NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2021

LIFE SCIENCES: PAPER I

Time: 3 hours 200 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages and a yellow Answer Booklet of 16 pages (i–xvi). Please check that your question paper is complete. Detach the yellow Answer Booklet from the middle of the question paper. Remember to write your examination number in the blocks provided.
2. This question paper consists of four questions.
3. Read the questions carefully.
4. Question 1 must be answered in the yellow Answer Booklet provided.
5. Questions 2, 3 and 4 must be answered in your Answer Book.
6. Start **each question** on a **new** page.
7. Number the answers exactly as the questions are numbered.
8. Use the total marks that can be awarded for each question as an indication of the detail required.
9. It is in your own interest to write legibly and to present your work neatly.

QUESTION 2

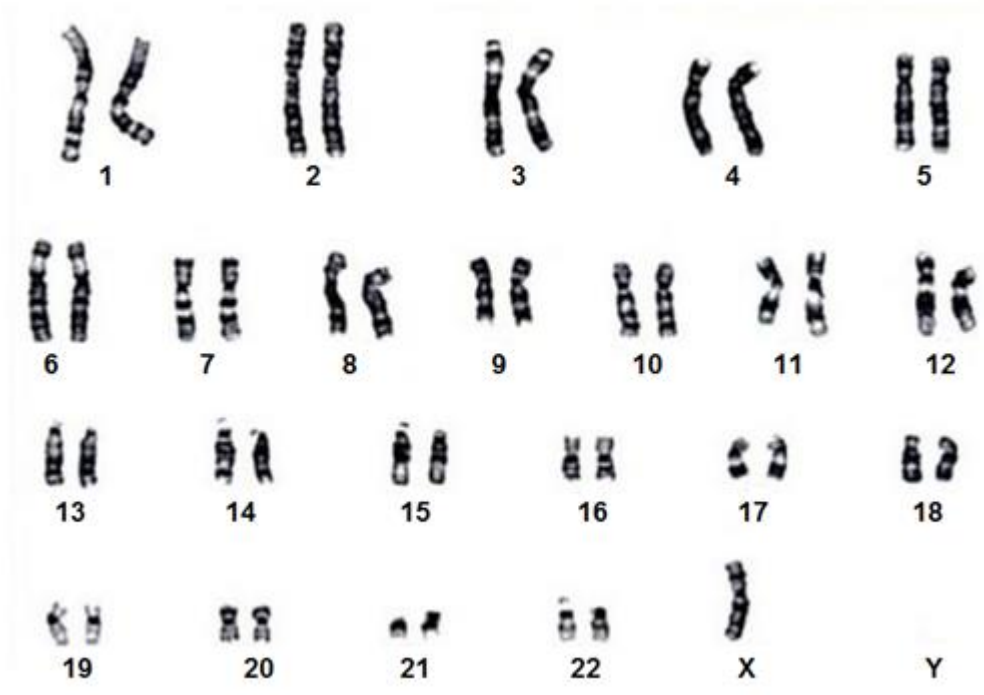
2.1 Read the information below on a genetic disorder known as Turner Syndrome. Use the information in the source and your own knowledge to answer the questions that follow.

Turner Syndrome

Turner syndrome is a disorder caused by a chromosomal mutation that affects females. Sufferers develop symptoms that affect many organ systems. Symptoms are caused by the loss of genetic information during meiosis, when chromosomes fail to separate properly. Turner syndrome is not hereditary and occurs by chance.

Pregnant mothers can have a genetic test where cells from the foetus are obtained to make a karyotype.

Figure 2.1: Karyotype of Turner Syndrome



[Adapted: <https://i.pinimg.com>]

Common symptoms of Turner syndrome include short height, delayed puberty, infertility and heart defects. Growth hormone production and the development of the ovaries are affected.

Turner syndrome females are treated with hormone replacement therapy. Genetic counselling is also recommended.

[Adapted: <https://rarediseases.org> ; <https://www.genetics.edu.au>]

2.1.1 Where in the cell would chromosomes be located? (1)

2.1.2 Give the term used to describe chromosomes numbered 1 to 22. (1)

2.1.3 Describe the chromosomal abnormality as seen in the Turner syndrome karyotype in Figure 2.1. (2)

2.1.4 Were these chromosomes taken from a somatic cell or a gamete? Give a reason for your answer. (2)

2.1.5 Explain clearly why Turner syndrome is not an inherited condition. (2)

2.1.6 Suggest why a karyotype analysis for genetic disorders is not routinely offered to all pregnant women. (2)

2.2 2.2.1 Name the following referred to in the source on Turner syndrome:

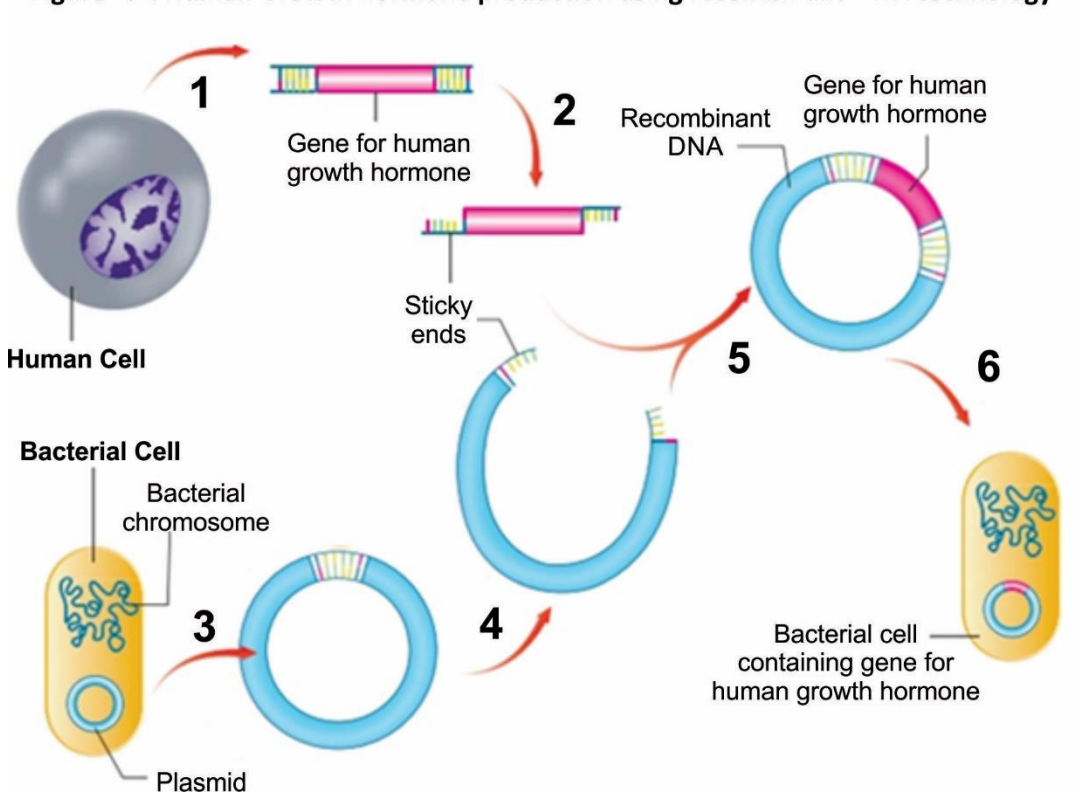
(a) the gland that secretes growth hormone. (1)

(b) two ovarian hormones requiring hormone replacement therapy. (2)

2.2.2 Suggest any TWO areas of training that are important in a genetic counsellor becoming a skilled professional. (2)

2.2.3 Growth hormone is important in promoting skeletal and muscular growth. It can be produced for people who do not secrete, or under secrete this hormone using recombinant DNA technology as shown in the Figure 2.2 below:

Figure 2.2: Human Growth hormone production using recombinant DNA technology



[Adapted: <https://img.brainkart.com/>]

(a) Name the enzyme that 'cuts' the DNA in steps 2 and 4. (1)

(b) Name the enzyme found in the process at step 5 and explain its role in recombinant DNA technology. (2)

(c) Why are bacteria useful organisms for recombinant DNA technology? (2)

2.3 The thyroid gland is composed of thyroid sacs. These are made up of a layer of cuboidal cells which secrete the hormone thyroxin. Study the micrographs below of thyroid tissue taken from both a sick cat and a healthy cat.

Figure 2.3: Thyroid tissue of a sick cat

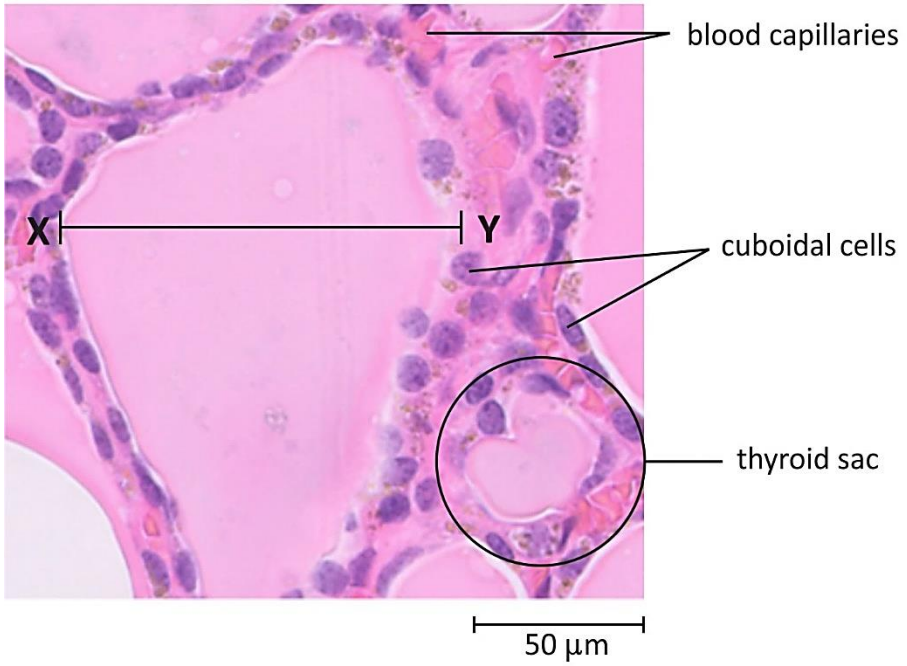
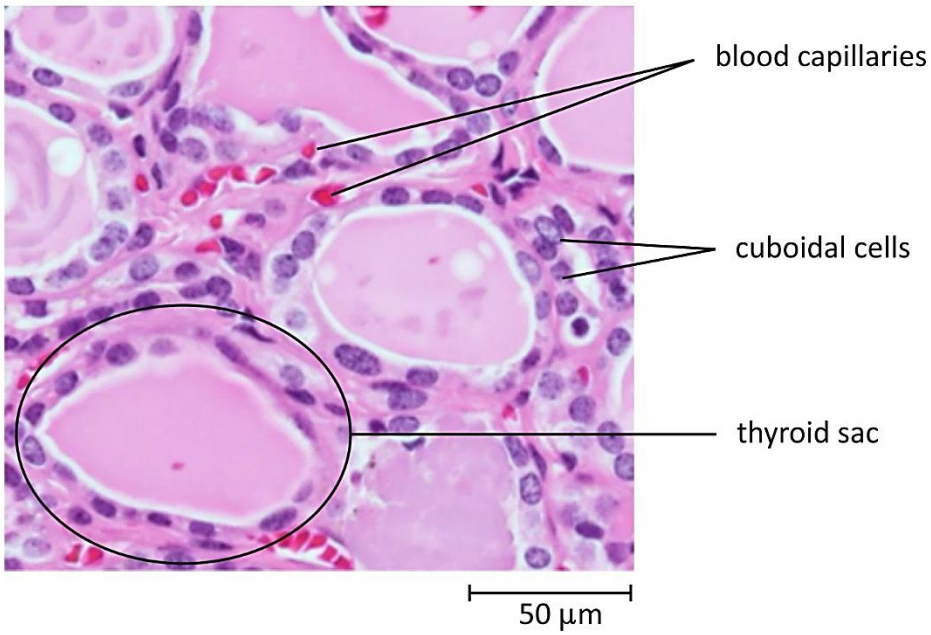


Figure 2.4: Thyroid tissue of a healthy cat



[Adapted: <https://www.researchgate.net>; <https://www.pathologyoutlines.com>]

2.3.1 State ONE function of the hormone thyroxin. (1)

2.3.2 List ONE symptom of an under secretion of thyroxin. (1)

2.3.3 Tabulate TWO differences as seen in the thyroid tissue of the sick cat and the healthy cat. (5)

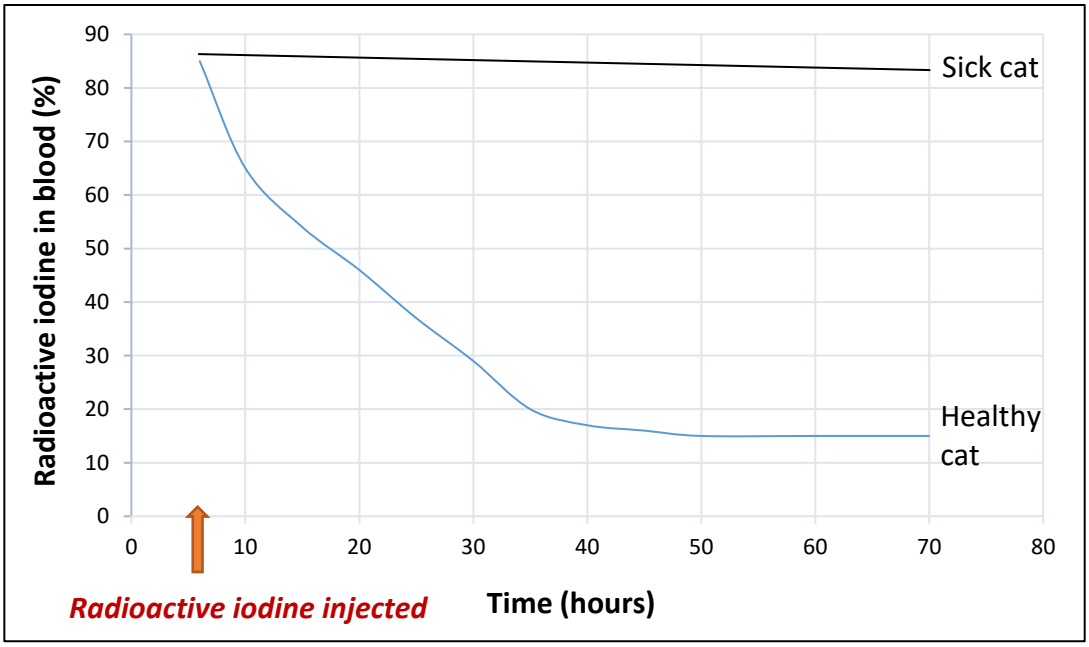
2.3.4 Calculate the actual length of the lumen of the thyroid sac from X to Y in the sick cat. Show all working. (4)

2.3.5 Why are many blood capillaries found in the thyroid tissue? (2)

2.3.6 A veterinary surgeon hypothesised that the sick cat might be suffering from a non-functioning thyroid gland. Iodine is essential for thyroxin formation. It is absorbed from the blood by the thyroid gland and is used to manufacture thyroxin in the thyroid gland.

To test this hypothesis, the veterinary surgeon gave the sick cat and the healthy cat radioactive iodine compounds and measured the levels in their blood. These levels were never high enough to cause harmful effects to the cats.

The results are shown in the graph below:



[Adapted: Rowland, M. 1992. Biology. Page 426]

(a) Provide a suitable title for the graph. (3)

(b) Do the results indicate that the sick cat does have a non-functioning thyroid gland? Provide reasons for your answer from the graph. (4)

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QUESTION 3

3.1 Read the information in the source below and answer the questions that follow.

The tuatara reveals ancient features of amniote evolution

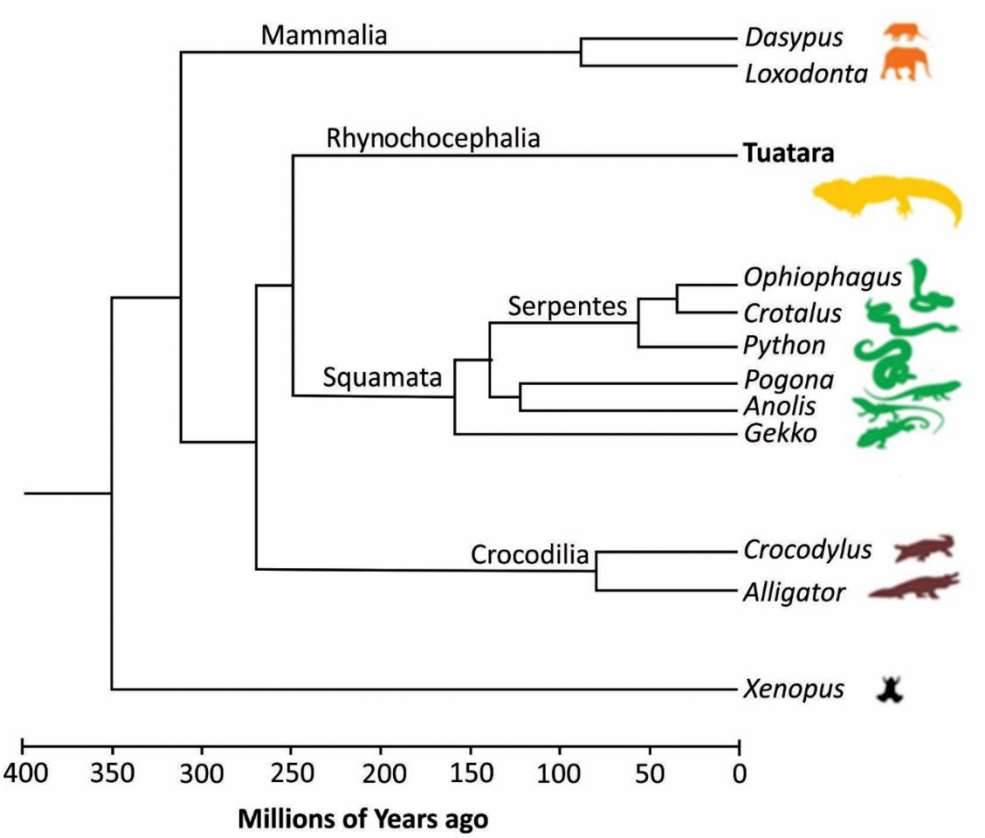
The tuatara is a land vertebrate unique to New Zealand. It is the only living member of the order Rhynochocephalia. The tuatara is an important link to the now extinct reptiles from which dinosaurs, modern reptiles, birds and mammals evolved and is important for our understanding of reptile and mammal evolution.

Figure 3.1: The tuatara

[Source: <https://www.sciencenews.org>]

In a recent study, scientists sequenced the genome of the tuatara. They worked in partnership with indigenous Māori tribe members who hold guardianship over the tuatara populations of New Zealand.

Figure 3.2: Phylogenetic tree of the tuatara



[Adapted: <https://www.nature.com>]

3.1.1 Give the meaning of the term *genome*. (2)

3.1.2 Explain your understanding of what is meant by "scientists sequenced the genome of the tuatara". (2)

3.1.3 Refer to the phylogenetic tree in Figure 3.2 on Page 7:

(a) How long ago did the tuatara and python share a common ancestor? (2)

(b) Explain why the evolution of *Dasypus* and *Loxodonta* can be described as an example of punctuated equilibrium and not gradualism. (2)

(c) Why is the tuatara more closely related to the serpent (Serpentes) lineage than the crocodile (Crocodilia) lineage? (1)

3.1.4 Explain why the amniotic egg is viewed as a "major evolutionary step" by scientists. (4)

3.1.5 Suggest why it is important that the scientists in the study partnered with the local indigenous people, the Māori's. (2)

3.2 Read the following extract and answer the questions that follow.

"**Little Foot**" is the nickname given to a nearly complete *Australopithecus* fossil skeleton found in 1994–1998 in the cave system of Sterkfontein, South Africa. The nickname was given to the fossil because of the small size of the ankle bones that were among the first parts of the skeleton to be discovered. From the structure of the four ankle bones, it was determined that Little Foot was able to walk upright.

[Adapted: <https://en.wikipedia.org>]

3.2.1 Give the term used to describe the ability to *walk upright*. (1)

3.2.2 List three features of the skeleton that would suggest to scientists that Little Foot walked upright. (3)

3.2.3 Describe TWO advantages of being able to walk upright for early hominids. (2)

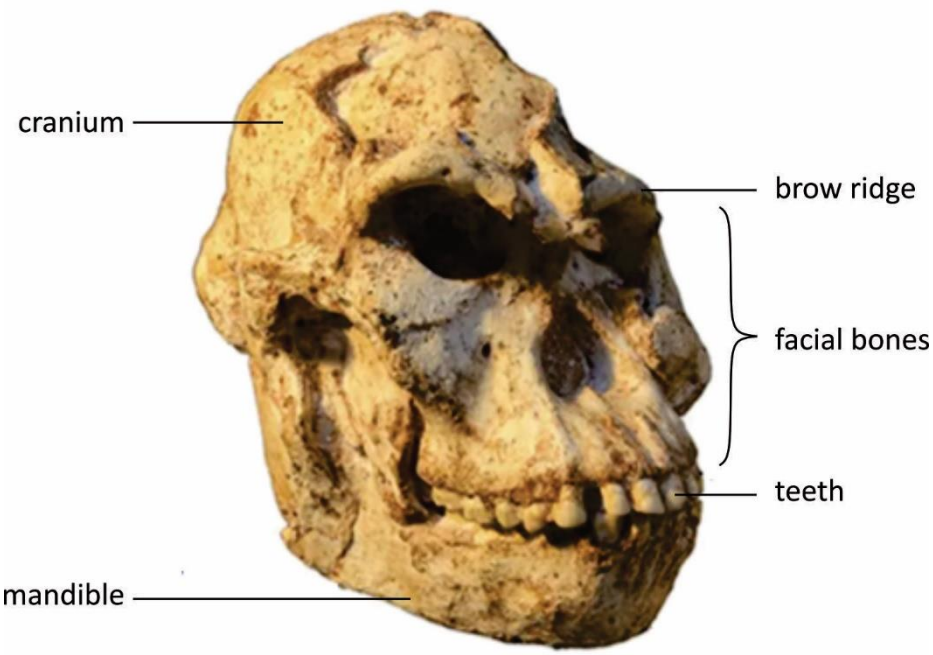
3.2.4 Why do caves like the Sterkfontein system provide ideal locations for finding fossils? (2)

3.3 Read the information below and answer the questions that follow.

In 2017, the complete Little Foot skeleton was unveiled to the public by Professor Ron Clarke and his team of researchers after 20 years of excavation.

Early attempts to date Little Foot placed the age around 2,2 million years old, suggesting Little Foot's classification to be *Australopithecus africanus.* However, it is now dated to 3,67 million years old. The skull bones and teeth are so unusual that Clarke and his colleagues have categorised her as a distinct species prompting Professor Clarke to reclassify Little Foot as *Australopithecus prometheus.*

Figure 3.3: The skull of Little Foot



[Adapted: <https://www.livescience.com>; <https://www.sciencemag.org>]

3.3.1 State how THREE labelled structures of the Little Foot skull seen above are different in a human skull. (3)

3.3.2 How have African fossils like Little Foot contributed to our understanding of hominid evolution? (3)

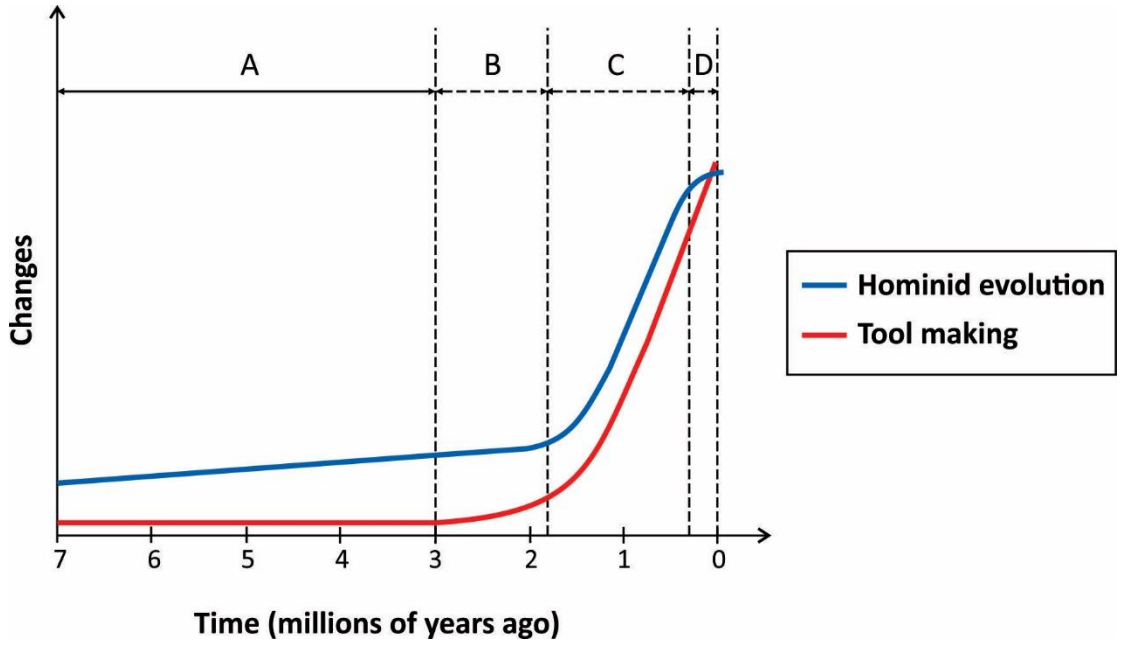
3.3.3 Suggest why it took a long time, over 20 years, for the scientists to reveal the complete Little Foot skeleton to the public. (2)

3.3.4 Why did Ron Clarke reclassify Little Foot as *Australopithecus prometheus*? (2)

3.3.5 Name ONE other fossil example of *Australopithecus africanus.* (1)

3.4 Study Figure 3.4 below and answer the questions that follow.

Figure 3.4: Changes in biological and cultural evolution over millions of years



[Adapted: <https://blog.waikato.ac.nz>]

3.4.1 Explain the relationship between hominid evolution and practices such as tool making. (2)

3.4.2 Discuss TWO ways in which an increase in brain size in hominids impacted cultural practices. (4)
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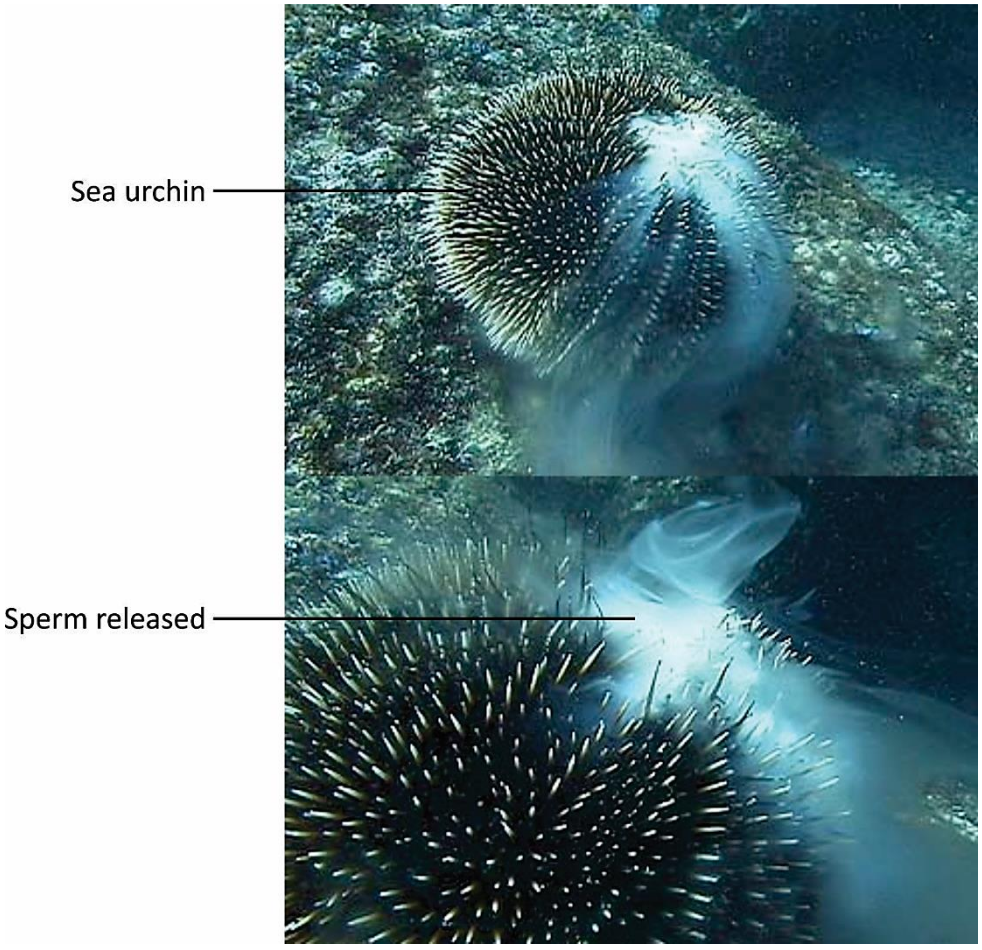
QUESTION 4

4.1 Study the images below and answer the questions that follow.

Sea urchins are small animals that live in the oceans. They can have long lifespans (over 30 years) but few reach their maximum lifespan. Sea urchins are preyed on by lobsters, crabs, otters and various fish. Sea urchins have separate male and female sexes. The males release millions of sperm and the females release thousands of eggs directly into the water, as the water currents help transport the gametes. Only a small percentage of the eggs are fertilised.

Sea urchin eggs and sperm are similar to human gametes, making sea urchins useful for the study of fertilisation and embryo development in a controlled environment in a laboratory. Sea urchins are easy to keep in aquaria and they release sperm readily. The gametes are also easy to collect and fertilisation takes place outside the body making it convenient to observe and monitor.

Figure 4.1: Sea Urchin releasing sperm



[Adapted: <https://www.scientificamerican.com>]

4.1.1 Does the sea urchin have internal or external fertilisation? Give a well explained reason for your answer. (3)

4.1.2 Why are sea urchins suitable animals to use in fertility studies? (2)

4.1.3 Sea urchin sperm is similar in structure to human sperm cells.

(a) Name the organ where sperm cells are produced in humans. (1)

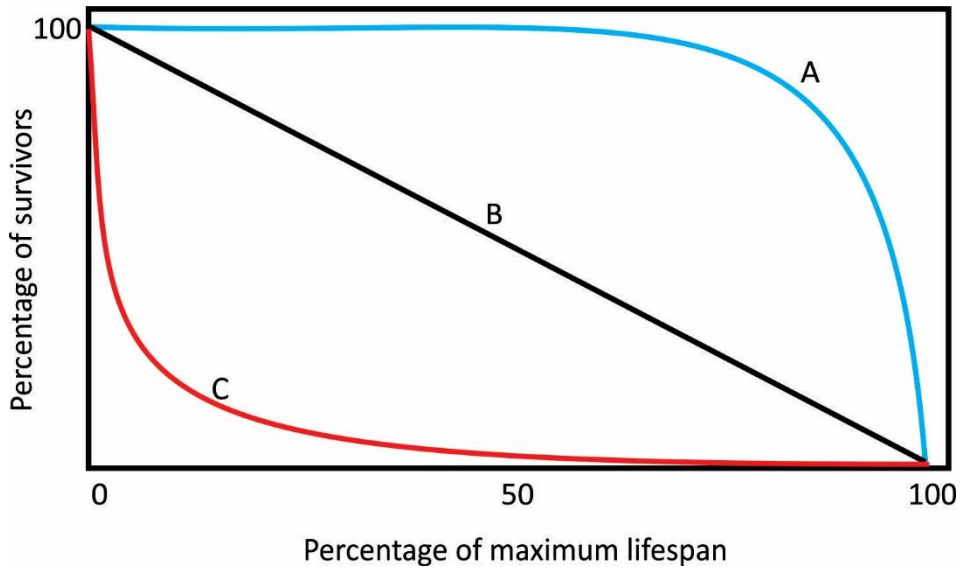
(b) Draw a diagram of a human sperm cell. Provide THREE suitable labels. (5)

(c) Do you think studying reproduction in sea urchins would be valuable to understanding more about human reproduction? Explain your answer. (2)

4.1.4 Suggest why human sperm cells contain many more mitochondria than sea urchin sperm cells. (2)

4.1.5 Three survivorship curves are shown in Figure 4.2 below:

Figure 4.2: Survivorship curves



[Adapted: <https://vt-vtwa-assets.varsitytutors.com>]

Suggest which line (A, B or C) would represent sea urchins. Provide reasons about sea urchin reproduction to support your answer. (4)

4.2 Read the information below and answer the questions that follow.

In 1856, Gregor Mendel conducted many experiments that investigated the inheritance of characteristics using nearly 30 000 garden pea plants. Pea plants naturally self-fertilise, which results in true-breeding or homozygous pea plants that always look like the parent plant.

Mendel performed hybridisations that involved two homozygous plants with different traits for a particular characteristic, e.g., flower colour. He called these dominant and recessive traits.

Figure 4.3 on the right shows the parts of a pea plant flower, similar to the flowers used by Mendel in his breeding experiments.

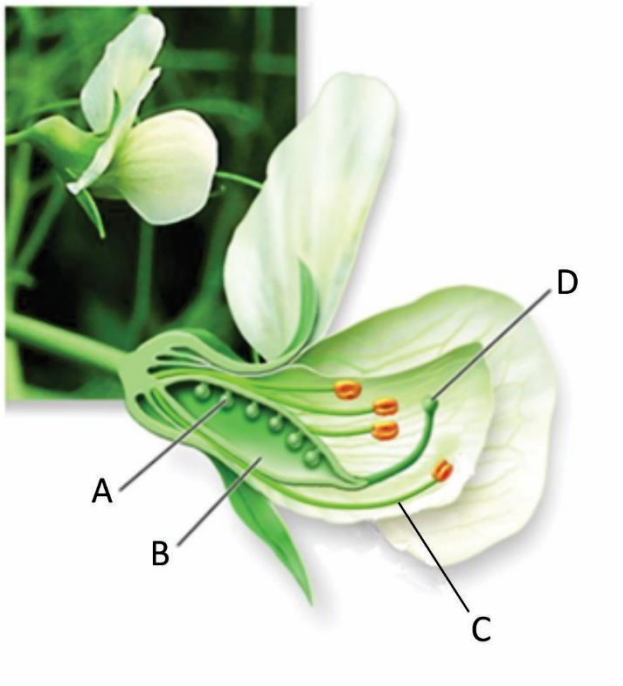


Figure 4.3: Structure of the pea flower

[Adapted: <https://biology-forums.com>]

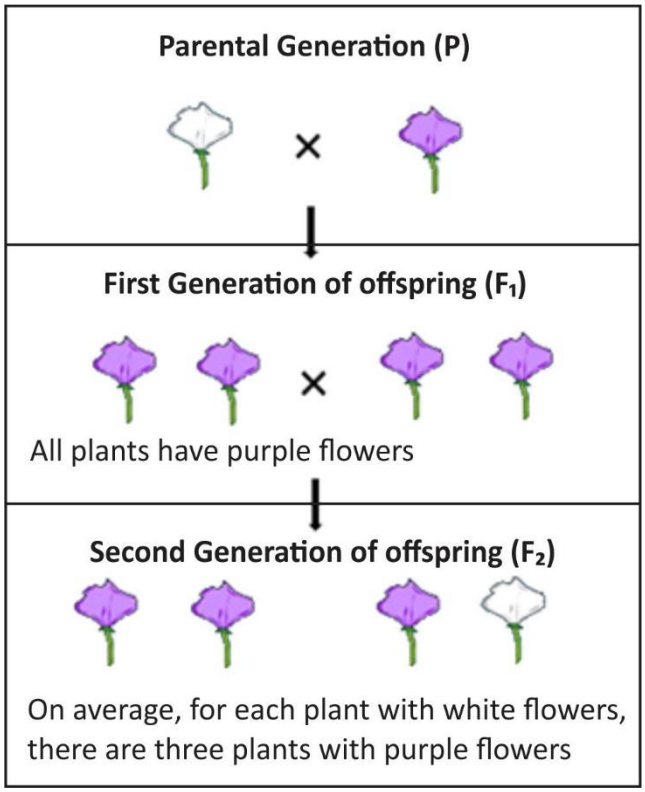
4.2.1 Provide labels for part A to D. (4)

4.2.2 What is the function of the part labelled D? (2)

4.2.3 Identify the type of section represented in the flower in Figure 4.3. (1)

4.2.4 State the letter from Figure 4.3 that contains the female gametes. (1)

4.2.5 In Mendel's hybridisation experiments, he crossed plants that were homozygous dominant for purple flowers (**A**) with plants that were recessive for white flowers (**a**). The image below shows the ratios of the F_1 and F_2 generations of offspring.



[Adapted: <https://www.cusd80.com/cms/lib>]

(a) State the genotype of the plant with white flowers in the parental generation. (1)

(b) Draw a Punnett diagram to illustrate the cross shown at the F_1 generation. Give the genotypic results of the F_2 generation. (6)

(c) How did Mendel ensure that he controlled cross pollination in his breeding experiments? (2)

4.2.6 Discuss how the results of Mendel's experiments advanced our knowledge of modern genetics. (4)

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Total: 200 marks