's saddle is more attractive to young women. This is checked on a sunny afternoon in July. Hans and Henri make a tour along the six outdoor cafés, indicated A to F. At every café they halt for 15 minutes. While standing in front of the café with their bikes and pretending they are having a talk together, they both try individually to make eye contact with as many as possible of the females sitting outside. The numbers are recorded and after each café Hans and Henri change bikes. The results of this experiment are shown in the table.

	Number of hits (eye contacts) at café A to F						
	A	B	C	D	E	F	Total
Hans	<u>12</u>	10	<u>14</u>	7	<u>17</u>	12	72
Henri	9	<u>17</u>	10	<u>10</u>	12	<u>20</u>	78
Total	21	27	24	17	29	32	150

Remark: underlined are the hits obtained by man (Hans or Henri)+bike with child saddle.

Hans and Henri expect that the man with a bike having an extra child saddle will be more attractive to females than the man with the bike without a child saddle. Possible arguments supporting this idea are based on the hypothesis that female organisms often show behaviour focusing on objects related to survival of species.

01. (1 point). Which of the following statements is a correct Null Hypothesis for the experiment of Hans and Henri?

1. Hans and Henri do have the same attractiveness for females.
2. The attractiveness of a man + bike with child's saddle is the same as man + 's saddle.
3. The six cafés do not differ in the character of the visiting females.
4. Having eye contact between a male and a female is not an indicator of attraction.
5. The attractiveness of a man+bike with child's saddle is greater than that of a man+bike without child's saddle.

02. (1 point). Hans and Henri do some calculations with their results.

	Number of hits per café	
	Mean (average)	Standard deviation
Hans	12	3.4
Henri	13	4.5
Hans+Henri	25	5.5
<u>Situation A:</u> Man + bike with child's saddle	15 (n_A)	3.7 (S_A)
<u>Situation B:</u> Man + bike without child's saddle	10 (n_B)	1.9 (S_B)

You have to check the significance of the differences between situation A and B using the t-test. The following table should be used.

Level of significance	Critical t-value
10.0 %	2.02
5.0 %	2.57
2.5 %	3.37
1.0 %	4.03
0.5 %	6.86

Calculate the standard deviation of the difference between the means of the two situations A and B in using the formula:

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$$S = \sqrt{\{(s_A^2/n_A) + (s_B^2/n_B)\}}$$

$S =$

03. (1 point). Calculate t, using the formula:

$$t = d/s$$

$t =$

d – difference between means (situation A and situation B).

04. (1 point). How sure can we be about rejecting the Null hypothesis (i.e. the difference between situation A and B is significant)

1. Less than 75.0 %
2. In between 75.0 % and 90.0 %
3. In between 90.0 % and 95.0 %
4. In between 95.0 % and 97.5 %
5. In between 97.5 % and 99.0 %
6. In between 99.0 % and 99.5 %
7. Over 99.5 %

05. (1 point). Hans and Henri show their results to Paula, their boss. Paula claims that Hans and Henri made a big mistake looking at the total number of hits per café since the six cafés differ too much as a spread of 17 up to 32 is too much. Hans and Henri do not agree with Paula and want to prove their point of view using the χ^2 test. Determine the χ^2 using the following formula.

$$\chi^2 = \frac{(O - E)^2}{E}$$

$\chi^2 =$

06. (1 point). Indicate the degree of freedom (df) for this test:

07. (1 point). Determine the probability (P) for this χ^2 test, using the following table. Estimate the answer in %.

(df)	Probability of random deviation (P)									
	0.995	0.975	0.9	0.5	0.3	0.25	0.1	0.05	0.025	0.01
1	0.00	0.00	0.02	0.46	1.07	1.32	2.71	3.84	5.02	6.64
2	0.01	0.05	0.21	1.39	2.41	2.77	4.61	5.99	7.38	9.214
3	0.07	0.22	0.58	2.37	3.67	4.11	6.25	7.82	9.35	11.35
4	0.21	0.48	1.06	3.36	4.88	5.39	7.78	9.49	11.14	13.28
5	0.41	0.83	1.61	4.35	6.06	6.63	9.24	11.07	12.83	15.09
6	0.68	1.24	2.20	5.35	7.23	7.84	10.65	12.59	14.45	16.81
7	0.99	1.69	2.83	6.35	8.383	9.04	12.02	14.07	16.0	18.48

08. (1 point). Which of the following conclusions based upon this χ^2 test is correct? Look at the total number of hits per cafe

1. The café's are different, but the differences are not significant
2. The differences between the cafés are significant
3. The results are dubious or questionable, something must be wrong in the design of this experiment
The cafés are not different, but this is not significant
4. The cafés are not different and this is significant

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Genetics (7 questions, 26 points).

B25. (4 points). For each species listed in the table below, indicate whether it can be routinely used to study, investigate or manipulate one or more of the numbered items.

1. Obtain gene mutations.
2. Obtain chromosomal mutations in eukaryotes
3. Make gene maps.
4. Investigate meiosis.
5. Investigate mitosis.
6. Investigate X-chromosome.
7. Obtain extranuclear mutations.
8. Use *Agrobacterium tumefaciens* Ti-plasmid for gene transfer to the cells of given organisms.
9. Perform the gene transfer by transduction.
10. Investigate the *lac*-operon regulation.
11. Determine the DNA sequences.

Indicate the correct statements by "X" in corresponding box of answer table:

Object	Item number(s)										
	1	2	3	4	5	6	7	8	9	10	11
<i>Zea mays</i>											
<i>Drosophila melanogaster</i>											
<i>Saccharomyces cerevisiae</i>											
<i>Caenorhabditis elegans</i>											
<i>Escherichia coli</i>											
<i>Bacteriophage λ</i>											
<i>Prions</i>											

B26. (5 points). The birth records for 4 children were lost at a hospital. The ABO blood groups of the four babies are known to be A, B, AB, and O. To determine parentage all of their parents were tested for blood group. (The father of third child wasn't found). The results are shown in the following table.

01. (4 points). Match the babies with their parents by marking the right blood types in the table .

Families		Blood group of each parent	Blood group of a baby
Parents 1	Father	AB	

	Mother	O	
Parents 2	Father	A	
	Mother	O	
Parents 3	Father	Unknown	
	Mother	A	
Parents 4	Father	O	
	Mother	O	

02. (1 points). What is/are the possible blood group(s) the unknown father could have?

B27. (3 points). Connect the terms widely used in population genetics in the left column with the correct statement in the right column.

	Term		Statement
1	Inbreeding depression.	A	Fixes advantageous alleles and removes disadvantageous alleles.
2	Gene flow.	B	Increases genetic diversity within and between sub-populations, but occurs rarely.
3	Selection.	C	Increases variation between sub-populations and decreases variations within sub-populations.
4	Outbreeding depression.	D	Fitness reduces due to increase in homozygosity, expression of deleterious alleles increases as a consequence of mating between closely related individuals.
5	Genetic drift.	E	Reduction of fitness due to mating of genetically divergent individuals.
6	Mutation.	F	Decreases variation between sub-populations and increases variation within sub-populations.

Term	1	2	3	4	5	6

<u>Answers:</u>						
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B28. (4 points). In an isolated human population of 8400 persons, the frequency of allele I^A is 30% and allele I^B is 10%.

What is the number and % of people with each blood group?

Group	People number	%
O		
A		
B		
AB		

B29. (4 points). Suppose that the difference between 10 cm high maize and 26 cm high maize is due to four pairs of additive genes. The individuals with 10 cm have the aabbccdd genotype and the 26 cm - AABBCcDD.

01. (1 point). Determine the phenotype of F1 if it is known that the parental plants are 10 cm and 26 cm of high.

Answer:

F1:

02. (1 point). How many phenotypes classes would be in F2?

Answer:

F2:

03. (1 point). Determine the phenotypes of F2 if it is known, that the parental plants are 10 cm and 26 cm high.

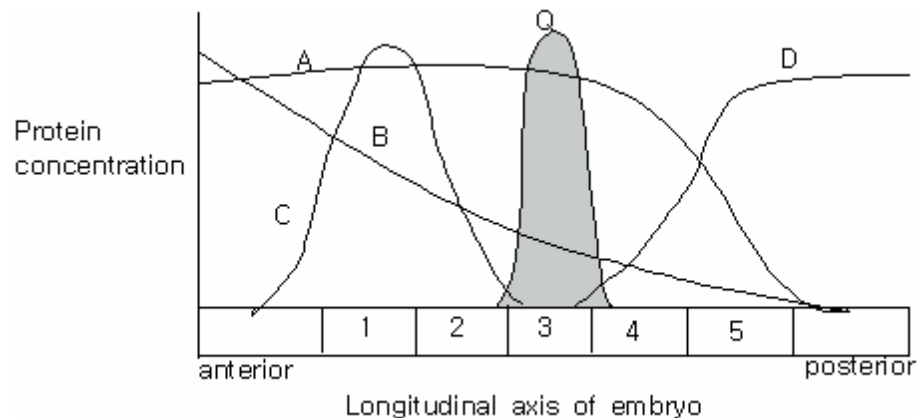
Answers:

04. (1 point). What fraction of the total number of plants in F2 will be 18 cm high ?

Answer:

B30. (4 points). The following figure shows the distribution of the concentrations of five hypothetical proteins in a *Drosophila* embryo. The anterior end is on the left and the posterior end is on the right. A and B gene products activate the expression of Q gene,

and C and D gene products repress the expression of Q gene.



If one of the A, B, C and D genes is mutated, where would the protein Q be found? Choose the number of the correct answer.

	Expression pattern of Q gene
Mutant A	
Mutant B	
Mutant C	
Mutant D	
<p>I. Would be found in the anterior end of the embryo body. II. Would be found in the posterior end of the embryo body. III. No significant change IV. Expression of Q gene would decrease significantly.</p>	

B31. (2 points). It is known that in some dioecious plants sex can be determined genetically as in animals. Examine the results of analysis of different types of polyploids and ascertain the type (mechanism) of sex determination in the given plant species. Choose the correct statement and put its number in the appropriate box.

<i>Rumex acetosa</i>		<i>Silene latifolia</i>	
Genotype	Sex	Genotype	Sex
2 +2		2 +2	
2 + +Y		2 + +Y	
2A+X+2Y		2A+X+2Y	
2A+X+3Y			
2A+2X+Y		2A+2X+Y	
2A+2X+2Y			
3A+X+2Y			
3A+X+3Y			

$3A+X+4Y$ $3A+2X$ $3A+2X+Y$ $3A+2X+2Y$ $3A+2X+3Y$ $3A+3X$ $3A+3X+Y$ $3A+3X+2Y$ $4A+2X+2Y$ $4A+2X+3Y$ $4A+2X+4Y$ $4A+3X$ $4A+3X+Y$ $4A+3X+4Y$ $4A+4X$ $4A+4X+Y$ $4A+4X+2Y$ $5A+5X$ $6A+4X+4Y$		$3A+2X$ $3A+2X+Y$ $3A+3X$ $3A+3X+Y$ $4A+X+Y$ $4A+2X$ $4A+2X+Y$ $4A+2X+2Y$ $4A+3X$ $4A+3X+Y$ $4A+3X+2Y$ $4A+4X$ $4A+4X+Y$ $4A+4X+2Y$	
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A – haploid number of autosomes.

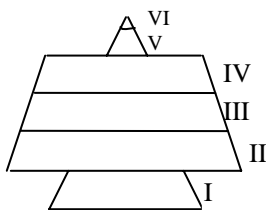
- Sex determination as in human.
- Sex determination as in *Drosophila*.
- Sex determination as in birds.
- Sex determination as in bees.
- In given plants X-chromosome determines maleness and Y-chromosome determines femaleness.
- The presence of the Y-chromosome is a necessary and sufficient condition for the formation of male flowers.
- Y-chromosome doesn't take part in sex determination.
- X-chromosome doesn't take part in sex determination.

01. *Rumex acetosa*

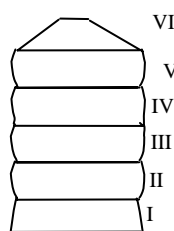
02. *Silene latifolia*

Ecology (5 questions, 19 points).

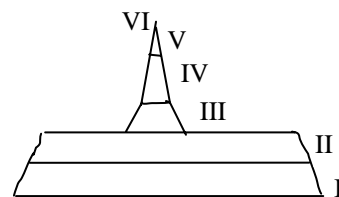
B32. (3 point). Three pond ecosystems (1, 2 and 3) were used for fish production. When the total number of fish in each pond was measured, the following pyramids were obtained. (Age of the fish is divided into six class intervals).



1.



2.



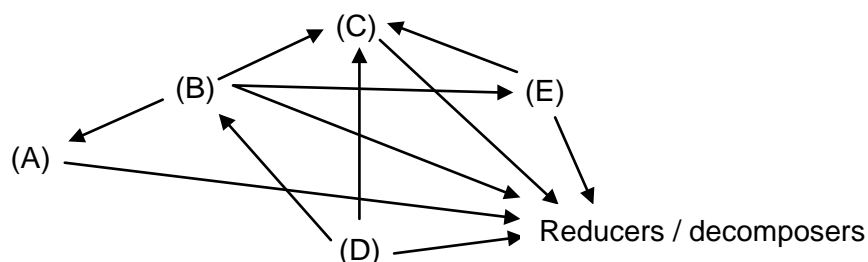
3.

Assign to these pyramids the appropriate features from the list below. Using letters indicate the answer(s) in the table.

- A. Pond with very intensive fish cropping.
- B. Pond with selective cropping of baby fish.
- C. Pond with limited fish cropping.
- D. Eutrophic pond.
- E. Pond cropped regularly.
- F. Pond with excessive turbidity and excessive phytoplankton.
- G. Pond with optimal age structure.

Pond	Statement
1	
2	
3	

B33. (2.5 points). The following figure shows the food web of a certain ecosystem with five species (A-E). Arrows indicate the flow of energy. Match the letters to the descriptions of the species:



Producer	
Herbivore	
Omnivore	
Carnivore	

B34. (8.5 points). Fresh water bodies can be subdivided into still-water systems (lentic waterbodies = ponds and lakes) and moving water systems (lotic waterbodies = creeks and rivers). Both groups differ in the abiotic factors and in their flora and fauna. **01. (2,5 points).** Indicate with a '+' which characteristics are typical of the lentic and lotic systems.

Water system characteristic	Water system type	
	lotic	lentic
Rapid decrease of the light density with the depth		

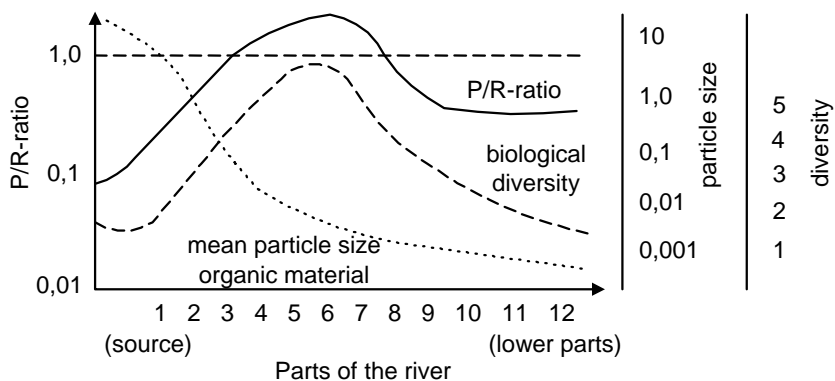
Normally staggered water temperature		
Occurrence of long-lasting plankton communities		
Streamlined animal bodies		
Animals with suction cups (suckers)		

02. (3 points). Rivers show a marked profile of various water quality parameters along their length. Samples taken near the source of the river show different values for various parameters compared to samples from down stream parts of the river. Mark the expected tendency of this difference using the symbols ‘+’ for increase, ‘-’ for decrease or ‘=’ for no change.

From near the river’s source \longrightarrow To lower part of the river.

- A. Water temperature.
- B. Oxygen content.
- C. Turbidity.
- D. Amount of sediments.
- E. Amount of nutrient minerals.
- F. Velocity of the flow.

03. (3 points). The graph shows values measured along a river (river continuum). The P/R ratio represents the ratio of production to respiration in the given part of the river. From the graph choose the correct parts of the river for the questions below.



Answer the three questions. Write the numbers of river parts in the boxes.

- A. Which parts of the river are autotrophic?

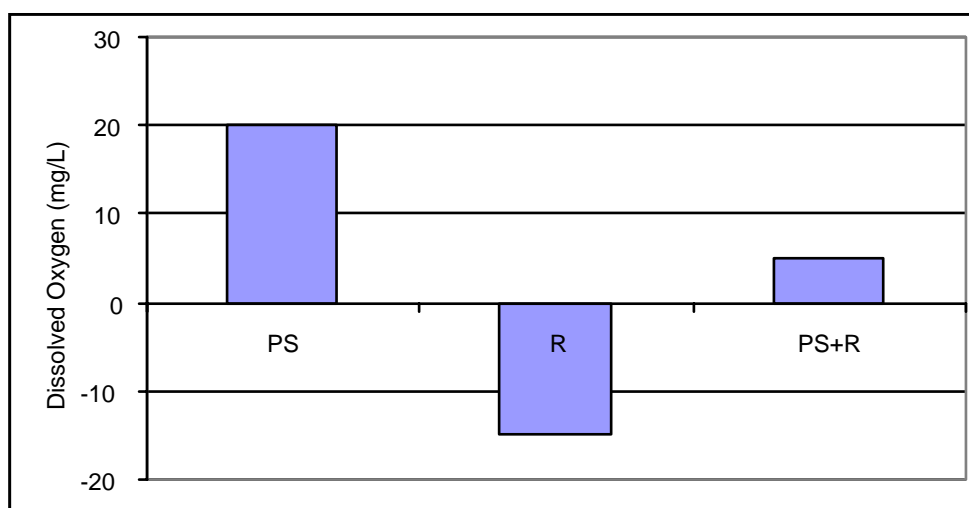
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B. In which parts is organic material (such as tree leaves) essential for the consumers?

C. In which parts can predators be found?

B35. (1 point). A student wished to estimate the size of a population of an endangered water beetle species in a small pond. He captured 30 individuals, marked and then released them back in the pond. After 24 hours, once again he captured 30 individuals. Of the newly captured individuals, only 14 were marked. Assume that no individuals were born, died, immigrated to or emigrated from the population during the experiment. What would be the student's estimation of the endangered water beetle population in the pond? Estimated population size of endangered water beetle in the pond is:

B36. (4 points). The graph shows the productivity of an aquatic ecosystem measured in terms of dissolved oxygen produced and consumed by green plants and photosynthetic algae where PS = photosynthesis and R = respiration.



Study the graph and answer the following questions, writing your answers in the box.

01. (1 points). Which bar represents net primary productivity?

02. (3 points). An algal bloom occurs until nutrient levels are exhausted, algae die off and microbial decomposition begins. How will this affect the graph parameters PS and R?

02.1. (1 point). What will happen during the algal bloom?

1. PS will be increased, R will be decreased.
2. PS will be decreased, R will be increased.
3. PS and R will not change.
4. PS + R will increase.
5. PS + R will decrease.

6. PS + R will remain unchanged.

02.2. (1 point). What will happen after decomposition has begun?

1. PS will be increased.
2. PS will be decreased.
3. R will be increased.
4. R will be decreased.
5. PS + R will be increase.
6. PS + R will be decrease.
7. PS + R remain unchanged.

02.3. (1 point). How would the grahns (parameter PS, R and PS + R) change?

community productivity per dissolved oxygen levels was measured?

1. PS will be increased, R will be decreased.
2. PS will be decreased, R will be increased.
3. PS and R will not change.
4. PS + R will increase.
5. PS + R will decrease.
6. PS + R will remain unchanged.

Biosystematics (4 questions, 16 points).

B37. (3 points). Below is a list of extant (living) mammalian genera. Assign them to the continents and subcontinents where they live and indicate the Order to which they belong. Insert the number of the animal into the correct boxes of tables **01** and **02**.

<i>GENUS</i>	
1.	<i>Ursus</i> (Bears)
2.	<i>Cebus</i> (New world monkeys)
3.	<i>Pan</i> (Chimpanzees)
4.	<i>Pongo</i> (Orangutans)
5.	<i>Elephas</i> (Elephants)
6.	<i>Macropus</i> (Kangaroos)

01. (1.8 points). Continents & subcontinents.

Australia	
North America	
India	
Africa	
Europe	
Asia	
South America	

02. (1,2 points). Order

Marsupialia	
Proboscidea	
Carnivora	
Primates	

B38. (3 points). Match the terms in the left column (1 to 6) with the names of organisms in the

right column (A to F).

- | | |
|---------------------|------------------------------|
| 1. Polyembryony. | A. Fasciola |
| 2. Heterogony. | B. <i>Helix</i> . |
| 3. Metagenesis | C. Apis |
| 4. Hermaphroditry. | D. Ichneumon |
| 5. Parthenogenesis. | E. Aurelia. |
| 6. Parthenocary. | F. <i>Amoeba (hyalina)</i> . |

Answer:

SKIPPED

1	2	3	4	5	6

B39. (3 points). The cladogram shows the phylogenetic relationships among seven hypothetical species.

(2 points) Which of the following is a paraphyletic group (A) and which is a polyphyletic group (B)?

1. E + F + G.
2. E + F.
3. E + F + G + H.
4. C + E.
5. B + C.

Answer:

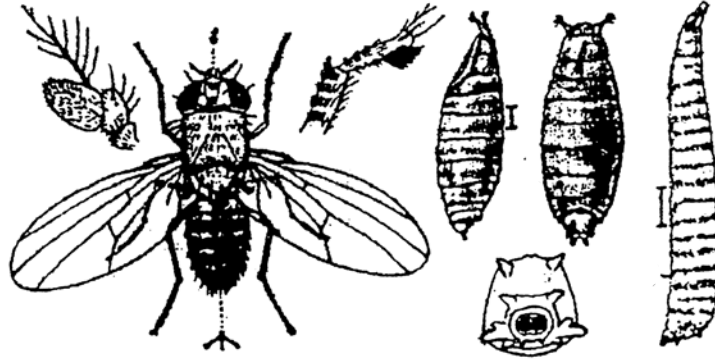
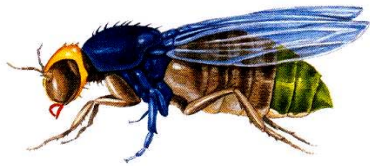
SKIPPED

02. (1 point). Which species are most closely related?

1. G and H.
2. G and F.
3. H and F.
4. Evolutionary closeness is equal for all species.

B40. In the figure is shown a well known organism.

01. (1,2 points). Give its systematic position by choosing suitable numbers from the list below.



- | | | |
|--------------------|------------------|--------------------|
| 1 – Animalia; | 11 – Gastropoda; | 21 – Drosophila; |
| 2 – Arthropoda; | 12 – Annelida; | 22 – Aphis; |
| 3 – Echinodermata; | 13 – Protozoa; | 23 – Leptinotarsa; |
| 4 – Mollusca; | 14 – Viviparus | 24 – Coleoptera; |
| 5 – Fungi; | 15 – Hymenoptera | 25 |
| 6 – Chilopoda; | 16 | 26 – Oligochaeta; |
| 7 – Insecta; | 17 – Arachnida; | 27 – Lepidoptera; |
| 8 | 18 – Cnidaria; | 28 – Anopheles; |
| 9 – Plantae; | 19 – Diptera; | 29 – Locusta; |
| 10 – Apis; | 20 | 30. |

Kingdom	
Phylum:	
Class:	
Order:	
Genus:	

02. (1 point). Choose the number corresponding to the type of the insect's leg.

1. Leaping.
2. Burrowing.
3. Swimming.
4. Gathering.
5. Walking.
6. Prehensile.

03. (1 point). Using the letters, list the leg structural elements this insect possesses in sequence (beginning with those closest to the body).

- . Femur.
- . Tibia.
- . Trochanter.
- D. Coxa.
- E. Tarsus.

04. (1 point). Give the number corresponding to the type of insect mouthpart.

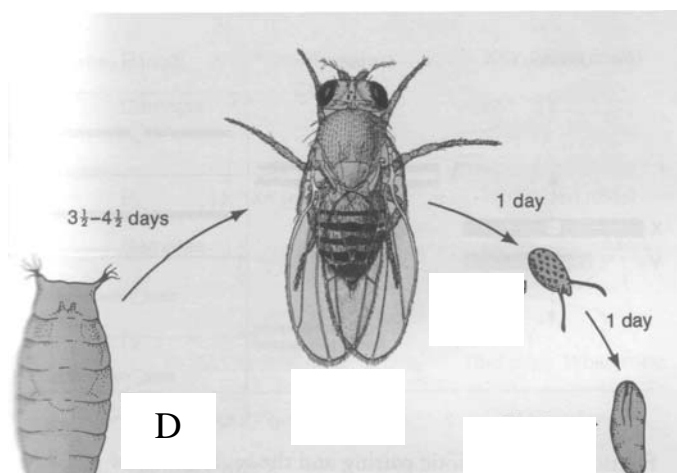
1. Piercing-suctorial.
2. Licking.
3. Biting.
4. Suctorial.

05. (1 point). Select the numbers of organs of other organisms, which are homologous to the wings of the insect concerned.

1. Sparrow wing.
2. Crayfish gills.
3. Bat wings.
4. Fish dorsal fin.
5. Fish pectoral fin.
6. Potato beetle elytrum.
7. Frog legs.

06. (0,8 point). In the answer table assign the developmental stages of this insect according to the letters in the figure.

- | | |
|-------------------|------------------|
| 1. Sporocyst. | 5. Imago. |
| 2. Egg. | 6. Redia. |
| 3. Graaf vesicle. | 7. Pupa. |
| 4. Larva. | 8. Hydatid cyst. |



Answer:

			D

07. (1 point). What is the significance of the species for humans?

1. Animal and human parasite.
2. Crop pest.
3. Object of genetic investigation.
Entomophagous.
4. Vector of sleeping sickness agent.