



WYPEŁNIA ZDAJĄCY

KOD

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PESEL

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Miejsce na naklejkę.

Sprawdź, czy kod na naklejce to

M-100.

Jeżeli tak – przyklej naklejkę.

Jeżeli nie – zgłoś to nauczycielowi.

Egzamin maturalny

Formuła 2023

BIOLOGIA

Poziom rozszerzony

Zadania dodatkowe w języku angielskim

Symbol arkusza

MBIA-Z0-100-2605

DATA: **21 maja 2026 r.**

GODZINA ROZPOCZĘCIA: **12:10**

CZAS TRWANIA: **80 minut**

LICZBA PUNKTÓW DO UZYSKANIA: **25**

Przed rozpoczęciem pracy z arkuszem egzaminacyjnym

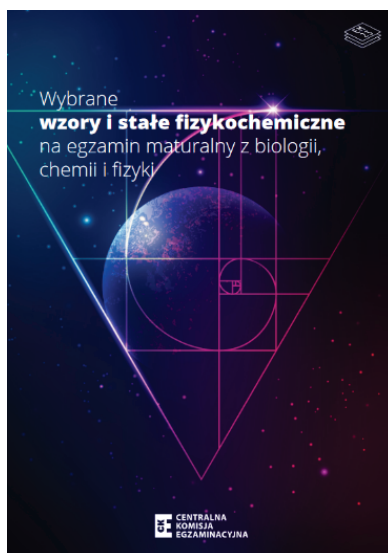
1. Sprawdź, czy nauczyciel przekazał Ci **właściwy arkusz egzaminacyjny**, tj. arkusz we **właściwej formule**, z **właściwego przedmiotu** na **właściwym poziomie**.
2. Jeżeli przekazano Ci **niewłaściwy** arkusz – natychmiast zgłoś to nauczycielowi. Nie rozrywaj banderol.
3. Jeżeli przekazano Ci **właściwy** arkusz – rozerwij banderole po otrzymaniu takiego polecenia od nauczyciela. Zapoznaj się z instrukcją na stronie 2.





Instrukcja dla zdającego

1. Sprawdź, czy arkusz egzaminacyjny zawiera 17 stron (zadania 1–8). Ewentualny brak zgłoś przewodniczącemu zespołu nadzorującego egzamin.
2. Na pierwszej stronie arkusza oraz na karcie odpowiedzi wpisz swój numer PESEL i przyklej naklejkę z kodem.
3. Odpowiedzi zapisz w miejscu na to przeznaczonym przy każdym zadaniu.
4. Pisz czytelnie. Używaj długopisu/pióra tylko z czarnym tuszem/atramentem.
5. Nie używaj korektora, a błędne zapisy wyraźnie przekreśl.
6. Pamiętaj, że zapisy w brudnopisie nie będą oceniane.
7. Możesz korzystać z *Wybranych wzorów i stałych fizykochemicznych na egzamin maturalny z biologii, chemii i fizyki*, z linijki oraz z kalkulatora prostego. Upewnij się, czy przekazano Ci broszurę z okładką taką jak widoczna poniżej.

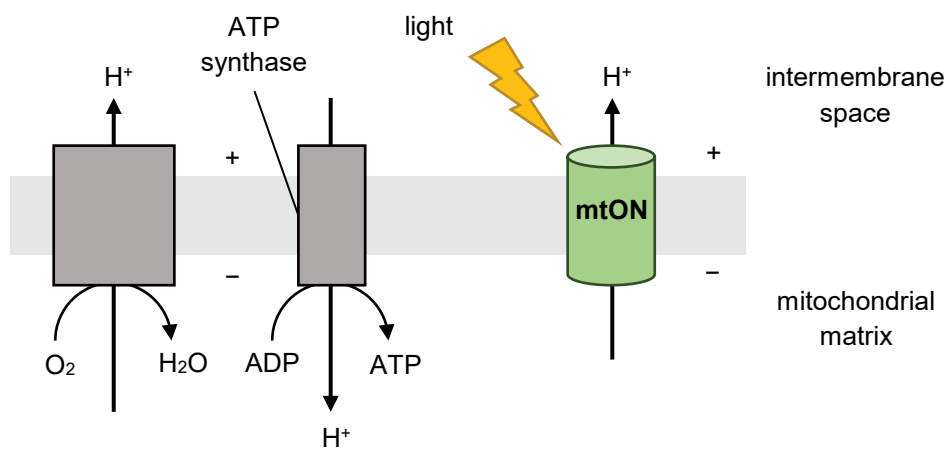


**Zadania egzaminacyjne są wydrukowane
na następnych stronach.**

Task 1.

In an experiment, mitochondria isolated from the nematode *Caenorhabditis elegans* were used, which contained a light-activated protein proton pump (mtON). The mtON pump gene originated from the fungus *Leptosphaeria maculans*, and the resulting mtON protein was integrated into the inner mitochondrial membrane of the nematode using genetic engineering techniques. During the experiment, the pump transported protons from the mitochondrial matrix to the intermembrane space. It was demonstrated that in illuminated mitochondria with the mtON protein, ATP synthesis efficiency was higher, and the lifespan of *C. elegans* individuals with the mtON protein was longer compared to control group nematodes without this protein.

The simplified diagram below shows the operation of the respiratory chain and the mtON pump in mitochondria.



Source: B.J. Berry et al., "Optogenetic Rejuvenation of Mitochondrial Membrane Potential Extends *C. elegans* Lifespan", *Nature Aging* 3, 2023;

B.J. Berry et al., "Optogenetic Control of Mitochondrial Protonmotive Force to Impact Cellular Stress Resistance", *EMBO Reports* 21(4), 2020.

Task 1.1. (0–1)

Explain how the light-activated mtON protein contributes to increased ATP synthesis in mitochondria.

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Task 1.2. (0–2)

Decide whether the sentences below concerning the nematode *C. elegans* that has the mtON protein are true (T) or false (F). Mark the appropriate letter.

1.	This nematode is a transgenic organism.	T	F
2.	This nematode performs photosynthesis.	T	F
3.	This nematode converts light energy into chemical energy.	T	F

Task 1.3. (0–1)

Complete the sentence describing ATP, the primary energy carrier in cells. Select the correct answer from points A, B or C and the correct answer from numbers 1, 2 or 3.

ATP is

A.	an amino acid,	which consists of	1.	amino-acid residues forming an active site.
B.	an enzyme,		2.	a nitrogenous base residue, a pentose residue and phosphate residues.
C.	a nucleotide,		3.	a carboxyl group, an amine group and a nitrogen-containing substituent.

Task 2. (0–2)

Complete the sentences below to correctly describe protein synthesis in a cell. Underline the correct term in each of the brackets.

During (*transcription* / *translation*), two subsequent amino acids are linked by

a (*peptide* / *hydrogen*) bond. The protein synthesis takes place in (*lysosomes* / *ribosomes*).

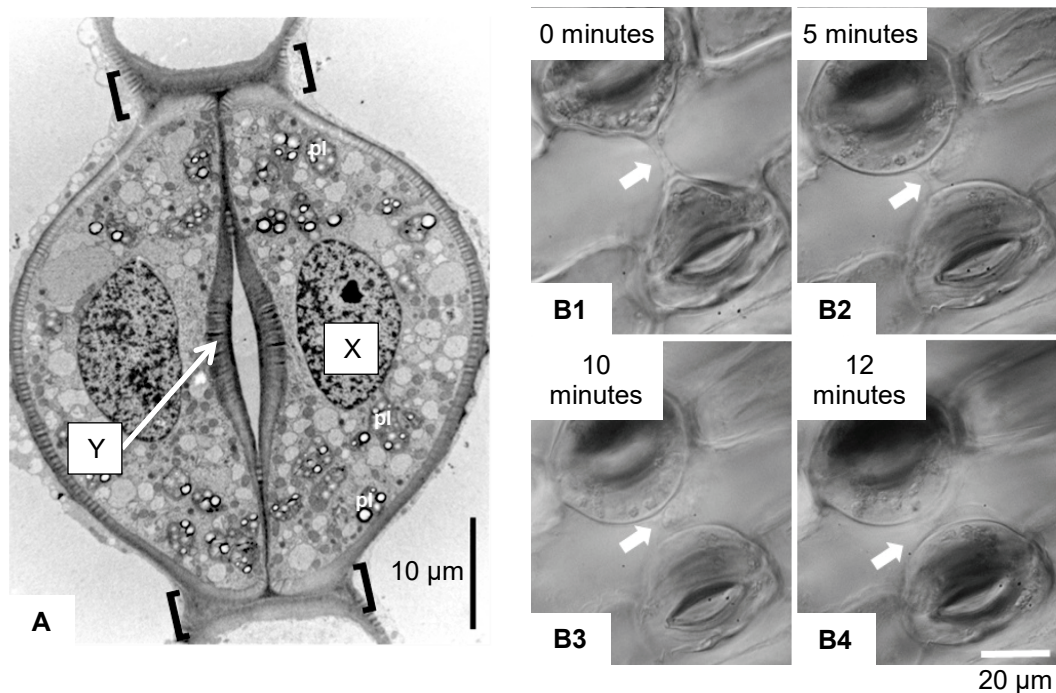
Task 3.

The microscopic image **A** shows the internal structure of guard cells in *Pancratium maritimum*, a species belonging to the *Amaryllidaceae* family. A feature of these plants is the presence of connections between the stomata (the connection is marked with an arrow in Photograph **B1**). The following hypothesis was formulated:

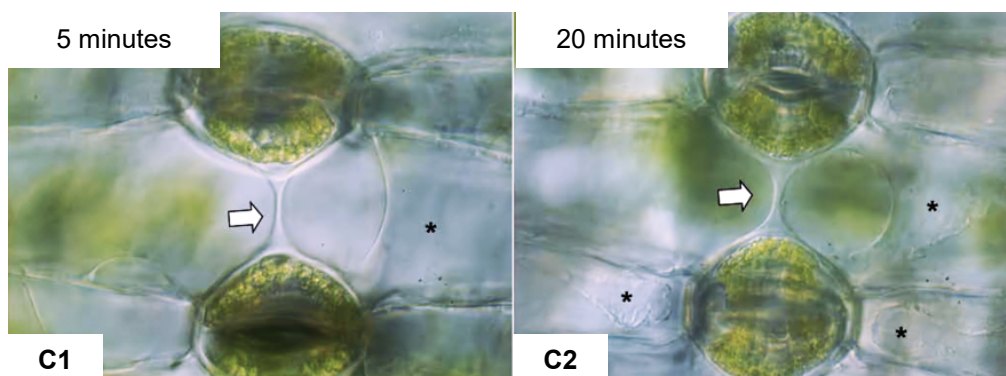
Connections between the stomata are formed by cytoplasmic strands.

Three experiments were carried out to verify this hypothesis.

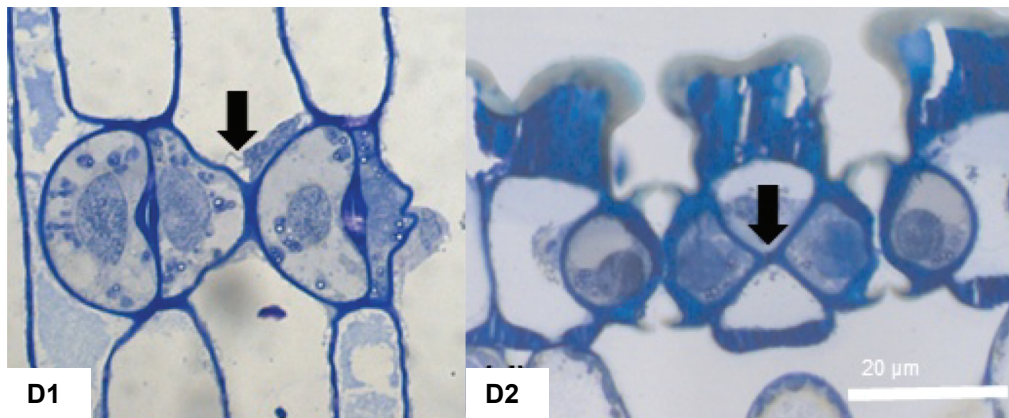
Experiment 1. The stomata of *P. maritimum* were treated for 12 minutes with a 3% solution of pectinase, an enzyme that digests pectin (which is a mixture of polysaccharides). Photographs **B1–B4** show the successive stages of the experiment.



Experiment 2. *P. maritimum* leaf epidermis cells were treated with a hypertonic mannitol solution. The presence of connections between stomata was observed after 5 and 20 minutes. The results of the experiment are presented in photographs **C1** and **C2** below. The cell protoplasts that underwent plasmolysis are marked with asterisks. The connections between stomata are marked with arrows.



Experiment 3. *P. maritimum* leaf epidermis cells were stained with a 1% solution of toluidine blue, a dye used to test for lignin bound to cellulose fibres. The outcome of this experiment is presented in photographs **D1** and **D2** below. The connections between stomata are marked with arrows.



Source: P. Saridis et al., "Stomata in Close Contact: The Case of *Pancratium maritimum* L. (Amaryllidaceae)", *Plants (Basel)* 11(23), 2022.

Task 3.1. (0–2)

Decide whether the hypothesis formulated by the researchers was supported or rejected. Give the reasoning behind your answer, referring to the results of the three experiments.

Decision:

Experiment 1:

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Experiment 2:

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Experiment 3:

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Task 3.2. (0–1)

Identify the guard cell structures labelled X and Y in Photograph A. Select the correct answer from the options given below.

- A. X – mitochondrion Y – cell membrane
- B. X – chloroplast Y – cytoskeleton
- C. X – chloroplast Y – cell membrane
- D. X – nucleus Y – cell wall

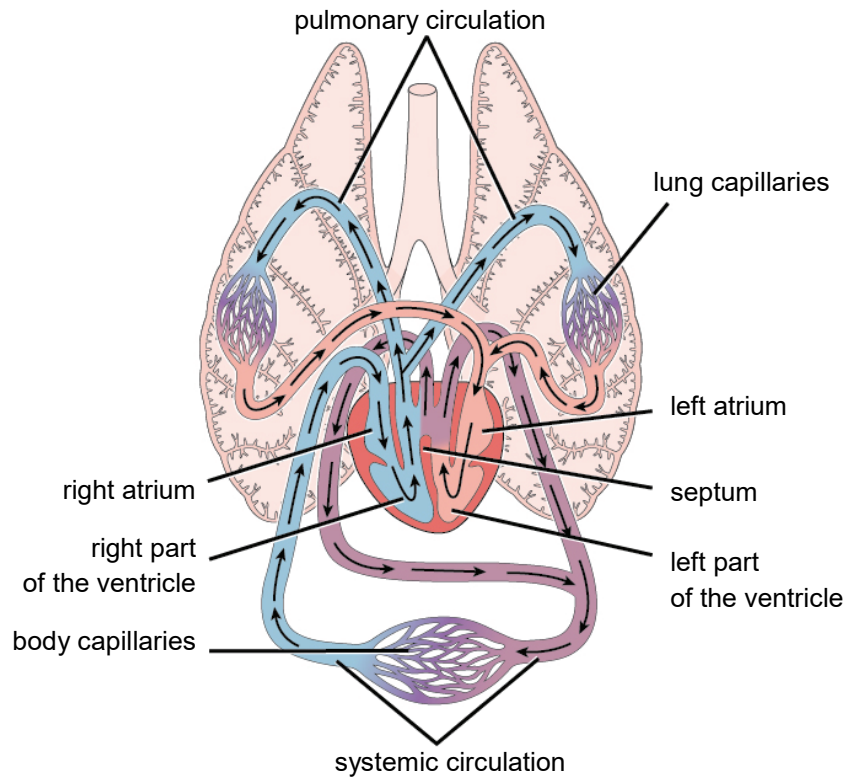
Task 3.3. (0–1)

Decide whether the sentences below concerning protoplast plasmolysis described in Experiment 2 are true (T) or false (F). Mark the appropriate letter.

1.	Protoplast plasmolysis occurred as a result of osmosis.	T	F
2.	As a result of plasmolysis, the protoplasts increased in volume.	T	F

Task 4.

The diagram below shows the structure of the lungs and circulatory system of a vertebrate.



Source: pressbooks.bccampus.ca

Task 4.1. (0–2)

Decide whether the diagram shows a heart and lung structure characteristic of most amphibians or of most reptiles. Give the reasoning behind your answer and refer to a structural feature of each of the organs in the diagram.

Decision:

Heart structure:

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Lung structure:

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Task 4.2. (0–1)

Describe the cooperation between the circulatory system and the lungs in removing carbon dioxide produced by working muscles from the body.

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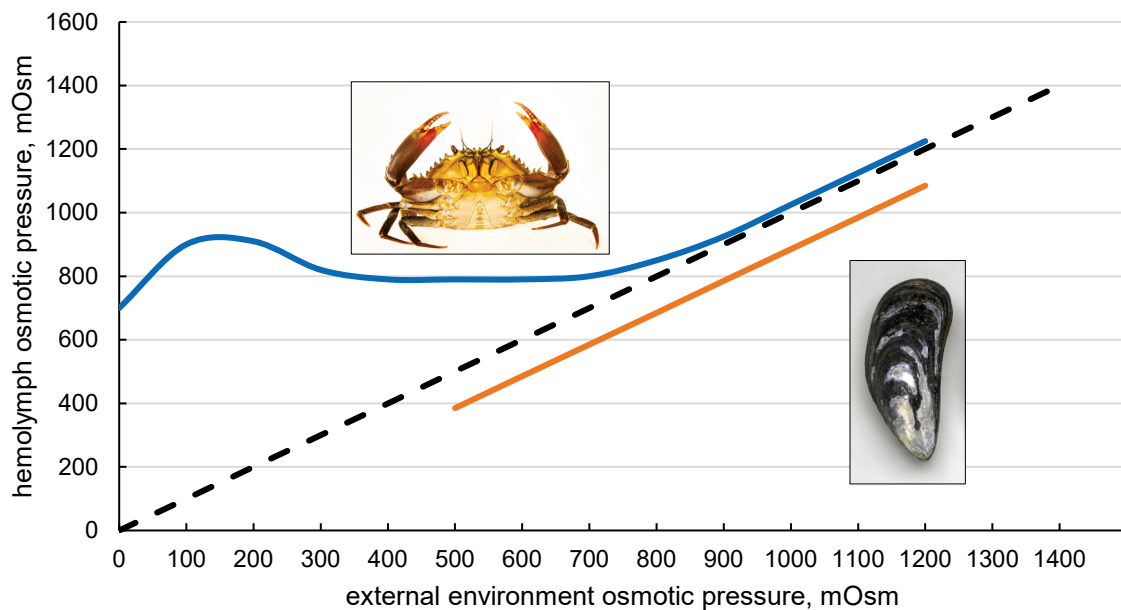
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Task 5.

Based on the type of osmoregulation, animals are categorised as:

- osmoconformers, which actively or passively adapt their body osmolarity to match salt concentrations in the environment; and
- osmoregulators, which actively regulate their body osmolarity, maintaining it at a constant level within a certain range of salt concentrations in the environment.

The diagram below shows the effect of environmental salinity (external osmotic pressure) on the internal osmotic pressure of crabs (blue line) and bivalves (orange line).



Source: A. Bal et al., "Influence of Anthropogenic Activities on Redox Regulation and Oxidative Stress Responses in Different Phyla of Animals in Coastal Water via Changing in Salinity", *Water* 14(24), 2022.
Photographs: J. Sartore and R. Zenz.

Task 5.1. (0–1)

Decide which animals – crabs or bivalves – are osmoconformers. Give the reasoning behind your answer and refer to the data provided.

Decision:

Reasoning:

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Task 5.2. (0–1)

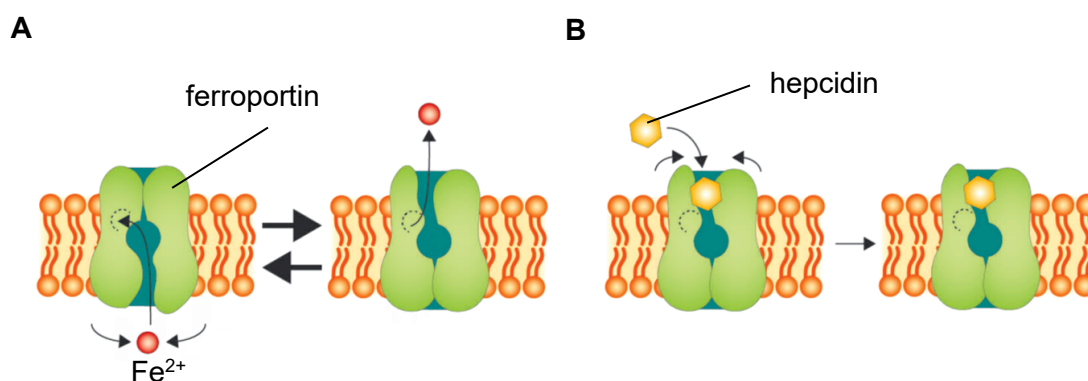
Decide whether the sentences below concerning crabs and bivalves are true (T) or false (F). Mark the appropriate letter.

1.	The main polysaccharide building block of the crabs' exoskeleton is chitin.	T	F
2.	The main nitrogenous metabolic waste product excreted by bivalves is uric acid.	T	F

Task 6.

Ferroportin is a transmembrane exporter protein that transports Fe^{2+} ions out of certain cells. Ferroportin is found, for instance, in the enterocyte cell membrane, which is in contact with the blood vessel wall. In humans, ferroportin is encoded by the *FPN* gene located on chromosome 2. A dominant mutation in one allele of this gene leads to a rare congenital condition, hemochromatosis type 4, where iron accumulates in cells and organs. One normal allele of the *FPN* gene is insufficient for the body to function properly, and symptoms of the condition usually manifest around the age of 40. A dominant mutation in both alleles, resulting in loss of ferroportin function, is lethal in embryos.

The activity and amount of ferroportin in cells is regulated by hepcidin – a peptide synthesised in the liver. The diagram below shows the transport of iron ions by ferroportin (A) and the regulation of this process by hepcidin (B).



Source: K. Sikorska et al., "Hemochromatoza dziedziczna – najczęstsza choroba genetyczna człowieka", *Postępy Higieny i Medycyny Doświadczalnej* 60, 2006;
A. Pietrangelo, "Ferroportin Disease: Pathogenesis, Diagnosis and Treatment", *Haematologica* 102(12), 2017.

Task 6.1. (0–1)

Decide whether hepcidin supports or limits the transport of iron ions to blood plasma in healthy individuals. Give the reasoning behind your answer and refer to the mechanism of action of ferroportin and hepcidin.

Decision:

Reasoning:

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Task 6.2. (0–3)

Give the genotypes of parents suffering from type 4 hemochromatosis and construct a genetic cross diagram. Based on this, calculate the probability that their newborn child will not be genetically predisposed to develop the condition in adulthood. Use the following allele symbols: *A* – dominant allele, *a* – recessive allele.

Mother's genotype: Father's genotype:

Genetic cross diagram:

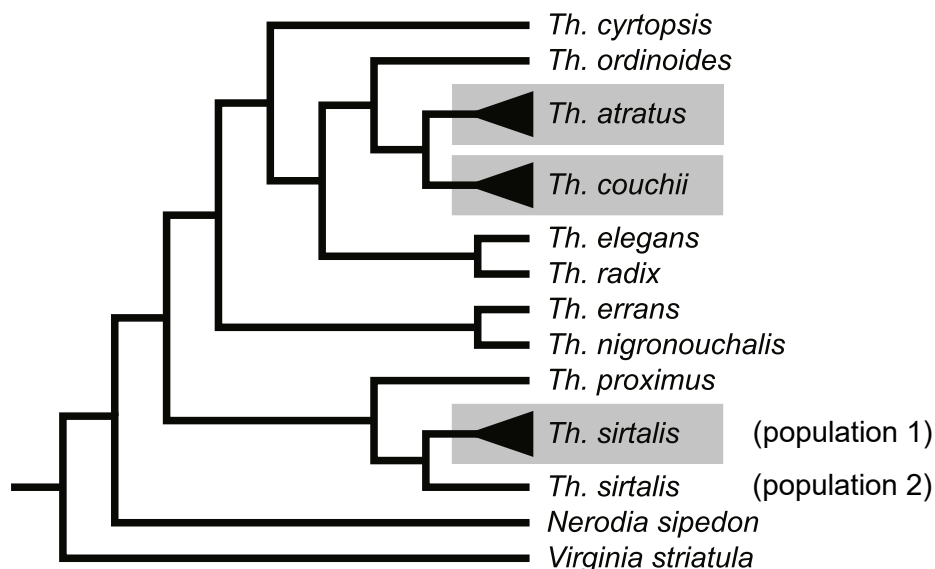
The probability that the newborn child will not be genetically predisposed to develop the condition in adulthood:

Task 7.

Tetrodotoxin (TTX) is a toxin produced by various animal species. In organisms sensitive to TTX, its molecules bind to sodium channels and thus block the transport of sodium ions through the neuronal membranes. TTX causes muscle paralysis and often death through asphyxiation. Many animal species have developed resistance to the toxin. In populations of organisms insensitive to TTX, mutations in the genes encoding sodium channels have become fixed.

TTX-resistant populations were identified among three predatory snake species of the genus *Thamnophis*. These populations hunt *Taricha* newts, which produce TTX. In each of the three snake species, substitutions in the amino acid sequence of the sodium channel are present, which are different in each species, but identical within populations of the same species.

The phylogenetic tree shown below is based on the analysis of mitochondrial DNA sequences. Black triangles indicate hunting for *Taricha* newts by the snakes; grey rectangles indicate the snakes' resistance to TTX.



Source: C.R. Feldman et al., "The Evolutionary Origins of Beneficial Alleles During the Repeated Adaptation of Garter Snakes to Deadly Prey", *Proceedings of the National Academy of Sciences of the United States of America* 106(32), 2009.

Task 7.1. (0–1)

Based on the information presented, determine the minimum number of times TTX resistance arose through independent evolution in snakes of the genus *Thamnophis*. Select the correct answer from the options given below.

- A. 1 time
- B. 2 times
- C. 3 times
- D. 4 times

Task 7.2. (0–1)

Decide whether the sentences below concerning the relationships between snakes of the genus *Thamnophis* are true (T) or false (F). Mark the appropriate letter.

1.	<i>Th. sirtalis</i> is more closely related to <i>Th. proximus</i> than to <i>Th. couchii</i> .	T	F
2.	TTX-resistant snakes of the genus <i>Thamnophis</i> form a monophyletic group.	T	F

Task 7.3. (0–1)

Explain why the blocking of membrane sodium channels by TTX inhibits nerve impulse conduction in a neuron.

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Task 7.4. (0–1)

Explain why a mutation in the gene encoding the membrane sodium channel may result in TTX resistance.

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Task 7.5. (0–1)

Describe the mechanism by which TTX causes an animal's death through asphyxiation.

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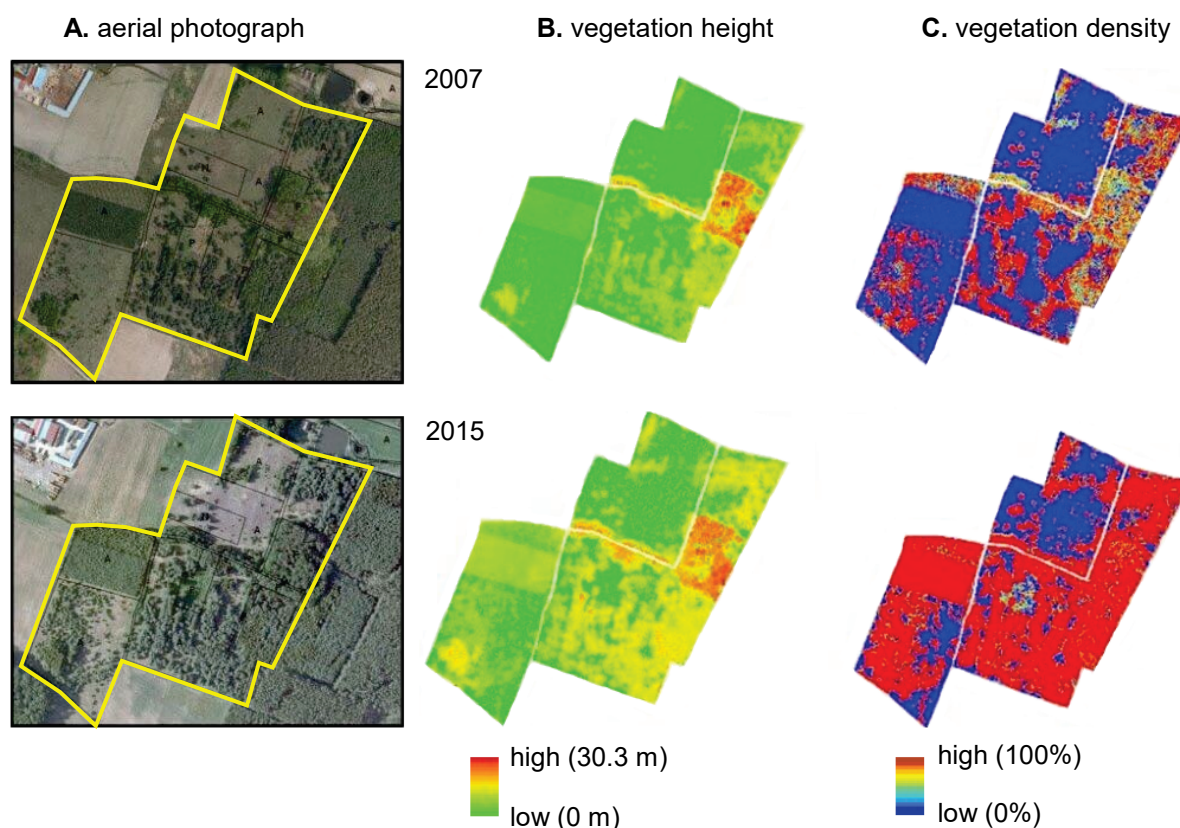
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Task 8. (0–1)

Digital technologies were used to monitor changes in vegetation cover in an area no longer used for agriculture. Over a few years, aerial photographs were taken and airborne laser scanning was carried out in the area. Processing this data yielded detailed information about the spatial structure of the tree and shrub communities covering the scanned area, including vegetation height and density.

The data obtained in 2007 and 2015 from the monitoring of the study area are presented below in the form of aerial photographs (A) and maps showing vegetation height (B) and density (C). In the aerial photographs, the area shown on the maps is outlined in yellow.



Source: M. Szostak and P. Wężyk, "Geoinformatyczne monitorowanie dynamiki [...] leśnej", 2021 (www.arcanagis.pl).

Describe two changes that occurred between 2007 and 2015 in the structure of plant communities in the post-agricultural area monitored.

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NOTES (not subject to evaluation)

BIOLOGIA

Poziom rozszerzony

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