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Biology
Higher level
Paper 1

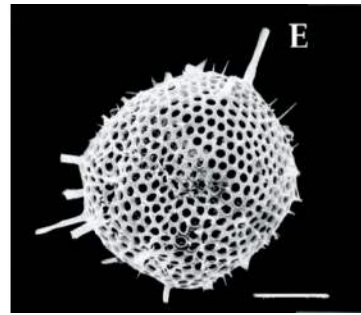
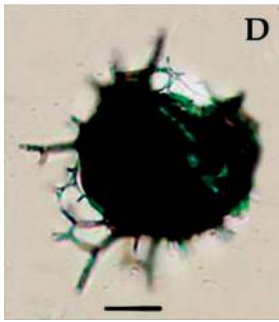
Wednesday 11 May 2022 (afternoon)

1 hour

Instructions to candidates

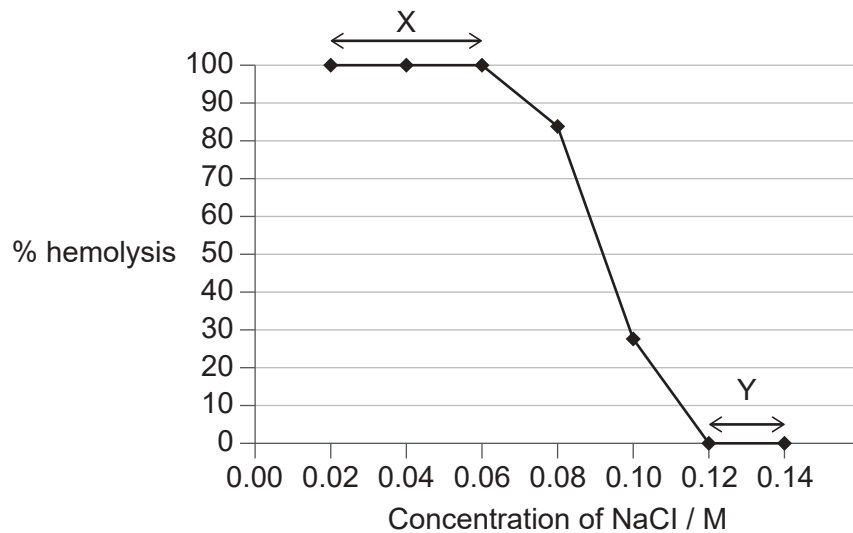
- Do not open this examination paper until instructed to do so.
- Answer all the questions.
- For each question, choose the answer you consider to be the best and indicate your choice on the answer sheet provided.
- The maximum mark for this examination paper is **[40 marks]**.

1. The images of the radiolarian, a single-celled marine organism, were produced using a light microscope (left) and a scanning electron microscope (right).



What is a reason for the difference in quality of these images?

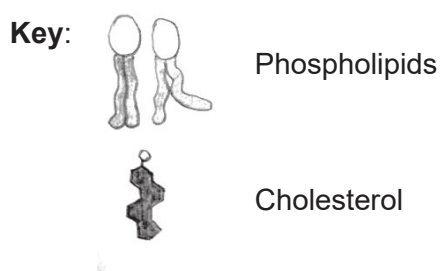
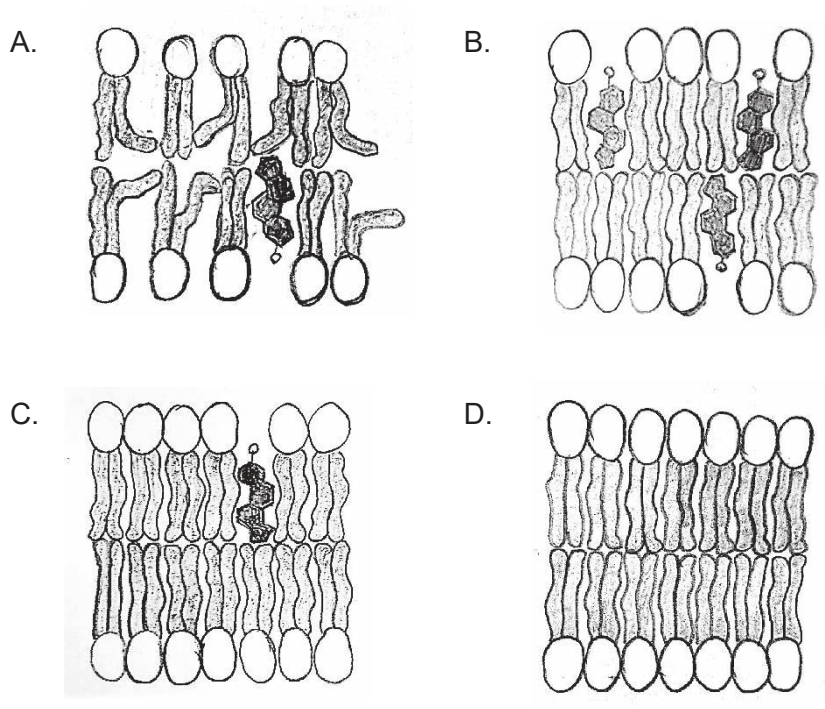
- A. Light cannot pass through the specimen.
 - B. Higher magnification can be achieved with the electron microscope.
 - C. The resolution of the electron microscope is higher.
 - D. Samples are stained with methylene blue when viewed with the light microscope.
2. Red blood cells from a small mammal were immersed in NaCl (sodium chloride) solutions of different concentrations for 2 hours. The graph shows the percentage of hemolysed (ruptured) red blood cells at each concentration.



What can be deduced from the graph?

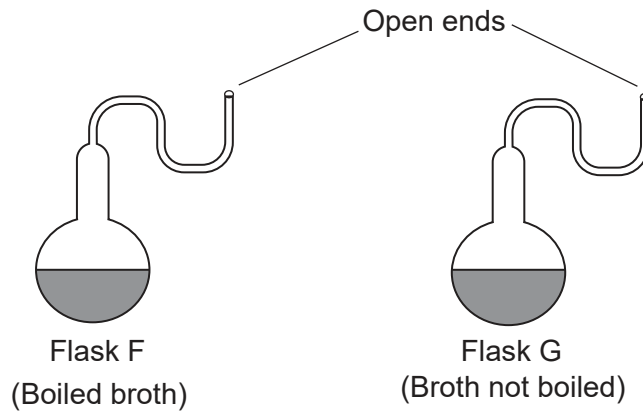
- A. At Y, the net movement of Na ions between red blood cells and the NaCl solutions is zero.
- B. At X, Na and Cl ions disrupt the structure of cell membranes.
- C. At Y, the hypertonic NaCl solutions diffuse into the red blood cells.
- D. At X, water has moved by osmosis into the red blood cells.

3. Which plasma membrane is the least fluid at high temperatures?



Turn over

4. Pasteur used swan-necked flasks and a nutrient broth to demonstrate that spontaneous generation of organisms does not occur on Earth. Some students performed a similar experiment using two swan-necked flasks, one containing broth which had been previously boiled and another containing broth which had not been boiled.



The flasks were left in the school laboratory and observed after one week. What is the evidence against the spontaneous generation theory?

- A. Microorganisms died in flask F due to high temperatures.
 - B. No microorganisms grew in either flask.
 - C. Microorganisms grew in flask G.
 - D. No microorganisms grew in flask F but many grew in flask G.
5. Which feature(s) allow(s) transport of glucose in blood plasma?
- I. It is hydrophobic.
 - II. It is polar.
 - III. Its solubility is low at 37°C.
- A. I only
 - B. II only
 - C. I and II only
 - D. II and III only

6. The diagram shows the structure of the protein CXCL12.

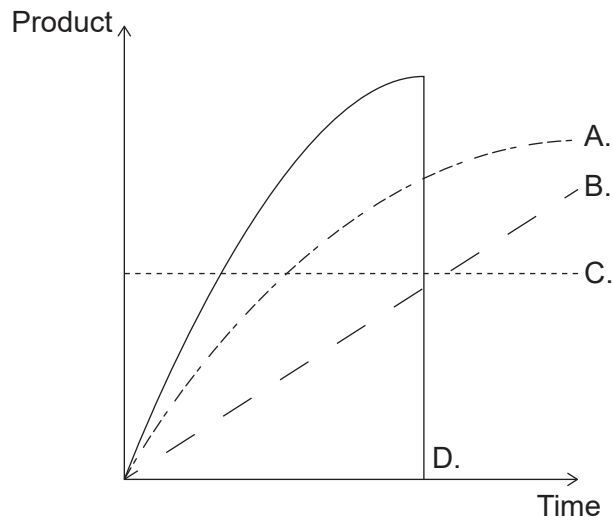


Which chemical group is found at X?

- A. NH_2
 - B. NOH
 - C. COH
 - D. COOH
7. What does an action spectrum for photosynthesis show?
- A. The range of conditions over which photosynthesis can occur in a plant
 - B. The percentage of light absorbed at each wavelength by photosynthetic pigments
 - C. The percentage of light absorbed at each energy level by a plant
 - D. The relative amount of photosynthesis at each wavelength of light
8. Cell metabolism involves anabolic and catabolic reactions. Which process directly involves anabolism?
- A. Active transport of ions
 - B. Release of energy from glucose
 - C. Production of intracellular enzymes
 - D. Breakdown of worn-out cell organelles by lysosomes

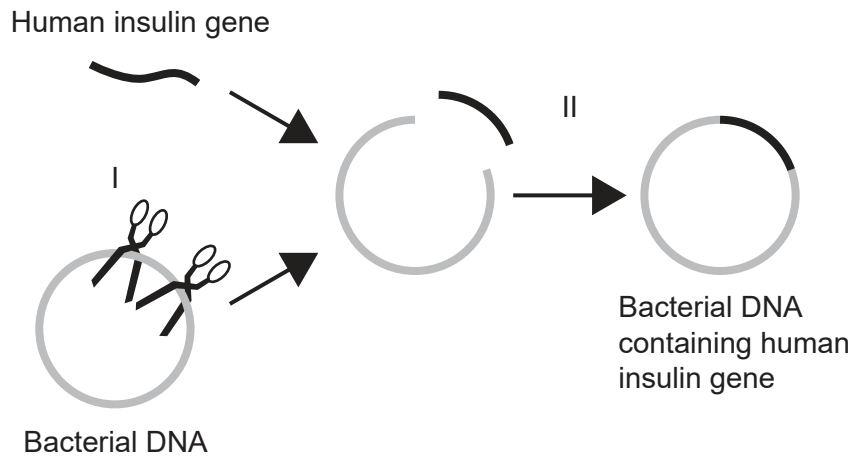
Turn over

9. Which curve shows the concentration of product during the course of an enzyme-catalysed reaction?



10. Where can the entire genome of an organism be found?
- A. In the DNA present in plasmids of a bacterial cell
 - B. In the DNA present in the nucleus of a eukaryotic cell
 - C. In the DNA present in the nucleus and chloroplasts of a plant cell
 - D. In the DNA present in the nucleus and mitochondria of an animal cell

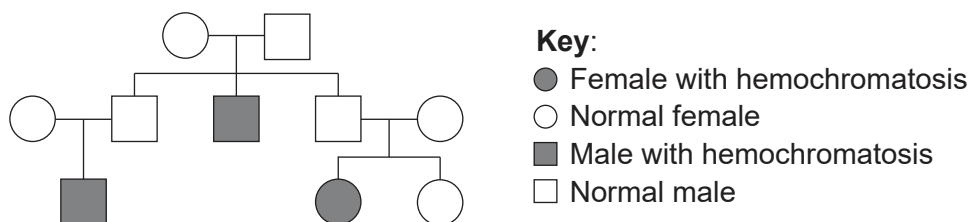
11. Bacteria can be genetically modified to produce human insulin. The diagram shows how the human insulin gene is transferred to bacterial DNA. Enzymes are required during the process.



Which enzymes are used in steps I and II?

	Step I	Step II
A.	ligase	DNA polymerase
B.	ligase	RNA polymerase
C.	restriction endonuclease	ligase
D.	restriction endonuclease	helicase

12. The pedigree chart shows the inheritance of hemochromatosis, a genetic disease which causes an excessive accumulation of iron in the body.

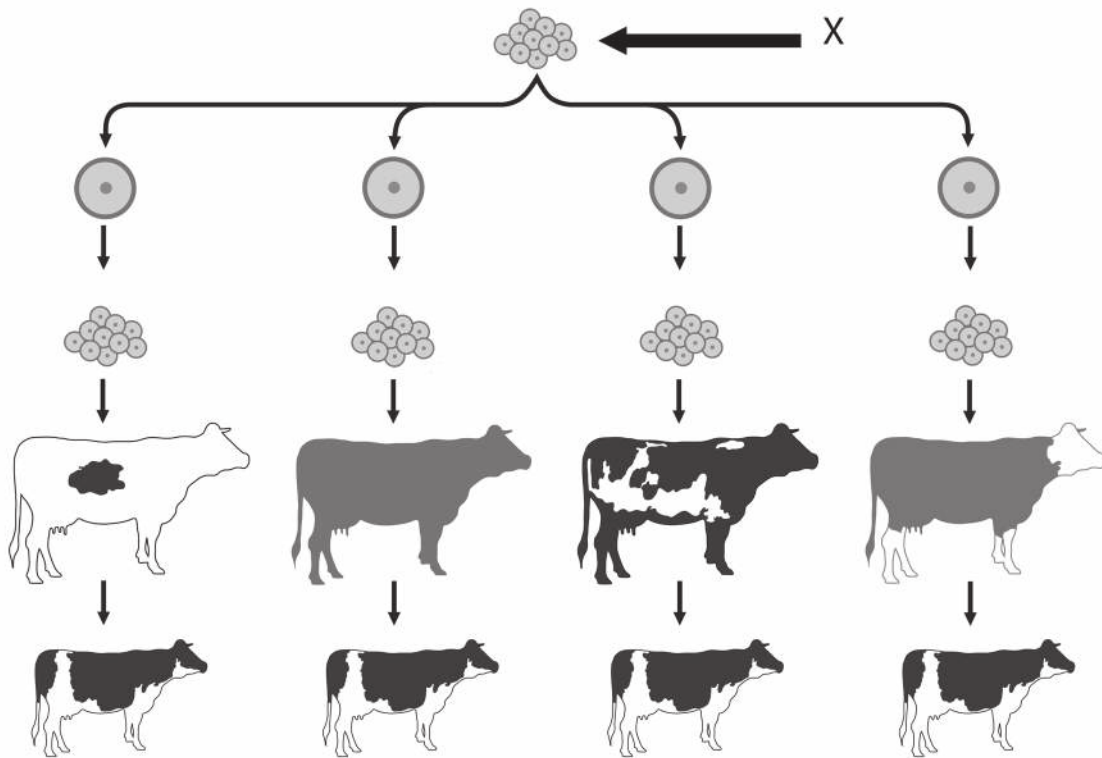


What can be deduced about this genetic disease from the pedigree chart?

- A. It is sex-linked.
- B. It is autosomal dominant.
- C. It is autosomal co-dominant.
- D. It is autosomal recessive.

Turn over

13. A cloning method used for livestock involves in vitro fertilization (IVF) with selected male and female gametes. The diagram shows the steps followed after in vitro fertilization.



What does X represent?

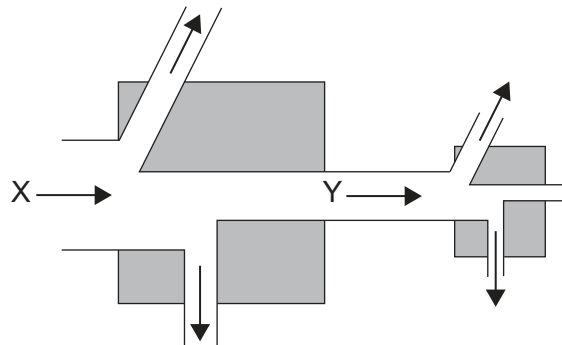
- A. A group of eggs
 - B. An embryo
 - C. A follicle
 - D. A group of zygotes
14. Which process contributes to the formation of limestone?
- A. Partial decomposition of biomass in waterlogged soils
 - B. Fossilization of biomass in anaerobic conditions in waterlogged soils
 - C. Decomposition of soft tissues of marine animals in sea beds
 - D. Fossilization of hard parts from marine animals in sea beds

15. The table shows features of greenhouse gases in the atmosphere.

Greenhouse gas	Concentration / ppm	Average lifespan / years
Carbon dioxide	397.00	50-200
Methane	1.79	12
Nitrous oxides	0.30	114
CFCs	0.00	100

According to the data in the table, which greenhouse gas contributes the most to climate change?

- A. Carbon dioxide because it is the most abundant greenhouse gas
 - B. Methane because it has the shortest lifespan
 - C. Nitrous oxides because they absorb the greatest amount of shortwave radiation
 - D. CFCs because they destroy the ozone layer
16. The diagram shows part of a food chain. The left box represents producers and the right box primary consumers. Arrows show energy flows.

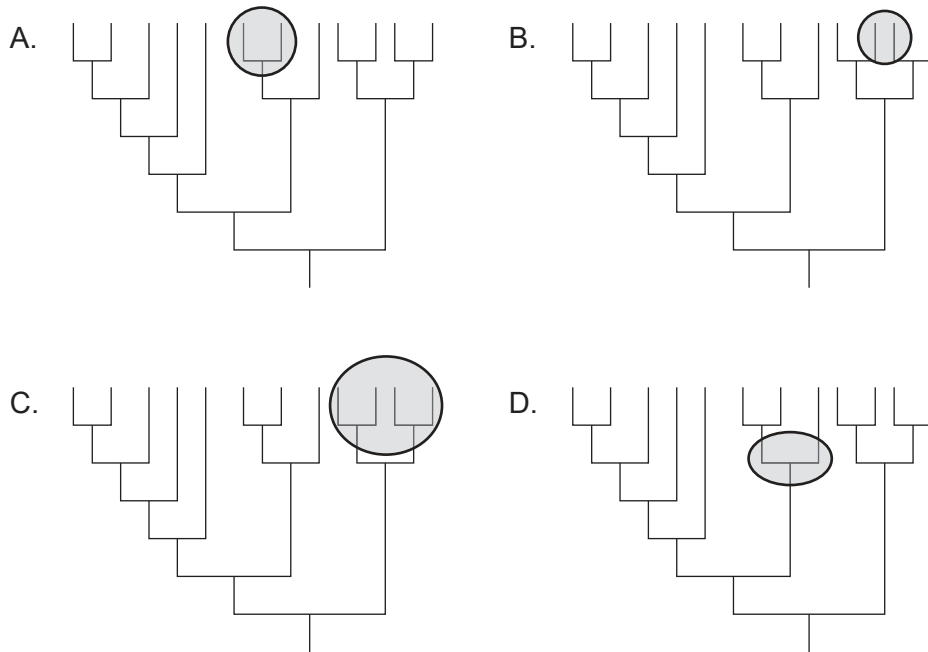


Which forms of energy are represented by X and Y?

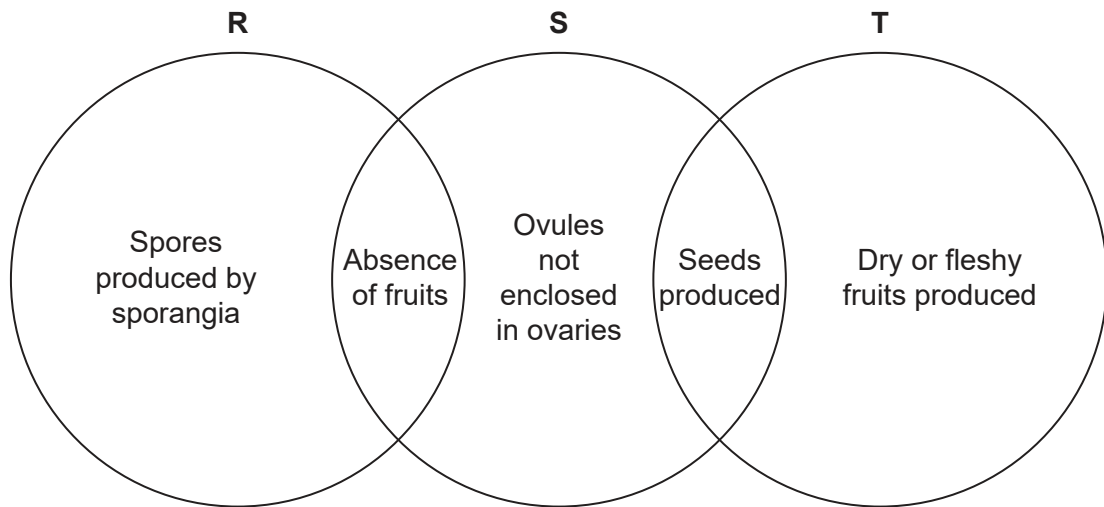
	X	Y
A.	heat	kinetic
B.	heat	chemical
C.	light	heat
D.	light	chemical

Turn over

17. Which encircled area shows a clade?



18. The diagram shows features of three plant phyla.



Which phyla are represented by R, S and T?

	R	S	T
A.	filicinophyta	bryophyta	coniferophyta
B.	bryophyta	angiospermophyta	coniferophyta
C.	bryophyta	filicinophyta	angiospermophyta
D.	filicinophyta	coniferophyta	angiospermophyta

19. Some strains of the pathogenic bacterium *Staphylococcus aureus* have developed mechanisms that protect them against foreign DNA. What effect does this have on the evolution of antibiotic resistance in these strains of *S. aureus*?
- A. Slower evolution, as bacteria with the antibiotic resistance gene will not reproduce
 - B. Slower evolution, as the antibiotic resistance gene from other species will not be accepted
 - C. Faster evolution, as mutations within a population are less likely to occur
 - D. Faster evolution, as antibiotic resistance genes can only be passed to individuals of the same species
20. The light micrograph shows two blood vessels, an artery and a vein, in transverse section.

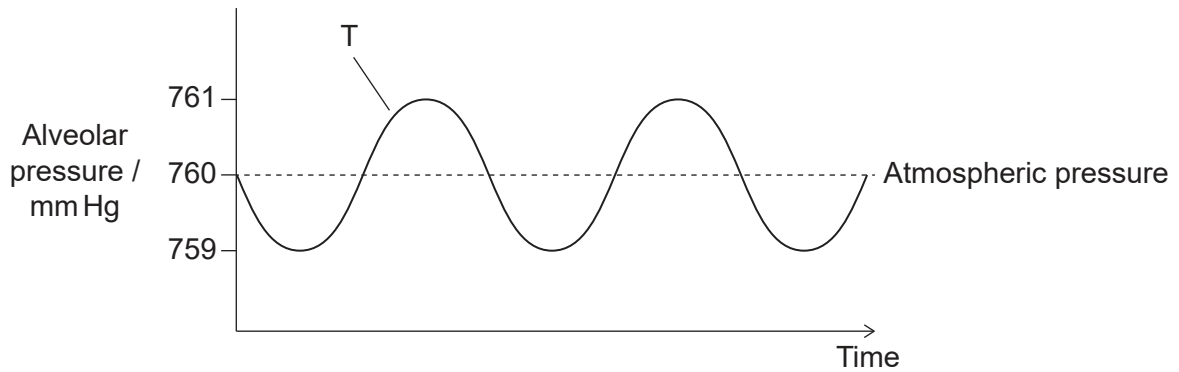


What explains the different shapes of these blood vessels?

- A. Arteries do not have valves.
- B. Muscle cells are found only in the walls of veins.
- C. Arteries have a larger lumen-to-wall thickness ratio.
- D. There are fewer elastic fibres in the walls of veins.

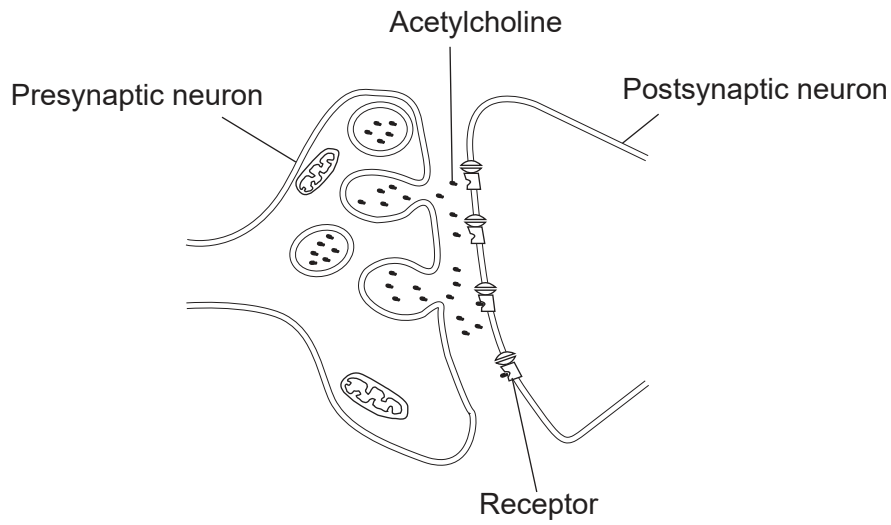
Turn over

21. Pressure changes inside the thorax cause the movement of air in and out of the lung alveoli during ventilation. Alveolar pressure correlates to thoracic pressure. The diagram shows pressure changes in lung alveoli during ventilation in relation to normal atmospheric pressure. What causes forced movement of air out of the lungs at T?



A.	external intercostal muscles contract	diaphragm relaxes
B.	internal intercostal muscles contract	abdominal muscles contract
C.	internal intercostal muscles contract	diaphragm contracts
D.	external intercostal muscles relax	abdominal muscles relax

22. The diagram shows the synaptic transmission of nerve impulses by the neurotransmitter acetylcholine.

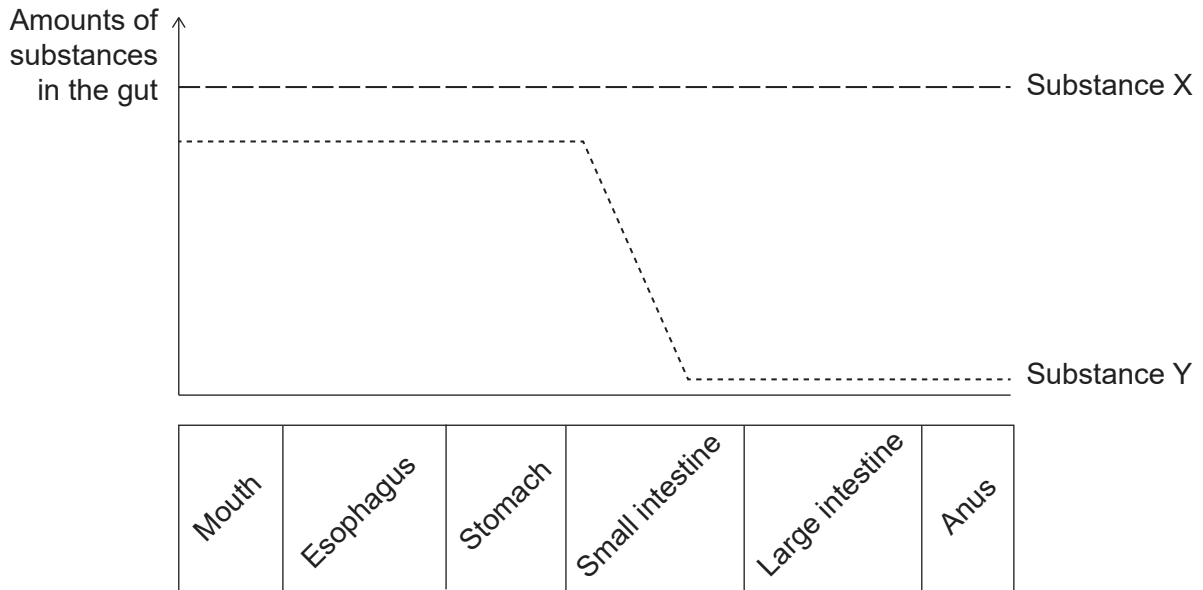


What is the fate of acetylcholine immediately after binding to the receptor?

- A. It is pumped into the postsynaptic neuron.
- B. It diffuses into the presynaptic neuron.
- C. It is broken down in the synaptic cleft.
- D. It binds to another receptor in the postsynaptic neuron.

Turn over

23. The graph shows the amounts of two substances present in food ingested by a healthy person as it moves along the gut.



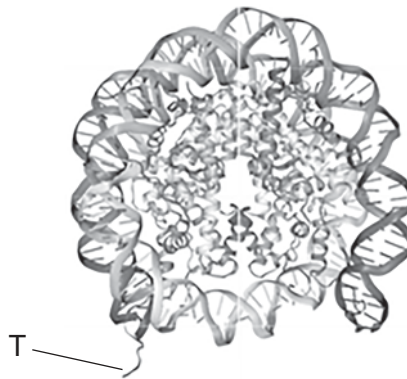
Which substances could X and Y be?

	Substance X	Substance Y
A.	amylose	glucose
B.	glucose	cellulose
C.	water	amylose
D.	cellulose	vitamin C

24. What is an example of negative feedback in the menstrual cycle?

- A. High levels of estrogen inhibit FSH secretion.
- B. High levels of LH stop progesterone secretion.
- C. High levels of FSH delay ovulation.
- D. High levels of progesterone make follicles less receptive to FSH.

25. Many blood-feeding insects inject an anticoagulant into their host in order to prevent blood from clotting. Female mosquitoes of the genus *Anopheles* inject the anticoagulant anophelin, which inhibits the action of the enzyme thrombin. Which statement explains how anophelin prevents blood clotting?
- A. Platelets are no longer produced.
 - B. Platelets cannot produce fibrin.
 - C. Fibrinogen is not converted to fibrin.
 - D. Prothrombin is not converted to thrombin.
26. The diagram shows the structure of a nucleosome.

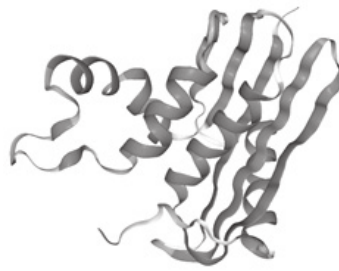


What is the structure labelled T?

- A. 5' end of RNA
 - B. 5' end of uncoiled DNA
 - C. N-terminal tail of one DNA strand
 - D. N-terminal tail of one histone
27. Promoters are non-coding regions in DNA. What is the role of a promoter?
- A. It starts translation.
 - B. It starts mRNA splicing.
 - C. It is a binding site for DNA polymerase during DNA replication.
 - D. It is a binding site for RNA polymerase during transcription.

Turn over

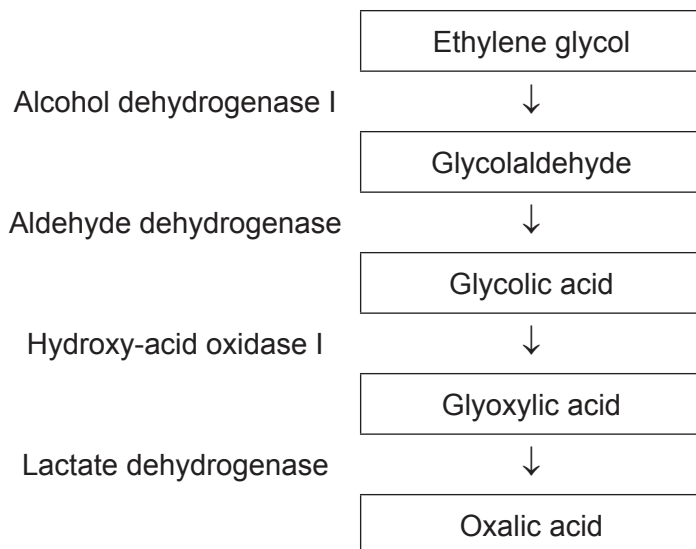
28. The diagram shows the structure of *E. coli* ribonuclease HI, a bacterial protein consisting of **one** polypeptide chain.



Which level(s) of protein structure is/are shown?

- A. Alpha helix only
- B. Quaternary only
- C. Primary and secondary
- D. Secondary and tertiary

29. Ethylene glycol is used as an antifreeze chemical. If a person ingests it accidentally, ethylene glycol is rapidly converted by a series of enzyme-catalysed reactions in the liver to oxalic acid, which is toxic. The diagram summarizes the steps and enzymes involved in the conversion of ethylene glycol to oxalic acid.

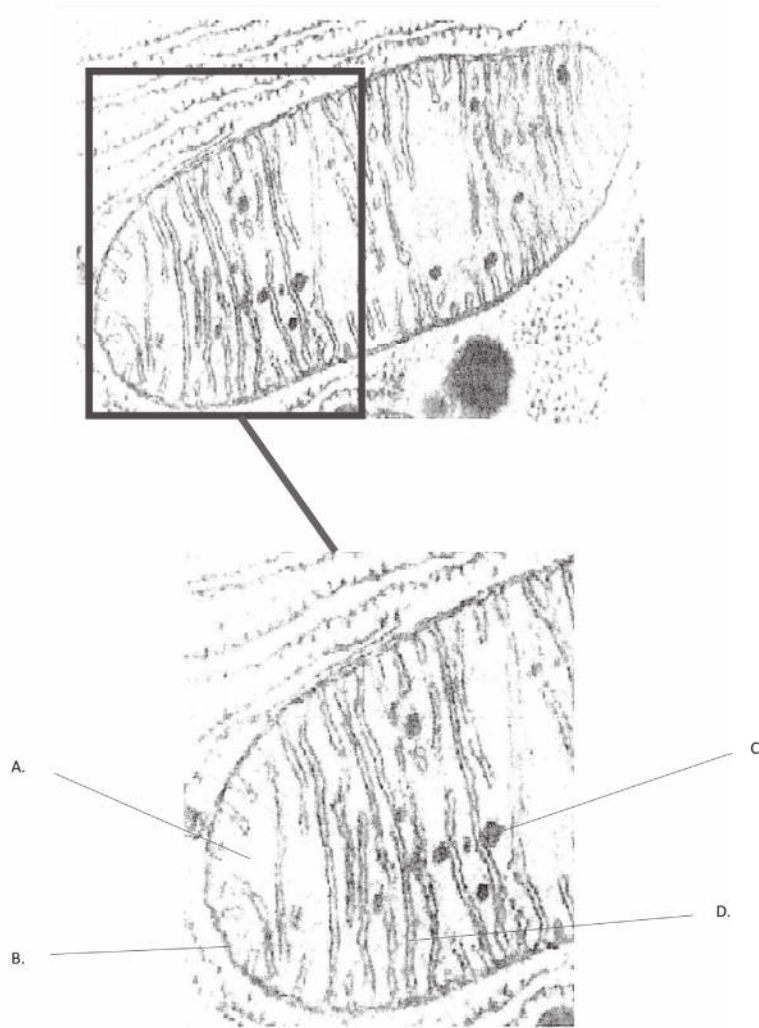


The production of oxalic acid can be prevented if the person drinks ethanol, a competitive inhibitor of the enzyme alcohol dehydrogenase I. Which statement explains the mode of action of ethanol on the reaction?

- A. It causes end product inhibition.
- B. It disrupts the shape of the active site by binding to another site on alcohol dehydrogenase I.
- C. It occupies the active site of alcohol dehydrogenase I, preventing ethylene glycol from binding.
- D. It binds to ethylene glycol, preventing it from fitting into the active site of alcohol dehydrogenase I.

Turn over

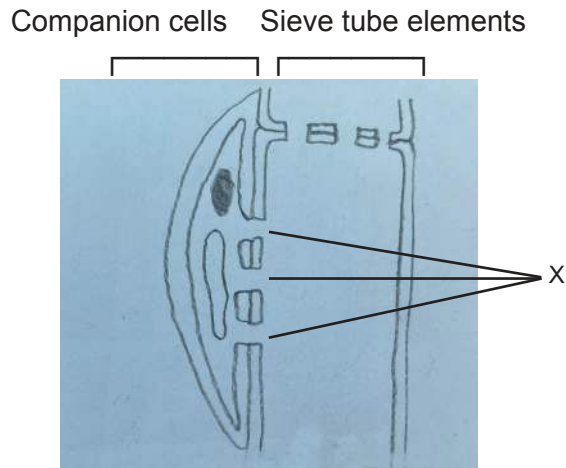
30. The mitochondrion in the electron micrograph shows some features that make it efficient for its function. Which labelled feature allows a rapid build-up of proton concentration for chemiosmosis?



31. Photolysis and carboxylation of RuBP occur during photosynthesis. Where in the chloroplast do these reactions occur?

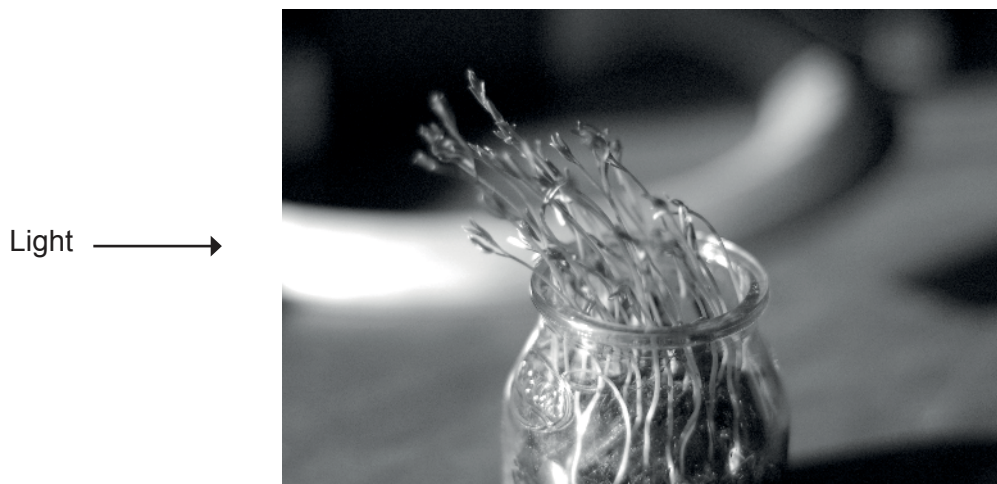
	Photolysis	Carboxylation of RuBP
A.	Outer membrane of the chloroplast envelope	Grana
B.	Thylakoids	Stroma
C.	Inner membrane of chloroplast envelope	Stroma
D.	Stroma	Grana

32. The diagram shows the longitudinal section of phloem tissue at a plant source.



What is a function of the structures labelled X?

- A. To provide the companion cell with carbon dioxide
 - B. To provide the companion cell with glucose
 - C. To allow movement of sucrose into the sieve tube
 - D. To allow movement of starch into the sieve tube
33. The picture shows lentils sprouts growing towards a light source from the left.



How has this response been brought about?

- A. A higher concentration of auxins on the light side caused faster photosynthesis.
- B. A higher concentration of auxins on the shaded side caused faster meiosis.
- C. A higher concentration of auxins on the shaded side caused faster cell elongation.
- D. A higher concentration of chloroplasts on the light side allowed for more photosynthesis.

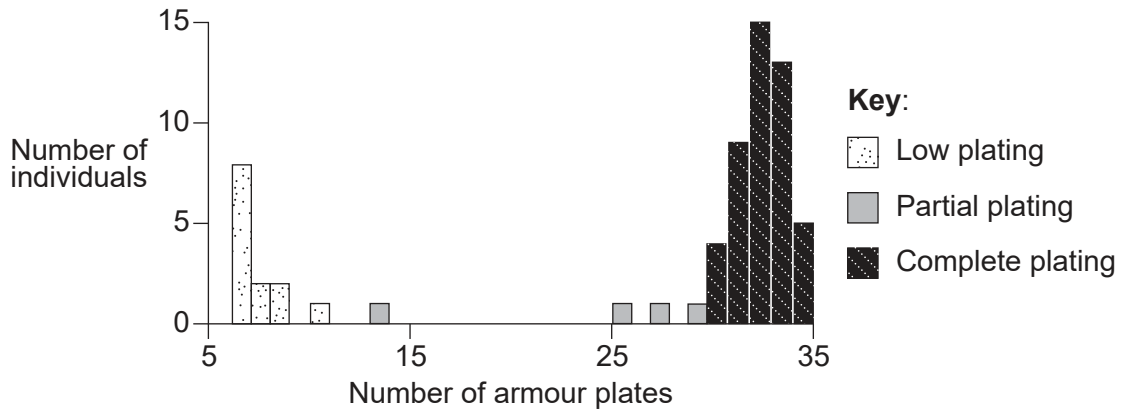
Turn over

- 34.** Students investigated the environmental factors needed for germination, using seeds from 20 different plant species. Which factors would prevent germination if they are absent?
- A. Mineral ions and carbon dioxide
 - B. Mineral ions and oxygen
 - C. Suitable temperature and oxygen
 - D. Suitable temperature and carbon dioxide
- 35.** When a cell divides by meiosis, chiasmata can be observed. Which are features of chiasmata?
- I. They are points of attachment between chromatids of non-homologous chromosomes.
 - II. They occur during meiosis I.
 - III. They increase stability of bivalents.
- A. I and II only
 - B. I and III only
 - C. II and III only
 - D. I, II and III

36. Three-spined stickleback fish (*Gasterosteus aculeatus*) vary in the number of armour plates.



The graph shows the frequency of individuals with low, partial or complete plating in a three-spined stickleback population living in Kennedy Lake, Vancouver Island, Canada.

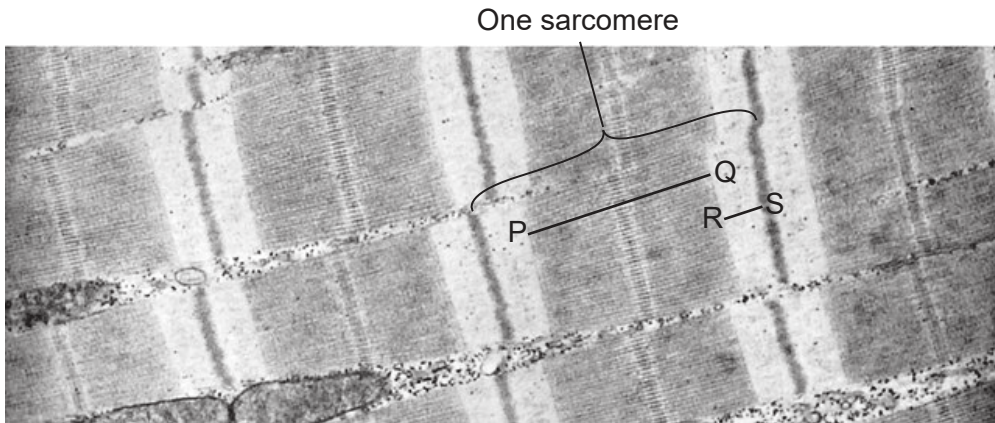


Which type of natural selection could result in this pattern of variation in the population?

- A. Disruptive
 - B. Directional
 - C. Stabilizing
 - D. Convergent
37. Cetuximab is a type of monoclonal antibody used to treat cancers of the large intestine. How are these monoclonal antibodies obtained?
- A. From hybridoma cells produced by fusion of cancer cells
 - B. From hybridoma cells produced by fusion of tumour cells and plasma cells
 - C. From plasma cells produced by small mammals in response to antigens from cancer cells
 - D. From hybridoma cells produced by small mammals in response to antigens from cancer cells

Turn over

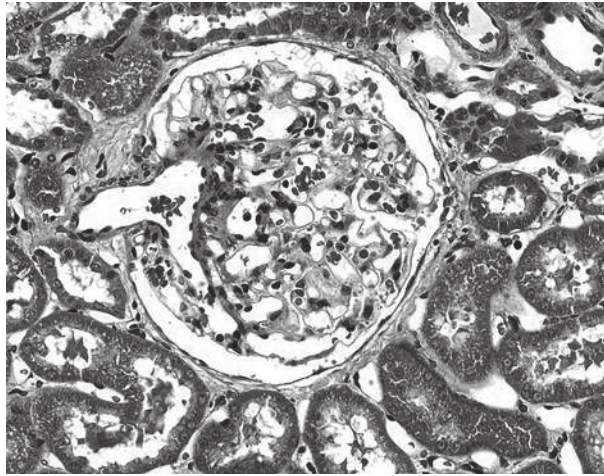
38. The electron micrograph shows sarcomeres in myofibrils of striated muscle during muscle contraction. The lines P-Q and R-S show two regions of one sarcomere.



How would regions P-Q and R-S change when the muscle relaxes?

	P-Q	R-S
A.	wider	narrower
B.	narrower	wider
C.	wider	no change
D.	no change	wider

39. The micrograph shows a glomerulus and Bowman's capsule, where ultrafiltration takes place in the kidney.



What facilitates the formation of glomerular filtrate?

- A. Many fenestrations in walls of capillaries in the glomerulus
 - B. High pressure in the Bowman's capsule
 - C. ADH secreted by the pituitary gland
 - D. Osmosis caused by a high concentration of urea in the blood
40. Hormones maintain the thickness of the endometrium during pregnancy. However, insufficient levels of hormones in early pregnancy may cause the breakdown of the endometrium, which leads to miscarriage. What could be a cause of miscarriage in early pregnancy?
- A. The embryo does not produce enough HCG.
 - B. The pituitary gland does not produce enough FSH.
 - C. The endometrium does not produce enough progesterone.
 - D. The ovarian follicle does not produce enough estrogen.

References:

1. Munir,S.;Sun,J.;Morton, S.L. The First Record and Classification of Planktonic Radiolarian (Phylum Retaria) and Phaeodarian (Phylum Cercozoa) in the Eastern Indian Ocean. *Biology* 2021, 10, 202. <https://doi.org/10.3390/biology10030202> Copyright: © 2021 by the authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).
2. Zaidan, T. , de Matos, W. , Machado, É. , Junqueira, T. , Vicentini, S. , Presta, G. and Santos-Filho, S. (2010) Cellular effects of an aqueous solution of Losartan® on the survival of Escherichia coli AB1157 in the presence and absence of SnCl₂, and on the physiological property (osmotic fragility) of the erythrocyte. *Advances in Bioscience and Biotechnology*, 1, 300–304. doi: 10.4236/abb.2010.14039. Available at https://www.scirp.org/pdf/ABB20100400005_18844979.pdf Licensed under a Creative Commons Attribution 4.0 International License (<https://creativecommons.org/licenses/by/4.0/>).
6. Lu, J., Chatterjee, M., Schmid, H. et al. CXCL14 as an emerging immune and inflammatory modulator. *J Inflamm* 13, 1 (2016). <https://doi.org/10.1186/s12950-015-0109-9> Distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>).
13. Aldona Griskeviciene / Shutterstock.com.
20. Columbia Center for New Media Teaching and Learning, n.d. Epithelium: Simple Squamous Epithelium. [image online] Available at: http://www.columbia.edu/itc/hs/medical/sbpm_histology_old/lab/lab02_squamous.html [Accessed 29 November 2019].
22. Zhang, X. A Mathematical Model of a Neuron with Synapses based on Physiology. *Nat Prec* (2008). <https://doi.org/10.1038/npre.2008.1703.1> available at <https://www.nature.com/articles/npre.2008.1703.1> Source adapted.
26. Zephyris. Nucleosome 1KX5 colour coded. Available at https://en.wikipedia.org/wiki/Nucleosome#/media/File:Nucleosome_1KX5_colour_coded.png This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license (<https://creativecommons.org/licenses/by-sa/3.0/deed.en>).
28. RCSB PDB. 1JL1 D10A E. coli ribonuclease HI. PDB DOI: 10.2210/pdb1JL1/pdb Mol* (Goedken, E.R., Marqusee, S. Native-state energetics of a thermostabilized variant of ribonuclease HI. (2001) *J Mol Biol* 314: 863–871 DOI: 10.1006/jmbi.2001.5184) [image online] Available at: <https://www.rcsb.org/structure/1jl1> [Accessed 25 November 2019]. This file is licensed under the Creative Commons CC0 1.0 Universal (<https://creativecommons.org/publicdomain/zero/1.0/>).
33. Russell Neches, Lentil sprouts reaching for the sun [image online] Available at <https://www.flickr.com/photos/rneches/2081938105/> This file is licensed under the Creative Commons Attribution 2.0 Generic (CC BY 2.0) <https://creativecommons.org/licenses/by/2.0/>.
36. Reprinted from *Current Biology*, 24, Marchinko, K.B., Matthews, B., Arnegard, M.E., Rogers, S.M. and Schluter, D., Maintenance of a Genetic Polymorphism with Disruptive Natural Selection in Stickleback. 2014. pp.1289–1292 with permission from Elsevier.
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