

Biology and Biotechnology: Second-round sample tasks for the Open Doors Master's and Doctoral Tracks

This sample test comprises 45 tasks, including 27 entry-level tasks with a single correct answer (each correct answer is assigned 1 point), 14 intermediate-level tasks with multiple correct answers (the correct answer is assigned 3 points), and 4 advanced-level tasks requiring a detailed answer (the answer is assigned 6 - 9 points depending on its correctness and completeness). For advanced-level tasks requiring a detailed answer, assessment criteria and a standard answer are provided.

Field of Science 1. Biotechnology and Applied Microbiology

Task 1

Entry level (1 point)

Which of the following is classified as a bioobject in phytobiotechnology?

- a) Protozoan cells
- b) Bacteriophages
- c) Ascomycete cells
- d) Algae cells
- e) Bacteria cells

Answer: d

Task 2

Entry level (1 point)

What change occurs in the nucleotide sequence of an organism's DNA as a result of the movement of a DNA transposon?

- a) Phenotype change - modification
- b) Mutation with a change in the number of chromosomes
- c) Gene mutation
- d) Deletion
- e) Chromosomal mutation

Answer: b

Task 3

Entry level (1 point)

Which amino acid is produced using biotechnology?

- a) Antibiotic
- b) A growth hormone
- c) Insulin
- d) Glycine
- e) Leukocyte interferon

Answer: d

Task 4

Entry level (1 point)

Which enzyme is responsible for synthesizing an RNA molecule using DNA as a template?

- a) Restriction enzymes
- b) Ligases
- c) Endonucleases
- d) Polymerases

Answer: d

Task 5
Entry level (1 point)

What is the purpose of maintaining a pressure difference between rooms of different cleanliness classes?

- a) To improve staff comfort
- b) To facilitate technological operations
- c) To reduce the risk of contamination of the manufactured product
- d) To ensure automatic closing of doors in clean rooms

Answer: c

Task 6
Intermediate level (3 points)

How is the synthesis of a secondary metabolite (e.g., an antibiotic) typically activated?
Select all that apply.

- a) Inhibition of the main enzyme responsible for the process of amino acid synthesis
- b) Suppression (repression) of the entire enzyme complex of enzymes responsible for the process of amino acid synthesis
- c) Activation of the transcription process
- d) Activation of the translation process
- e) Repression of the transcription process

Answer: c, d

Task 7
Intermediate level task (3 points)

Which physical methods can be used to immobilize enzymes?
Select all that apply.

- a) Covalent bonding
- b) Linking enzyme molecules together
- c) Encapsulation
- d) Inclusions in liposomes

Answer: c, d

Task 8
Advanced level (6 points)

Describe the method for isolating cell biomass by filtration.

List ways to speed up the filtration process.

Note that the assessment will take into account both the solution process and the reasoning behind it; simply providing the final answer will not be sufficient.

Assessment criteria

1. Answer: The method of isolating cell biomass by filtration involves retaining the biomass on a porous filter membrane - 2 points.
2. Answer: Ways to speed up the filtration process:
 - a) Select a porous material (filter) - 1 point.
 - b) Carry out pressure filtration - 1 point.
 - c) Use devices – vacuum pump - 1 point.
 - d) Clean filters regularly - 1 point.

Field of Science 2. Biology

Task 9

Entry level (1 point)

Determine the total number of chromosomes observed in 100 *Drosophila melanogaster* cells at the metaphase stage, given that this species has a karyotype consisting of 4 pairs of chromosomes.

- a) 800
- b) 400
- c) 80
- d) 1200
- e) 40

Answer: a

Task 10

Entry level (1 point)

What is the chromosomal set found in a spermatid of the model organism *Drosophila melanogaster*?

- a) nc
- b) n2c
- c) 2n2c
- d) 2n4c
- e) 4n4c

Answer: a

Task 11

Intermediate level (3 points)

Which of the following reproductive strategies can be observed in fungi of the genus *Aspergillus* under altered cultivation conditions?

Select all that apply.

- a) Schizogony

- b) Parthenogenesis
- c) Conjugation
- d) Division of hyphae (mycelium)
- e) Formation of ascospores

Answer: d, e

Task 12 Advanced level (8 points)

You have acquired 10 male and 10 non-fertilized female *Drosophila melanogaster* (fruit flies). The study is scheduled to begin 10 days after the purchase of the animals and the expected day of fertilization of the females. It is known that each female *Drosophila melanogaster* can lay up to 100 eggs at a time, and the development period from egg to adult is 10 days, when the flies are kept at a temperature of 25°C.

1. Identify the type of development in *Drosophila melanogaster*.
2. List all stages of development in *Drosophila melanogaster*, starting from the egg.
3. Calculate the total number of different developmental stages of *Drosophila melanogaster* that will be available 10 days after the purchase of the animals and the expected fertilization. Assume no mortality at different stages.

Assessment criteria

1. Answer: indirect (with metamorphosis) - 1 point; with complete transformation, with complete metamorphosis – 1 point.
2. Answer: egg, larva, pupa in puparia, imago – 1 point.
3. Answer: total number of different stages of development = $(10 \times 100 = 1\,000 + 10 \text{ females} + 10 \text{ males}) = 1\,020$ – 5 points.

Field of Science 3. Genetics and Heredity

Task 13 Entry level (1 point)

Which characteristic of a polyploid organism is defined by the number of chromosome sets it possesses?

- a) Phenotype
- b) Karyotype
- c) Genotype
- d) Reaction norms
- e) Environmental factor

Answer: b

Task 14 Entry level (1 point)

To conduct a study, you need a homozygous organism for a specific recessive trait. Which of the following organisms would be appropriate for your research?

- a) aaBB
- b) AaBB
- c) AA Vv
- d) Aa Vv
- e) AABB

Answer: a

Task 15
Entry level (1 point)

In the virtual fly model, there are 8 pairs of chromosomes in the karyotype. Which karyotype represents a normal male in this virtual fly model?

- a) 7A+XY
- b) 14A+XX
- c) 7A+XX
- d) 14A+XO
- e) 9A+ XY

Answer: d

Task 16
Intermediate level (3 points)

Which types of mutations result in changes to the number of chromosomes in the karyotype? Select all that apply.

- a) Nucleotide duplication
- b) Nucleotide insertion
- c) Deletion of the short arm of a chromosome
- d) 44A+XXX
- e) 45A+XXY
- f) Nucleotide deletion

Answer: d, e

Task 17
Intermediate level (3 points)

During the experiment, the DNA nucleotide sequence AAAGGGCCCTTT changed to AAAGGCCCTT. Analyze the DNA sequences and determine the changes that occurred during the experiment with the hereditary material.

Select all that apply.

- a) Replacement of nucleotide G with A
- b) Nucleotide A insertion
- c) Nucleotide T insertion
- d) Deletion of nucleotide G
- e) Nucleotide T deletion

- f) Replacement of nucleotide G with C

Answer: d, e

Task 18 Advanced level (8 points)

You are conducting research on a model animal. During the study, it was determined that the model animal possesses the fourth blood group and is Rh-negative.

1. Identify the type of cell in which the proteins determining the ABO blood group are located.
2. Identify the type of cell in which the proteins determining the Rh factor are located.
3. Specify the cellular structure in which the proteins responsible for the ABO blood group are expressed.
4. Specify the cellular structure in which the proteins responsible for the Rh factor are expressed.
5. How many proteins responsible for determining both the ABO blood group and the Rh factor can be identified in this model animal?
6. List the proteins that determine the ABO blood group of the virtual model animal.
7. Provide all possible genotypes that could correspond to this model animal, taking into account both the ABO blood group and Rh factor.

Note that the assessment will take into account both the solution process and the reasoning behind it; simply providing the final answer will not be sufficient.

Assessment criteria

1. Answer: red blood cell – 1 point.
2. Answer: red blood cell – 1 point.
3. Answer: cytoplasmic membrane complex, including the glycocalyx – 1 point.
4. Answer: cytoplasmic membrane complex, including the glycocalyx – 1 point.
5. Answer: 2 – 1 point.
6. Answer: A and B – 2 points.
7. Answer: $I^A I^B \text{Rh-Rh-}$ – 2 points.

Field of Science 4. Cell Biology

Task 19 Entry level (1 point)

Which of the following components is found in an Escherichia coli (E. coli) cell?

- a) Circular DNA molecule and murein protein
- b) Core
- c) Mitochondria
- d) Chloroplasts
- e) Centrioles

Answer: a

Task 20
Entry level (1 point)

A leukocyte is characterized by the presence of...

- a) Nucleus
- b) Chloroplasts
- c) Capsid
- d) Cellulose cell wall
- e) Starch grains

Answer: a

Task 21
Intermediate level (3 points)

The double-membrane organelles of a eukaryotic cell are...
Select all that apply.

- a) Endoplasmic reticulum
- b) Mitochondria
- c) Centriole
- d) Leukoplast
- e) Golgi complex

Answer: b, d

Task 22
Intermediate level (3 points)

Identify all growing plant tissues.
Select all that apply.

- a) Cambium
- b) Bone
- c) Meristem
- d) Connecting
- e) Nervous

Answer: a, c

Field of Science 5. Ecology

Task 23
Entry level (1 point)

According to its functional role in the ecosystem, the tuberculosis bacillus (Koch bacillus) is classified as a consumer because it ...

- a) feeds on ready-made organic matter
- b) synthesizes organic substances from inorganic ones
- c) releases oxygen
- d) decomposes organic substances into inorganic ones
- e) is the first link in the food chain

Answer: a

Task 24
Entry level (1 point)

The habitat of the malaria plasmodium is the erythrocyte. What is special about this environment?

- a) Presence of a protein-rich substrate
- b) Abundance of light
- c) Presence of oxygen
- d) Presence of carbon dioxide
- e) Presence of iron hydrogen sulfide

Answer: a

Task 25
Intermediate level (3 points)

What abiotic factors can influence the development and survival of cyanobacteria on wooden surfaces of buildings?

Select all that apply.

- a) Air humidity
- b) Impregnation of wooden surfaces with synthetic chemical agents that prevent rotting
- c) Sunlight
- d) White mold
- e) Putrefactive bacteria

Answer: a, c

Task 26
Intermediate level (3 points)

Which of the following are parasitic protozoan organisms affecting humans?

Select all that apply.

- a) Guinea worm
- b) White planaria
- c) Flea
- d) Ascaris
- e) Malarial plasmodium
- f) Giardia

Answer: e, f

Field of Science 6. Microbiology

Task 27
Entry level (1 point)

Which of the following microorganisms is an eukaryote?

- a) Mycoplasmas
- b) Ascomycetes
- c) Rickettsia
- d) Bacteriophages
- e) Bifidobacteria

Answer: b

Task 28
Entry level (1 point)

Which of the following microorganisms has rod-shaped cells?

- a) Clostridia
- b) Mycoplasma
- c) Vibrio
- d) Spirochete
- e) L-form

Answer: a

Task 29
Entry level (1 point)

Copying of hereditary information in bacteria occurs in the matrix known as...

- a) Circular DNA molecule
- b) Circular RNA molecule
- c) Linear DNA molecule
- d) DNA double helix

Answer: a

Task 30
Entry level (1 point)

To obtain a bacterial culture resistant to aerobic environmental conditions, it is necessary to use a storage medium and cultivation conditions with...

- a) Increased oxygen content
- b) Low oxygen content
- c) Elevated temperature
- d) High blood pressure
- e) Low temperature

Answer: a

Task 31

Intermediate level (3 points)

The plague pathogen is characterized by...
Select all that apply.

- a) No core
- b) Presence of glycogen in the cell wall
- c) Spherical cell shape
- d) Linear DNA
- e) Rod-shaped cell

Answer: a, e

Field of Science 7. Virology

Task 32

Entry level (1 point)

Which of the following structures is present in the Hepatitis A virus, an RNA-containing virus?

- a) Chloroplasts
- b) Capsid
- c) Mitochondria
- d) Ribosomes
- e) Cell center

Answer: b

Task 33

Entry level (1 point)

The biological model for the cultivation of the polio virus is ...

- a) Artificial nutrient medium
- b) Enriched nutrient medium
- c) Cell culture
- d) Bacteriophages
- e) Complex nutrient medium

Answer: c

Task 34

Entry level (1 point)

At which stage of the bacteriophage life cycle does the synthesis of viral proteins occur?

- a) Adsorption on the cell surface
- b) Cell penetration
- c) Exit from the affected cell
- d) Nucleic acid synthesis
- e) Translation of bacteriophage components

Answer: e

Task 35
Entry level (3 point)

To induce active immunity, which of the following immunobiological preparations should be used? Select all that apply.

- a) Viral vaccine
- b) Anatoxin
- c) Erythrocyte diagnosticum
- d) Allergen
- e) Diagnostic bacteriophage

Answer: a, b

Field of Science 8. Biochemistry and Molecular Biology

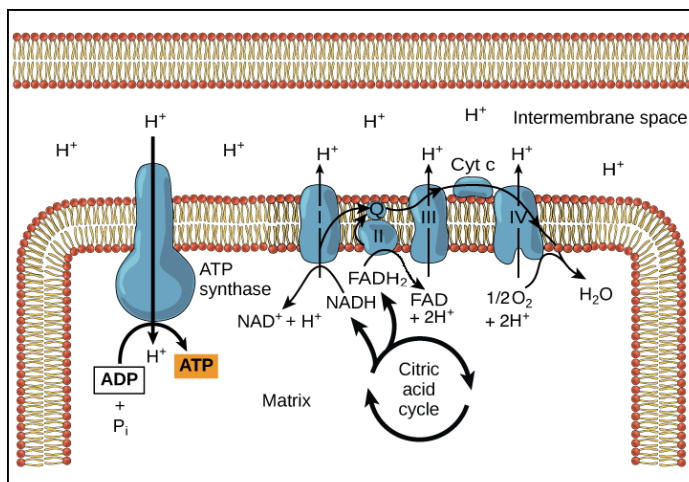
Task 36
Entry level (1 point)

Which of the following is found in the composition of a pyrimidine nucleotide in DNA?

- a) Nitrogenous base thymine
- b) Monosaccharide ribose
- c) Monosaccharide fructose
- d) Nitrogenous base uracil
- e) Monosaccharide glucose

Answer: a

Task 37
Entry level (1 point)



Which of these molecules transfers electrons and protons to the electron transport chain during cellular respiration?

- a) NAD⁺
- b) CO₂

- c) ATP
- d) PVC (pyruvate)
- e) Lactic acid

Answer: a

Task 38
Entry level (1 point)

Which enzyme is required to synthesize DNA using the bacteriophage DNA strand as a template?

- a) DNA polymerase
- b) RNA polymerase
- c) tRNA synthetase
- d) ATP synthetase
- e) Reverse transcriptase

Answer: a

Task 39
Entry level (1 point)

What process occurs during the dark phase of photosynthesis?

- a) ATP formation
- b) O₂ formation
- c) Fixation of atmospheric carbon dioxide
- d) Photolysis of water
- e) Krebs cycle

Answer: c

Task 40
Entry level (1 point)

The synthesis of ATP during chemosynthesis occurs in the cells of...

- a) Spirogyra
- b) Hydrogen bacteria
- c) Aspergillus
- d) Euglena green
- e) Parasitic bacteria

Answer: b

Task 41
Entry level (1 point)

Which intracellular pathogen induces the formation of a cellular immune response?

- a) Measles virus

- b) Tuberculosis bacillus
- c) Diphtheria bacillus
- d) Plague bacillus

Answer: a

Task 42
Intermediate level (3 points)

Which of the following hormones are classified as gonadal hormones?
Select all the correct answers.

- a) Somatotropin
- b) Insulin
- c) Estradiol
- d) Thyroxine
- e) Testosterone
- f) Glucagon

Answer: c, e

Task 43
Intermediate level (3 points)

What substances are involved in the automatic regulation of breathing frequency?
Select all that apply.

- a) Norepinephrine
- b) Acetylcholine
- c) Vitamins
- d) Digestive enzymes
- e) Bile
- f) Mucin

Answer: a, b

Task 44
Intermediate level (3 points)

Which of the following digestive enzymes are responsible for the breakdown of carbohydrates?
Select all that apply.

- a) Lipase
- b) Maltase
- c) Mucin
- d) Amylase
- e) Trypsin
- f) Chymotrypsin

Answer: b, d

Task 45
Advanced level (9 points)

During a routine examination of a 5-year-old child, leg curvature and abnormal chest development were observed. The parents reported that the child's sleep and wakefulness patterns are disrupted, with frequent waking and crying.

1. Which vitamin deficiency is likely responsible for these symptoms?
2. How will the level of this vitamin compare to the normal range in a biochemical analysis?
3. Is a fat-containing component necessary for the proper absorption of this vitamin? If so, why?
4. Besides recommending a vitamin course, what additional advice should be given to the parents to ensure proper care for their child?

Note that the assessment will take into account both the solution process and the reasoning behind it; simply providing the final answer will not be sufficient.

Assessment criteria

1. Answer: vitamin D – 5 points.
2. Answer: reduced/hypovitaminosis – 1 point.
3. Answer: yes – 1 point; D is fat-soluble – 1 point.
4. Answer: Encourage regular sun exposure, daily walks, holidays at the seaside, and preventive doses of vitamin D – 1 point.