



All IBO examination questions are published under the following Creative Commons license:



CC BY-NC-SA (Attribution-NonCommercial-ShareAlike) - <https://creativecommons.org/licenses/by-nc-sa/4.0/>

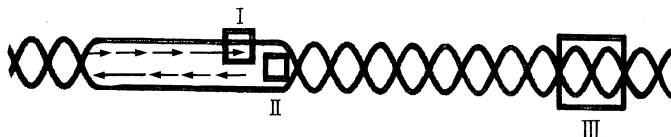
The exam papers can be used freely for educational purposes as long as IBO is credited and new creations are licensed under identical terms. No commercial use is allowed.

## Theoretical Test - Part B

### Cell biology

**B 1.** [3 points] The diagram pertains to the replication of double-stranded DNA. DNA shown with *arrows* indicates the newly synthesized strands and the direction of replication.

Match each site of action with the appropriate enzyme.



1. Telomerase.
2. DNA topoisomerase.
3. DNA polymerase.
4. DNA helicase.
5. DNA ligase.

- this enzyme functions at the square marked **I** on the diagram.
- this enzyme functions at the square marked **II** on the diagram.
- this enzyme functions at the square marked **III** on the diagram.

**B 2.** [6 points] The two compartments (A and B) of a tank contain each one liter of solution and are separated by a membrane whose permeability characters are to be identified.

One has placed in A: 300 g heparin (MW: 6000)

in B: 22.5 g formamide (MW: 45) and 5.8 g NaCl (MW: 58).

At equilibrium, a small rise in liquid level is observed in compartment A.

Mark your answer by putting an **X** in the appropriate box.

**a)** At the start of the experiment, the molar concentration in compartment A is equal to:

- 0.05 molar.
- 0.5 molar.
- 2 molar.
- 5 molar.

## 12<sup>th</sup> International Biology Olympiad

**b)** At the start of the experiment, the molar concentration in compartment B is equal to:

- 0.2 molar.
- 0.5 molar.
- 0.6 molar.
- 0.7 molar.
- 2.1 molar.

**c)** According to the results of the experiment, what are the conclusions that can be made concerning the permeability characteristics of the membrane that was used?

- the membrane is permeable to compounds that have a molecular weight lower than 6000 daltons.
- the membrane is permeable only to molecules that are not ionised.
- the membrane is permeable only to molecules that are ionised.
- the membrane is only permeable to water.

**d)** At the final equilibrium, the concentration of formamide in compartment B:

- will be unchanged.
- will be decreased by half.
- will be doubled.
- will be impossible to calculate.

**e)** With respect to the molecules that have been placed in the two sides of the container, this membrane:

- has the same permeability characteristics as the plasma membrane of a red blood cell.
- is more permeable than the plasma membrane of the red blood cell.
- is less permeable than the plasma membrane of the red blood cell.

# 12<sup>th</sup> International Biology Olympiad

- has the same permeability characteristics as as the plasma membrane of a onion cell.
- has the same permeability characteristics as the plasma membrane of a red blood cell and a onion cell.

**f)** What would happen if a few red blood cells were placed in compartment B at the beginning of the experiment?

- they would all explode.
- some would swell while others would explode.
- they would all shrink.
- some would shrink while others be normal.
- they would have a normal shape and size.

**B 3.** [6 points] The bacterium *Escherichia coli* adapts to lactose present in his medium by means of the lactose operon. Cytoplasmic components used for the function of this operon are randomly distributed among boxes of the following table. Each component is designated by a number.

- |                                |  |
|--------------------------------|--|
| 1. $\beta$ -galactosidase gene | 10. Plasmic membrane   |
| 2. Repressor                   | 11. RNA polymerase   |
| 3. Operator                    | 12. Ribosomal apparatus  |
| 4. Lactose                     | 13. Transacetylase gene ( <i>lacA</i> )                                      |
| 5. Lactose-permease            | 14. Transacetylase   |
| 6. Repressor messenger RNA     | 15. $\beta$ -galactosidase   |
| 7. Regulator gene              | 16. Glucose  |
| 8. Promotors                   | 17. Messenger RNA,<br>$\beta$ -galactosidase, permease<br>and transacetylase |
| 9. Lactose-permease gene       | 18. Galactose  |

What are the elements present in the cytoplasm of the bacteria growing on a medium without lactose (put an **X** in the appopriate boxes).

- |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1                        | 2                        | 3                        | 4                        | 5                        | 6                        | 7                        | 8                        | 9                        | 10                       | 11                       | 12                       | 13                       | 14                       | 15                       | 16                       | 17                       | 18                       |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**B 4.** [5 points] Match each item in column A with one in column B to which

# 12<sup>th</sup> International Biology Olympiad

---

it is most closely associated. (Put the corresponding numbers of column B in the boxes in front of column A).

Column A	Column B
<input type="checkbox"/> A. leucoplasts	1. Krebs cycle
<input type="checkbox"/> B. rough ER	2. bacterial DNA anchorage
<input type="checkbox"/> C. genome	3. microtubule-organizing center
<input type="checkbox"/> D. mitochondria	4. protein modification and targeting
<input type="checkbox"/> E. centriole	5. complete set of genetic instructions
<input type="checkbox"/> F. mesosome	6. starch storage
<input type="checkbox"/> G. lysosome	7. immunoglobulin
<input type="checkbox"/> H. microfilament	8. lipid synthesis
<input type="checkbox"/> I. smooth ER	9. digestive enzymes
<input type="checkbox"/> J. Golgi apparatus	10. cytoskeleton

**B 5.** [2 points] Mannitol / salt agar is a culture medium that contains a high salt (NaCl) concentration, mannitol (a fermentable sugar) and a chemical pH indicator that is yellow at acidic conditions and red at alkaline conditions. (Acids are released when microorganisms ferment mannitol). This medium also contains other carbohydrates that allow growth of nonfermenting, halophilic organisms (i.e nonfermenting organisms that tolerate high salt concentrations). Nonhalophilic organisms will not grow on mannitol / salt agar.

For each of the following situations, assume that the organisms described are the only organisms involved.

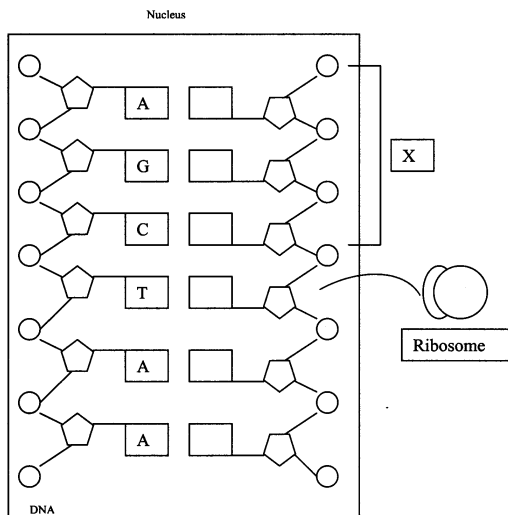
Place the number of the term in front of the box of the sentence that best describes the way the medium is being used.

1. selective medium
2. differential medium
3. both selective and differential medium
4. neither selective nor differential medium

# 12<sup>th</sup> International Biology Olympiad

- onto mannitol salt agar you inoculate a halophilic fermenter, a halophilic mannitol nonfermenter and a nonhalophilic mannitol fermenter.
- onto mannitol salt agar you inoculate a halophilic mannitol fermenter and a halophilic mannitol nonfermenter.
- onto mannitol salt agar you inoculate a halophilic mannitol nonfermenter that is pigmented yellow, and a halophilic mannitol nonfermenter that is pigmented red. These two organisms show the same pigmentation (yellow and red, respectively) on a general purpose medium such a nutrient agar.
- onto mannitol you inoculate a halophilic mannitol nonfermenter and a nonhalophilic mannitol fermenter.

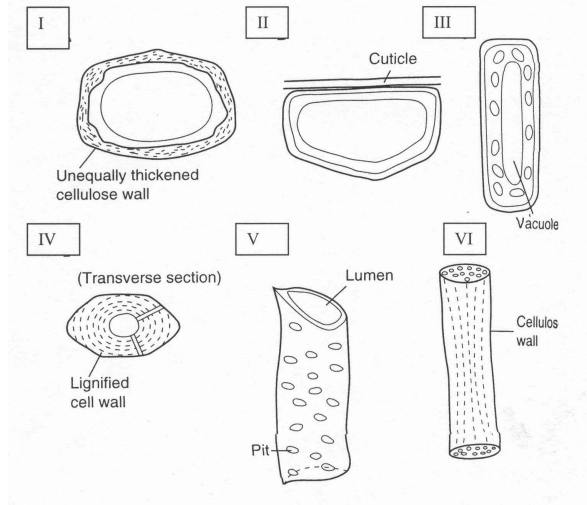
**B 6.** [1 point] The diagram below represents a function of the nucleic acid, DNA. Based on the diagram, what is the most likely nucleotide sequence of the messenger RNA. Put an X in the appropriate box.



- |   |   |   |   |   |
|---|---|---|---|---|
| A | U | T | T | T |
| G | C | C | C | U |
| C | G | G | G | G |
| T | A | A | U | A |
| A | U | T | T | T |
| A | U | T | T | T |
|   |   |   |   |   |

**Plant anatomy and physiology**

**B 7.** [3 points] Observe the diagrams I to VI illustrating different types of plant cells and identify the cell types. Match the numbers in front of the cell types (A-F) with the figures.



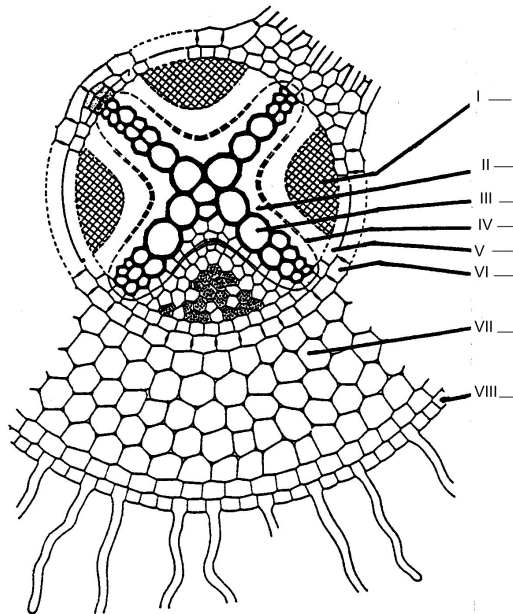
- A. sieve tube.
- B. collenchyma.
- C. sclereid.
- D. xylem vessels.
- E. epidermis.
- F. palisade cell.

**B 8** A drawing of a cross-section of a (dicot) root is presented and 4 questions (a, b, c and d) relate to this figure. In this drawing several tissues and cell types have been marked (with a letter). A list of tissues and cell types have been numbered (1-14).

**a)**[4 points] Match the number with the markings on the drawing.

# 12<sup>th</sup> International Biology Olympiad

- |                    |                      |
|--------------------|----------------------|
| 1. collenchyma     | 2. xylem             |
| 3. cortex          | 4. phloem            |
| 5. companion cells | 6. mesophyl          |
| 7. trichome        | 8. pericycle         |
| 9. endodermis      | 10. cambium          |
| 11. epidermis      | 12. xylem parenchyma |
| 13. root cap       | 14. pollen tube      |



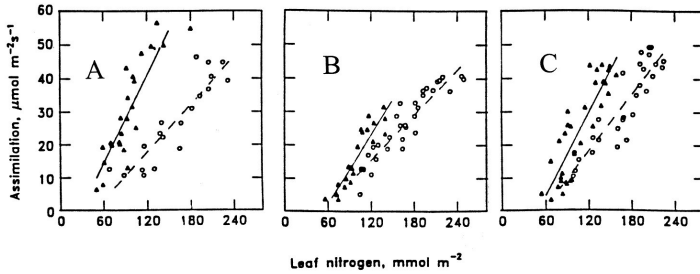
b) [5 points] Nutrients are taken up from the soil or from nutrient solution and translocated to the aerial parts of the plant.

- which tissue (in the figure above) translocates the nutrients from root to shoot? Mark the correct roman number in the box.
- in this part of the root some cells contain suberine (cork-like substances). Which cells do contain suberine? Mark the correct roman number in the box.
- the (dicot) root, depicted in the figure contains dead cells. Which cells in this section are dead? Mark the correct roman numbers in the boxes.



# 12<sup>th</sup> International Biology Olympiad

**B 9.** The relationship between light saturated photosynthetic rate of single leaves and organic leaf nitrogen in two plant species (represented by open circles and solid triangles) is presented in 3 graphs (A, B and C) below. Photosynthesis was measured at three temperatures: 20 °, 27 ° and 34 °C. One of the two plant species used is a C<sub>3</sub> plant, the other a C<sub>4</sub> plant.



a) [1 point] Which symbol represents the C<sub>4</sub> plant, ○ or ▲  
Mark the correct answer with a cross in the appropriate box.

○

▲

b) [3 points] Which temperature corresponds to which graph?  
Mark the right combination with crosses in the appropriate boxes.

	20 °C	27 °C	34 °C
A	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
B	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
C	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**B 10.** [1 point] Even when starving, snails still stay green for some time. Only after longer periods of starving they take up a brown-yellowish color. Scientists investigated the weight loss (wl) of starving snail. Which results could they have observed comparing starving green (gr) with starving brown-yellow (by) snails? Mark your answer with a **X** in the box.

wl(gr) = 0 ; wl(by) > 0

wl(gr) > 0 ; wl(by) = 0

wl(gr) > 0 ; wl(by) > 0

wl(by) > wl(gr) > 0

# 12<sup>th</sup> International Biology Olympiad

---

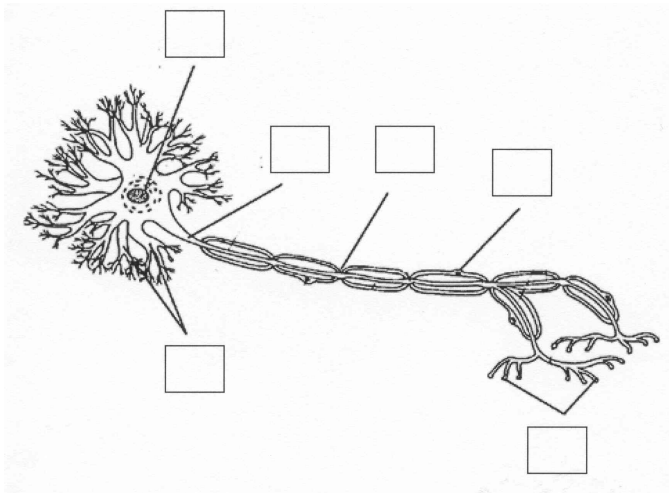
**B 11.** [5 points] Match the terms numbered 1,2,3 with the phrases under column A

<b>A</b>	<b>B</b>
<input type="checkbox"/> contain palisade parenchyma	<b>1.</b> roots
<input type="checkbox"/> possess a cuticle	<b>2.</b> stems
<input type="checkbox"/> possess a pronounced periderm	<b>3.</b> leaves
<input type="checkbox"/> contain an x-shaped central core of xylem	
<input type="checkbox"/> modified to a potato	
<input type="checkbox"/> contain Casparian strips	
<input type="checkbox"/> modified to a carrot	
<input type="checkbox"/> contain an atactostele	
<input type="checkbox"/> contain growth rings	
<input type="checkbox"/> modified to corms (e.g. <i>Crocus</i> )	

**B 12.** DELETED

**Animal anatomy and physiology**

**B 13.** [3 points] Write down the correct code on the lines of the drawing.



Code

1.     Ranvier node.
2.     nucleus.
3.     dendrites
4.     axon initial segment.
5.     Schwann cell.
6.     terminal button.

**B 14.** [1 point]

1.     most of the invertebrates neurons are not myelinated.
  2.     myelin sheats wrap the full length of the axon except in its end and in the Ranvier nodes.
  3.     there are no ribosomes neither in the axons nor in the nerve endings.
  4.     some neurons of the nervous system don't have any axon.
- From the list above, which is the correct combination of statements?

- 1, 2, 3
- 2, 4
- 1, 3, 4
- all are correct.

## 12<sup>th</sup> International Biology Olympiad

---

**B 15.** [4 points] Choose a word or phrase from the right column which is related to each word or phrase in the left column by placing a number in front of the word or phrase in the blank space in front of each word or phrase on the left (each word can be used only once).

- |  |   |
|--|---|
| <input type="checkbox"/> macrophage                              | 1. yellow marrow  |
| <input type="checkbox"/> specific receptor on a B cell surface   | 2. contains large number of granules                            |
| <input type="checkbox"/> cytokines                               | 3. astrocyte  |
| <input type="checkbox"/> site of differentiation for lymphocytes | 4. oligodendrocyte  |
| <input type="checkbox"/> neutrophil                              | 5. microglia cell   |
| <input type="checkbox"/> a major protein in plasma               | 6. complement   |
| <input type="checkbox"/> target of HIV virus                     | 7. B cell   |
| <input type="checkbox"/> fat tissue inside a bone                | 8. antibody   |
| <input type="checkbox"/> macrophage in brain                     | 9. chemicals secreted by several types of cell in immune system |
|  | 10. T cell  |
|  | 11. peptides and proteins                                       |
|  | 12. spleen or thymus  |
|  | 13. bone marrow   |
|  | 14. albumin   |

# 12<sup>th</sup> International Biology Olympiad

---

## B 16. DELETED

**B 17.** [1 point] Two types of muscles participate in the locomotion of an earthworm. When moving forward, the earthworm first squeezes the front segments into a long tube (I) and then drags its back part (II). Which muscles are contracted (C) and relaxed (R) in I and II respectively?

	I	II
Longitudinal muscles/circular muscles		Longitudinal muscles/circular muscles
<input type="checkbox"/>	R/C	R/C
<input type="checkbox"/>	R/C	C/R
<input type="checkbox"/>	C/R	C/R
<input type="checkbox"/>	C/R	R/C

**B 18** [1 point] Which substance does not usually appear in the glomerular filtrate of mammals?

- urea
- glucose
- amino acids
- plasma proteins

**B 19** [1 point] Several parts of the body are involved in the transmission of a stimulus. Which of the following represents the correct sequence as a stimulus is carried along the reflex pathway?

- sense organ; efferent neuron; spinal cord; afferent neuron; muscle/gland
- muscle/gland; efferent neuron; spinal cord; afferent neuron; sense organ
- sense organ; afferent neuron; spinal cord; efferent neuron; muscle/gland
- sense organ; afferent neuron; efferent neuron; spinal cord; muscle/gland

# 12<sup>th</sup> International Biology Olympiad

---

**B 20.** [5 points] Types of nonspecific defense mechanisms. Indicate whether each of the following is a general (G) physical (P) chemical (C) or biological (B) defense mechanism by putting a «X» in the appropriate boxes.

	General G	Physical P	Chemical C	Biological B
Skin	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Interferon	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Gastric acid	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mucociliary Blanket	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Inflammation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fever	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Lysozyme	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Phagocytosis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bile	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Urine	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



*Relaxing at the Campus of the Vrije Universiteit Brussel after the theoretical test*

**Ethology**

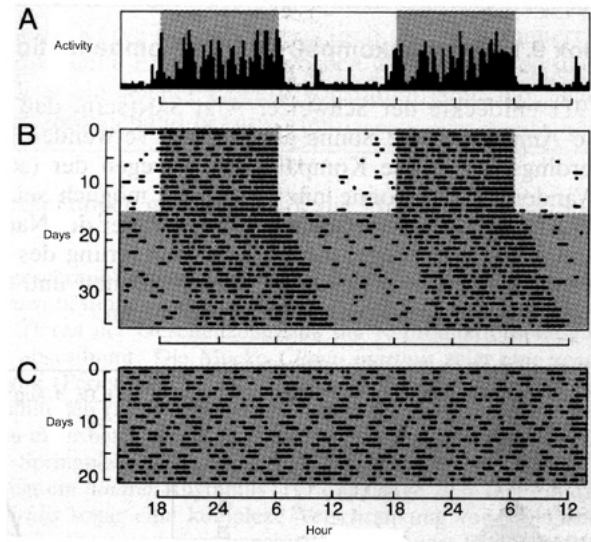
**B 21. DELETED**

**B 22.** [1point] The following diagrams show the circadian rhythmic activity of rats. The gray background represents dark phases.

Diagram 1: single record of locomotive activity within 48 hours

Diagram 2: summary activity over a period of 35 days

Diagram 3: activity of an arrhythmic rat after destruction of the Nucleus suprachiasmaticus



From the given information one can conclude that a normal rat has an endogenous period of rhythmicity of:

Put a **X** in the appropriate box.

- less than 24 hours
- exactly 24 hours
- more than 24 hours
- the period varies strongly
- there is not enough information for a conclusion

**Genetics - evolution**

**B 23.** [3 points] Consider the following set of eight hybridised human-mouse cell lines:

Cell line	Chromosome								
	1	2	6	9	12	13	17	21	X
A	+	+	-	q	-	p	+	+	+
B	+	-	p	+	-	+	+	-	-
C	-	+	+	+	p	-	+	-	+
D	+	+	-	+	+	-	q	-	+
E	p	-	+	-	q	-	+	+	q
F	-	p	-	-	q	-	+	+	p
G	q	+	-	+	+	+	+	-	-
H	+	q	+	-	-	q	+	-	+

Each cell line may carry an intact (numbered) chromosome (+), only its long arm (q), only its short arm (p), or it may lack the chromosome (-). The following human enzymes were tested for their presence (+) or absence (-) in cell lines A-H. Identify the chromosome carrying each enzyme locus. Where possible, identify the chromosome arm.



# 12<sup>th</sup> International Biology Olympiad

---

	Cell line							
Enzyme	A	B	C	D	E	F	G	H
<input type="checkbox"/> Steroid sulphatase	+	-	+	+	-	+	-	+
<input type="checkbox"/> Phosphogluco- mutase-3	-	-	+	-	+	-	-	+
<input type="checkbox"/> Esterase D	-	+	-	-	-	-	+	+
<input type="checkbox"/> Phosphofructo- kinase	+	-	-	-	+	+	-	-
<input type="checkbox"/> Amylase	+	+	-	+	+	-	-	+
<input type="checkbox"/> Galactokinase	+	+	+	+	+	+	+	+

**B 24.** [2 points] A certain haploid fungus is normally red due to a carotenoid pigment. Mutants were obtained that were different colours due to the presence of different pigments: orange ( $P^-$ ), pink ( $P^-$ ), white ( $W^-$ ), yellow ( $Y^-$ ), and beige ( $B^-$ ). Each phenotype was inherited as if a single gene mutation governed it. To determine what these mutations signified, double mutants were constructed with all possible combinations, and the results were as follows:

<b>Mutations:</b>	$P^-$	$W^-$	$Y^-$	$B^-$
$B^-$	-	pink	white	yellow beige
$P^-$	-	-	white	pink . pink .
$W^-$	-	-	-	white white
$Y^-$	-	-	-	-
				yellow

**a)** Determine the sequence of the five mutations in pathway of pigment biosynthesis. Mark with **X** correct answer.

$P^- - Y^- - B^- - O^- - W^-$

$Y^- - P^- - B^- - W^- - O^-$

# 12<sup>th</sup> International Biology Olympiad

---

- W<sup>-</sup> - P<sup>-</sup> - Y<sup>-</sup> - B<sup>-</sup> - O<sup>-</sup>
- O<sup>-</sup> - B<sup>-</sup> - Y<sup>-</sup> - P<sup>-</sup> - W<sup>-</sup>

**b)** Determine the sequence of the colour intermediates in the biochemical pathway of pigment biosynthesis. Mark with **X** correct answer.

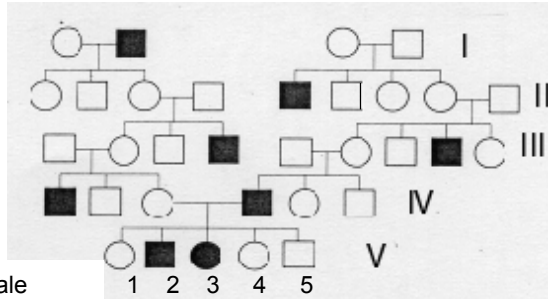
- white, pink, yellow, beige, orange, red
- orange, pink, yellow, white, beige, red
- beige, white, orange, pink, yellow, red
- white, orange, yellow, pink, beige, red

**B25.** [4 points] Match each item in column A with one in column B to which it is most closely associated. Mark the corresponding numbers of column "B" in boxes on the left side of column "A".

Column A	Column B
<input type="checkbox"/> A. 5—bromouracil	1 translation termination
<input type="checkbox"/> B. alternative form of a gene	2 intercalating agent
<input type="checkbox"/> C. auxotroph	3 substitution one amino acid for another
<input type="checkbox"/> D. ethidium bromide	4 chromosome aberration
<input type="checkbox"/> E. nonsense mutation	5 substitution one purine for pyrimidine
<input type="checkbox"/> F. missense mutation	6 nutritional mutant
<input type="checkbox"/> G. inversion	7 base analog
<input type="checkbox"/> H. transversion	8 allele

# 12<sup>th</sup> International Biology Olympiad

**B 26.** [3 points] Study the following pedigree of a trait which has 100% penetrance.



- : unaffected female
- : affected female
- : unaffected male
- : affected male

a) The probable mode of inheritance of this trait is:

- X-linked dominant
- autosomal recessive
- X-linked recessive
- autosomal dominant

b) What are the genotypes of the mother and father of V-3?

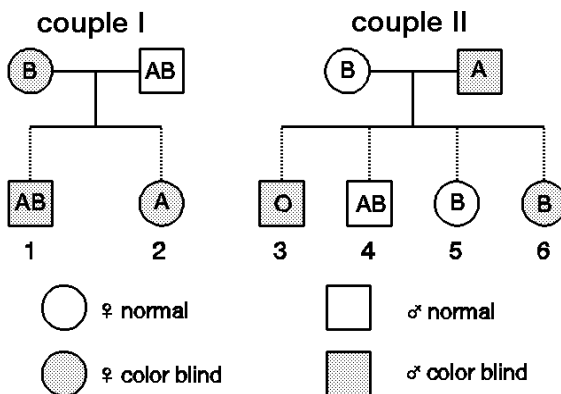
- Aa and a/Y
- AA and AA
- aa and A/Y
- Aa and Aa

c) If the individual V-2 marries a homozygous normal person, what is the probability that their first child will be a carrier?

- |                          |                          |                          |                          |
|--------------------------|--------------------------|--------------------------|--------------------------|
| 25 %                     | 100 %                    | 50 %                     | 0                        |
| <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## 12<sup>th</sup> International Biology Olympiad

**B 27.** [1point] Three alleles are determining the ABO-blood groups:  $I^A$ ,  $I^B$  and  $i$ . Colour blindness is caused by a recessive X-chromosomal allele. Inspect the following family trees where colour blindness and blood groups have been indicated.



Directly after birth a baby of couple I must have been changed with a baby of couple II. Indicate the numbers of the changed babies.

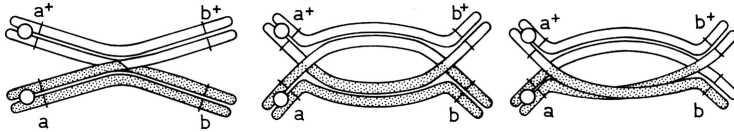
Answer: ..... & .....

**B 28.** [1 point] A dominant gene , A, causes yellow coat colour in rats. The dominant allele of another independent gene , R, produces black coat colour. When the two dominants occur together, they interact to produce gray. When the two recessives interact, they produce cream colour. A mating between a gray male and a cream female produced a litter in which 3/8 of the offspring were yellow, 3/8 were gray, 1/8 were black and 1/8 were cream. If the genotype of the female was “aarr”, what was the genotype of the male?

- AARR
- AaRr
- AaRR
- AARr
- Aarr

# 12<sup>th</sup> International Biology Olympiad

**B 29.** [1 point] What are the frequencies of recombinant chromatids for the genes a and b if single crossing over, double crossover between two chromatids and double crossover between three chromatids take place as shown in the figure below?



	Crossing over	Double crossing over between 2 chromatids	Double crossing over between 3 chromatids
<input type="checkbox"/>	25 %	50 %	75 %
<input type="checkbox"/>	50 %	50 %	75 %
<input type="checkbox"/>	50 %	0 %	50 %
<input type="checkbox"/>	75 %	25 %	0 %

## Ecology

**B 30.** [1 point] The growth of an animal population depends on the biological characteristics of the individuals within such as: life expectancy, fecundity (number of births given by a female during its life), the duration of the reproductive period, the distribution of the fecundity along the female age, the development time (the time between birth and the laying of the first egg) and the age at the first egg laying. Moreover, the age structure of the population (i.e. the distribution of the age according to the age pyramids will influence the way these characteristics will be expressed.

Let us consider two populations A and B. Which one of these two populations will undergo the more rapid growth in relationships with the following statements, all other elements being constant?

- population A is mostly composed of young individuals whereas population B is characterised by a stable age structure.

## 12<sup>th</sup> International Biology Olympiad

---

- inside population A, females reached sexual maturity two times faster than B however females from B survived 1/3 longer.
- in population A female fecundity is uniformly distributed during all their life, whereas for B it is concentrated at the beginning of adult life.
- in population B female fecundity is two times higher than in A but life expectancy is two times shorter than in A.

**B 31.** [1 point] Social Hymenoptera (such as ants, social bees and wasps) are characterised by the frequent repetition of altruistic behaviours between individuals. This altruism may even lead to the death of some individuals such as soldiers. These behaviours are more frequent between close relatives. Reproduction in Hymenoptera is quite special as it relies on haplodiploid parthenogenesis. This means that an unfertilised egg gives birth to a haploid male while a fertilised egg produces a diploid female. Under these conditions calculate (in %) the mean degree of relatedness between:

- a female and her daughter
- a female and her son
- two sisters
- a sister and her brother
- an aunt and her niece

**B 32.** [1 point] In order to measure the biodiversity in tropical forest, the following experiment was undertaken. A canopy tree was isolated using a plastic sheet before fumigation with an insecticide. All insects killed were collected. (this experiment was conducted by Terry Erwin and his staff from Smithsonian Institution, Panama). Investigators mostly concentrate on Coleoptera. They collected 1200 species. By studying that group, they observed that 20 % of phytophagous Coleoptera were specific of that tree's species. They concluded that each tree species in tropical forest welcomes 160 species of Coleoptera that are specific of the tree considered. Knowing that 40 % of the insect species already described on earth are Coleoptera they infer that, in average, each tree harbours 400 insect species. In tropical forest, only 2/3 of the insect are living in the canopy. Thus if the tree is taken in its totality (branches, trunk, roots, etc.) it would shelter 600 insect species.

# 12<sup>th</sup> International Biology Olympiad

---

Finally, as presently 50.000 tree species are identified in tropical forest, the total number of insect species should be of 30.000.000. Less than one million of insect species are actually described meaning that we know a very little part of the total earth biodiversity. Which among the following propositions is **not** correct?

- 30 millions of insects is an underestimation as it does not take into account species living in other countries.
- 30 millions is an overestimation as most tree species share common species.
- this experiment does not give an overall view because it is too limited in space and time but it just showed that we are lacking data on biodiversity.
- 0 millions is an overestimation as it does not take into account the species already described.

**B 33.** DELETED

**B 34.** DELETED

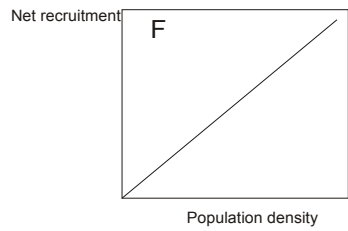
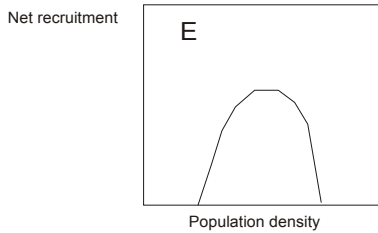
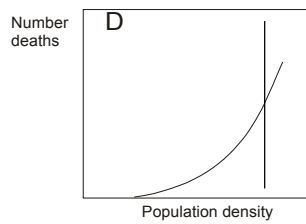
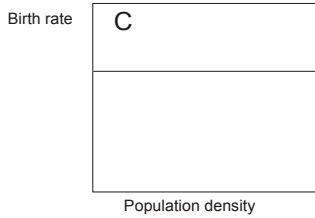
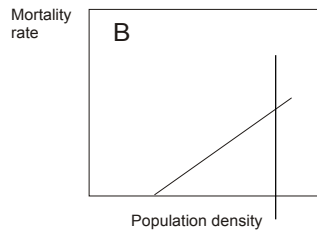
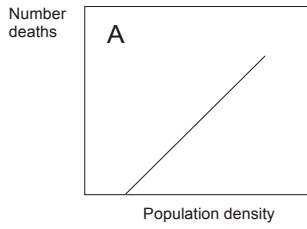
**B 35.** DELETED

**B 36.** [6 points] For each figure answer YES or NO to the following question: Does the figure show that population density is affected by birth or death rates, thereby representing a mechanism able to regulate population's size.

YES    NO

- |                          |                          |    |
|--------------------------|--------------------------|----|
| <input type="checkbox"/> | <input type="checkbox"/> | A. |
| <input type="checkbox"/> | <input type="checkbox"/> | B. |
| <input type="checkbox"/> | <input type="checkbox"/> | C. |
| <input type="checkbox"/> | <input type="checkbox"/> | D. |
| <input type="checkbox"/> | <input type="checkbox"/> | E. |
| <input type="checkbox"/> | <input type="checkbox"/> | F. |

# 12<sup>th</sup> International Biology Olympiad





**Biosystematics**

**B 37.** [4 points] The following table contains a list of some cellular structures and processes. Make a comparison between Eubacteria, Archaeobacteria and Eucaryotes by making a cross (X) in appropriate boxes of the table, if these structures/processes are present in those domains.

Cellular structures and processes	Eubacteria	Archaeobacteria	Eucaryotes
RNA	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Introns	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Ribosomes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mitochondria	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Diploid stages	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chlorophyll-based	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Photosynthesis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Methanogenesis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Nitrogen fixation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**B 38.** [5 points] Among the members of the Animal Kingdom, some have body cavities, some do not. The following animals (1 - 9) possess different types of body cavities.

1. Rotifers
2. Gastropods
3. Insects
4. Sponges
5. Nematodes
6. Corals
7. Oligochaetes
8. *Planaria*
9. Sea anemones

# 12<sup>th</sup> International Biology Olympiad

Identify which animals of the list above belong to what group of body cavity by filling in the blanks with the corresponding numbers. Each group may have more than one related animal.

- Animals with true coeloms (coelomates)
- Animals with pseudocoeloms (pseudocoelomates)
- Animals with no coeloms (acoelomates)
- Animals with gastrovascular cavities
- Animals with spongocoel

**B 39.** [3 points] Taxonomical classification of organisms can be realised in different ways.

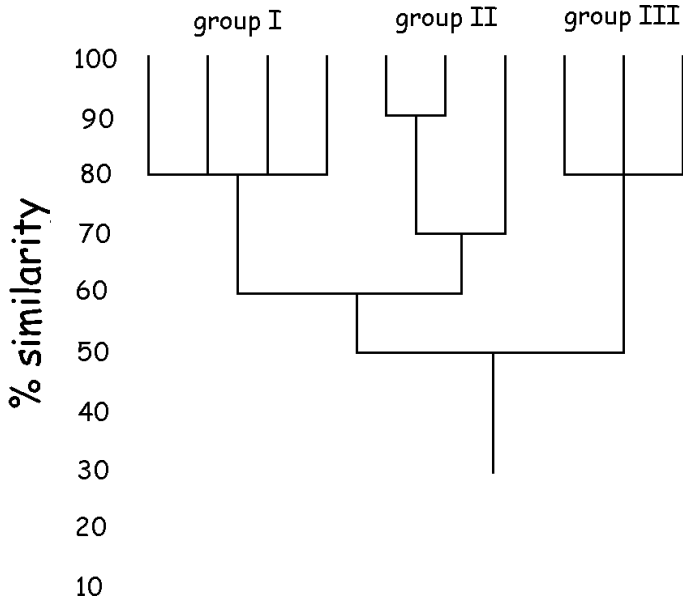
One method is to take in consideration selected characteristics of a number of organisms and construct a grid (data matrix) showing the percentage of similarity between these characteristics.

An example of such a similarity matrix of 10 organisms 1 to 10 is:

1	100									
2	54	100								
3	80	55	100							
4	63	57	62	100						
5	62	57	64	74	100					
6	81	55	85	63	64	100				
7	50	86	51	56	56	54	100			
8	83	56	86	65	67	87	54	100		
9	50	87	50	56	56	52	85	54	100	
10	61	56	62	90	72	65	55	67	55	100
	1	2	3	4	5	6	7	8	9	10

# 12<sup>th</sup> International Biology Olympiad

Based on this matrix it is possible to produce a tree like diagram showing one group of four related organism (group I), one group of three (two + one) related organisms (group II) and another group of three organisms (group III) in the following way:



Indicate which organisms belong to group I, II and III:

Group I:.....

Group II:.....

Group III:.....

# 12<sup>th</sup> International Biology Olympiad

**B 40.** [5 points] Every insect Order is characterised by a specific structure and function of wings.

Insects	Order	Number
dragonflies	Odonata	1.
grasshoppers	Orthoptera	2.
lice	Anoplura	3.
beetles	Coleoptera	4.
flies	Diptera	5.

Complete the following statements by filling in the spaces, with the number of the appropriate insect order.

- similar in size non-foldable fore wings and hind wings with netlike venation are characteristic for individuals of the order.
- sclerotised fore wings and membranous hind wings with netlike venation are characteristic for individuals of the order.
- secondary reduced wings combined with protruding-sucking mouth parts are characteristic for ectoparasitic individuals of the order.
- hard fore wings having a protection function and membranous hind wings are characteristic for individuals of the order.
- membranous fore wings and hind wings transformed into halteres having a function of stabilisation during flight are characteristic for individuals of the order.



*The test is over, unstress yourself*