

Biology

Elective and Research

Part of the 5-point exam

Instructions for examinees

- א. Duration of the exam: One and a half hours
- ב. Structure of questionnaire and point breakdown:
This questionnaire has two parts. The first part includes three topics and the second part includes four topics.

Part One

Topic	Page
I — Circulatory, Respiratory, Secretory, and Immune Systems	2
II — Plant Nutrition and Animal Nutrition	5
III — Heredity	7

Part Two

Topic	Page
IV — Reproduction	10
V — Microorganisms	12
VI — Evolution and Development	14
VII — Biotechnology	16

Answer questions for one topic from each part of the exam.

The topic you choose for Part One of the exam will be worth 60 points and the topic you choose for Part Two will be worth 40 points. Total: 100 points

ג. Material that may be used during the exam:

A Hebrew-foreign language/foreign language-Hebrew dictionary.

ד. Special instructions:

- (1) Answer questions only for topics that you studied.
- (2) Follow the instructions given for each topic.
- (3) **On the outer cover of your answer booklet, write the two topics for which you chose to answer questions.**

Write all of your rough work (notes, calculations, etc.) on separate pages of the answer booklet only.

Write the word "טייטה" on the top of each of these pages.

If you write any sort of work outside the answer booklet, your exam may be disqualified!

Good Luck!

ביו לוג יא

נושאי בחירה ונושא מחקר

חלק מבחינת 5 יחידות לימוד

הוראות לנבחן

א. משך הבחינה: שעה וחצי.

ב. מבנה השאלון ומפתח ההערכה:

בשאלון זה שני פרקים,
בפרק הראשון שלושה נושאים
ובפרק השני ארבעה נושאים.

פרק ראשון

נושא	עמוד
I — מערכות הובלה, נשימה, הפרשה והגנה	2
II — הזנה בצמחים ובבעלי חיים	5
III — תורשה	7

פרק שני

נושא	עמוד
IV — רבייה	10
V — מיקרואורגניזמים	12
VI — אבולוציה וטיפוח	14
VII — ביוטכנולוגיה	16

עליך לענות על נושא אחד מכל פרק.

לנושא בפרק הראשון — 60 נקודות,

לנושא בפרק השני — 40 נקודות; סה"כ — 100 נקודות

ג. חומר עזר מותר בשימוש:

מילון עברי-לועזי / לועזי-עברי.

ד. הוראות מיוחדות:

(1) ענה על שאלות רק בנושאים שלמדת.

(2) ענה על פי ההנחיות המפורטות בראש כל נושא.

(3) **רשום על כריכת המחברת את שני הנושאים שענית עליהם.**

כתוב במחברת הבחינה בלבד, בעמודים נפרדים, כל מה שברצונך לכתוב כטייטה (ראשי פרקים, חישובים וכדומה).

רשום "טייטה" בראש כל עמוד טייטה. רישום טיטות כלשהן

על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

בהצלחה!

This questionnaire has two parts. Three topics are covered in Part One and four topics are covered in Part Two. For each part, choose one topic that you studied and answer the questions for that topic, according to the directions given for that topic. (You must answer a total of four questions for the topic that you choose for Part One, and a total of three questions for the topic you choose for Part Two.)

Note: You must answer questions from both Part One and Part Two of the exam, on one topic for each part. Write the two topics for which you chose to answer questions on the outside cover of the booklet.

Questions

Part One (60 points)

This part of the exam includes questions on three different topics:

The Circulatory, Respiratory, Secretory and Immune Systems; Plant Nutrition and Animal Nutrition; and Heredity.

Choose one of these topics and answer **four** questions for that topic, following the directions given for that topic.

Topic I — The Circulatory, Respiratory, Secretory and Immune Systems

Answer four questions: Question 1 and Question 2 (both required), one of the questions 3-4 and one of the questions 5-6.

Answer both Question 1 and Question 2 (**required**).

1. The table below shows the concentrations of two substances in the renal artery and renal vein of a given healthy person.

Conc. in the renal vein (mg / 100 mL blood)	Conc. in the renal artery (mg / 100 mL blood)	Substance
80	80	glucose
10	30	urea

- a. Which of the substances listed in the table was excreted in his urine and which one was not?

Explain your answers based on the data in the table and explain the importance of the excretion or non-excretion of this substance in urine. (7 points)

- b. In a healthy person, will the concentrations of glucose and urea excreted in the urine (increase / decrease / remain unchanged) several hours after:

- (1) a meal rich in protein?
- (2) a meal rich in carbohydrates?

Explain your answer for each sub-item. (In your explanations, refer to both the concentration of glucose and the concentration of urea).

(8 points)

/continued on page 3/

2. An experiment concerning the immune system is described below. In the experiment, mice were assigned to 3 groups, א-ג. Each group received a different treatment program, as described in the table below.

Second injection (45 days after the first injection)	First injection	Group
weakened snake venom	weakened snake venom	א
weakened snake venom	—	ב
weakened flu virus	weakened snake venom	ג

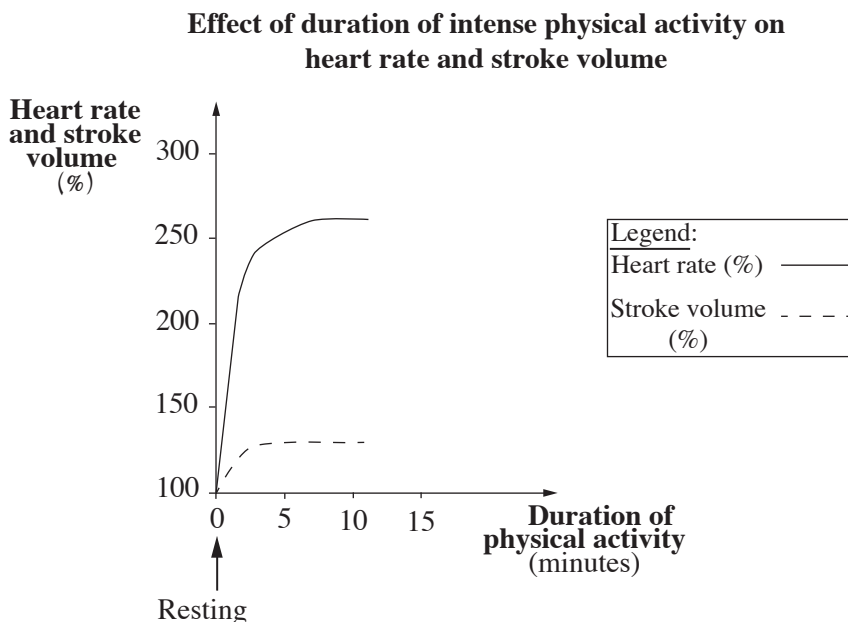
60 days after the start of the experiment, the researchers checked the level of antibodies to snake venom among each of the groups.

Rank the three groups, א-ג, based on the level of snake-venom antibodies found in the blood of the mice, from lowest to highest. Explain your answer (15 points)

Answer one of the questions 3-4.

3. The rate of breathing is regulated in coordination with the level of physical activity.
- א. Explain why the rate of breathing needs to be regulated. (4 points)
 - ב. Briefly describe the regulation mechanism. In your answer, mention the processes that occur, from the physical activity through the change in the rate of breathing. (11 points)

4. The graph below describes the relationship between the duration of intense physical activity and the heart rate and cardiac stroke volume of one examined individual. (100% indicates the levels measured in the individual when he was resting.)



- א. Explain how the increased stroke volume and increased heart rate (described in the graph) allow the body to perform intense physical activity. (8 points)
- ב. (1) During the period of intense physical activity, was there an increase in the amount of blood flowing (mL / minute) through all of the tissues and organs of the body?
- (2) Explain how blood flow is regulated during a period of intense physical activity.
- (7 points)

Answer one of the questions 5-6.

5. Explain why the regulation of the opening and closing of stomata [פיוניות] is essential for the growth of plants under warm and dry conditions. (15 points)
6. Damage to the phloem of a plant decreases its active absorption of salts from the soil. Explain why. (15 points)

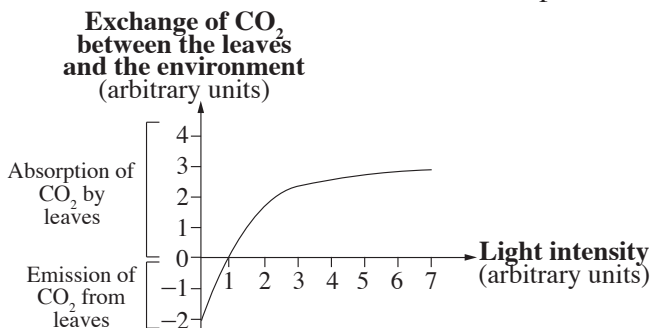
Topic II — Plant Nutrition and Animal Nutrition

Answer four questions:

Question 7 and Question 8 (both required), one of the questions 9-10 and one of the questions 11-12.

Answer both Question 7 and Question 8 (**required**).

7. A green plant was grown in a closed, transparent system that was illuminated with light of different intensities. The graph below describes the movement of carbon dioxide between the leaves of the plant and the surrounding air.



Explain the changes that occurred in the emission and absorption of carbon dioxide as a function of light intensity within the range of 0-7. In your answer, refer to respiration and photosynthesis. (15 points)

8. Data concerning the oxygen consumption of athletes during different competitions are presented in the table below.

4	3	2	1
Ratio of the actual volume of oxygen taken in (Column 3) to the calculated needed volume (Column 2)	<u>Actual</u> volume of oxygen taken in by the runner during the race (liters)	<u>Calculated*</u> volume of oxygen needed for the race (liters)	Length of the race (meters)
0.05	0.5	10	100
0.33	9	27	800
0.50	18	36	1,500
0.98	685	700	42,195 (marathon)

*The volume of oxygen needed for the race (Column 2) was calculated based on the amount of energy needed for the race.

- א. What can you conclude about the different races (Column 1) when you compare the different values in Column 4? (5 points)
- ב. Explain the differences between the energy-producing processes carried out in the cells during the shortest race (100 m) and those carried out during the marathon, as expressed in the data in the table. (10 points)

/continued on page 6/

Answer one of the questions 9-10.

9. א. Two columns are shown below. Different organs of the digestive system are listed on the right and processes carried out in digestive organisms are listed on the left.

Processes	Organs
(1) secretion of the enzyme pepsin	mouth
(2) breakdown of proteins	liver
(3) breakdown of starch	stomach
(4) absorption of most of the digested food	small intestine (including the duodenum [תריסריון])
(5) mechanical breakdown of food	
(6) digestion aided by digestive juices from the pancreas	
(7) production of bile salts [מלחי מרה]	

For each organ in the right-hand column: Note all of the processes in the left-hand column that occur in that organ. (A process may occur in more than one organ.) (9 points)

- ב. In different parts of the digestive system, the pH level is different. Explain the advantage of this. (6 points)

10. The process of photosynthesis includes two phases:

Phase א: the absorption of light

Phase ב: the fixation of CO₂

- א. Name the products of each phase, א and ב. (8 points)

- ב. A plant that had been kept under light was moved into the dark. In the dark, will it continue to fix CO₂? Explain. (7 points)

Answer one of the questions 11-12.

11. א. Explain how aerating soil aids a plant's absorption of some minerals. (9 points)

- ב. What is similar about the role of the root hairs [יניקות] found on the root of a plant and the role of the microvilli [סיסונים] of the small intestine? Explain how the structure of root hairs and the structure of microvilli help them to do their job. (6 points)

12. Energy is produced in cells through cellular respiration.

- א. Explain the advantage of using oxygen for cellular respiration. In your answer, refer to the relationship between the products of the process and the energy that is produced. (9 points)

- ב. The production of energy through cellular respiration proceeds in stages and not all at once. What might be an advantage of producing energy in stages? (6 points)

Topic III — Heredity

Answer four questions:

Question 13 and Question 14 (both required), one of the questions 15-16 and one of the questions 17-18.

Answer both Question 13 and Question 14 (**required**).

- 13.** The color of the petals of a plant of a certain species is determined by a single gene that has three alleles.

This species is known to have petals of four colors: red, blue, purple and white.

The results of the cross-breeding of plants of this species are presented in the table below.

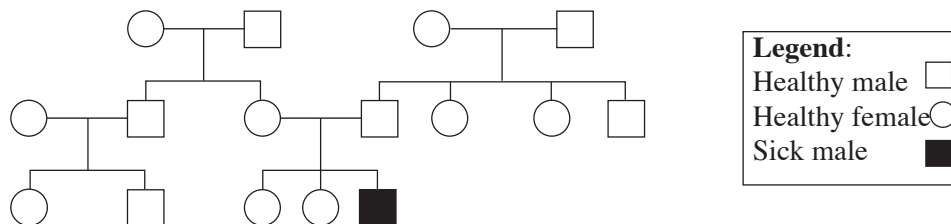
Petal Colors of the Offspring	Petal Colors of the Parents	Cross
red ones and white ones	red × red	1
blue ones and white ones	blue × blue	2
red ones and blue ones	purple × white	3
red ones, blue ones and purple ones	purple × purple	4
red ones, blue ones, purple ones and white ones	blue × red	5

- א. Based on the results of the cross-breeding, determine the relationship between the different alleles of the gene, in terms of dominance and recessiveness. (7 points)
- ב. Use a table or diagram to describe Cross 5. Note the genotypes and phenotypes of the parents and the offspring. Include an appropriate legend in your answer. (8 points)
- 14.** A strand of DNA that codes for a protein contains a coding gene and its promoter [אתר המקדם].
- א. Can a mutation in the coding gene cause the production of a protein that is different from the normal protein? Explain. (7 points)
- ב. Can a mutation in the promoter region cause the production of a protein that is different from the normal protein? Explain. (8 points)

Answer one of the questions 15-16.

15. A boy with a rare hereditary disease was born to a family.

The family's pedigree chart is shown in below.



- א. Based on the chart, what are the two possible hereditary characteristics of this disease? Explain which of the two possibilities is more probable. (7 points)
- ב. If you learned that the sick individual had a sister who also had the disease, would that change your answer for Item א? Explain. (8 points)

16. A couple had a baby who carries the following sex chromosomes: XXY.

We know that the non-disjunction [אי-הפרדה] of the chromosomes happened in the father.

Did the non-disjunction event occur during the first part of meiosis or during the second part? Explain. (15 points)

Answer one of the questions 17-18.

- 17. א.** In the AIDS virus, there was a point mutation in the gene responsible for the production of the viral-envelope protein.

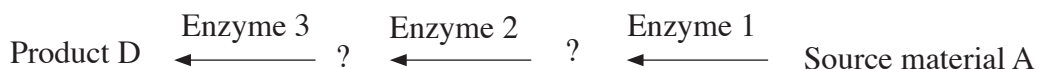
What type of mutation is least likely to change the protein: the substitution of a base, the deletion of a base or the addition of a base? Explain. (8 points)

- ב.** There are 20 known amino acids in living organisms. How many different types of transfer RNA (tRNA) are there: fewer than 20, exactly 20 or more than 20? Explain. (7 points)

- 18.** Substance D is necessary for the reproduction of bacteria.

The biosynthetic pathway for the production of Substance D in bacteria requires the source material A. In this pathway, source material A is used to produce the intermediate substances B and C. Three enzymes, 1, 2 and 3, are involved in the production of Substance D from Substance A and these enzymes are controlled by three genes. Each enzyme is controlled by one gene. In the wild type (in which all three genes are normal), Substance D is produced when the growth medium of the bacteria contains Substance A or B or C. In contrast, in a mutant bacterium, Substance D is produced only when the growth medium contains Substance B.

A diagram of the biosynthetic pathway in the wild type is shown below.



- א.** Copy the diagram into your answer booklet and fill in the missing intermediate substances. (7 points)
- ב.** In which gene did the mutation occur? If there is no Substance B in the growth medium, Substance C will accumulate in the mutant. Explain why. (8 points)

Part Two (40 points)

Part Two includes questions on four different topics: Reproduction, Microorganisms, Evolution and Development, and Biotechnology.

Choose one of these topics and answer **three** questions for that topic, according to the directions given for that topic.

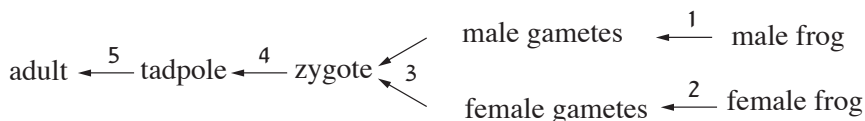
Topic IV — Reproduction

Answer three questions:

Question 19 (required), one of the questions 20-21 and one of the questions 22-23.

Answer Question 19 (**required**).

19. The diagram below describes the stages in the reproduction of a frog (an amphibian [דו-חיים]).



- א.** During which of the phases 1-5 (labeled arrows) does meiosis occur and during which phases does mitosis occur? Explain your answers.
(7 points)
- ב.** One frog produces many gametes. Is the hereditary content of each of these gametes the same? Provide two explanations to support your answer.
(8 points)

Answer one of the questions 20-21.

- 20.** In a certain field, three plant species are grown: Species א reproduces through reproductive buds on its bulb, Species ב cross-pollinates and Species ג self-pollinates.

Rank the levels of genetic variation among the offspring of each species: from the species whose offspring are most different from one another to the species whose offspring are the least different from one another. Explain your answer. (12 points)

- 21.** There are many species of plants whose seeds are distributed across significant distances, so that they do not sprout right next to the mother plant. In contrast, the seeds of some plants do sprout right next to their mother plant.

- א. What are two ways in which seeds are carried away from the mother plant?

For each way that you mentioned, describe one adaptation of the plant for this method of seed distribution. (8 points)

- ב. What is one possible advantage of plants sprouting near the mother plant? (4 points)

Answer one of the questions 22-23.

- 22. א.** At the beginning of a pregnancy, the young fetus secretes the hormone HCG, which prevents the corpus luteum [גופיף הצהוב] from atrophying.

Explain the importance of this fact for the normal progress of a pregnancy. (6 points)

- ב. Explain how the use of birth control pills prevents pregnancy. (7 points)

- 23.** Once a man has reached sexual maturity, his body will produce sperm continuously and this production is regulated by feedback. Describe this feedback. Use the following terms in your answer:

pituitary gland [היפופיזה], hypothalamus [היפותלמוס], testicle [אשך], testosterone [טסטוסטרון], LH and FSH. (13 points)

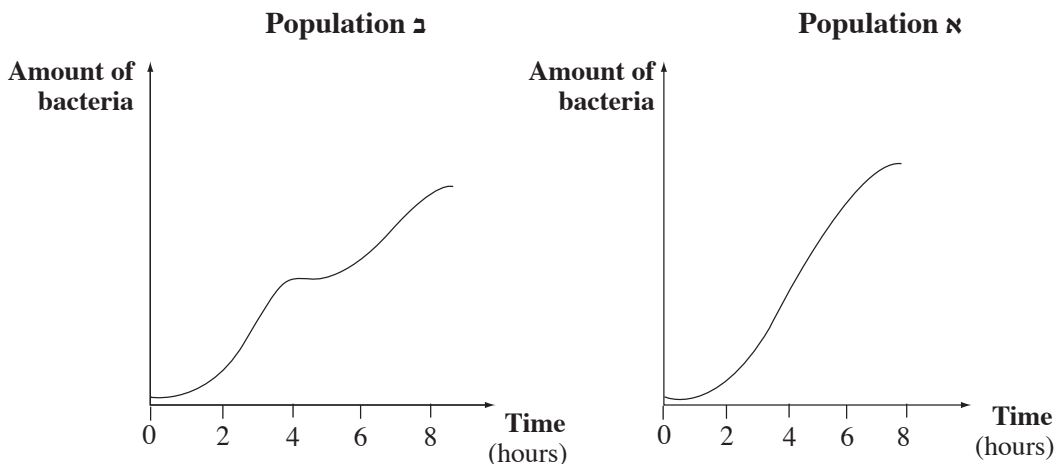
Topic V — Microorganisms

Answer three questions:

Question 24 (required), one of the questions 25-26 and one of the questions 27-28.

Answer Question 24 (**required**).

- 24.** The graphs below describe the growth of two identical populations of *E. coli* bacteria on two different types of growth media. The two media contained the same total amount of sugar but, in the medium in which Population א was grown, the only sugar present was glucose; whereas the medium in which Population ב was grown contained both glucose and lactose (a disaccharide [דו-סוכר]).



Explain the change in the amount of bacteria over time in each population.
(15 points)

Answer one of the questions 25-26.

- 25.** The disease anthrax attacks livestock. Bacteria suspected to be responsible for this disease were found in the blood of cows that are sick with anthrax. Describe the process that should be carried out, in order to determine whether the suspicious bacteria is indeed the cause of the anthrax.
(12 points)
- 26.** Certain species of bacteria can turn into spores.
- א. Name two ways in which a bacterial spore differs from the bacterial cell from which it was formed. (6 points)
 - ב. How does the ability to become spores benefit bacteria?
(6 points)

Answer one of the questions 27-28.

27. There are those who propose that, in certain situations, bacteriophages should be used instead of antibiotics.

- א.** Explain why bacteriophages could serve as an alternative to antibiotics.
(6 points)
- ב.** Describe the process that is the reason why there is a need to find alternatives to antibiotics. (7 points)

28. Milk left outside the refrigerator will go sour after a period of time.

- א.** Explain the process that occurs in the milk and causes it to sour.
(7 points)
- ב.** Will the process that you described for Item א end after a period of time? Explain your answer. (6 points)

Topic VI — Evolution and Development

Answer three questions:

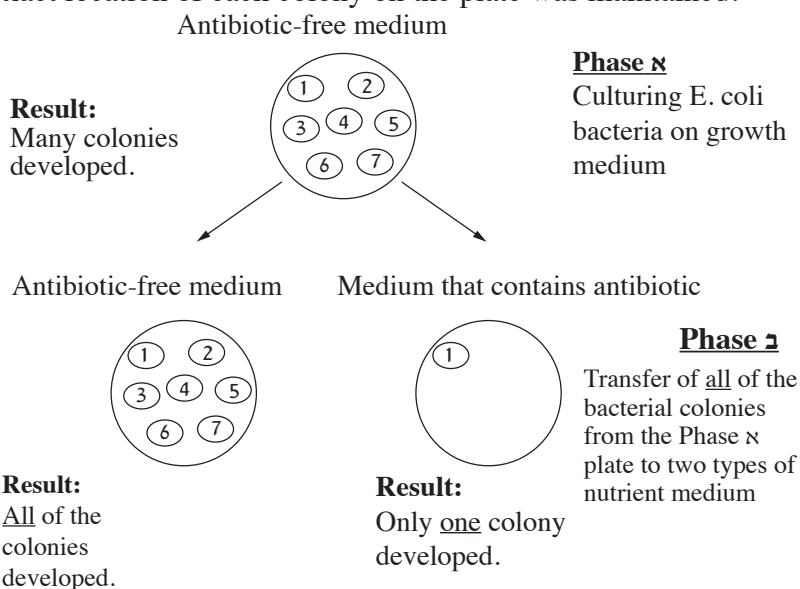
Question 29 (required), one of the questions 30-31 and one of the questions 32-33.

Answer Question 29 (**required**).

29. Professor Lederberg conducted an experiment to answer the following question: Does bacterial resistance to an antibiotic develop following exposure to the antibiotic or does it appear beforehand, independent of any exposure to the antibiotic?

The experiment included two phases. In Phase א, Prof. Lederberg cultured bacteria on a plate (solid nutrient medium) and many colonies developed on that plate. (Each colony developed from one original bacterium.)

In Phase ב, he transferred colonies from the plate used in Phase א to two plates: a plate that contained an antibiotic and a plate without any antibiotic. The exact location of each colony on the plate was maintained.



Prof. Lederberg repeated Phase ב of the experiment many times and, each time, the results were as described in the figure above.

- א. Based on the results of the experiment, does antibiotic resistance develop following exposure to an antibiotic or does it develop beforehand, independent of any exposure to the antibiotic? Explain. (8 points)
- ב. Explain how the process of natural selection [בררה טבעית] is expressed in the results of the experiment. (7 points)
- /continued on page 15/

Answer one of the questions 30-31.

30. There are two theories that explain the development of species: Lamarck's theory and Darwin's theory.

- א. How do each of these theories explain the fact that today's horses are larger than their ancient ancestors? (7 points)
- ב. For hundreds of years, in China, it was customary to tightly bind the feet of young girls, so that when they grew up their feet would be very small. Despite this, their daughters (whose feet were not bound) had normal-sized feet.

Which of the two theories does this fact disprove? Explain your answer. (6 points)

31. In many parts of the world, wheat yields are reduced by a parasitic fungus that causes a disease known as rust [חילדון]. Farmers are trying to develop wheat cultivars that are resistant to this rust.

- א. Describe two methods for developing a rust-resistant wheat cultivar. (7 points)
- ב. Present one biological advantage of each method. (6 points)

Answer one of the questions 32-33.

32. About 100 years ago, remains of a mammal were found in Greece. At first, the remains were thought to be those of an ancient elephant. But, after further examination based on comparative anatomy and, later, molecular tests, researchers reached the conclusion that the remains were those of a pygmy mammoth [ממותה ננסית] (a member of the Elephantidae family).

Which of the two types of tests used by the researchers provides stronger support for their conclusion? Explain the principle upon which that type of test is based. (12 points)

33. Fish and other animals exhibit group behavior.

In a large lake in Africa, there are small tilapia fish known as Blue Flash. These fish travel through the water only as a group that contains hundreds of individuals. The group looks like one body that continually changes its shape, while maintaining its unified structure.

Describe an evolutionary mechanism that could have led to the development of the group behavior of these fish. (12 points)

/continued on page 16/

Topic VII — Biotechnology

Answer three questions:

Question 34 (required), one of the questions 35-36 and one of the questions 37-38.

Answer Question 34 (**required**).

34. Bacteria can be used to produce a biofuel from plants. In order to produce this biofuel, four plasmids were constructed. Different genes were inserted into the plasmids, as described in the table below.

Genes Inserted into the Plasmid	Plasmid
cellulase, beta-galactosidase, resistance to kanamycin	p-cellulose
6 genes from an operon for the production of fatty acids, resistance to chloramphenicol	p-fatty acid
7 genes from an operon for the production of butanol, resistance to chloramphenicol	p-butanol
8 genes from an operon for the production of pinene, resistance to chloramphenicol	p-pinene

- a. Determine which of the plasmids listed in the table should be inserted into bacteria, in order to produce butanol. Explain your answer.
(8 points)
- b. What would happen if all of the plasmids contained a gene for resistance to the same antibiotic? (7 points)

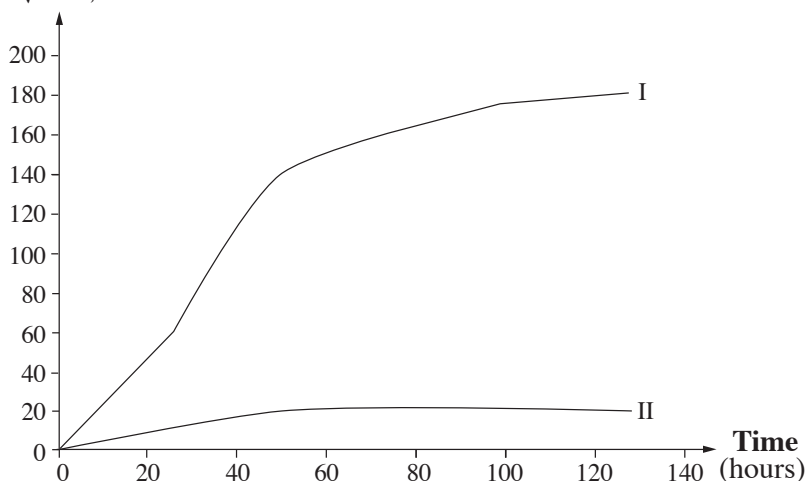
Answer one of the questions 35-36.

35. Engineered *E. coli* bacteria can be used to produce biofuel. These bacteria are grown on treated millet.

- א. Explain the importance of the treatment applied to the millet before bacteria are grown on it. (6 points)
- ב. The graph below shows two curves, I and II, which describe the growth of wild-type and genetically engineered *E. coli* of the same species on treated millet.

No. of bacteria/mL

($\times 10^7$)



Which curve, I or II, describes the growth of the genetically engineered bacteria and which curve describes the growth of the wild-type bacteria? Explain. (7 points)

36. א. Describe two methods of checking whether the bacteria in which a gene coding for the production of the enzyme cellulase was inserted actually express that gene. (7 points)
- ב. For an industrial production process, it is important that the genetically engineered bacteria be genetically stable. The article "Genetically engineered bacteria produce biofuel from grasses" describes a bacterium that produces butanol. Explain why those bacteria are not genetically stable. (6 points)

/continued on page 18/

Answer one of the questions 37-38.

37. Patients suffering from ADA-SCID disease lack the enzyme adenosine diaminase. Bacteria can be engineered to produce this enzyme, which can then be injected into patients.

- א. Does the plasmid that is inserted into the bacteria to produce the enzyme that can be injected into patients need to contain DNA or complementary DNA (cDNA)? Explain. (6 points)
- ב. Describe one advantage and one disadvantage of treating patients with enzyme injections, as opposed to gene therapy. (6 points)

38. For gene therapy of ADA-SCID patients, researchers used a retrovirus vector.

- א. Explain the process of the preparation of the vector. (6 points)
- ב. What problem can arise when a virus is used as a vector for inserting a gene into cells? (6 points)

Good Luck!

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בהצלחה!

זכות היוצרים שמורה למדינת ישראל
אין להעתיק או לפרסם אלא ברשות משרד החינוך