ACCESS EDUCATION

Victorian Certificate of Education
2020 Trial Paper

Letter

STUDENT NUMBER | | | | | | | | | |

STUDENT NAME _____

BIOLOGY
Written examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	80
			Total 120

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** for the question.

A correct answer scores 1, an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Use the following information to answer questions 1 - 3

Amylase is an enzyme in saliva that digests starch to glucose. A student, Amy, set up an experiment to test her hypothesis that the rate at which amylase catalyzes the breakdown of starch is greater at 20°C than at 4°C. To do this, she set up two test tubes containing a starch solution. Tube A was kept at room temperature (20°C) and Tube B was kept in the refrigerator (4°C) for two hours. Amy then used testape to test each test tube for the presence of glucose and recorded that neither tube contained any glucose. She then added 1 ml of amylase solution to each tube, placed Tube A back in the refrigerator and left Tube B on the bench. After ten minutes, she measured the concentration of glucose in each of the test tubes.

Question 1

In this experiment, the temperature is the

A. dependent variable.

B. independent variable.

C. extraneous variable.

D. control.

Question 2

An uncontrolled extraneous variable in Amy's experiment is

A. the rate of the reaction.

B. the temperature of the substrate solution.

C. the light each test tube was exposed to.

D. the volume of the enzyme solution.

Question 3

Recording the glucose concentration of a solution using testape involves dipping the testape into the solution and then watching a colour change in the testape (from yellow to dark green). The colour of the tape is compared to a key that can be used to ascertain the concentration of glucose. This relies on a person accurately matching the shade of green on the testape to the shade of green on the key. If Amy incorrectly matched the colours, her results would be inaccurate due to

A. a random error.

B. a limitation.

C. a systematic error.

D. a lack of validity.

Question 4

Which of the following molecules can diffuse most quickly through the phospholipid bilayer of an animal cell?

A. a glucose molecule.

B. a carbon dioxide molecule.

C. a protein.

D. a chloride ion.

Question 5

The drawing below shows an animal cell

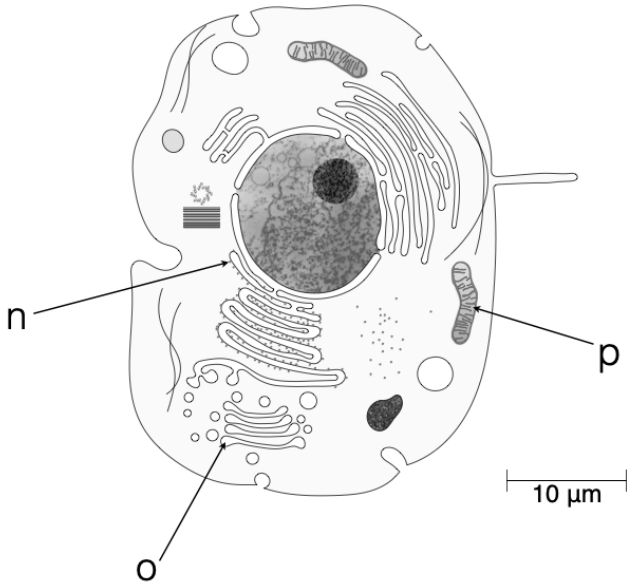


Image source: © Andrew Douch

Which of the following statements is true?

A. Electron transport takes place at n.

B. Modification of proteins takes place at o.

C. DNA is found within n.

D. Glycolysis takes place within organelle p.

Question 6

The *lac* operon is a group of three genes (*lac* Z, *lac* Y and *lac* A) associated with the breakdown of lactose. One of these genes, *lac* Z encodes the enzyme β galactosidase, which digests lactose to galactose and glucose. It is true to say that whenever the *lac* Z gene is being expressed

A. the lac Y and lac A genes are also expressed.

B. there is a repressor at the operator.

C. there is an absence of lactose in the cell.

D. the concentration of β galactosidase is too high.

Question 7

The lac Y gene encodes Beta-galactoside permease which embeds in the cell membrane and allows lactose to more easily move down a concentration gradient into the cell. The movement of lactose into the cell through Beta-galactoside permease is called

A. diffusion.

B. facilitated diffusion.

C. active transport.

D. bulk transport.

Question 8

Beta-galactoside permease and β galactosidase are enzymes. It is also true to say that they

A. lack a tertiary structure.

B. are composed of long chains of nucleotides.

C. contain nitrogen.

D. cannot be affected by the pH of their environment.

Question 9

Messenger RNA and DNA are similar in that

A. they both have a sugar-phosphate backbone.

B. they both contain uracil.

C. they are both involved in translation.

D. they are both single-stranded.

Question 10

NADH

A. is an input to the process of the light-independent stage of photosynthesis.

B. is an output of electron transport in cellular respiration.

C. is an output of the light-dependent stage of photosynthesis.

D. is an output of glycolysis in cellular respiration.

Question 11

Which of the following is an example of paracrine signalling?

A. acetylcholine; a neurotransmitter secreted from the axon terminal of a neuron into a synapse, across which it diffuses to bind to a receptor on the membrane of another neuron.

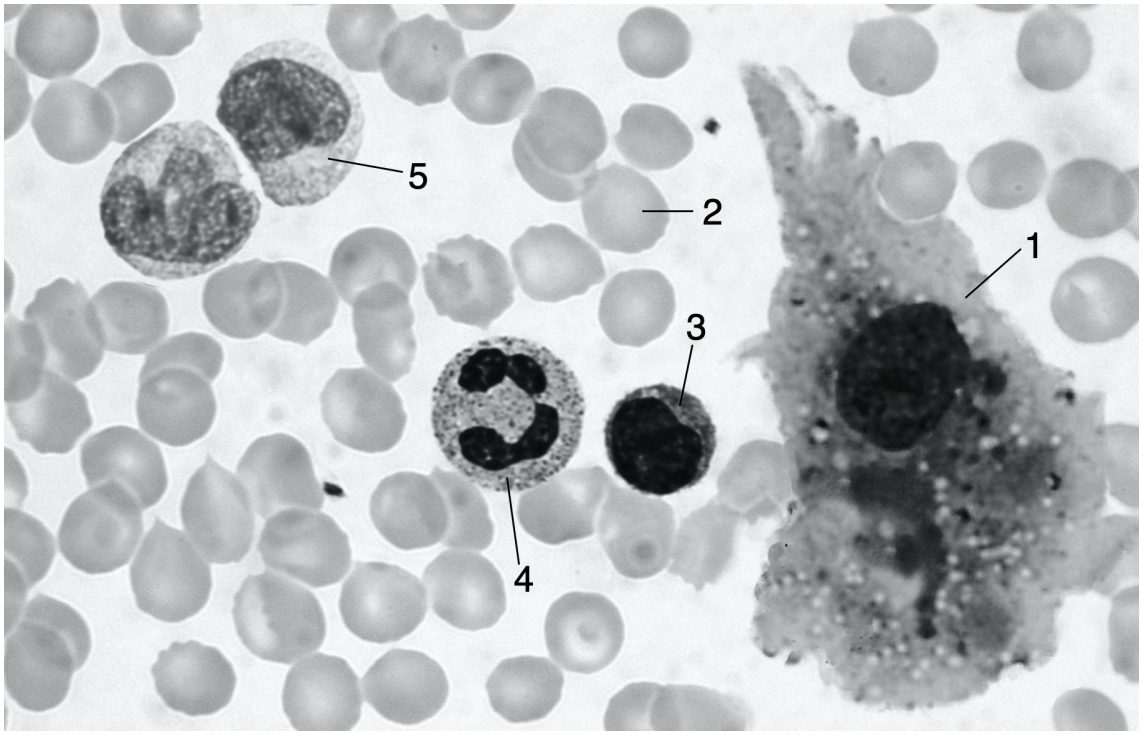
B. insulin; a hormone secreted by beta cells in the pancreas, and that binds to a receptor on a liver cell, stimulating it to absorb glucose from the bloodstream.

C. Interleukin-2; a cytokine secreted by a Th cell and which binds to a receptor on the surface of the Th cell that produced it, stimulating that cell to proliferate.

D. methyloctahydroindolizine; a pheromone secreted by a pharaoh ant, which enables other pharaoh ants to follow a trail to food.

Question 12

The photograph below shows a blood sample as seen through a light microscope.



Which of the following is true?

A. Cell 4 is a neutrophil.

B. Cell 1 is a red blood cell.

C. Cell 2 is a leucocyte.

D. Cell 3 is a macrophage.

Question 13

The main reason for which plants undertake photosynthesis in order to

A. prevent the carbon dioxide concentration of the earth's atmosphere from increasing.

B. produce oxygen for animals to breathe.

C. make water to keep their cells hydrated.

D. make glucose for use by the plant in cellular respiration.

Question 14

Professional antigen-presenting cells

A. secrete antibodies into the blood plasma.

B. do not have MHC I markers on their surface.

C. include macrophages and dendritic cells.

D. are non-self-cells.

Question 15

The mitochondrial apoptotic pathway results in the programmed death of cells. Which of the following statements is true of the biochemical pathway involved?

A. It is initiated by a death ligand secreted by a natural killer cell or Tc cell.

B. It involves enzymes called caspases.

C. It may be caused by trauma to the cell resulting from an acute injury.

D. Unlike the extrinsic pathway, it is reversible.

Question 16

Caspase 3 is a protein critical to apoptosis by both the extrinsic and intrinsic pathways. It is formed when one of several other molecules in a cell (including caspase 8 and caspase 9) activate procaspase 3. Procaspase 3 is a protein encoded by the CASP3 gene on Chromosome 4. It is reasonable to think that a mutation to the CASP3 gene in a liver cell may result in

A. an increased metabolic rate.

B. an increased rate of apoptosis.

C. an increased chance of tumor development.

D. incomplete separation of the webbing between fingers and toes of an embryo.

Question 17

Which of the following is not involved in an innate immune response?

A. Natural killer cells.

B. Dendritic cells.

C. Complement proteins.

D. Helper T cells.

Question 18

Anaphylactic shock is an extreme and inappropriate allergic response. The antibody class that is responsible for anaphylactic shock is

A. IgG.

B. IgM.

C. IgE.

D. IgD.

Question 19

Which of the following immune cell types matures in the thymus gland?

A. B lymphocytes

B. T lymphocytes

C. Mast cells

D. Macrophages

Question 20

A modern approach to delivering chemotherapy drugs to cancer cells is to attach the chemotherapy drug as a 'payload' to an antibody which is specific to an antigen expressed on the surface of the patient's cancer cells but not expressed on the surface of healthy cells.

The antibodies used for this purpose are created in a laboratory, by injecting a rodent with the specific antigen from the patient's cancer cell, then harvesting the plasma cells that are produced in the rodent and fusing them with 'immortal' cancerous B-cells. These fused cells (called hybridomas) continue to produce antibodies specific to the patient's cancer cells. The antibodies produced in this way are referred to as

A. recombinant antibodies.

B. polyclonal antibodies.

C. IgE antibodies.

D. monoclonal antibodies.

Question 21

Some public health experts, estimate that in the future, once 70% of the population has immunity to COVID-19, either through exposure to the coronavirus (SARS-CoV-2) that causes it, or by vaccination, the rate of community transmission will become so low, that even people who have neither been vaccinated nor had COVID-19 will be unlikely to get the disease. The biological term for this predicted fall in new case numbers is

A. convalescence.

B. passive immunity.

C. herd immunity.

D. social distancing.

Use the following cladogram to answer questions 22 and 23

Consider the following simplified cladogram which summarises the evolutionary relationship between birds, reptiles and amphibians.

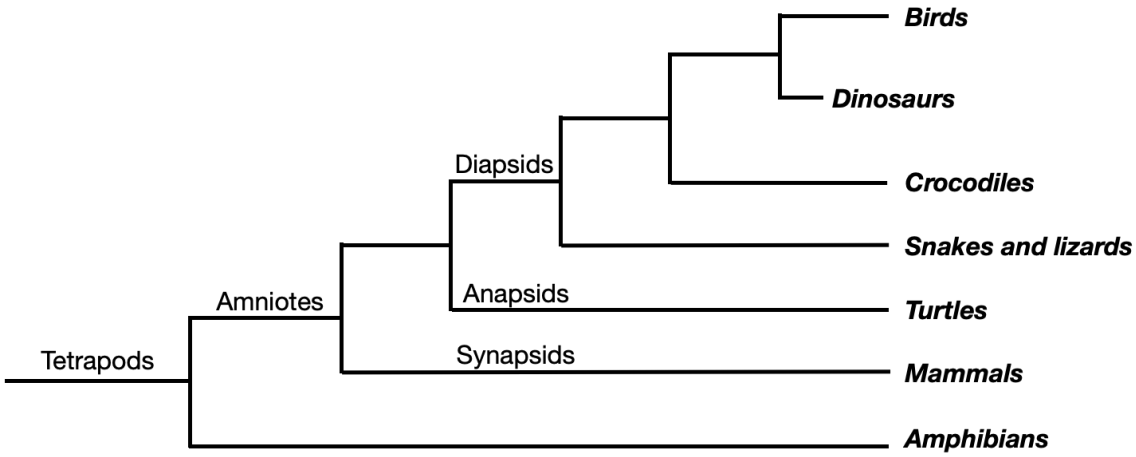


Image source: Andrew Douch

Question 22

B lymphocytes were named "B" because they were first identified in the Bursa of Fabricus – a lymphoid organ found in birds but not mammals or reptiles. From this information, and the cladogram, the most reasonable conclusion is that

A. B lymphocytes were present in the bodies of dinosaurs.

B. B lymphocytes were absent in the immune systems of early Anapsids.

C. The Bursa of Fabricus was present in early mammals but has since been lost.

D. The Bursa of Fabricus may be present in amphibians.

Question 23

Based on the cladogram above, it can be concluded that

A. Crocodiles can be thought of as "living dinosaurs."

B. Crocodiles are more closely related to birds than to lizards.

C. The most recent common ancestor of mammals and amphibians were Amniotes.

D. Turtles are more closely related to snakes than to crocodiles.

Question 24

Genetic drift is most likely to have a significant impact on the frequencies of alleles in a population if

A. the population is very small.
B. the species occupies a very restricted habitat type.
C. there is a lack of genetic diversity in the population.
D. the frequency of different alleles in the population is approximately even.

Question 25

If the genomes and proteomes of birds and crocodiles were compared,

A. there would be more difference in amino acid sequence of their haemoglobin proteins than in the nucleotide sequences encoding the haemoglobin protein.
B. the number of differences in their DNA would be equal to the number of differences in their proteins.
C. There would be three times as many differences in their genome as in their proteome.
D. Differences in the genome would outnumber differences in the proteome by less than three times.

Question 26

Another name for gene flow is

A. founder effect.
B. frameshift mutation.
C. migration.
D. genetic bottleneck.

Question 27

The GFP gene found in some species of jellyfish encodes a protein called GFP (green fluorescent protein). GFP gives off a dull green light, which makes the jellyfish, glow in the dark. Molecular biologists have managed to cut the GFP gene out of a jellyfish genome and insert it into the embryonic stem cell of a mouse. The mice that were then cloned from this embryonic stem cell glowed green. This is possible only because the genetic code is

A. redundant.
B. ambivalent.
C. unambiguous.
D. universal.

Question 28

The fossil below is a trilobite, found in sedimentary rock in Utah, USA.

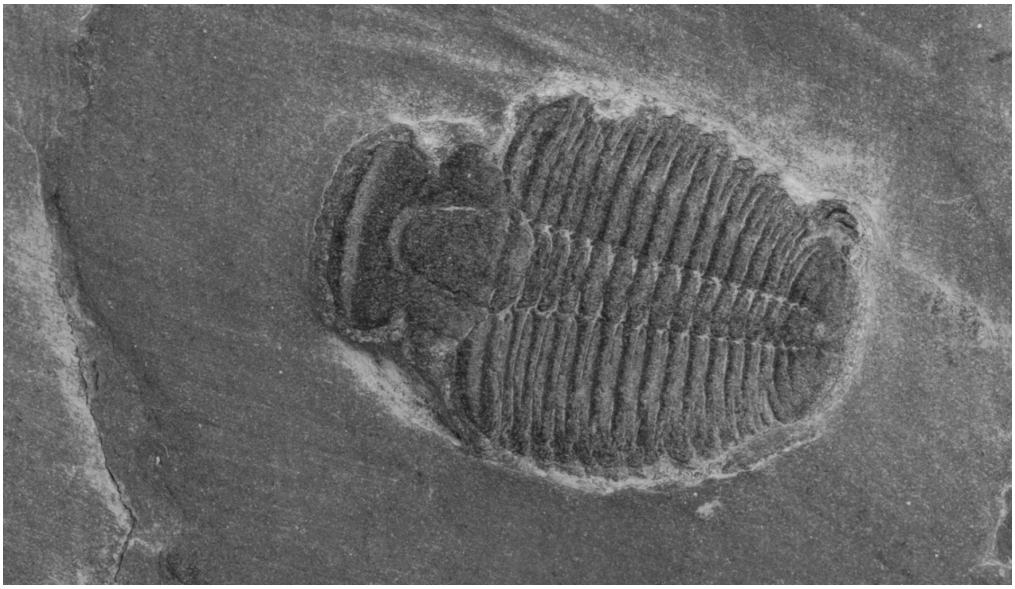


Image source: Yoshi/Shutterstock

This fossil can best be described as

A. a mineralised trilobite.

B. a cast.

C. a mold.

D. a trace fossil.

Refer to the following information to answer Questions 29 and 30

Ardipithecus ramidus is a hominin which was discovered in the Afar region of Ethiopia in 1994. The fossils were discovered in a sedimentary rock layer sandwiched between two volcanic rock strata. It was dated to 4.4 million years old.

Question 29

The fossil dating technique used to determine that the Ardipithecus ramidus fossils were 4.4 million years old was

A. Potassium-Argon dating.

B. Stratigraphy.

C. Radiocarbon dating.

D. Uranium-Lead dating.

Question 30

Ardipithecus ramidus belongs to tribe Hominini (the hominins). Which of the following species does not belong to tribe Hominini?

A. *Pan troglodytes*

B. *Australopithecus africanus*

C. *Paranthropus robustus*

D. *Homo erectus*

Question 31

There are many similarities between SARS-CoV-2 (the virus that causes COVID-19) and an influenza virus. They are both RNA viruses, both cause a respiratory tract infection, and both have a lipid envelope. Yet Relenza® which is effective in the treatment of influenza is not effective in the treatment of COVID-19. The main reason for this is

A. The enzymes on the surface of SARS-CoV-2 are a different shape to the enzymes on the surface of an influenza virus.

B. SARS-CoV-2 does not contain any DNA whereas influenza viruses do.

C. Influenza viruses are non-living, whereas SARS-CoV-2 is a living organism.

D. SARS-CoV-2 secretes enzymes that are able to inactivate Relenza.

Question 32

Although the ring-tailed lemur (*Lemur catta*) of Madagascar looks like a possum it is classified as a primate. From this it is reasonable to assume that the lemur has

Image source: https://unsplash.com/photos/83gB_koMuvA

A. relatively inflexible shoulders.

B. a relatively large olfactory (smell) region in the brain.

C. an opposable thumb.

D. a small brain in proportion to overall body size.

Question 33

Compared to *Homo sapiens*, *Homo neanderthalensis*

A. had a larger cranial capacity.

B. had smaller brow ridges.

C. had smaller molar teeth.

D. was shorter in stature.

Question 34

It is now understood that *Homo neanderthalensis* and *Homo sapiens* interbred. The evidence supporting this includes

A. Homo sapiens DNA discovered in the fossils of *Homo neanderthalensis* in Europe.

B. cave paintings discovered in Israel, depicting *Homo sapiens* and *Homo neanderthalensis* mating.

C. DNA from *Homo neanderthalensis* found in the genome of modern Africans.

D. the existence of *Homo neanderthalensis* DNA in modern Asians.

Question 35

In 1934 it was discovered that the drug chloroquine worked as a prophylaxis (protection) against malaria caused by the protozoan *Plasmodium falciparum*. Today it is rarely prescribed, however, because many strains of *Plasmodium falciparum* have emerged, that are resistant to chloroquine.

The process by which *Plasmodium falciparum* strains have become resistant to chloroquine is

A. natural selection.

B. induced passive immunity.

C. genetic drift.

D. natural active immunity.

Question 36

Unborn babies diagnosed with adenosine deaminase deficiency severe combined immune deficiency (ADA-SCID) have been successfully treated using gene therapy while still in-utero. Successful gene therapy involved using a viral vector to insert corrective alleles into hematopoietic stem cells of the foetus, which was homozygous for a faulty allele of the gene.

The hematopoietic stem cells, with a corrective gene in them can be referred to as

A. Transformed cells.

B. Transgenic organisms.

C. GMOs.

D. transfected cells.

Question 37

Plasmids are a useful tool in the process of gene cloning. Plasmids

A. are enzymes that can cut DNA at specific base sequences.

B. are small extra-chromosomal loops of DNA.

C. are lengths of DNA that contain no genes.

D. are found naturally occurring in viruses.

Question 38

A plasmid with three recognition sites for the endonuclease EcoR1, was incubated with EcoR1, and the resulting DNA product was run on a vertical electrophoresis gel. Which of the lanes in the following image most accurately depicts the banding pattern that would be expected in the gel?

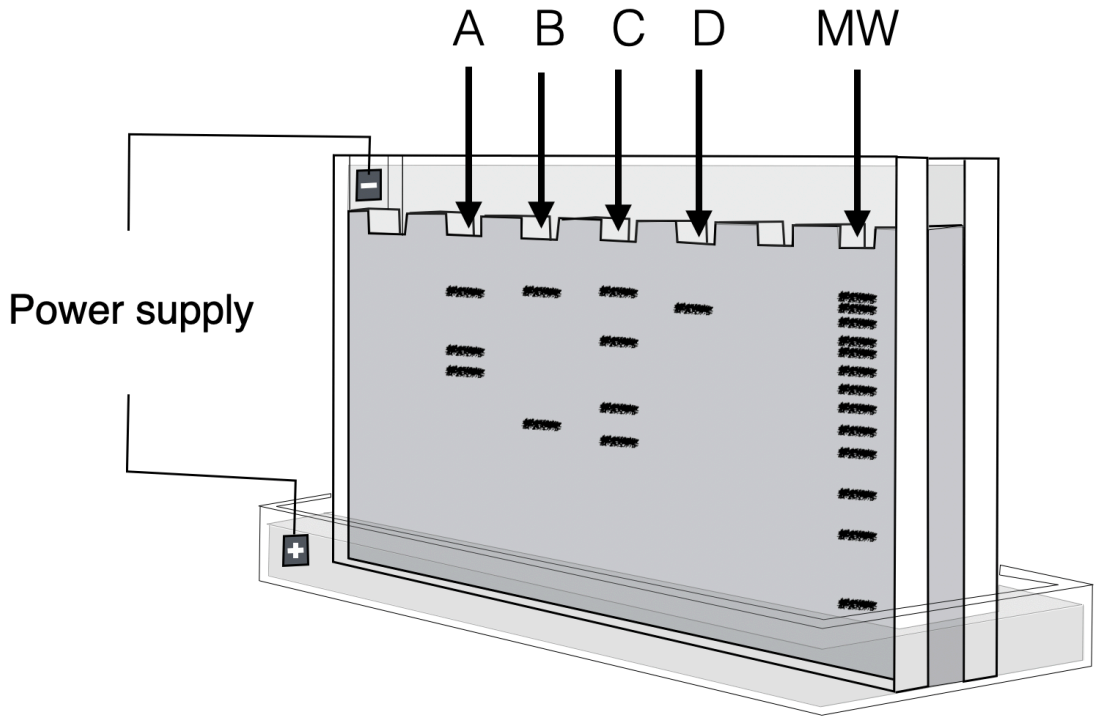


Image source: © Andrew Douch

A. Lane A

B. Lane B

C. Lane C

D. Lane D

Question 39

In 2020 Samoa faced two significant health crises: a measles epidemic and the COVID-19 pandemic. The reason measles has been referred to as an epidemic and COVID-19 as a pandemic is that

A. COVID-19 is more dangerous to the health of those infected, than measles.

B. COVID-19 affected many countries, but the measles outbreak was contained in Samoa.

C. COVID-19 had a greater economic impact than measles.

D. COVID-19 is more infectious than measles.

Question 40

One fear that epidemiologists have, is that the SARS-CoV-2 virus may mutate, so that even those who have been infected and recovered from COVID-19 will be susceptible to being re-infected. The stage of the viral reproductive cycle at which such a mutation is most likely to occur is

A. within the virus particle when it is sitting on an object such as a door handle.

B. within the cell of an infected person, when the viral DNA in the host's nucleus is transcribed to mRNA.

C. within the virus particle while it is being transmitted from one person to another in a droplet of saliva following a sneeze.

D. within the cell of an infected person when the contents of the virus first enter the host cell.

SECTION B – Short-answer questions

Instructions for Section B

Answer **all** questions in the spaces provided. Write using a black or blue pen.

Question 1 (6 marks)

The diagram below shows a section of a polypeptide found within human cells

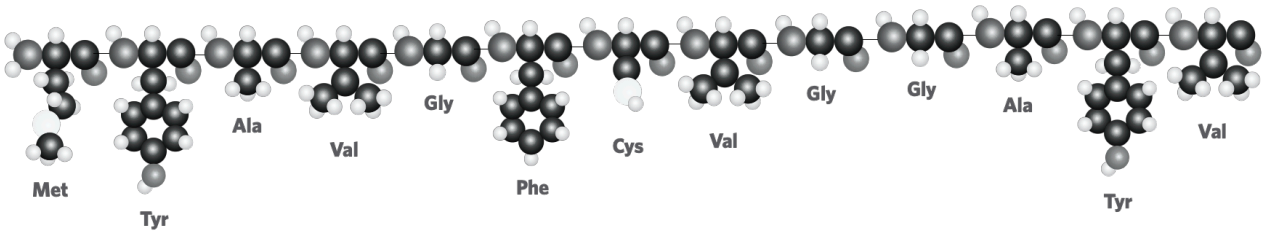


Image source: © Andrew Douch

a. What name is given to the monomers of this molecule? 1 mark

_____

b. What level of protein structure is depicted in the diagram? 1 mark

_____

c. What is the minimum number of DNA nucleotides that would be required to provide the coded instructions for the synthesis of the section of the polypeptide shown? 1 mark

_____

d. The molecule shown in the diagram, contains five different elements. Three of these are carbon, hydrogen and oxygen. Name one of the other two elements. 1 mark

_____

_____

e. The horizontal lines between the monomers, represent a chemical bond. What name is given to the type of bond represented? 1 mark

_____

f. What name is given to the process by which this molecule was synthesized? 1 mark

_____

Question 2 (8 marks)

The diagram below shows a mitochondrion.

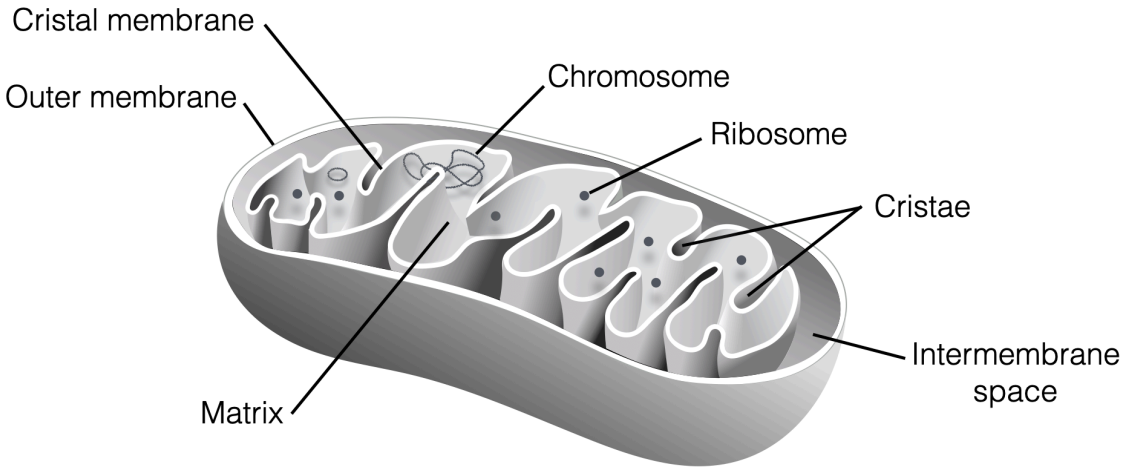


Image source: © Andrew Douch

a. Although mitochondria are organelles within a eukaryotic cell, they have a number of features which resemble features characteristic of prokaryotic cells. The endosymbiotic theory suggests that mitochondria have their origins as free-living bacteria which were incorporated into eukaryotic cells. Identify two features of prokaryotes that suggest their bacterial origin. 2 marks

_____

_____

_____

_____

b. According to the endosymbiotic theory of bacterial origins the ancestors of eukaryotic cells were so dependent on mitochondria that their association became permanent. What important process that takes place in mitochondria are eukaryotic cells dependent on. 1 mark

_____

c. Rotenone is a powerful commercial insecticide. It is toxic to wildlife and humans as well as to insects. It acts by interfering with the electron transport chain in mitochondria. Specifically, it interferes with the mitochondrion's ability to remove hydrogen from NADH molecules.

Explain how the inability to remove hydrogen from NADH in the mitochondria will lead to the death of insects. 2 marks

d. Where in the mitochondrion does the Krebs cycle take place? 1 mark

e. Where in the mitochondrion does electron transport take place? 1 mark

f. What function do ribosomes have in a mitochondrion? 1 mark

Question 3 (8 marks)

COVID-19 is an infection caused by the coronavirus SARS-CoV-2. SARS-CoV-2 like other coronaviruses primarily infects cells in the upper respiratory tract.

When a person is infected by SARS-CoV-2 it takes several weeks before they recover from COVID-19. It is possible to tell whether someone has had COVID-19 and recovered, by testing their blood for the presence of antibodies.

a. Not everyone who comes into contact with SARS-CoV-2 will develop a COVID-19 infection. One reason for this is that in order to cause infection, the virus must first enter the body. Name one barrier that the body has which may prevent this from happening and outline how it prevents the virus from entering the body. 2 marks

b. Even if a virus particle does enter the body, there is a chance that it will not have time to cause an infection before being destroyed by immune cells. Name an immune cell which may rapidly remove a virus from the body before it has time to cause infection. 1 mark

There are five classes of antibody, which differ in structure and function, as illustrated in the following table.

	Antibody Class				
	IgM	**IgG**	**IgA**	**IgE**	**IgD**
Complex					
Crosses placenta	no	yes	no	no	no
Concentration in blood (mg/mL)	1.5	13.5	3.5	0.00005	0.03
Present in mucus	no	no	yes	no	no
Present in tears	no	yes	yes	no	no
Present in breast milk	yes	yes	yes	yes	yes
Order of release	1	2	3	4	5

c. A woman was infected with COVID-19 and recovered from the disease. Three weeks after recovering she gave birth to a baby. Would you expect her baby to be born with the same level of immune protection to COVID-19 as his mother? Explain your answer. 2 marks

d. On some occasions, a person's immune system may produce significantly more than 0.0005 mg/mL of IgE antibodies in response to a particular antigen. Explain the effect of this overproduction of IgE on the health of the person. 2 marks

e. Which cells in the body are responsible for producing IgE antibodies? 1 mark

Question 4 (9 marks)

Guillain-Barré Syndrome is an incurable disease caused when the body's immune system mistakenly launches an attack on the Schwann cells, the myelin-producing cells surrounding the neurons of the peripheral nervous system. The symptoms of Guillain-Barré Syndrome include tingling sensations in the fingers and toes, muscle weakness, difficulty walking, talking, chewing and swallowing, and lower back pain.

a. What name is given to diseases, such as Guillain-Barré Syndrome, which are caused by an inappropriate attack launched by the immune system on self-cells? 1 mark

_____

b. Which cells of the immune system are directly responsible for the death of Schwann cells, in the case of Guillain-Barré Syndrome? 1 mark

_____

_____

c. Name another disease caused by a mistaken attack by the body's own immune system, on the myelin sheath surrounding nerve cells. 1 mark

_____

Another disease, once thought to be incurable is Ebola virus disease (EVD), caused by ebolaviruses. Symptoms include muscle pain, headaches, vomiting and bleeding. Untreated, it is one of the world's most deadly diseases with an average mortality rate of 50%.

In 2019 an experimental drug, REGN-EB3 was introduced which dramatically reduced the mortality rate to 29% in patients to whom it was administered. The drug contains antibodies which give the patient a type of immunity to EVD because they bind to a protein on the surface of the ebolavirus. Infected patients receive a single injection of the antibodies, as soon as possible after infection.

d. What kind of immunity to EVD does REGN-EB3 give to a patient? 1 mark

_____

_____

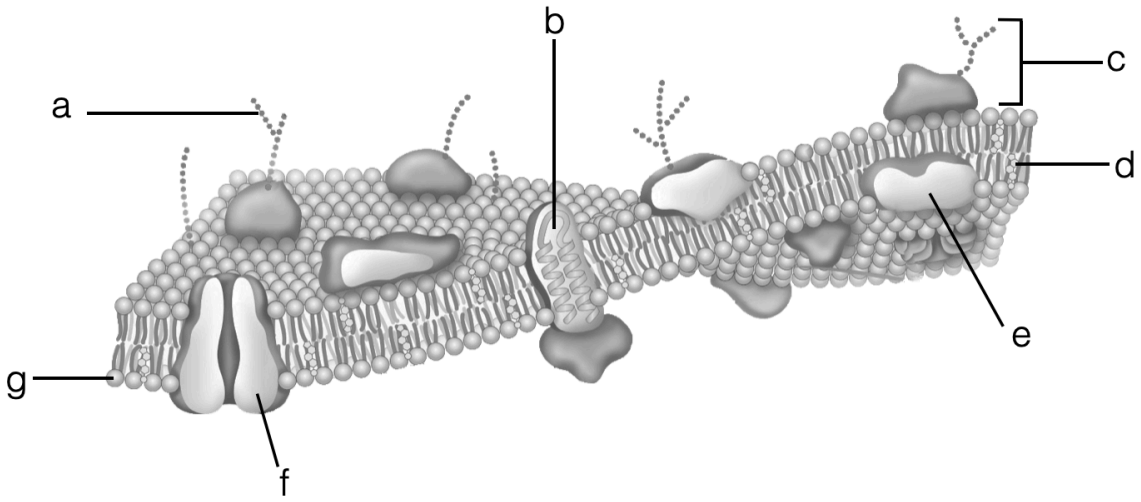
e. Explain how REGN-EB3 might help a patient overcome EVD. 2 marks

f. Since 2015, a vaccine against Ebola called rVSV-ZEBOV has been available. What type of immunity would a person have, if vaccinated against EVD with rVSV-ZEBOV? 1 mark

g. Explain how vaccination with rVSV-ZEBOV gives a person immunity to EVD. 2 marks

Question 5 (8 marks)

The image below represents a section of a plasma membrane.



source: modified from CNX OpenStax / CC BY (https://creativecommons.org/licenses/by/4.0)

a. Name molecule g. 1 mark

_____

b. Name molecule f and describe its function. 2 marks

_____

_____

_____

_____

c. Which labelled molecule in the diagram is a peripheral protein? 1 mark

_____

d. Molecule c is a glycoprotein. Explain what this means. 1 mark

_____

_____

_____

e. What important function to glycoproteins in the plasma membrane of a cell perform? 1 mark

_____

_____

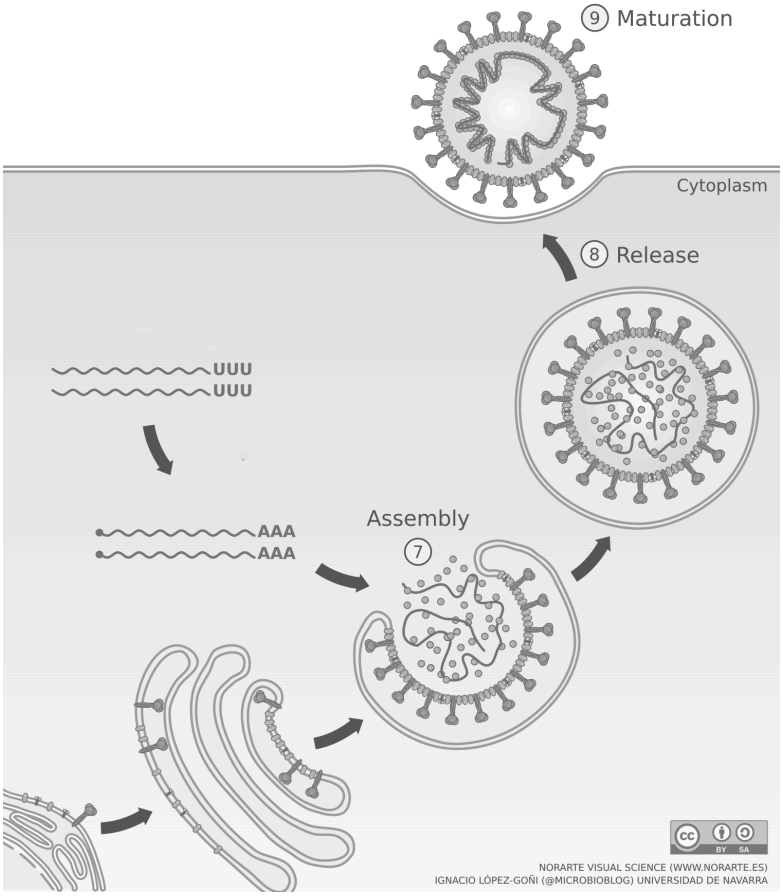
_____

f. Molecule d is cholesterol. What is the function of cholesterol in the plasma membrane? 1 mark

_____

_____

The diagram below shows the final stage of the lytic cycle of the SARS-CoV-2 virus, as a newly formed virus particle exits the host cell which produced it.



source: https://commons.wikimedia.org/wiki/File:SARS-CoV-2_cycle.png

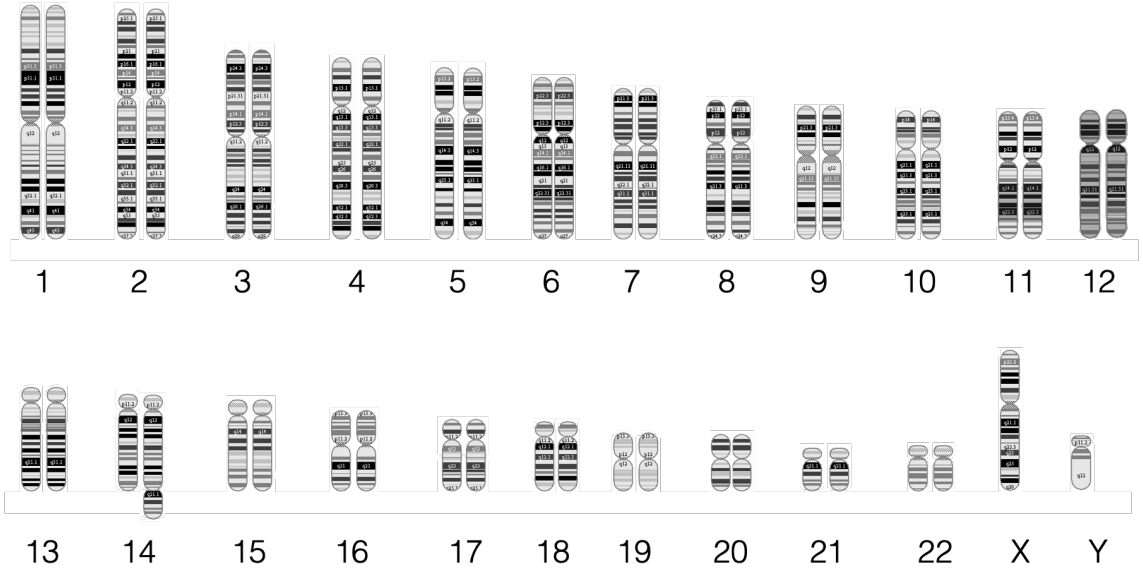
g. By what process is the virus released from the host cell (at stage 8)? 1 mark

_____

Question 6 (8 marks)

Down syndrome is usually caused by the presence of an extra chromosome 21, but a rarer form of Down syndrome called 'familial Down syndrome' is caused by a block mutation in which most of chromosome 21 is attached to chromosome 14. Whereas sufferers of Down syndrome are usually infertile, those with familial Down syndrome are fertile and able to have children.

A karyotype representing the genotype of a person diagnosed with familial Down syndrome is shown below.



Source: modified from https://en.wikipedia.org/wiki/Virtual_karyotype#/media/File:Virtual_karyotype_karyogram.jpg

a. What general term is used to describe a block mutation in which part of one chromosome becomes attached to another chromosome. 1 mark

_____

b. Explain why people with familial Down syndrome are still fertile. 1 mark

_____

_____

_____

_____

Tay-Sachs disease is a genetic disorder that results in the destruction of nerve cells in the brain and spinal cord. It is caused by a mutation in the HEXA gene on Chromosome 15. One of the most common mutations to cause Tay-Sachs disease is shown in the diagram below.

Normal HEXA allele … CGT ATA TCC TAT GCC CCT GAC …

Tay-Sachs allele … CGT ATA TCT ATC CTA TGC CCC TGA C …

c. What is the mRNA sequence encoded by the normal HEXA allele. 1 mark

d. Describe the change that has taken place in the DNA to create the Tay-Sachs allele. 1 mark

e. Explain whether this mutation can be considered a block mutation. 1 mark

f. Many mutations cause a change in a single amino acid in the polypeptide encoded by a gene. The Tay-Sachs mutation, however, causes many amino acids to change. Explain why this happens. 2 marks

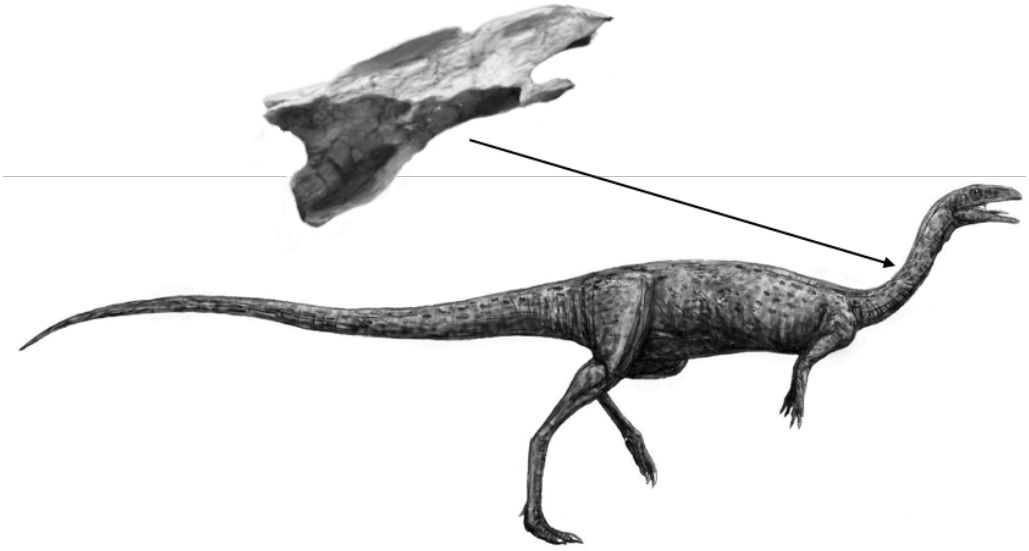
g. Why does a change to the sequence of amino acids in the polypeptide encoded by the HEXA gene cause a change in the way the protein works in the body? 1 mark

Question 7 (6 marks)

In 2020, Swinburne University paleontologist Stephen Poropat published that his team had identified a fossil belonging to a plant-eating dinosaur known as an elaphrosaur; closely related to *Tyrannosaurus rex* and velociraptors.

The fossil was discovered in Cape Otway, Victoria in 2015 by a volunteer paleontologist named Jessica Parker.

The fossil was a 5cm vertebra from the neck of the elaphrosaur. The fossil was dated to the mid-Cretaceous period, approximately 110 million years ago. Most elaphrosaurs found in other parts of the world (in Africa and China) have been dated to the Jurassic period, 160 million years old. Elaphrosaurs were not previously thought to have lived in Australia.



Elaphrosaur and elaphrosaur cervical vertebra: Adapted from https://en.wikipedia.org/wiki/Elaphrosaurus#/media/File:Elaphrosaurus_mount_MfN_Berlin_2018_neck_detail.jpg and https://en.wikipedia.org/wiki/Noasauridae#/media/File:Elaphrosaurus_(flipped).jpg

The fossil was discovered in Cretaceous sedimentary rock, at a fossil hotspot location known as "Eric the Red West" where a fast-flowing river once existed. It was uncovered among a "jumbled-up" series of fossils of various species including several other dinosaur species, turtles and several fish.

a. How was the Cape Otway elaphrosaur fossil most likely dated to 110 million years? Explain your answer. 2 marks

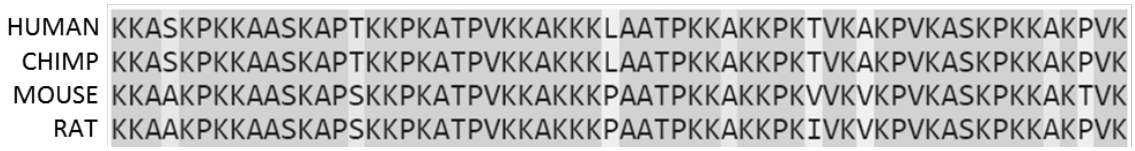
b. Outline the conditions that would have been required for an elaphrosaur fossil to form. 3 marks

c. Suggest why the paleontologists only found a fossil a single elaphrosaur bone and not a complete skeleton. 1 mark

Question 8 (5 marks)

Histone H1 is one of five main types of histone proteins found in eukaryotic cells. The diagram below shows amino acids (amino acid residues) 120 to180 of the human, chimp, mouse and rat histone H1.

Histone H1 (residues 120-180)



Source: Image of amino acid sequence - https://en.wikipedia.org/wiki/Conserved_sequence

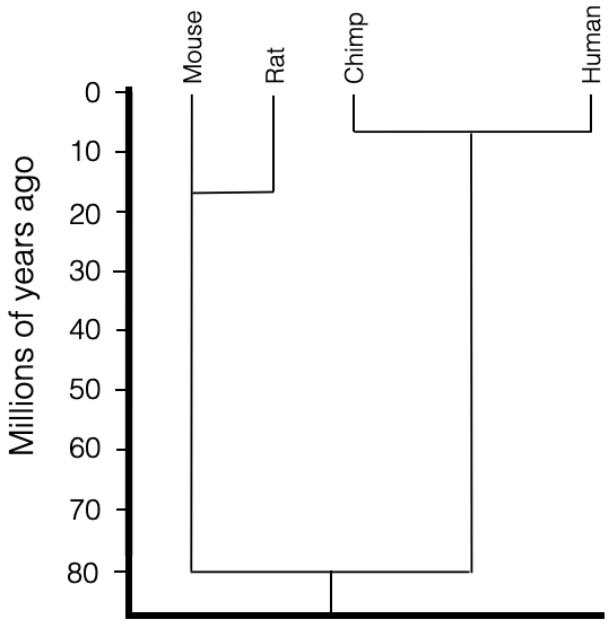
Six regions that differ between the four species are highlighted. The letters each represent a different amino acid, as shown in the one-letter code key below.

Amino acid	One letter code
Alanine	A
Arginine	R
Asparagine	N
Aspartic acid	D
Cysteine	C
Glutamic acid	E
Glutamine	Q
Glycine	G
Histidine	H
Isoleucine	I
Leucine	L
Lysine	K
Methionine	M
Phenylalanine	F
Proline	P
Serine	S
Threonine	T
Tryptophan	W
Tyrosine	Y
Valine	V

a. With reference to a specific amino acid position, describe one difference between histone H1 in rodents and in hominoids. 1 mark

b. A biologist compared the DNA sequences encoding histone H1 in each of a human, chimp, rat and mouse. Are the results likely to show more or fewer than six differences? Explain. 1 mark

c. Below is a phylogram showing the phylogenetic relationships of the four species under investigation.



Data source: Nei M. and Glazko G.V. 2002 The Journal of Heredity 2002:93(3) Estimation of Divergence Times for a Few Mammalian and Several Primate Species.

According to the phylogram, chimps and humans share a more recent common ancestor than do rats and mice. Is this supported by the evidence from the amino acid sequence in histone H1? Explain why or why not. 1 mark

Use the following genetic code table to answer question d.

First Position	Second Position: U	Second Position: C	Second Position: A	Second Position: G	Third Position
U	Phenylalanine	Serine	Tyrosine	Cysteine	U
	Phenylalanine	Serine	Tyrosine	Cysteine	C
	Leucine	Serine	Stop	Stop	A
	Leucine	Serine	Stop	Tryptophan	G
C	Leucine	Proline	Histidine	Arginine	U
	Leucine	Proline	Histidine	Arginine	C
	Leucine	Proline	Glutamine	Arginine	A
	Leucine	Proline	Glutamine	Arginine	G
A	Isoleucine	Threonine	Asparagine	Serine	U
	Isoleucine	Threonine	Asparagine	Serine	C
	Isoleucine	Threonine	Lysine	Arginine	A
	Methionine	Threonine	Lysine	Arginine	G
G	Valine	Alanine	Aspartic acid	Glycine	U
	Valine	Alanine	Aspartic acid	Glycine	C
	Valine	Alanine	Glutamic acid	Glycine	A
	Valine	Alanine	Glutamic acid	Glycine	G

d. Suggest a mutation that may have taken place in the DNA to result in the difference between rat and mouse histone H1 at position 178. 1 mark

e. On the phylogram (previous page), place an arrow to indicate a possible point at which the mutation you described above may have taken place. 1 mark

Question 9 (10 marks)

Between 1947 and 1976 General Electric released PCBs (polychlorinated biphenyls) into the Hudson River at Hudson Falls, 315 km upstream of New York City, causing the disappearance of most fish species in the Hudson River. PCBs interfere with normal gene regulation in embryonic fish. Fish exposed to PCBs are born with abnormally small hearts and other birth defects.

PCBs are lipophilic organic compounds that bind to AHR2 (aryl hydrocarbon receptor 2); an intracellular receptor that transports them into the nucleus. There, the toxin-receptor complex binds to the promoter region of genes that are not usually transcribed in embryonic fish and initiates inappropriate transcription.

a. What is meant by "gene regulation"? 1 mark

b. Explain why PCBs bind to an intracellular receptor and not a receptor on the surface of the cell. 1 mark

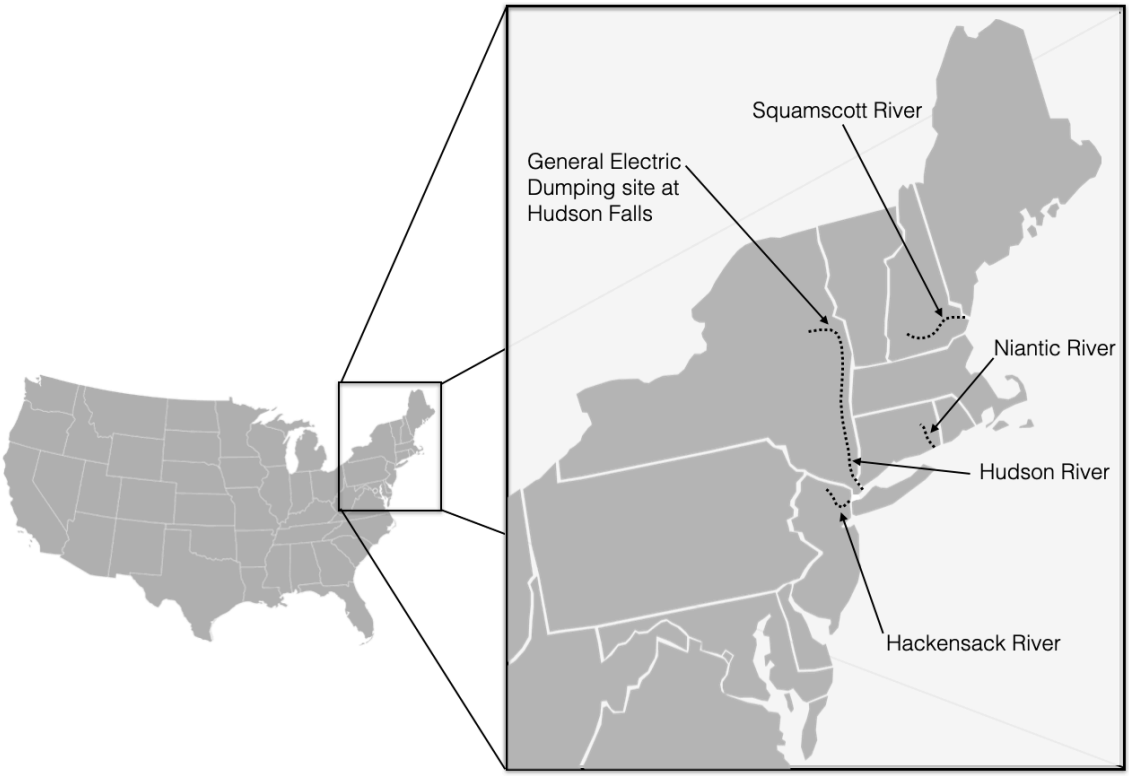
One fish species which thrived in the Hudson, despite the PCB pollution, was the Atlantic tomcod (*Microgadis tomcod*), a bottom-dwelling fish which inhabits rivers and shallow coastal waters on the east coast of North America.

Tomcod: Image source- https://upload.wikimedia.org/wikipedia/commons/thumb/d/d6/Atlantic_tomcod.jpg/220px-Atlantic_tomcod.jpg

In 2011, scientists identified that 99% of tomcods in the Hudson river, carry a mutation in the AHR2 gene (called the AHR2-1 allele), The receptor protein encoded by the AHR2-1 allele has an affinity for PCBs that is 100 times weaker than the normal AHR2 receptor.

c. In what way must the AHR2-1 receptor differ from the normal AHR2 receptor, that would account for its weaker affinity for PCBs? 1 mark

In the nearby Hackensack River of New Jersey, 92% of tomcods also have the AHR2-1 mutation. In Connecticut's Niantic River 6% have the AHR2-1 allele. In New Hampshire's Squamscott River, there were no tomcods recorded to have the mutant AHR2-1 allele.



Location of four US rivers. Image source modified from: https://commons.wikimedia.org/wiki/File:US_East_Temples_Outline_Map.svg and https://commons.wikimedia.org/wiki/File:Blank_US_Map_(states_only).svg

The scientists postulated that prior to 1947, the AHR2-1 mutation was not prevalent in the population of tomcods in the Hudson river, but that the fish had evolved in response to the PCB pollution of the river between 1947 and 1976.

d. What name is given to the process by which the tomcods evolved to be resistant to PCB poisoning? 1 mark

_____

e. Outline the steps that took place in the Hudson River tomcod population, which led to their evolving resistance to PCBs. 3 marks

_____

_____

_____

_____

_____

f. PCBs were never released into the Hackensack River or Niantic River, yet a significant proportion of tomcods in these rivers also contain the AHR2-1 mutation. What is the most likely explanation for this observation? 1 mark

g. What biological term describes the process you have described above? 1 mark

h. Suggest why no tomcods in the Squamscott River were recorded to have the AHR2-1 allele. 1 mark

Question 10 (7 marks)

G6Pase is an enzyme that that helps in the formation of glucose-6-phosphate in the lumen of the endoplasmic reticulum. G6Pase is encoded by the gene G6PC1 located on the long arm of chromosome 17. An autosomal recessive mutation to G6PC1 results in Von Gierke's disease.

A biologist needed to make multiple copies of the mutated G6Pase enzyme for her research. To do this she created plasmids containing the G6PC1 gene, allowed *E. coli* bacteria to take up the plasmids and divide by binary fission, replicating the plasmids. She then purified the defective G6Pase enzyme from the bacteria.

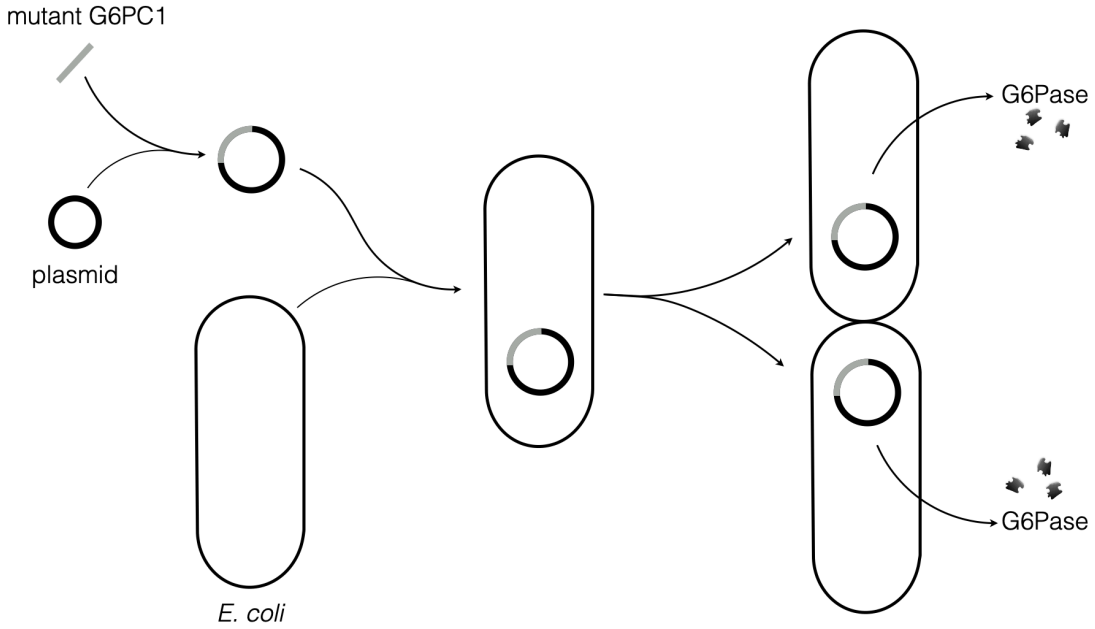
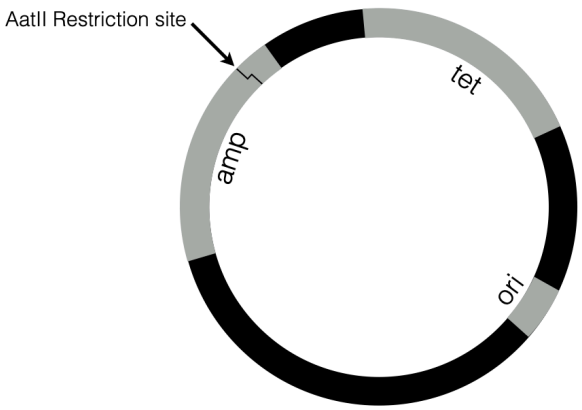


Image source: ©Andrew Douch

a. What general name is given to the process of using a plasmids and bacteria to make quantities of a protein, as described? 1 mark

The first step involved cutting the human G6PC1 gene and the plasmid with the restriction enzyme AatII. A plasmid map showing the restriction site for AatII is shown below. The map also shows the origin of replication, and the location of two antibiotic resistance genes.



Restriction map for plasmid showing the restriction site for AatII, ori (the origin of replication), tet (the gene for tetracycline resistance) and amp (a gene for ampicillin resistance). Image source: © Andrew Douch

Then, the human DNA fragments and plasmids were mixed together. When this was done, some plasmids incorporated the G6PC1 gene.

b. Why was it important to use the same restriction enzyme on both the G6PC1 gene and the plasmid? 1 mark

_____

c. What name is given to a plasmid which has incorporated a gene from a different source, such as the G6PC1 gene from a human? 1 mark

_____

The plasmids were then incubated with *E. coli* bacteria. A small number of bacteria took up a plasmid. Of those bacteria that took up a plasmid, some took up a plasmid that included the G6PC1 gene.

d. Explain how the researcher was able to distinguish between bacteria that had taken up a plasmid, and those that had not. 2 marks

_____

_____

_____

_____

_____

_____

_____

e. Explain how she was able to distinguish between bacteria that had taken up a plasmid containing the G6PC1 gene, and those that had taken up a plasmid without the G6PC1 gene. 2 marks

Question 11 (5 marks)

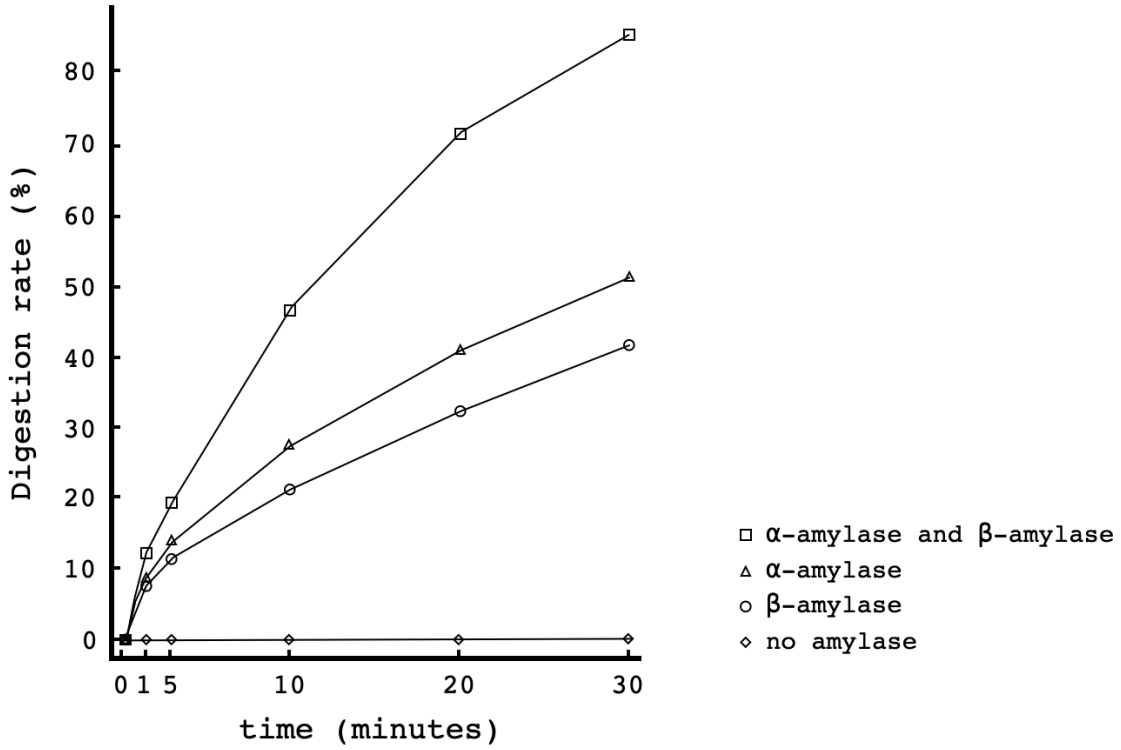
Seed embryos (the part of the seed that contains the earliest forms of the plants roots and stems) of Barley *(Hordeum vulgare)* contain two enzymes that digest starch: α-amylase and β-amylase. A group of university students hypothesized that the combination of α-amylase and β-amylase would digest starch faster than either enzyme acting alone.

The group set up four test tubes, each containing 0.5 ml of 1% starch solution in 0.05 acetate buffer with a pH of 4.8.

- To test tube 1, they added 0.1 ml α-amylase (192 units of α-amylase in 0.2% calcium acetate solution).
- To test tube 2, they added 0.1 ml β-amylase (192 units of β-amylase in 0.2% calcium acetate solution).
- To test tube 3, they added 0.05 ml α-amylase (96 units of α-amylase in 0.2% calcium acetate solution) and 0.05 ml of β-amylase (96 units of β-amylase in 0.2% calcium acetate solution).
- To test tube 4, they added nothing.

The results were recorded using a technique known as the Perton method, which involves paper chromatography to separate the degradation products of starch, at 0, 1, 5, 10, 20 and 30 minutes.

The results are shown in the graph below:



Data source: Iwao Maeda, Shigeo Kiribuchi & Michinori Nakamura (1978) Digestion of Barley Starch Granules by the Combined Action of α- and β-Amylases Purified from Barley and Barley Malt, Agricultural and Biological Chemistry, 42:2, 259-267, DOI: 10.1080/00021369.1978.10862967

1 mark

a. Describe the purpose of test tube 4.

b. Name one variable other than those specifically mentioned above, which the students would have needed to be careful to control. 1 mark

c. What was the dependent variable in the students' experiment? 1 mark

d. Was the hypothesis of the experiment supported by the results? 1 mark

k. Suggest one way in which the students' experiment could be improved. 1 mark

END OF QUESTION AND ANSWER BOOK