



**Victorian Certificate of Education
2019 Trial Paper**

Letter

STUDENT NUMBER

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STUDENT NAME

BIOLOGY
Written examination

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
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.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

Which of the following molecules must enter a cell, by facilitated diffusion via a carrier protein?

- A. Testosterone
- B. Glucose
- C. Carbon dioxide
- D. Water

Question 2

The human proteome

- A. is larger than the human genome.
- B. is equal to the number of structural genes in a human somatic cell.
- C. is the same as that of other primate species.
- D. is the proportion of proteins in a human cell that have quaternary structure.

Question 3

DNA polymerase

- A. creates peptide bonds between amino acids, to form a polypeptide.
- B. cuts DNA at a specific base sequence.
- C. builds a messenger RNA (mRNA) molecule in a 5' to 3' direction.
- D. catalyses the condensation polymerization of nucleotides.

Question 4

Which of the following statements illustrates the unambiguous nature of the genetic code?

- A. The amino acid histidine (His) is encoded by either CAU or CAC.
- B. UGG codes for the amino acid tryptophan (Trp) in humans, plants and bacteria.
- C. CCC always codes for Proline (Pro).
- D. There are six different codons that each code for Serine (Ser).

Question 5

Operons (such as the lac operon) are not found in human cells but are a feature of many bacterial genomes. An operon

- A. is a series of genes that share a single promoter.
- B. is a gene that has three exons and two introns.
- C. is a gene that is translated without the need for a ribosome.
- D. is a gene that can be switched on when needed, and off when not needed.

The diagram below represents an IgG antibody. IgG is composed of four polypeptide chains held together by disulfide bonds. There are two heavy polypeptide chains and two light chains.

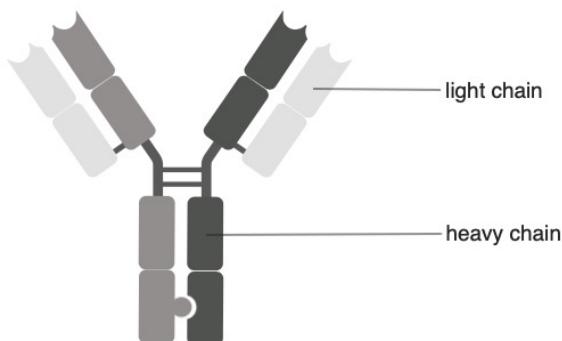


Figure 1. IgG

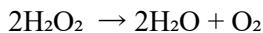
Question 6

Unlike proteins that contain a single polypeptide, proteins like IgG, which contain several polypeptides are said to possess

- A. primary protein structure
- B. secondary protein structure
- C. tertiary protein structure
- D. quaternary protein structure

Question 7

Catalase catalyses the breakdown of hydrogen peroxide (H_2O_2) into water (H_2O) and oxygen gas (O_2) as follows:



Some students undertook an experiment, in which they altered the concentration of hydrogen peroxide in the substrate solution. For their control, they used 50 mL hydrogen peroxide solution given to them by their teacher and added 1 mL catalase solution to it. They recorded the average rate at which oxygen was produced.

Then, they repeated the procedure, but this time they used 25 mL of the teacher's hydrogen peroxide solution and diluted it with 25 mL water (to make 50 mL of diluted hydrogen peroxide solution). All other variables were kept controlled.

The results of the experiment showed that diluting the hydrogen peroxide did not affect the rate of the reaction.

A likely explanation for this is that

- A. substrate concentration does not influence the rate of an enzyme catalysed reaction.
- B. the temperature was higher the second time, and this increased the rate of reaction.
- C. the catalase was saturated with hydrogen peroxide in both the control and experimental groups.
- D. the students did not have an independent variable for the experiment.

Question 8

The light-independent stage of photosynthesis takes place in which part of a chloroplast?

- A. On the thylakoid membrane.
- B. In the matrix.
- C. On the cristae.
- D. In the stroma.

Question 9

The chemical inputs of the light-independent stage of photosynthesis are

- A. NADPH, ATP and CO₂
- B. H₂O, NADH and O₂
- C. H₂O, ADP and Pi
- D. C₆H₁₂O₆ and O₂

Question 10

Which of the following has the **least** effect on the rate of photosynthesis in green plants?

- A. Light intensity
- B. Temperature
- C. Carbon dioxide concentration
- D. Oxygen concentration

Question 11

Fermentation and aerobic cellular respiration share the process of

- A. electron transport
- B. the Krebs cycle
- C. glycolysis
- D. the Calvin cycle

Question 12

The results of an experiment are said to be reliable if

- A. the experiment measures what it intends to measure.
- B. there is a small amount of variance in the data.
- C. the limitations have been minimised.
- D. there are no uncontrolled extraneous variables.

Question 13

Which of the following is not evidence of the endosymbiotic theory of mitochondrial origin?

- A. A mitochondrion and a bacterium each contain a single, circular chromosome.
- B. Both bacteria and mitochondria contain ribosomes.
- C. Neither bacteria nor mitochondria have introns.
- D. Mitochondria reproduce independently of the cell in which they exist.

Question 14

The ATP yield of anaerobic respiration is

- A. 2
- B. 32
- C. 36
- D. 38

Question 15

Apoptosis initiated by a cytotoxic T lymphocyte

- A. is an example of the extrinsic apoptotic pathway.
- B. does not involve the activation of caspases.
- C. is sometimes called the mitochondrial pathway.
- D. does not result in blebbing.

Question 16

Autoimmune disorders such as multiple sclerosis involve the inappropriate action of

- A. mast cells.
- B. cytotoxic T cells.
- C. dendritic cells.
- D. complement proteins.

Question 17

Water moves from the roots of a vascular plant to its leaves through

- A. the phloem.
- B. sieve tube cells.
- C. stomata.
- D. xylem vessels.

Use the following information to answer Questions 18 and 19

Corticotropin (ACTH) is a polypeptide hormone produced within the anterior pituitary gland. The release of ACTH by the anterior pituitary is stimulated by corticotropin-releasing factor (CRF) which is secreted by the hypothalamus. ACTH stimulates the adrenal glands to secrete cortisone, a steroid hormone which is important in a number of physiological functions in the body including the down-regulation of inflammation. It does this in a number of ways, including suppression of the rate at which mast cells secrete histamine.

Question 18

Based on this information and your knowledge of signaling molecules, it is reasonable to conclude that:

- A. cortisone binds to receptor on the outer surface of mast cells.
- B. CRF is a neurohormone.
- C. ACTH is hydrophobic.
- D. ACTH is a second messenger.

Question 19

The adrenal cortex is divided into three layers, or ‘zones’, as shown in the diagram below.

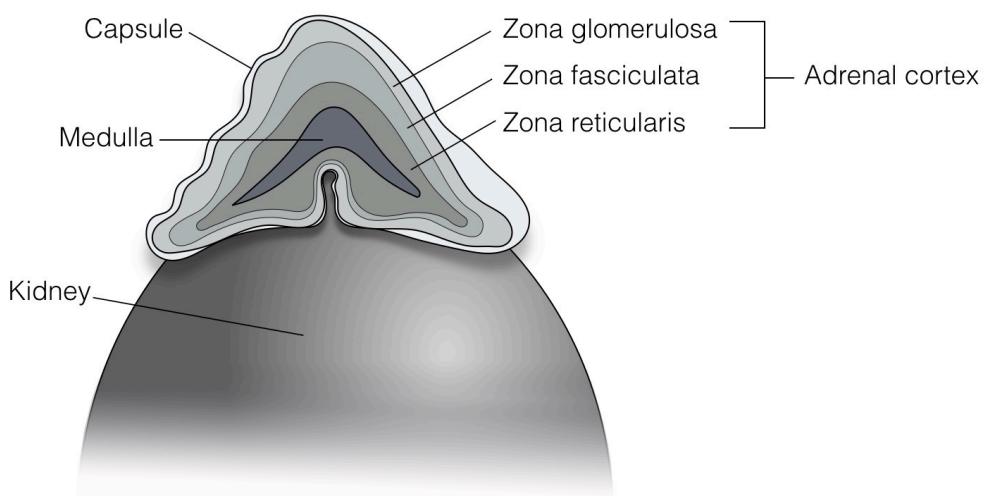


Figure 2. Adrenal gland

ACTH stimulates the cells in the zona fasciculata of the adrenal cortex, but it does not stimulate the cells in the zona reticularis. The reason for this is most likely that

- A. ACTH is not able to reach the zona reticularis.
- B. the zona reticularis contains different genes to the zona fasciculata.
- C. cells in the zona reticularis are metabolically inactive.
- D. the cells in the zona reticularis do not have receptors for ACTH.

Question 20

Which of the following mutations is expected to result in the **least** change to the polypeptide encoded by a gene?

- A. A deletion of a single base.
- B. A deletion of two adjacent bases.
- C. A deletion of three adjacent bases.
- D. A deletion of four adjacent bases.

Use the following information to answer questions 21 and 22

Second Position

	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	START / Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Figure 3. Genetic Code in mRNA codons.

Consider the following DNA sequence, which represents the sequence of nucleotide bases in the exon of a gene.

T A C A A C A T A A T G A C G A T C

Question 21

How many amino acids does the above sequence encode in a polypeptide?

- A. Three
- B. Four
- C. Five
- D. Six

Question 22

Which of the following mutations will **not** result in the shortening of the length of the polypeptide chain encoded by this sequence?

- A. A single base deletion of the G in the fifth base triplet.
- B. A single base substitution in which the ninth base is changed to C.
- C. A single base substitution in which the fifteenth base is changed to T.
- D. A single base addition in which a T is inserted after the eleventh base.

Question 23

- The blood of a newborn baby was tested and found to contain IgG antibodies against the influenza (flu) virus. The most likely explanation for the presence of these antibodies is that
- A. the baby's mother was immunised against the influenza virus whilst pregnant.
 - B. the baby has artificial passive immunity to the influenza virus.
 - C. the baby was vaccinated against the influenza virus at birth.
 - D. the baby has natural active immunity to influenza virus antigens.

Question 24

- Many stomach cancer cells contain on their surface, a growth-promoting protein called HER2. The blood of a cancer patient was tested and found to contain trastuzumab, a type of monoclonal antibody which is specific to HER2. It is likely that these trastuzumab antibodies
- A. were produced by the plasma cells of the cancer patient.
 - B. give the patient artificial active immunity to stomach cancer.
 - C. were purified from the blood of a horse.
 - D. are attached to a toxin.

Question 25

The diagram below shows some laboratory apparatus used in the manipulation of DNA.

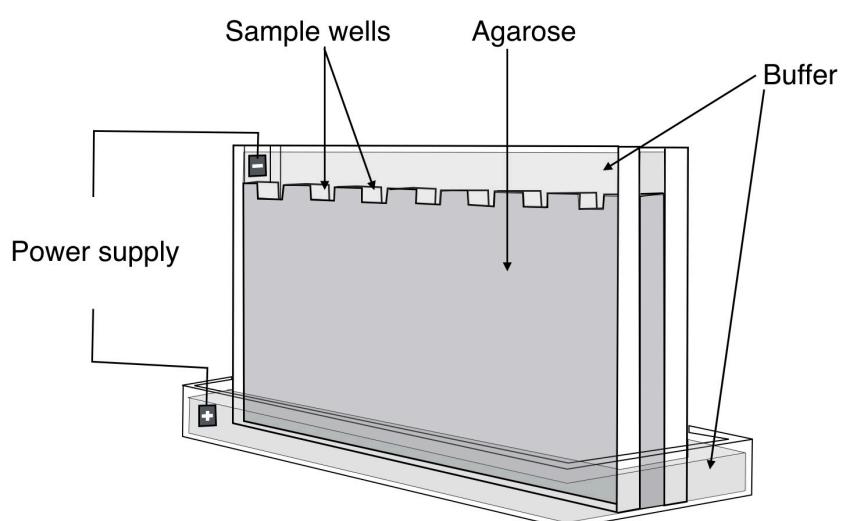


Figure 4. laboratory apparatus used in DNA manipulation

This apparatus is used to

- A. amplify DNA fragments.
- B. transform bacteria by gene cloning.
- C. synthesise DNA probes.
- D. sort DNA fragments by size.

Use the following information to answer Questions 26 and 27

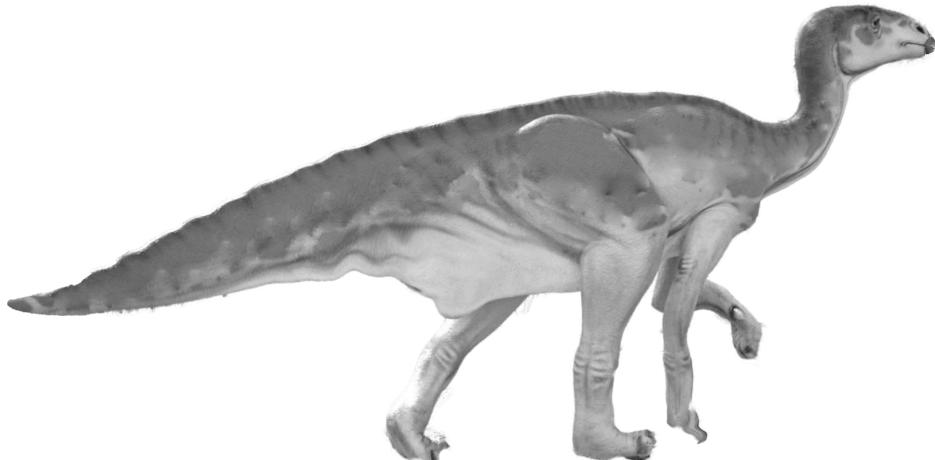


Figure 5. Source: modified from <https://www.flickr.com/photos/futuredu/19648701670>

In 2019 a new species of dinosaur was identified from fossil remains discovered in an opal mine near Lightning Ridge in NSW. Named *Fostoria dhimbangunmal* the dinosaur looked similar to an *Iguanodon*, to which it is believed to be related. The fossils of *Fostoria dhimbangunmal* have been dated to 100 million years. Fossils of *Iguanodon* have also been dated to just over 100 million years. *Iguanodon* fossils have only been found in Europe (in Spain, Belgium and England).

Question 26

The age of *Fostoria*, was **least** likely determined using

- A. stratigraphy
- B. radiocarbon dating
- C. potassium-argon dating
- D. uranium-lead dating

Question 27

In the same opal mine, in which the fossils of *Fostoria* were discovered, there were fossils of *Cunninghamites australis*, a species of coniferous plant which became extinct at the end of the Cretaceous period, 65 million years ago. The fossils of *Cunninghamites australis* were found in a rock layer closer to the surface of the mine than the fossils of *Fostoria dhimbangunmal*. From this information it is reasonable to conclude that

- A. the *Fostoria dhimbangunmal* fossils are younger than those of *Cunninghamites australis*.
- B. lava containing the fossils of *Cunninghamites australis* fossils intruded into the existing rock layers above.
- C. The fossils of *Fostoria dhimbangunmal* were already there when the fossils of *Cunninghamites australis* were formed.
- D. The rock strata have been inverted at some time in the past due to tectonic activity.

Question 28

Which of the following lists groups of organisms in the order in which they appear in the fossil record, from oldest to youngest?

- A. fish – reptiles – birds
- B. fish – mammals – reptiles
- C. ferns – reptiles – fish
- D. flowering plants – ferns – insects

Use the following information to answer Questions 29 and 30

Gonorrhea is a sexually transmitted disease, caused by the bacterium *Chlamydia trachomatis*. There is currently no available vaccine for gonorrhea, though researchers have recently made progress in the attempt to develop one.

The graph below shows the number of reported cases of gonorrhea per 100,000 people, in the United States of America from 1941 to 2017.

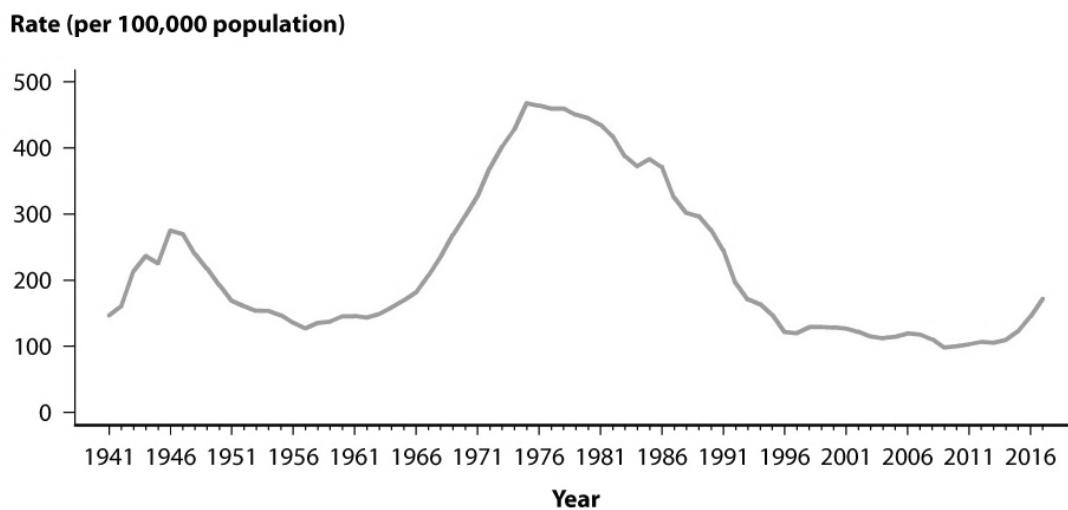


Figure 6. Source: <https://www.cdc.gov/std/stats17/gonorrhea.htm>

Question 29

Note that the rate of reported cases of gonorrhea in 1975 was much higher than in 2009. The most likely reason for this difference is that:

- A. People were less likely to tell their doctor about their symptoms in 2009 than in 1975.
- B. During the 1980s and 90s, antiviral drugs were developed that were effective against gonorrhea.
- C. The population of the USA developed herd immunity to gonorrhea during the 1990s.
- D. The use of condoms became more common during the 1980s and 90s.

Question 30

Note that the rate of reported cases of gonorrhea has been increasing since 2009. A possible explanation for this increase is

- A. Some strains of *Chlamydia trachomatis* have developed resistance to antibiotics used to treat gonorrhea.
- B. People have developed resistance to gonorrhea.
- C. People are no longer embarrassed to tell their doctor that they have a sexually transmitted disease.
- D. The population of the United States is growing.

Question 31

How many cycles of PCR are required to make 64 copies of a DNA fragment?

- A. Three.
- B. Four.
- C. Five.
- D. Six.

Question 32

In May 2019, there was a sharp rise in the number of reported cases of measles in Melbourne. In each case, the development of the disease was linked to travelers who had returned home after being overseas. Six cases, including a baby, were linked to a single man in his 30s who had visited Vietnam. This sharp rise in the number of people contracting measles in May is best described as

- A. a pandemic.
- B. an epidemic.
- C. an outbreak.
- D. an endemic.

Question 33

Ligase is an endonuclease that joins Okazaki fragments on the lagging strand during DNA replication. It is true to say that

- A. When Okazaki fragments are joined by ligase, water is released.
- B. Ligase joins the base Adenine to the base Thymine.
- C. Ligase is useful in the laboratory in the process of PCR.
- D. Each ligase enzyme joins DNA at a specific six-base recognition sequence.

Question 34

Which of the following DNA base sequences is likely to be the restriction site for the restriction enzyme *BcuI*?

- A. GGTTGG
- B. GCTGCT
- C. ACTAGT
- D. ATTTAA

Use the following information to answer Questions 35 and 36

Cystic fibrosis (CF) is the most common genetic disorder in Australia. It is caused by a deletion of three bases in the CFTR gene on the long arm of chromosome 7. The disease is recessive, meaning that in order to have the symptoms of cystic fibrosis, a person must have two copies of the faulty, shorter allele of the CFTR gene.

A married couple have a daughter with cystic fibrosis. The woman is pregnant with a second child and underwent a genetic test to determine whether the unborn second child will also have cystic fibrosis. The results of the genetic test are represented in the image below:

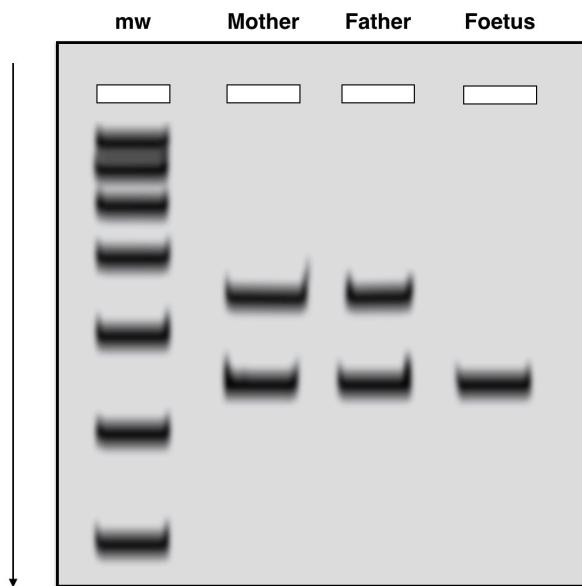


Figure 7. Gene Test for CF

Question 35

Consider the diagram. Which of the following statements is reasonable to state?

- A. The negative electrode is at the top of the diagram.
- B. There is evidence that the DNA samples have been contaminated.
- C. The diagram shows that the foetus has fewer genes than either parent.
- D. The foetus' other band has run off the end of the gel.

Question 36

Which of the following conclusions is possible to make from the results of this genetic test?

- A. The baby will not have CF
- B. The baby will have CF
- C. The baby is likely to have CF, but another STR should be tested to increase certainty.
- D. The test does not indicate whether or not the baby will have CF.

Question 37

The proboscis monkey (*Nasalis larvatus*) belongs to order Primates.



Figure 8. Proboscis monkey (*Nasalis larvatus*). Source: Pixabay

Features of the proboscis monkey that are possessed by all primates include

- A. an opposable thumb, flexible shoulder joints and a large brain.
- B. hair, an opposable thumb and a tail.
- C. forward-facing eyes, even-sized teeth, and flat fingernails.
- D. A strong sense of smell, arms longer than legs and sexual dimorphism.

Question 38

Homo sapiens is the only surviving species of hominin. All species of hominin, including extinct species

- A. buried their dead.
- B. made tools.
- C. walked upright.
- D. were in genus *Homo*.

Use the following information to answer Questions 39 and 40

The diagram below shows the approximate appearance and disappearance from the fossil record of various hominin species.

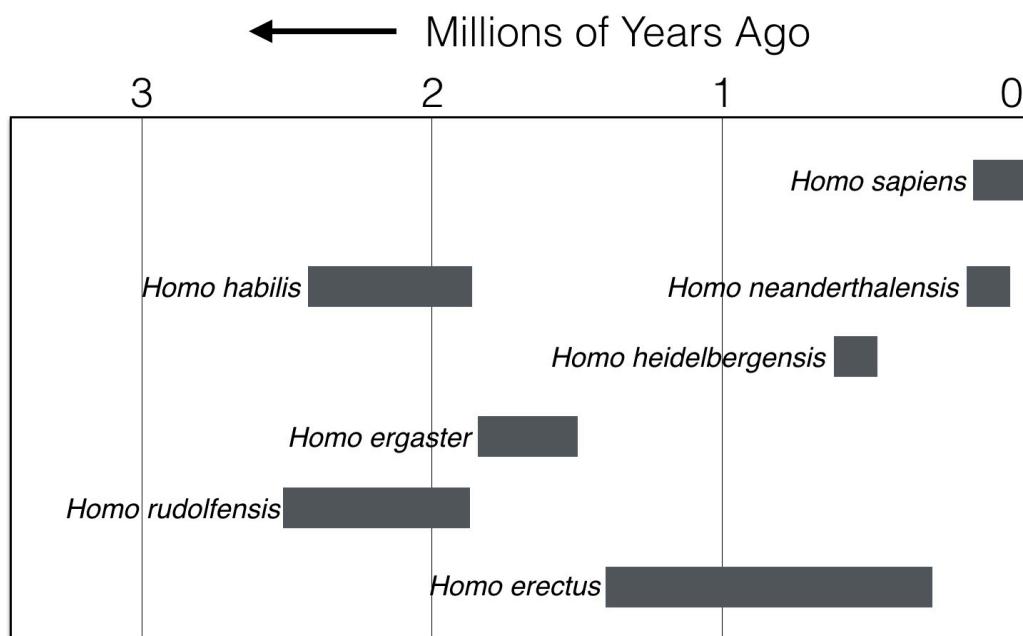


Figure 9. Genus *Homo* as represented in the fossil record. Modified from https://annex.exploratorium.edu/evidence/lowbandwidth/INT_hominid_timeline.html

Question 39

Based on this information and your knowledge of hominin evolution, it is reasonable to state that

- A. *Homo habilis* had a smaller cranial capacity than *Homo erectus*.
- B. *Homo rudolfensis* had smaller molar teeth than *Homo heidelbergensis*.
- C. *Homo heidelbergensis* had larger brow ridges than *Homo ergaster*.
- D. *Homo sapiens* has a larger jaw bone than *Homo rudolfensis*.

Question 40

From the information presented and your knowledge of hominin evolution, it is reasonable to conclude that

- A. *Homo rudolfensis* may have evolved from *Homo ergaster*.
- B. *Homo sapiens* and *Homo neanderthalensis* may both have evolved from *Homo heidelbergensis*.
- C. *Homo rudolfensis* may have evolved from *Homo habilis*.
- D. *Homo heidelbergensis* and *Homo habilis* may both have evolved from *Homo ergaster*.

SECTION B – Short-answer questions

Instructions for Section B

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

Question 1 (9 marks)

Interleukin 4 (IL4) is a cytokine produced by helper T cells (CD4 cells). IL4 has an important function in stimulating the proliferation of activated B lymphocytes.

A schematic representation of the structure of the IL4 protein is shown below. IL4 contains a single polypeptide chain.

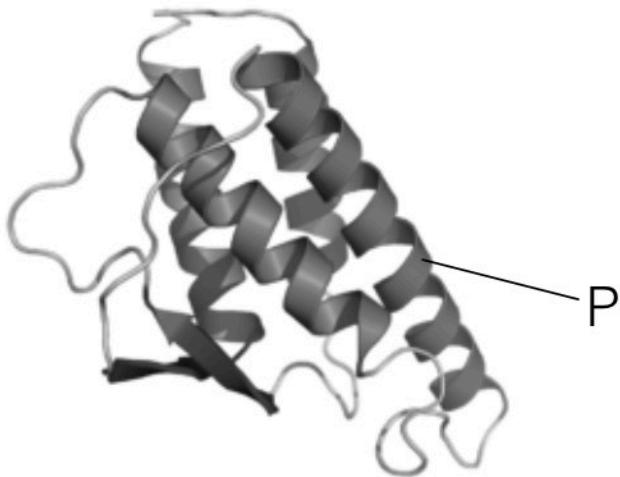


Figure 10. Interleukin 4. Source: Wikimedia commons

When a CD4 cell is stimulated by foreign antigen binding to its T cell receptor, signal transduction results in the expression of the gene for IL4. Gene expression involves transcription, RNA processing and translation.

- a. Describe the process of transcription of the IL4 gene.

3 marks

- b. Describe two modifications made to pre-mRNA, during RNA processing.

2 marks

- c. Describe the process of translation which results in the synthesis of IL4. 2 marks

- d. What feature of the secondary structure of IL4 is labelled P on Figure 10? 1 mark

- e. Explain whether IL4 has quaternary structure. 1 mark

Question 2 (7 marks)

Cytokinins are a class of plant hormones which promote cell division (cytokinesis) in plant shoots and roots, leading to their growth and branching. Zeatin is a cytokinin, found naturally in the tissues of many plants.

The diagram below is a simplified representation of the signal transduction pathway initiated by zeatin.

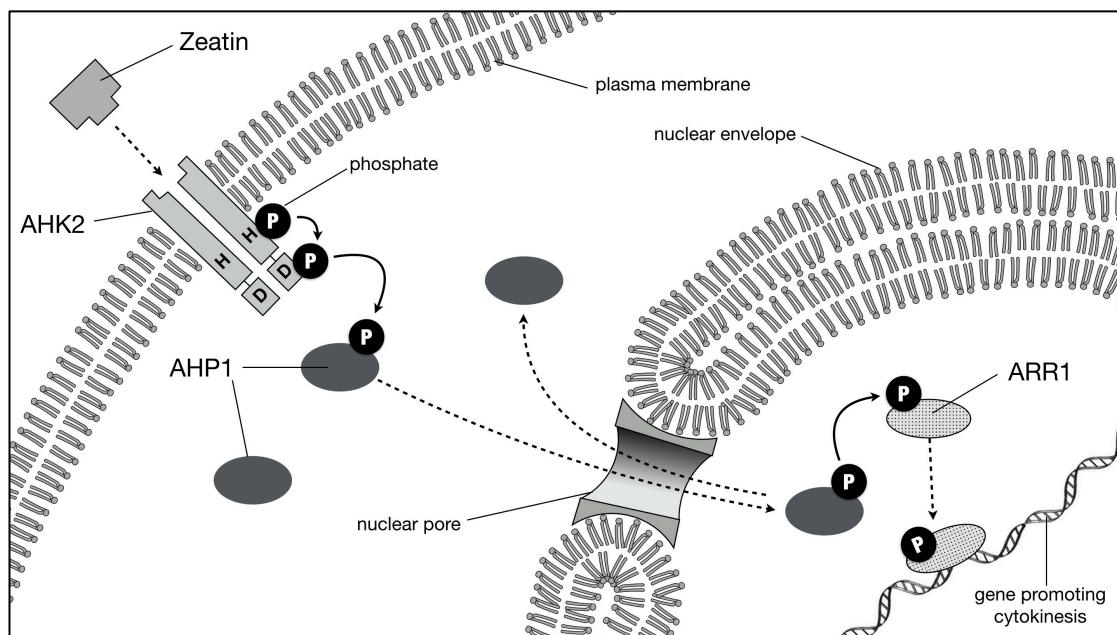


Figure 11: Signal transduction pathway for zeatin.

When *Arabidopsis* histidine kinase 2 (AHK2) binds zeatin, its H-domain passes a phosphate ion to its D-domain. The D-domain of AHK2, then passes the phosphate to *Arabidopsis* histidine phosphotransfer (AHP1). The AHP1 protein carries the phosphate into the nucleus where it transfers it to *Arabidopsis* response regulator 1 (ARR1). ARR1 proteins, once phosphorylated, attach to the DNA at an enhancer region, upstream of a gene that encodes cytokinesis-promoting factors.

- a. Is zeatin hydrophobic or hydrophilic? Justify your answer.

1 mark

- b. Describe two features of AHK2 that enable it to bind zeatin.

2 marks

c. Name a second messenger in this signal transduction pathway. 1 mark

d. Phosphorylated ARR1 acts to upregulate (increase) the rate of a process which occurs in the nucleus. Name the process. 1 mark

e. Describe two ways in which zeatin differs from the animal hormone insulin. 2 marks

Question 3 (8 marks)

Macrophages and neutrophils are two kinds of phagocyte. Neutrophils are much more numerous than macrophages, accounting for approximately 70% of the leucocytes in human body. Neutrophils are also the most important phagocytes in ridding the body of bacteria and other microbes. They are highly mobile, and strongly attracted by cytokines released from cells at the site of tissue damage. As a result, neutrophils ‘swarm’ in large numbers to the site of infection (a process called chemotaxis), where they phagocytose the microbes causing the infection.

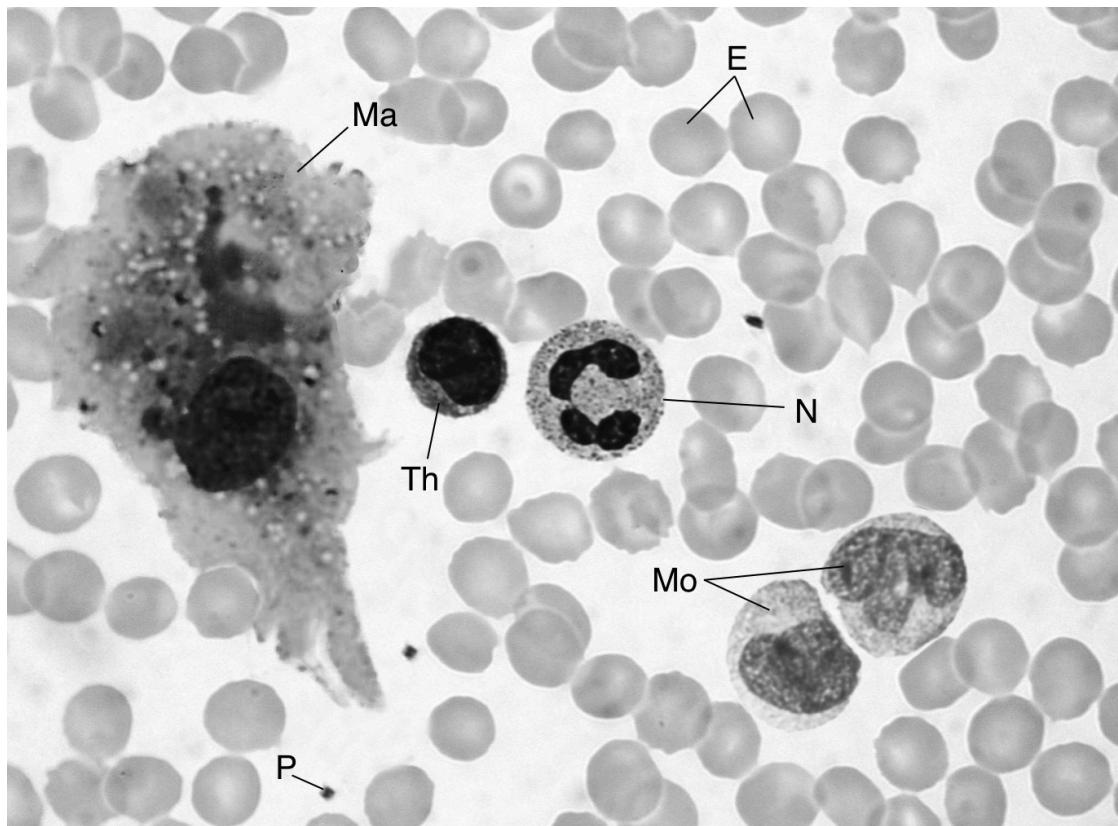


Figure 12. Blood smear. Ma: macrophage, E: erythrocyte (red blood cell), Th: helper T lymphocyte, N: neutrophil, Mo: monocyte, P: platelet. Source: Shutterstock

- a. Is the response of neutrophils to bacteria adaptive or innate? Explain your answer. 1 mark

Macrophages are less mobile and live longer than neutrophils. They are less active than neutrophils in the phagocytosis of bacteria, but they play a more important role than neutrophils in the phagocytosis of apoptotic bodies, a job to which their large size suits them.

- b. What is meant by ‘apoptotic body’?

1 mark

- c. Why is it important that apoptotic bodies be engulfed by macrophages?

1 mark

When a neutrophil phagocytoses a bacterium, it expresses a protein called PECAM-1. A macrophage encountering a neutrophil displaying PECAM-1, engulfs and digests the neutrophil and then displays the bacterial antigens that were within the neutrophil, on its own MHC II markers.

- d. For what purpose does a macrophage display bacterial antigen on its MHC II markers? 1 mark

- e. Name two other cell types in the body that also possess MHC II markers.

2 marks

Neutrophils only live from 5 to 90 hours. For this reason, the human body produces 100 billion new neutrophils per day! It is thought that the short life of neutrophils is an evolutionary adaptation, which protects the body from parasites that might target phagocytes.

- f. Suggest why phagocytes might be a potential target for parasites.

1 mark

- g. Explain how the short life of neutrophils might help to protect the body against parasites.

1 mark

Question 4 (9 marks)

Most Australian children are vaccinated against measles, mumps and rubella (M-M-R) at the age of 12 months and again at 18 months under the National Immunisation Program.

- a. Explain why two vaccinations for measles, mumps and rubella are given, six months apart at 12 and 18 months, rather than a single vaccination at 16 months. 2 marks

Rubella causes a rash in a child and is not normally life-threatening. It is still considered a serious disease, however, because a pregnant woman who catches rubella, has an increased chance of giving birth to a baby suffering deafness, blindness, heart defects and mental deficits.

Before the rubella vaccine was developed, as many as 20,000 babies were born each year with birth defects due to rubella.

- b. Generations ago, many parents sent their children to ‘rubella parties’, where their healthy children would play with children who had rubella. Explain why a parent would send their child to a ‘rubella party’. 2 marks

- c. The rubella vaccine is made from ‘attenuated viral material’. Explain what this means. 2 marks

In the Northern Rivers region of NSW (around Byron Bay) only 52% of children were vaccinated with M-M-R in 2015-16, compared with 92.9% nationally. Health authorities are concerned that the Northern Rivers region does not have herd immunity against measles, mumps and rubella, putting at risk the lives of those in the community who are unable to be vaccinated.

2 marks

- d. Suggest two groups of people in the community who may be unable to be vaccinated.

- e. Explain why an unvaccinated person living in Byron Bay is more likely to get measles than a similarly unvaccinated person living in Melbourne.

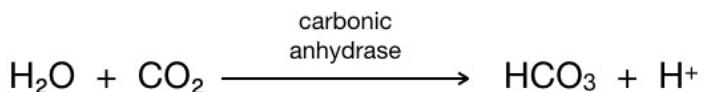
1 mark

Question 5 (5 marks)

Dorzolamide is a carbonic anhydrase inhibitor. It is used as a drug to treat glaucoma by reducing the fluid pressure inside the eye.

The pressure inside the eye, is maintained by the presence of bicarbonate ions, created from carbon dioxide and water by carbonic anhydrase.

The reaction catalysed by carbonic anhydrase is shown below.



By inhibiting carbonic anhydrase, dorzolamide reduces the rate at which aqueous humour (the fluid in the eye) forms.

- a. Name a substrate in the above reaction. 1 mark

- b. Explain why a high concentration of bicarbonate ions inside the eye might lead to high fluid pressure. 1 mark

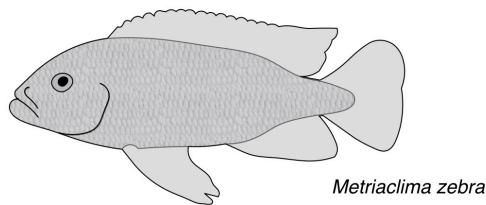
Dorzolamide was developed by the pharmaceutical company Merck. To develop the drug, scientists first used X-ray crystallography to map the three-dimensional structure of carbonic anhydrase, then synthesised a molecule that would inhibit its action.

- c. What name is given to the process of developing a synthetic drug based on a knowledge of the three-dimensional structure of the drug target? 1 mark

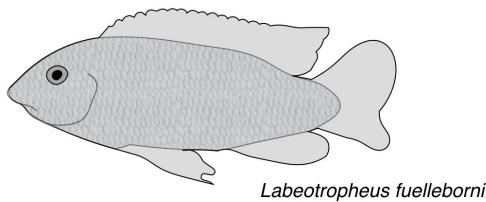
- d. Suggest how, at a molecular level, dorzolamide might inhibit carbonic anhydrase. 2 marks

Question 6 (4 marks)

Cichlids are a family of fishes (family Cichlidae) from Africa. They occupy a range of habitats in lakes and rivers and feed on a wide variety of food types, depending on the species. The drawing below represents two species of cichlid fish from Malawi, Africa.



Metriaclima zebra



Labeotropheus fuelleborni

Figure 13: Two species of cichlids, *Metriaclima zebra* and *Labeotropheus fuelleborni*

Metriaclima zebra lives in rivers and feeds by sucking food into its mouth. Its lower jaw is elongated, can open wide, and contains 30 loosely-packed, long, bicuspid teeth spread along its length.

Labeotropheus fuelleborni occupies lakes and has a mouth suited to biting. Its jaw is short, robust and contains 18 tightly-packed, short, tricuspid teeth.

Although the jaws and teeth of the two species are quite different in appearance and function, the structural genes controlling bone and tooth development are identical. The differences between the two fish are due to the expression of the master regulatory gene BMP4.

- a. Explain the difference between a structural gene and a regulatory gene. 2 marks

- b. Explain how differences in the expression of the BMP4 gene might be responsible for such different jaw structures in the two fish species. 2 marks

Question 7 (9 marks)

In the African bush elephant (*Loxodonta africana*), both male and female elephants usually have highly modified incisor teeth called “tusks”. The elephant uses tusks as a weapon against predators and for digging, stripping bark from trees and moving fallen logs to find food. Males also use their tusks to battle other males for mating rights.

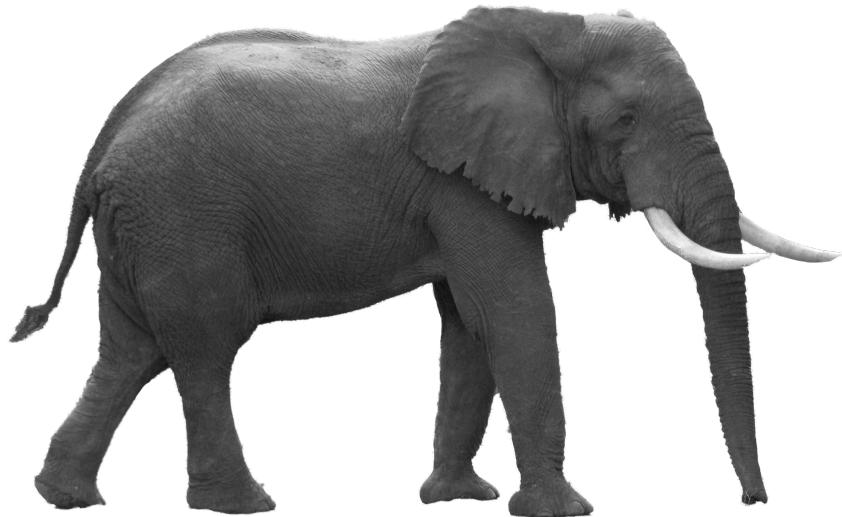


Figure 14. African bush elephant (*Loxodonta africana*). Source: Pixabay

Statistics from the 1960s showed that 3% of female elephants in a natural population possess a trait known as “tusklessness”. Tuskless elephants do not develop tusks.

- a. Explain how variation within a species, such as the presence or absence of tusks, can exist.

1 mark

- b. Suggest why in a natural population, such a low percentage of female elephants have the tuskless trait.

2 marks

In the late 1970s and early 1980s significant poaching of elephants took place. Hunters killed elephants to remove their tusks, which they sold to the ivory trade.

A study compared the size of African bush elephants’ tusks in 2013 with those of elephants in 1968. It was found that the tusks of males are now, on average, 20% smaller and those of females are 30% smaller. This decrease in tusk size has been attributed to poaching.

- c. Explain how poaching has caused a decrease in average tusk size in the African bush elephant.

4 marks

- d. A study is planned to collect data on the percentage of female elephants that have the tuskless trait in 2019. Predict what the results of this study will show. Explain your prediction.

2 marks

Question 8 (6 marks)

In 1891 Eugène Dubois discovered the incomplete fossil remains of a hominin in the banks of the Solo River in Java, Indonesia. The find consisted of three fragments: a skull-cap, a femur and a single tooth. Nicknamed 'Java man', the species was later classified as *Homo erectus*.

The fossils have been dated to between 700,000 and 1,000,000 years old.

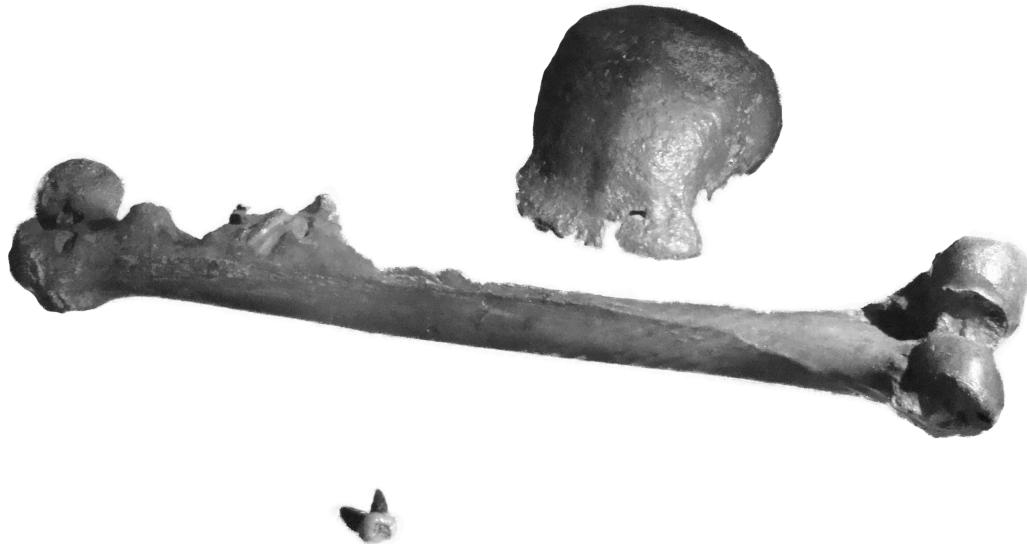


Figure 15. Fossils of "Java man". Source: Wikimedia commons

- a. Describe two necessary conditions that must have been true for the Java man fossils to form. 2 marks

1.

2.

- b. Suggest two reasons that might explain why the Java man fossil is incomplete. 2 marks

1.

2.

In 1912 Charles Dawson claimed to have discovered a previously unknown hominin species which he named *Eoanthropus dawsoni*. He claimed to have found the fossil in gravel beds near Piltdown Village in Sussex, England. The specimen was nicknamed ‘Piltdown man’. Dawson dated Piltdown man to 500,000 years old, based on the Pleistocene rock layer in which he ‘found’ it.

Forty-one years later, in 1953, three scientists published an article exposing the Piltdown man fossil as a hoax; a composite of three separate fossils. The cranium was human, and the jaw fragment was from an orangutan into which filed-down chimpanzee teeth had been fixed.

It was further shown that the fossil of the skull had an absolute age of only 520 – 720 years.



Figure 16. “Piltdown man fossil”. Source: Wikimedia commons

- c. Name the dating method most likely used to date the skull to between 520 and 720 years.

1 mark

- d. Briefly explain why the dating method you named above could not also be used to date the Java man fossil discovered by Eugène Dubois?

1 mark

Question 9 (13 marks)

Cats (Family Felidae) first appeared in the northern hemisphere (in what is now Europe) about 30 million years ago. About 11 million years ago, they began to spread to all continents except Australasia and Antarctica. Their power and agility enabled them to outcompete existing carnivores on each continent becoming established as the dominant predators in most ecosystems.

- a. Australia, South America and Africa were all once part of Gondwana. Explain why there are native cats in South America and Africa, but not in Australia.

2 marks

The phylogenetic tree below, summarises the evolutionary relationships of 25 cat species, based on DNA evidence.

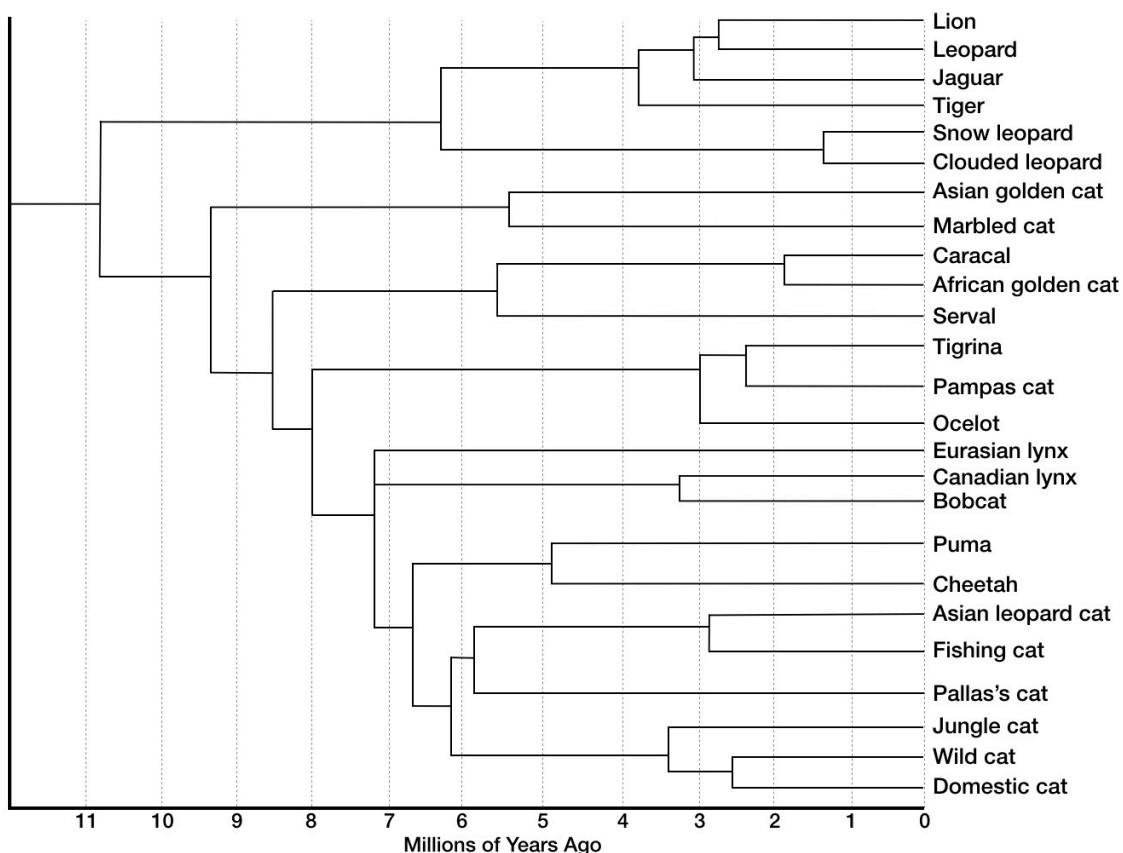


Figure 17. Phylogenetic tree of modern cats

- b. Is the domestic cat more closely related to the cheetah or to the ocelot? Explain your answer. 2 marks

- c. How many years ago did Pallas's cat diverge from the fishing cat? 1 mark

DNA-DNA Hybridisation was used to generate the phylogenetic tree. This technique involves hybridizing DNA strands from two different species, then heating the DNA to record the temperature at which the strands separate (the 'melting temperature').

- d. When DNA-DNA hybridisation was used to compare the DNA of the Canadian lynx with that of the Eurasian lynx and the bobcat, what conclusion can you make about the temperatures at which the hybrid DNA strands separated? 1 mark

Leopards (*Panthera pardus*) are native to Africa. Tigers (*Panthera tigris*) are native to Asia. Therefore, in the wild leopards and tigers never encounter each other. In captivity, however, mating between leopards and tigers can be arranged and sometimes results in offspring called 'tigards'. All known tigards have been still-born (dead at birth).

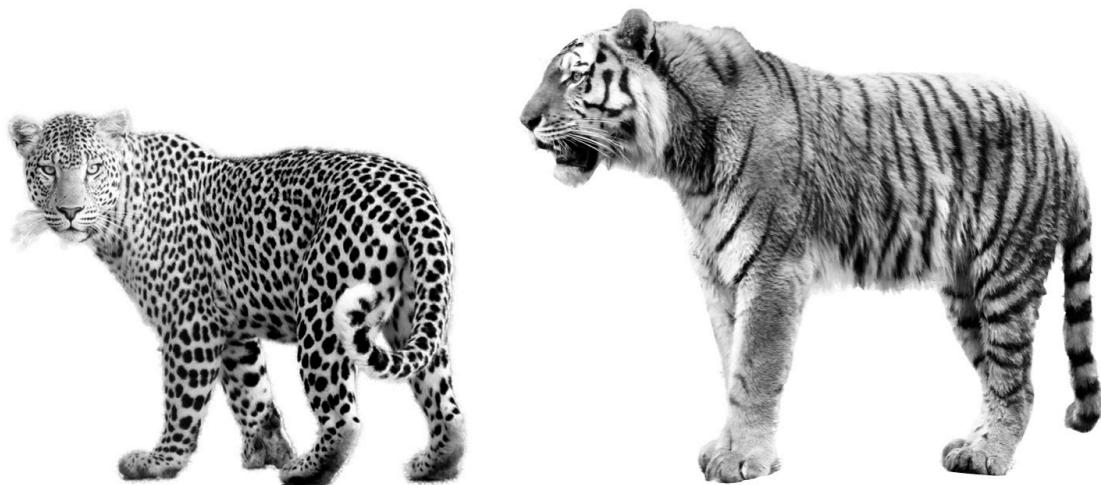


Figure 18. Left: leopard (*Panthera pardus*). Right: tiger (*Panthera tigris*). Source: Pixabay

- e. Explain why leopards and tigers are considered different species. 1 mark

- f. Name and describe the process by which leopards and tigers evolved to become separate species.

Name of process: _____ 1 mark

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Description of process: 3 marks

Thylacoleo carnifex (the ‘marsupial lion’) is an extinct leopard-like carnivore which lived in Australia from 2 million to 46 thousand years ago. Although it was more closely related to kangaroos and koalas, it looked like a cat, was about the size of a leopard, and like a leopard, had powerful jaws, long stabbing incisor teeth, slicing premolars and sharp claws. It also had an enlarged ‘thumb-claw’ encased in a sheath, just as leopards do.



Figure 19. *Thylacoleo carnifex* preying on *Diprotodon optatum*. Source: Wikimedia commons

- g. Explain whether the sheathed claw of *Thylacoleo* is homologous or analogous to the sheathed claw of leopards. 2 marks

Question 10 (10 marks)

Scientists wished to clone the human gene THPO which encodes thrombopoietin, a hormone produced in the kidneys and liver, which stimulates cells in the bone marrow to produce platelets.

They used the restriction enzyme SphI to cut out the THPO gene from human chromosome 3 and mixed it with plasmids which had also been cut with SphI.

- a. Explain why it is necessary to use the same restriction enzyme to cut both the human DNA and the plasmid.

1 mark

The scientists considered two plasmids (pSTBlue-1 and pBR322) which contain a restriction recognition site for SphI. Both plasmids also contain two genes for resistance to an antibiotic. pSTBlue-1 contains genes for resistance to kanamycin (KanR) and ampicillin (AmpR). pBR322 contains genes for resistance to tetracycline (TcR) and ampicillin (AmpR). The two plasmids are represented in the diagram below.

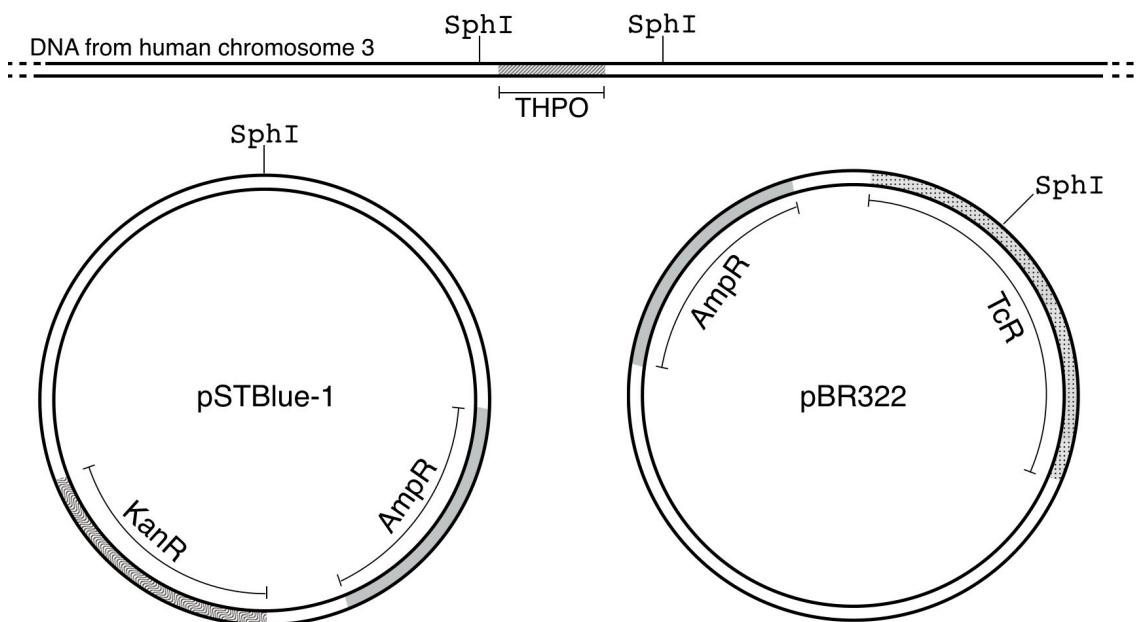


Figure 20. SphI - restriction site for restriction enzyme. KanR - gene for resistance to kanamycin. AmpR - gene for resistance to ampicillin. TcR - gene for resistance to tetracycline.

- b.** Which plasmid would the scientists have most likely chosen? Briefly justify your answer.

1 mark

After the restricted plasmids had been mixed with the human DNA fragments containing the THPO gene, another enzyme was added to the mixture.

- c.** What was this enzyme and why was it necessary?

2 marks

Next, the plasmids were incubated with *E. coli* bacteria which had been chemically treated and heat-shocked to make them competent to take up plasmids.

After incubating the bacteria with the plasmids, the bacteria were plated onto agar plates containing an antibiotic.

- d.** What term is used to describe bacteria that have taken up a plasmid?

1 mark

- e.** Which antibiotic will the scientists be able to use to distinguish between bacteria that took up a plasmid and those that did not? Explain your answer.

2 marks

- f.** Explain how scientists are able to distinguish bacteria that took up a *recombinant* plasmid from those that took up a non-recombinant plasmid.

2 marks

- g.** Suggest one practical purpose for which scientists might want to clone the THPO gene? 1 mark

END OF QUESTION AND ANSWER BOOK