

## Biology

### Reform for Meaningful Learning Program

#### Questions and Analysis of Scientific Research in the Core Topic Areas Questions in Areas of In-Depth Study

#### Instructions for examinees

א. Duration of the exam: Three hours

ב. Exam structure and breakdown of points:

This exam has four parts.

Part One — 32 points

Part Two — 35 points

Part Three — 18 points

Part Four — 15 points

Total — 100 points

ג. Material that may be used during the exam:

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

ד. Special instructions:

For the items in Part One, mark your answers on the answer sheet found at the end of the answer booklet (page 19).

For the questions in Part Two, Part Three and Part Four, write your answers in the answer booklet.

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!

## ביולוגיה

### על פי תכנית הרפורמה ללמידה משמעותית

#### שאלות וניתוח מחקר מדעי בנושאי הליבה שאלות בנושאי ההעמקה

#### הוראות לנבחן

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:

בשאלון זה ארבעה פרקים.

פרק ראשון — 32 נקודות

פרק שני — 35 נקודות

פרק שלישי — 18 נקודות

פרק רביעי — 15 נקודות

סה"כ — 100 נקודות

ג. חומר עזר מותר בשימוש:

מילון עברי-לועזי / לועזי-עברי.

ד. הוראות מיוחדות:

את תשובותיך על הסעיפים בפרק הראשון סמן בתשובון שבסוף מחברת הבחינה (עמוד 19).

את תשובותיך על שאלות בפרק השני, השלישי והרביעי כתוב במחברת הבחינה.

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

רשום "טייטה" בראש כל עמוד טייטה. רישום טייטות כלשהן על דפים שמחוץ למחברת הבחינה עלול לגרום לפסילת הבחינה!

Good Luck!

בהצלחה!

## Questions

### Part One (32 points)

Part One consists of one question, made up of Items א to ט.

You must answer all of the items. If you answer at least 17 of the items correctly, you will receive all 32 points.

#### Question 1 (32 points)

Four possible answers are presented for each item. Choose the most appropriate answer.

- \* Mark the answer you have chosen on the answer sheet at the end of the answer booklet (page 19).
- \* For each item, draw an ✕ in pen in the box under the number (1-4) that represents the answer you chose.

Example:

נט. Which disease is carried by mosquitoes?

1. jaundice
2. rubella
3. malaria
4. whooping cough

In this case, you would mark your answer on the answer sheet as follows:

4	3	2	1	נט.
<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	

- \* Draw only one ✕ for each item.
- \* To erase an answer, fill in the entire box like this: ■ .
- \* You may not use White-Out to erase answers.

**Note:** In order to limit the need to erase answers on the answer sheet, we recommend that you first mark the correct answers inside this booklet and only later enter them into the answer sheet.

Answer all of the items א to ז.

- א. What do a sperm cell and an egg cell (ovum) have in common?
1. Both are the smallest cells in the body.
  2. Both are the largest cells in the body.
  3. Each has  $n$  chromosomes in its nucleus.
  4. Each has  $2n$  chromosomes in its nucleus.
- ב. In a desert habitat one expects to find mainly:
1. animals that are active during the day and plants with branched roots
  2. animals that are active during the night and plants with branched roots
  3. animals with thin fur and plants with large, broad leaves
  4. animals with thick fur and plants whose leaves have stomata [פיוניות] on their upper surface
- ג. A person touches a hot pot and immediately moves that hand away in a reflex reaction. What triggers this reaction?
1. the spinal cord
  2. the brain stem
  3. the cortex
  4. the temperature regulation center in the brain
- ד. Which of the following statements about enzymes is correct?
1. They are active in eucaryotic cells and not in procaryotic cells.
  2. They are active only inside cells.
  3. In an enzymatic reaction, their concentration rises as substrate concentration falls.
  4. In an enzymatic reaction their concentration remains constant.

ה. Breathing rate (gas exchange) rises during physical activity. What causes this?

1. a decrease in the concentration of glucose in the blood
2. a rise in the concentration of carbonic acid in the blood
3. a decrease in blood temperature
4. a rise in the concentration of oxygen in the blood

ו. The area of land on earth covered by forests is shrinking.

What might be the result of this loss of forested land?

1. an increase in the greenhouse effect
2. depletion of ozone in the atmosphere
3. an increase in oxygen concentration in the air
4. an increase in species diversity on earth

ז. In mice, the allele for gray fur is dominant and the allele for white fur is recessive.

A white male mouse was crossed with a gray homozygous female mouse, and their offspring (generation  $F_1$ ) were interbred.

What is the chance of obtaining homozygous offspring in generation  $F_2$ ?

1. 50%
2. 25%
3. 0%
4. 75%

ח. A healthy person's urine does not contain protein. What is the reason for this?

1. Protein is reabsorbed from the filtrate [תסנין] into the blood.
2. Protein does not pass from the blood into the filtrate.
3. Protein is utilized in the filtrate for cellular respiration.
4. Protein turns into urea in the filtrate.

- ט. Which of the following statements correctly describes cellular respiration in plants and animals?
1. In plants, unlike in animals, cellular respiration is photosynthesis.
  2. Cellular respiration in animals takes place during the day and night, and in plants it takes place only at night.
  3. In both, most of the energy is generated in processes that take place in the mitochondria.
  4. In both,  $\text{CO}_2$  serves as an energy source.
- י. What would happen if we injected protein from cow's milk into a human's blood?
1. The body would use the protein to generate energy.
  2. The body would secrete the protein in the urine.
  3. The body would not produce antibodies, because the protein is of animal origin.
  4. The body would produce antibodies that bind to the protein.
- יא. Human body temperature is kept more or less constant, even when the ambient temperature is low. What is the reason for this?
1. The peripheral blood vessels expand.
  2. Cellular respiratory rate increases.
  3. The body absorbs heat from the sun.
  4. Drinking warm fluids supplies the body with heat.
- יב. What determines the amino-acid order in a protein produced in a cell?
1. the amount of messenger RNA (mRNA) in the nucleus
  2. the number of transfer RNA (tRNA) molecules
  3. the types of amino acids present in the cell
  4. the sequence of nitrogenous bases in the messenger RNA (mRNA)

יג. An increase in the number of gazelles in a population inhabiting a given territory may cause, within a short time:

1. an increase in the number of species that are primary consumers
2. an increase in the quantity of plants that the gazelles feed on
3. increased competition between the gazelles
4. a decrease in the number of predator species that hunt gazelles.

יד. Listed below are three signs seen in some diabetes patients:

- (1) insulin deficiency
- (2) excretion of large amounts of urine
- (3) a rise in glucose concentration in the blood

In what order do these signs occur?

1. (2) → (3) → (1)
2. (1) → (2) → (3)
3. (3) → (2) → (1)
4. (1) → (3) → (2)

טו. There are no ribosomes in viruses. What is the consequence of this?

1. They use sugars instead of proteins.
2. They have no genetic material.
3. They have no proteins.
4. They need a host cell to produce proteins.

טז. Which of these mutations will have a greater impact on the evolution of a specific species?

1. a mutation that does not change an individual's competence and occurs in a reproductive cell (gamete)
2. a mutation that does not change an individual's competence and occurs in a body (somatic) cell
3. a mutation that increases an individual's competence and occurs in a reproductive cell (gamete)
4. a mutation that increases an individual's competence and occurs in a body (somatic) cell

- יז. The seed of a plant generates the energy it needs to germinate directly from:
1. the minerals in the seed
  2. the oxygen in the air
  3. the organic compounds in the seed
  4. water in the soil
- יח. Which of the following statements is true for the natural selection process in a specific population?
1. Certain individuals modify themselves and transmit their acquired traits to their offspring.
  2. Over their lifetime, the individuals adapt to changes in their environment, so they all survive.
  3. Only traits that have a survival advantage are passed on genetically.
  4. Individuals are genetically diverse, and only some of them survive after changes occur in their environment.
- יט. Which one of the following groups of substances is present in the blood of a healthy person?
1. enzymes, starch, fats
  2. oxygen, amino acids, hormones
  3. oxygen, polysaccharide [רב סוכר],  $\text{CO}_2$
  4. antibodies, minerals, glycogen
- כ. Which of the following processes requires energy?
1. passage of water through the cell membrane
  2. passage of  $\text{CO}_2$  from the body's cells into the capillaries
  3. enzyme production in the body's cells
  4. air exiting the lungs at rest

## Part Two (35 points)

Part Two is made up of seven questions, 2-8.

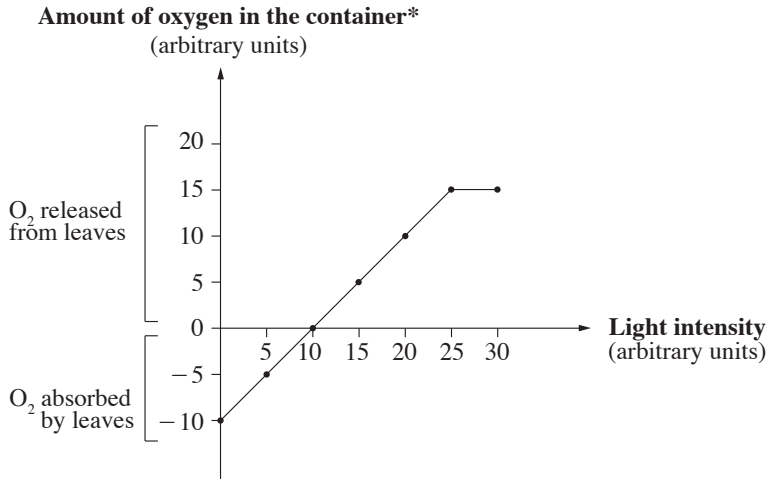
Choose five of these questions and write your answers in the **answer booklet** (each question — 7 points).

2. א. The heart's left ventricle wall is thicker than the right ventricle wall. Explain how the difference in wall thickness between the right ventricle and the left ventricle is related to the function of each of the two ventricles. (4 points)
- ב. Can a defect in the valves between the atria and the ventricles cause oxygen-rich blood to mix with oxygen-poor blood? Explain your answer. (3 points)
3. Horseflies bite various mammals and suck their blood. Horseflies transmit pathogens to animals they have bitten. As a result of the transmitted diseases, the number of those individuals in the population declines.
- א. Two methods are available for controlling the flies: importing wasps that kill the flies or chemical pest control.
- (1) Which method do you think should be used to kill the flies?  
Suggest one argument supporting the method that you prefer and one argument against it.
- (2) Explain why you prefer your method of choice, despite the drawback you mentioned. (4.5 points)
- ב. Zebras are a species of horses (Equidae) with a black body and white stripes. Researchers have found that horseflies bite zebras less often than they bite black horses.  
It is assumed that zebras evolved from black horses.  
Read the following two statements. **Decide** which statement correctly describes the influence of the environment on the appearance of white stripes on the coat of black horses, and **explain** your decision.
- I. An environment with many horseflies caused mutations in black horses; these mutations caused the appearance of white stripes.
- II. Mutations which caused the appearance of white stripes occurred in the past in black horses. In an environment with many horseflies, more individuals with white stripes survived. (2.5 points)



4. א. A point mutation occurred in the influenza virus gene that codes the virus's envelope protein. What type of mutation (base substitution, base deletion, or base insertion) has the smallest chance of producing a protein that is different than the envelope protein? Explain. (4 points)
- ב. Influenza viruses are subject to many mutations. The health authorities advise getting a repeat vaccination against influenza viruses every year. Explain the connection between influenza virus mutations and this recommendation. Refer to a feature of the immune system in your answer. (3 points)
5. Several plants of the same species were grown in identical closed containers that were transparent. The light intensity in each of the containers was different. The amount of oxygen in each of the containers was measured at the beginning and at the end of the experiment. All the containers began with the same amount of oxygen. The amounts of oxygen measured at the end of the experiment, relative to the initial amount of oxygen, are shown in the graph below.

**Amount of oxygen absorbed or released by plants at different light intensities**



- א. Explain the results obtained at light intensities 0, 10, 20. Refer to respiration and photosynthesis processes in your answer. (4.5 points)
- ב. The biomass of organisms in the top layer of water in the oceans, where light does penetrate, is greater than that in the deeper layers. Explain the relation between light intensity and the organisms' biomass. (2.5 points)

6. א. Reproductive glands (ovaries and testes) are the target organs for certain hormones and these glands secrete other hormones.  
**Choose one** human reproductive gland and **name** one hormone for which this gland is a target organ and one hormone that this gland secretes.  
**Describe** one effect of each of the hormones you listed. (4 points)
- ב. Reproductive cells (gametes) are produced in the reproductive glands. The reproductive cells of one set of parents will produce offspring that are genetically variable relative to each other. List two factors that contribute to this variability. (3 points)

7. A certain unicellular algae grows in sea water. Look at the table below and answer both items that follow.

**Concentration of sodium and potassium in algae cells and in seawater**

Solutes	In the cell (mM)	In seawater (mM)
Sodium	90	470
Potassium	500	10

- א. Explain how the solute concentrations in the algae cell (listed in the table) are kept more or less constant over time. (3.5 points)
- ב. What would happen if the algae cells were placed in a container with distilled water: would the cells swell a little, shrink a little, or explode? Explain. (3.5 points)
8. Occasionally, albino (not green) corn seedlings occur. These seedlings survive for a short time only and do not reach the seed-producing stage.
- א. Explain why these seedlings do not survive for long. (3.5 points)
- ב. Albinism in plants is an inherited trait. Explain how it is possible for this trait to appear in the next generations, even though albino plants do not have offspring. Your answer must suggest an explanation other than the occurrence of a mutation. (3.5 points)

### Part Three (18 points)

Part Three is made up of three questions, 9-11.

Read the description of a research study presented below and answer all of the questions 9-11. (The point value of each item is given.)

#### Parental behavior

(Based on: Scott, N. et al [2015]. *A sexually dimorphic hypothalamic circuit controls maternal care and oxytocin secretion*. **Nature**, 525, 519-522)

Just like many other mammals, female mice exhibit maternal behavior even before their pups are delivered, but mostly afterwards. Before delivery, their maternal behavior is largely centered around selecting a suitable place for delivery and building a nest. After delivery, maternal behavior is expressed, among other ways, by caring for the pups and protecting them. Maternal behavior is affected by activity in certain areas of the brain. This activity is expressed in the transmission of nerve impulses.

9. א. There are several stages in the transmission of a nerve impulse from one neuron to another. List three of these stages. (3 points)
- ב. List one difference between transmission of a nerve impulse along a nerve cell (neuron) and transmission of an impulse across a synapse. (2 points)

Among mice, like many other mammals, the females care for the pups most of the time and the males rarely take care of them. Researchers found a difference in parental behavior between individuals who are parents and individuals who are not parents.

Researchers at the Weizmann Institute of Science decided to investigate whether the differences in parental behavior in mice are related to the differences that exist between males and females in the structure of the brain and in brain function.

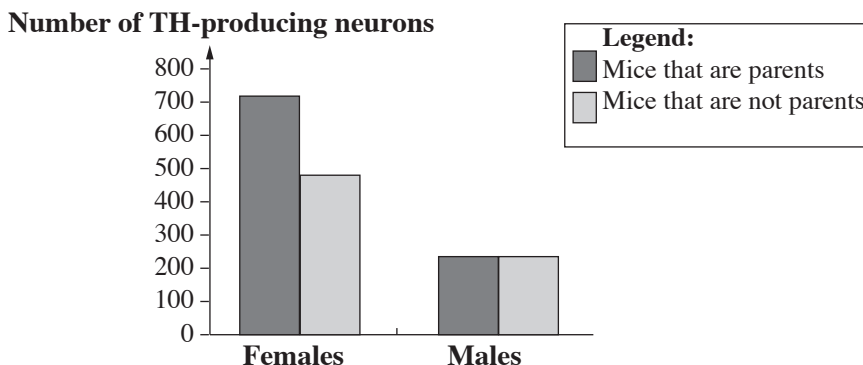
Researchers focused on a small area in the brain called the AVPV, because this area of the brain is different in females than in males. Brain activity in this area involves secreting the neurotransmitter **dopamine** into the synapses. Dopamine is produced in a process that involves the enzyme TH (tyrosine hydroxylase). Researchers chose to determine dopamine levels by checking levels of TH and in this way determine the level of brain activity.

(The text continues on the next page.)

In the first stage of this study, researchers investigated how many neurons produce the enzyme TH in the AVPV area in the brain of four groups of mice: females who were mothers, females who were not mothers, males who were fathers, and males who were not fathers. All the mice were the same age and were raised in the same cages and under identical conditions.

Results of the first stage are shown in Graph 1, below.

**Graph 1: Number of TH-producing neurons in the AVPV area of the brain**



10. א. Determine if there is a relation between the number of neurons that produce TH and mouse gender. Use the graph to explain your decision. (2.5 points)
- ב. Determine if there is a relation between the number of neurons that produce TH and the fact that the individual is a parent. Your answer should relate to both females and males. Use the graph to explain your decision. (2.5 points)

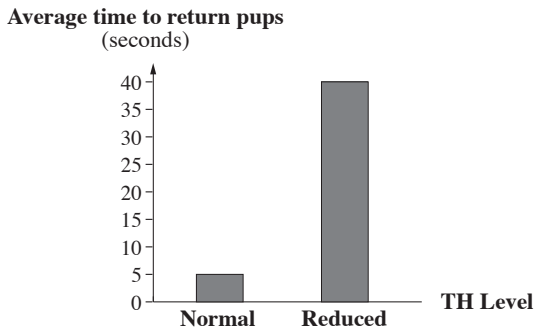
In the second stage of the study, researchers investigated the effect of levels of the enzyme TH on parental behavior of females living in cages. Parental behavior was measured by the amount of time it took a mother to return a pup placed in the corner of the cage to the breeding nest, which is a protected space in the cage.

The researchers took mother females and divided them into two groups: The females in one group received treatment to reduce production of TH in AVPV neurons, and the females in the other group were not treated. The researchers measured the amount of time it took the females to return pups placed in the corner of the cage to the breeding nest.

Results of this experiment are shown in Graph 2, on the following page.

/continued on page 13/

**Graph 2: Time taken by mothers with normal or reduced TH levels in the brain to return pups to nest**



11. א. What can you conclude from the results of this experiment about the relation between TH level and parental behavior? Base your answer on the data shown in Graph 2. (3 points)
- ב. Read the following statement: "The level of dopamine secreted in the brain of a female mouse is related to the mouse being a mother and affects its parental behavior."  
Explain how the information brought in the first page of the study description (page 11) and the results shown in Graphs 1 and 2 support this statement. (5 points)

### Part Four (15 points)

Part Four is made up of questions on three topics: Regulation of Gene Expression and Genetic Engineering; Developmental Comparative Physiology; and Bacteria and Viruses in the Human Body. Choose one topic and answer **two** questions on that topic, according to the directions given for that topic.

#### Topic I — Regulation of Gene Expression and Genetic Engineering

Answer two questions: Question 12 (required) and one of the questions 13-14.

Answer Question 12 (**required**).

**12.** Every cell has several control mechanisms that influence gene expression in that cell.

- א. The number of protein types produced in a eukaryotic cell is larger than the number of genes expressed in the same cell. Name the process which makes this possible, and briefly explain how it facilitates the production of different types of proteins from the same gene.

(2.5 points)

- ב. Explain why some proteins are produced only in specific cells in the human body and not in other cells.

(2.5 points)

- ג. When a person climbs to a high elevation, the number of red blood cells in his or her blood changes under the influence of the hormone erythropoietin. Production of this hormone (which is a protein) is controlled at transcription level.

Below is a list of changes that occur in the human body when a person climbs to a high elevation.

- (1) Copy the changes to your notebook in order of their occurrence.

- change in concentration of the hormone erythropoietin
- change in the quantity of red blood cells
- change in the quantity of oxygen entering the lungs
- change in the transcription level of the gene that codes for the hormone erythropoietin

- (2) For each of the four changes, determine what the trend is — upward or downward.

(4 points)

/continued on page 15/

Answer one of the questions 13-14.

**13.** In the genetic disease sickle cell anemia, individuals who are sick are homozygous recessive for a certain gene.

A pair of healthy parents have a sick child. The mother is pregnant again, and the parents would like to know whether the fetus is homozygous recessive for the gene of the disease.

**א.** What is the probability of the fetus being homozygous recessive ?

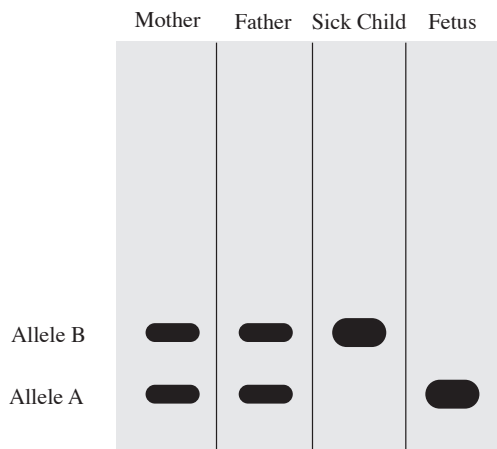
Explain. You may use a diagram or a table to do so. (3 points)

**ב.** The fetus was genetically tested by gel electrophoresis, a method in which the alleles of the tested gene are separated.

The fetus's alleles were identified by this genetic testing, and they were compared to the alleles of both parents and those of the sick child.

The results are shown in the figure below.

### Results of gel electrophoresis to identify the allele for sickle-cell anemia



Based on the fetal test results, determine whether the child that will be born will be healthy or sick. Explain your answer. (3 points)

14. Human growth hormone can be produced by genetically engineering bacteria: A plasmid is inserted into bacteria that are killed by the antibiotic X. The plasmid contains a gene that codes for growth hormone and also a gene for resistance to the antibiotic X.

- א. Antibiotic X is added to the bacteria's growth medium. Explain why. (2.5 points)
- ב. The growth-hormone gene that is inserted into the plasmid is not the original gene that was isolated from human cells. Explain why the original gene cannot be used. (3.5 points)

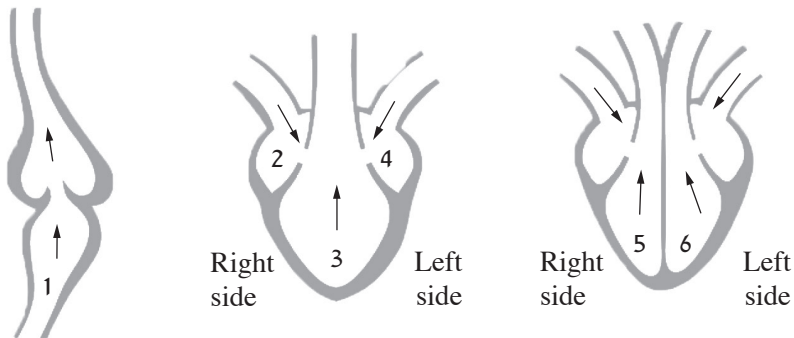
## Topic II — Developmental Comparative Physiology

Answer two questions: Question 15 (required) and one of the questions 16-17.

Answer Question 15 (**required**).

15. א. Look at the figures below. The arrows in the figures represent the direction of blood flow.

### Heart structure in animals of different classes



**Fish**

**Amphibian**

**Bird**

For each of the compartments 1-6 determine whether the blood flowing through it is poor in oxygen, rich in oxygen, or mixed?

- (3 points)
- ב. Which of the classes - amphibians or birds - is homeothermic? Explain the link between heart structure and being homeothermic. (3 points)
- ג. Because of the structure of the circulatory system in fish, blood flows to their body tissues at a low pressure. Explain why. (3 points)



Answer one of the questions 16-17.

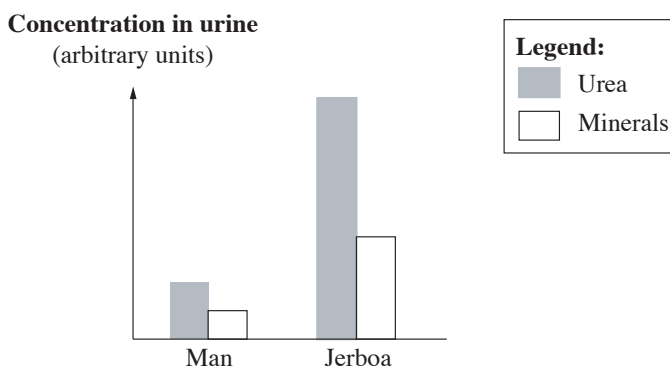
16. א. Copy the following table into your notebook and complete the missing information. (3 points)

**Gas exchange organs and type of circulatory system in different animals**

Mammal	Fish	Adult amphibian	Insect	
				Organs through which gas exchange occurs
				Type of circulatory system (open/closed)

- ב. Compare the circulatory system in insects to the circulatory system in mammals. Your answer must refer to one feature that is different in the two systems and one feature that is common to the **structure** of both systems. (3 points)
17. Mammals and birds are animals that are adapted to life on dry land.
- א. Give one adaptation of the reproductive process to life on dry land that is common to mammals and birds. Explain this adaptation. (3 points)
- ב. The jerboa and man are both mammals that live on dry land. The percentage of water in their bodies is similar. Look at the graph below and answer the question following it.

**Concentration of minerals and urea in human urine and in jerboa urine**



Is man or the jerboa better adapted to a dry environment? Use the graph to explain your answer. (3 points)

### Topic III — Bacteria and Viruses in the Human Body

Answer two questions: Question 18 (required) and one of the questions 19-20.

Answer Question 18 (**required**).

**18.** Viruses are obligate parasites whose reproduction is dependent on their host cell.

א. List three **different types** of substances in a host cell that the virus uses to reproduce. (2 points)

ב. **AIDS** (HIV) viruses reproduce inside human lymphocytes. Researchers conducted an experiment:

In Treatment I, lymphocytes were infected with whole HIV viruses, and the viruses reproduced in the cells.

In Treatment II, lymphocytes were injected only with the viruses' genetic material and with no other components, and the viruses did not reproduce.

Name the viral component whose absence in Treatment II prevented the viruses from reproducing, and explain this component's significance to viral reproduction. (4 points)

ג. A certain medicine inhibits DNA replication in the **herpes** virus. Is the medicine effective during the virus's active phase or during its latent phase? Explain. (3 points)

Answer one of the questions 19-20.

**19. א.** Occasionally, mutations occur in bacteria which make them resistant to antibiotics. There are several ways for this resistance to express itself, and each of them prevents the antibiotic from affecting the bacteria.

List two of these ways. (3 points)

ב. Select one of the following antibiotics: penicillin, erythromycin.

Describe how the medicine harms bacteria, and explain why it does not harm human cells. (3 points)

- 20. א.** There are many types of bacteria in the digestive tract of a healthy person. One of them is *Clostridium difficile*. The number of bacteria of this type in a healthy person's gut is small, and they are harmless. When this bacteria's population in the digestive system is very large, it causes severe inflammation of the gut.
- (1)** In the digestive tract of a healthy person, the *Clostridium difficile* population remains small. Explain the reason for this.
- (2)** Suggest an explanation for the fact that when a person takes antibiotics for an extended period, the bacteria *Clostridium difficile* may cause inflammation of the gut. (5 points)
- ב.** It has been found that, occasionally, when bacteria that are sensitive to a certain antibiotic grow with bacteria that are resistant to the same antibiotic, they also become resistant. What is the process that causes this? (1 point)

**Good Luck!**

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**בהצלחה!**

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