NATIONAL SENIOR CERTIFICATE EXAMINATION
SUPPLEMENTARY EXAMINATION – MARCH 2018

LIFE SCIENCES: PAPER II

Time: 2 hours | 100 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

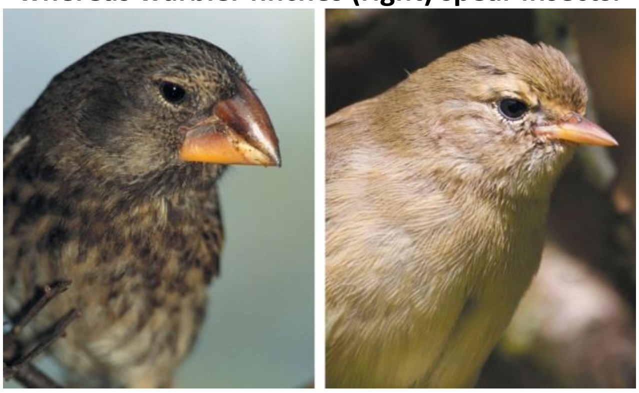
1. This question paper consists of 16 pages. Please check that your question paper is complete.
2. All questions must be answered in the Answer Booklet provided.
3. This paper consists of three questions. Question 1 and Question 2 are case studies and Question 3 is an essay.
4. Read the questions carefully.
5. Read the sources provided for the data response questions and use the information and your own knowledge to answer Questions 1 and 2.
6. Source material is also provided for the essay. Use this information and your own knowledge to first plan and then write your response.
7. Number the answers exactly as the questions are numbered.
8. Use the total number of marks that can be awarded for each part of the questions in Question 1 and 2 as an indication of the detail required.
9. It is in your own interest to write legibly and to present your work neatly.

QUESTION 1

Read the information below on the speciation of the Galápagos finches and use the information to answer the questions that follow.

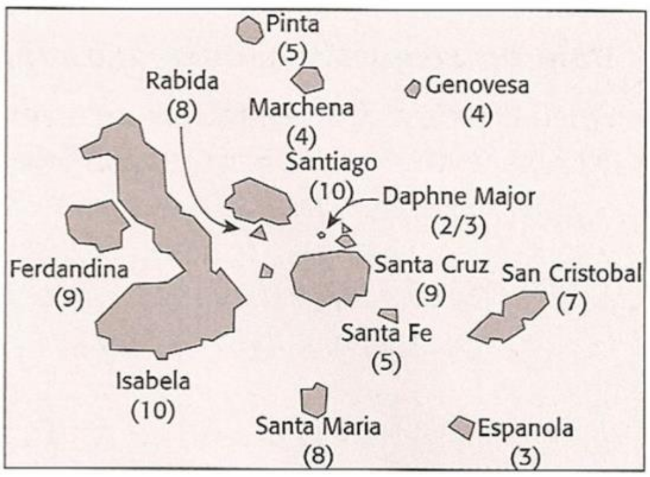
When Charles Darwin visited the Galápagos Islands in September 1835, it was the start of five weeks that would change the world of science, although he did not know it at the time. Among other finds, he observed and collected the variety of small birds that inhabited the islands. When he was back in London, puzzling over the birds, he realised that they were all different, but closely related species of finch and this observation led him to formulate the principle of natural selection. Darwin noted, "One might really fancy that, from an original paucity (lack) of birds in this archipelago (a group of islands), one species had been taken and modified for different ends."

Ground finches (left) tend to have large beaks for cracking seeds, whereas warbler finches (right) spear insects.



[Source: <http://www.nature.com>]

The Galápagos Islands have been called a living laboratory where speciation can be seen at work. A few million years ago, one species of finch migrated to the rocky Galápagos from the mainland of Central or South America.



The Galápagos archipelago with the number of species of finch found on each island

Map showing position of Galápagos Islands

[Source: <http://Galapagos-Islands-Map.jpg>]

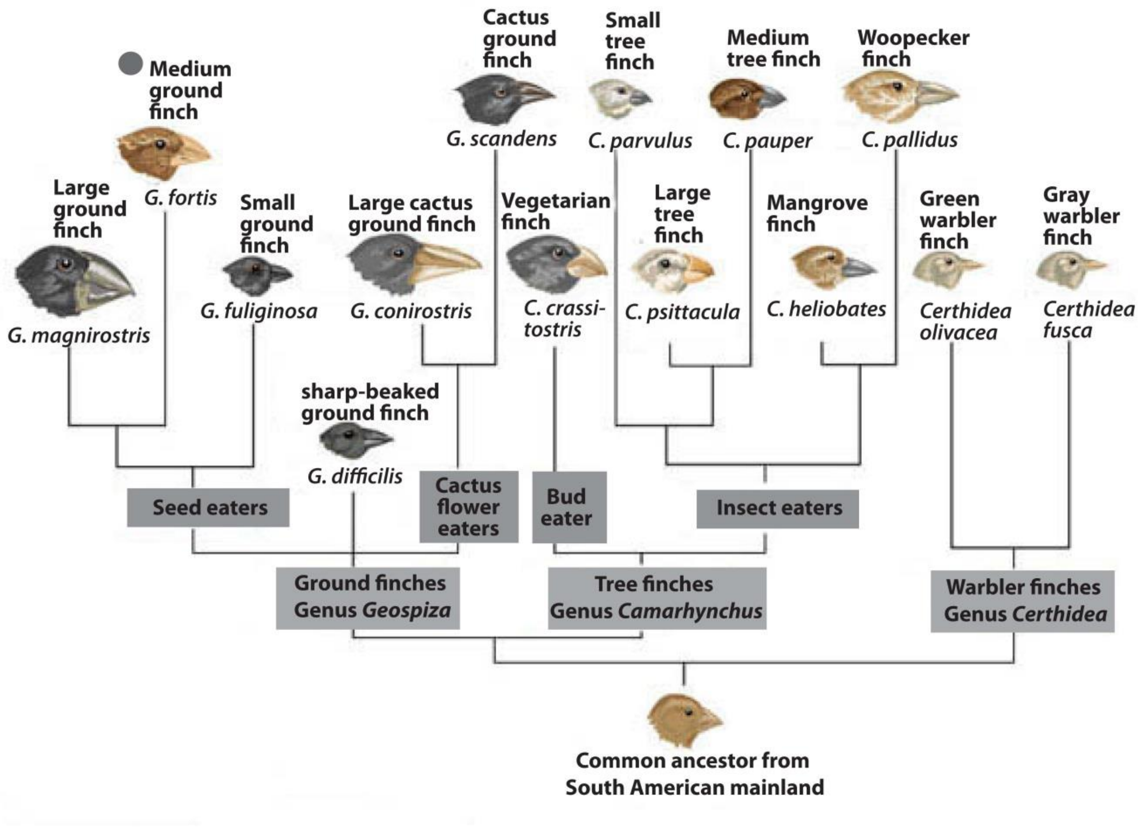
Adaptive radiation of Galápagos finches

The process in which one species gives rise to multiple species that exploit different niches is called adaptive radiation. The ecological niches exert the selection pressures that push the populations in various directions. On various islands, finch species have become adapted for different diets: seeds, insects, flowers, the blood of seabirds, and leaves.

The ancestral finch was a ground-dwelling, seed-eating finch. After the burst of speciation in the Galápagos, a total of 14 species evolved: three species of ground-dwelling seed-eaters; three others living on cactuses and eating seeds; one living in trees and eating seeds; and 7 species of tree-dwelling insect-eaters.

Scientists, long after Darwin, spent years trying to understand the process that had created so many types of finches that differed mainly in the size and shape of their beaks.

Family tree of Darwin's Galápagos finches



"Instant" evolution seen in Darwin's finches

Evolution may sometimes happen so fast that it's hard to catch in action. In their investigation, biologists Peter and Rosemary Grant from Princeton University observed a species of finch in the Galápagos Islands that evolved to have a smaller beak within 20 years.

They have spent many years in the Galápagos, seeing changing climatic conditions from year to year dramatically altering the food supply. As a result, certain of the finches have lived or died depending on which species' beak structure was best adapted for the most abundant food – just as Darwin would have predicted. Peter and Rosemary Grant have received great honour and recognition for their long-term research on the evolutionary impact of the Galápagos Islands.

Changing beaks, changing diet

In their natural laboratory, the 100-acre island called Daphne Major, the Grants and their assistants watched the struggle for survival among individuals of Darwin's finches. The struggle is mainly about food – different types of seeds – and the availability of that food is dramatically influenced by year-to-year weather changes.

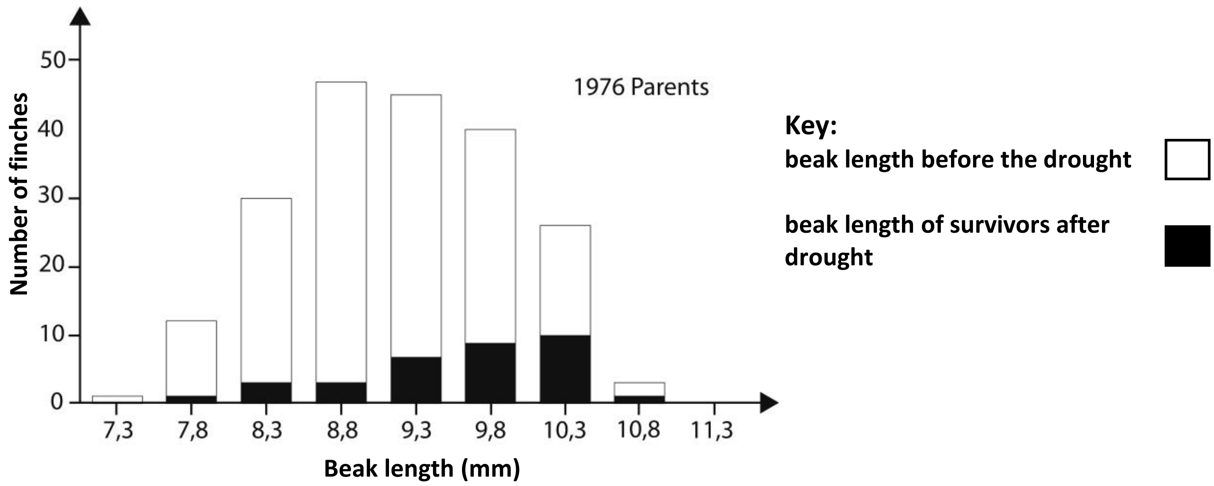
The Grants wanted to find out whether they could see the force of natural selection at work, judging by which birds survived the changing environment. For the finches, the size and shape of their beaks are traits that vary in adapting to environmental niches or changes in those niches. Beak variation occurs randomly. The birds with the best-suited bodies and beaks for the particular environment survive and pass along the successful adaptation from one generation to another through natural selection.

During a severe drought in 1977 the vegetation withered. Seeds of all kinds were scarce. The small, soft ones were quickly eaten by the birds, leaving mainly large, tough seeds that the finches normally ignore. One of the plants to make it through the drought produces seeds in large, tough fruits that are virtually impossible for birds with a small beak to eat.

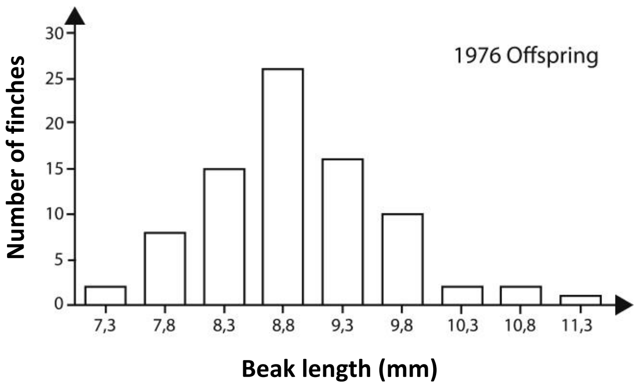
The struggle to survive favoured the larger birds with deep, strong beaks for opening the hard seeds. Smaller finches with less-powerful beaks died. So, the birds that were the winners in the game of natural selection lived to reproduce. The big-beaked finches just happened to be the ones favoured by the particular set of conditions Nature imposed that year. The Grants found that the offspring of the birds that survived the 1977 drought tended to be larger, with bigger beaks. So, the adaptation to a changed environment led to a larger-beaked finch population in the following generation.

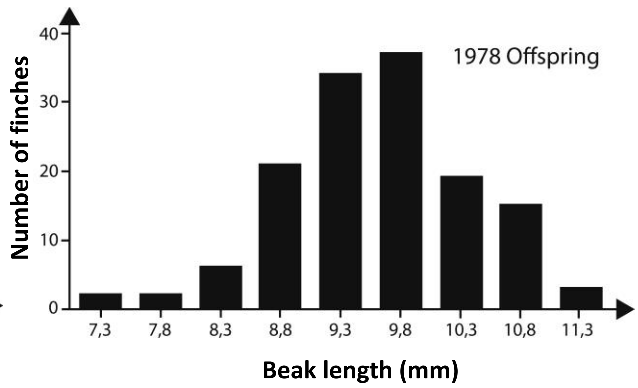
The effects of competition are apparent in the graph below when this event is compared to a drought in 1977.

GRAPH A: Distribution of beak length in the breeding population of medium ground finches (*Geospiza fortis*) on the island of Daphne Major in 1976 and of the survivors of the 1977 drought.



GRAPHS B: The distributions of beak lengths of offspring after hatching in 1976 and 1978. The difference is a measurement of evolutionary change between generations.





Genome sequencing of Galápagos finches

Recently geneticists at Uppsala University have sequenced the genomes of all 14 species of Darwin's finches, revealing a key gene responsible for the diversity in the birds' beaks. The study, published online in *Nature*, analysed samples from 120 individual birds. The researchers were able to pinpoint the genes responsible for beak morphology. One of those genes, *ALX1*, is involved in the facial development of vertebrates, including fish and mammals. In humans, for example, loss of *ALX1* leads to severe facial deformities. They suspect that *ALX1* drove the adaptation in the beaks of finches. What would Darwin make of the findings? "We would have to give him a crash course in genetics," Grant says. "But then he would be delighted. The results are entirely consistent with his ideas."

[Adapted from: <http://animals.nationalgeographic.com>; <https://myweb.rollins.edu>; <http://www.hhmi.org>; <http://www.pbs.org/wgbh/evolution>]

1.1 Write down the term/name from the text which matches the following descriptions:

1.1.1 An organism's complete set of DNA, including all of its genes. (1)

1.1.2 The diversification of a group of organisms into forms filling different ecological niches. (1)

1.1.3 The gene responsible for facial development in vertebrates. (1)

1.1.4 The process by which different kinds of living organism are believed to have developed from earlier forms during the history of the earth. (1)

1.2 Use information from the family tree of finches on page 3 to draw up a table of ONE difference in beak shape between seed eaters and cactus flower eaters and ONE named example of each type of finch. (5)

1.3 Use information from the graphs on pages 4 and 5 to answer the following questions:

1.3.1 Based on the data provided by graph A, what conclusion can be drawn about the effect of drought on the beak of the medium ground finch? (2)

1.3.2 Calculate the difference in the greatest beak length between the finch offspring in the years 1976 and 1978 as seen in graphs B. (2)

1.4 1.4.1 Explain clearly the selection pressure caused by the drought that drove the beak adaptations in the medium ground finch. (3)

1.4.2 Describe ONE observation that would confirm that the development of the medium ground finches with longer beaks are a new species of finch. (1)

1.5 1.5.1 From the information provided, explain how the diversification of many finch species from a common ancestor is an example of Darwin's theory of natural selection. (6)

1.5.2 Is the evolution of the many finch species on the Galápagos Islands an example of sympatric or allopatric speciation? Give clear reasons for your answer. (3)

1.5.3 How would Lamarck have explained the shift in beak size in the medium ground finch? (2)

1.6 Suggest what Peter Grant meant when he said that the finch genome sequencing would have 'delighted' Darwin after he was given a 'crash course in genetics'. (2)

[30]

QUESTION 2

Read the information below on the evolution of hominid skulls and use the information to answer the questions that follow.

Slicing meat may have aided human evolution

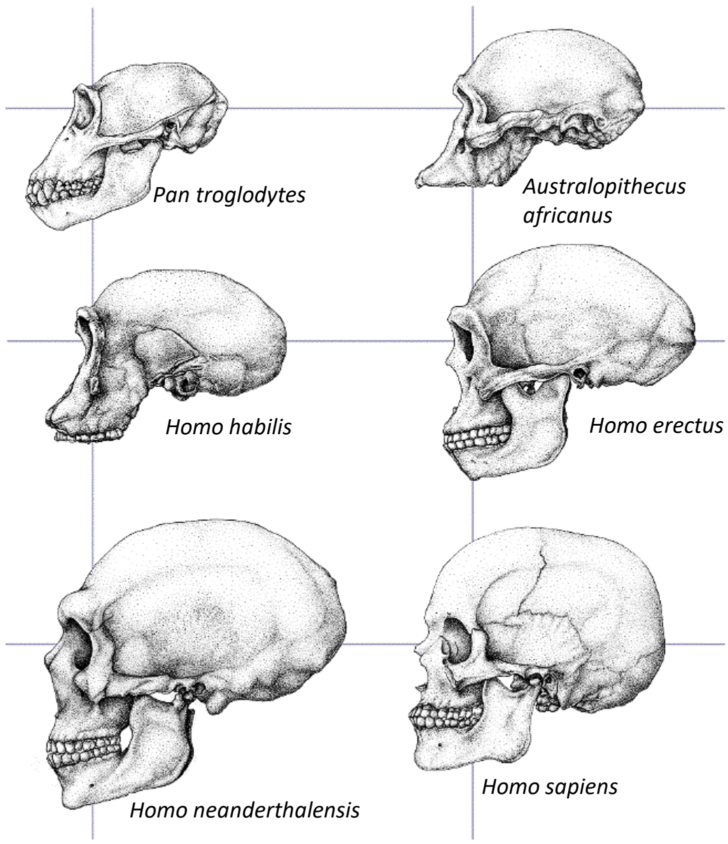
The change in diet of hominids from a plant-based diet to a more meat-eating one meant less energy was required for chewing. Sliced meats, usually cooked, are part of many modern diets. But our ancestors may have been eating raw slices. And that could have led to changes in the human body, a new study finds.

Early members of *Homo*, the human genus, had a flair for preparing raw sliced meat, a new study suggests. That meaty diet may have literally changed the face of *Homo* evolution. It also may have enabled advances in talking and walking.

The early human ancestor that used stone tools to slice up raw meat before eating it is known as *Homo erectus*. These early hominids lived some 1,8 million years ago in Africa and Eurasia. Slicing meat would have made it possible to consume more calories while reducing chewing effort, say Katherine Zink and Daniel Lieberman. They are paleoanthropologists at Harvard University. They reported their findings online on March 9, 2017 in *Nature*.

With less chewing needed, faces and jaws could get smaller, they conclude. And an energy-rich diet allowed hominid brains and bodies to enlarge. The shrinkage of bones and muscles involved in chewing also would have affected other parts of the body, these scientists argue. An expanded vocal tract would have boosted the ability of these early ancestors to make speech sounds. And a realignment of the base of the skull would have led to a repositioning of the spinal cord. That led to an increased ability to walk and run long distances.

Homo erectus (shown alongside) and other early members of the *Homo* genus evolved relatively small jaws and faces because they sliced raw meat with stone tools. That would have made it easier to chew and digest, the study concludes.



Diagrams showing the skulls of hominids and a chimpanzee

Zink and Lieberman made their findings through a study of modern-day humans. A total of 34 adults were given measured portions of goat meat or three plants rich in starch. These were jewel yams, carrots and red beetroots. Food came either unprepared, sliced, cooked, or pounded using a stone to soften it. The volunteers had one job: Chew the food. The scientists then analysed how much the face muscles worked and tallied the number of chews needed to ready the different foods for swallowing. After an average of 40 chews, participants still struggled to break apart 3-gram chunks of raw goat meat. Cooked chunks were no easier to chew into pieces. Meat sliced from raw, 3-gram chunks, however, required an average of about 31 chews to break into pieces small enough to easily swallow and digest.

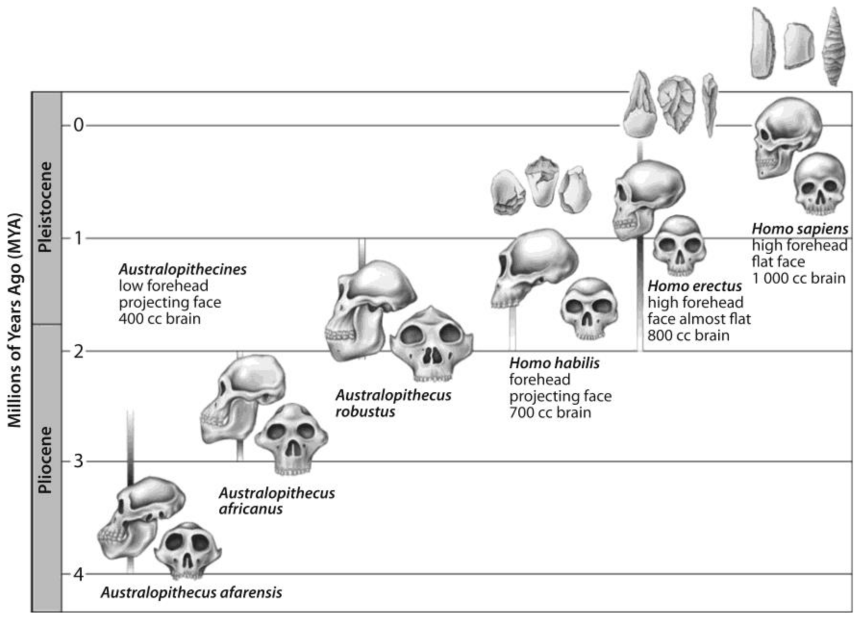
The researchers assumed that *H. erectus* may have gotten one-third of its total calories from sliced meat. The rest would have come from stone-pounded plants, such as jewel yams. With that ratio, *H. erectus* would have needed to chew its food 17 percent less and exert 26 percent less force than if only unprepared plants were consumed, the scientists now estimate. Over a year, they calculate, dining on sliced meat could have saved *H. erectus* more than 2,5 million chews.

Images of the lower jaw and teeth of a chimpanzee (left),
***Australopithecus afarensis* (middle) and *Homo sapiens* (right)**

[Source: <https://www.quora.com/Why-dont-humans-have-chimpanzees-like-teeth>]

Cooking makes it even easier to chew and digest meat and edible plants such as yams, Zink and Lieberman noted. But they estimate that our hominid ancestors began to regularly cook food only about 500 000 years ago. Cooking, the researchers say, would have stimulated further jaw and facial shrinkage in *Homo sapiens* – our species – but not in *H. erectus*. Instead, they conclude, a taste for sliced, raw meat got those facial changes off to a fast start in *H. erectus*.

Graph showing the increase in brain size of hominids over time



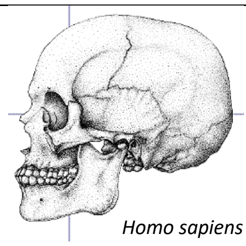
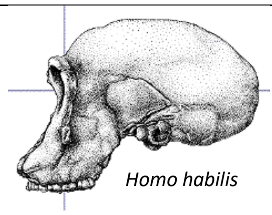
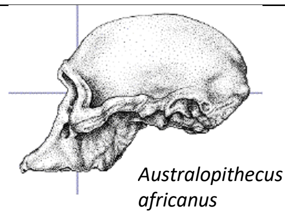
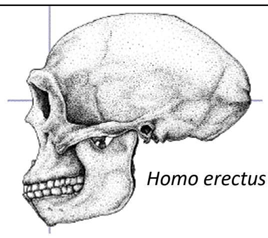
[Adapted from: <http://www.mhhe.com/biosci/genbio/>]

Researchers have long noted that *H. erectus* skulls display relatively smaller jaws and faces than relatives that preceded the *Homo* genus more than 2 million years ago. The new study provides the first evidence for a decades-old assumption that tools for meat-eaters prompted the evolution of smaller faces in early *Homo*, says Manuel Domínguez-Rodrigo.

He works at the Complutense University of Madrid in Spain. "The key is the consumption of sliced meat," he says. And it, he notes, was "enabled by the use of stone tools. *H. erectus* must have regularly hunted prey to maintain a diet of about one-third meat," Domínguez-Rodrigo adds.

[Adapted from: <https://www.sciencenewsforstudents.org/article/slicingmeatmayhaveaidedhumanevolution>]

2.1 Match the information in column A with the correct skull in column B. Write only the number from column A and the matching letter from column B in your Answer Book.

A.	Description of skull	B.	Skull of hominid
2.1.1	Projecting face 400 cc brain	A.	
2.1.2	Flatter, less sloping face 800 cc brain	B.	
2.1.3	Flat face 1000 cc brain	C.	
2.1.4	Projecting face 700 cc brain	D.	

*cc = cubic centimetres (4)

2.2 2.2.1 Sketch a simple bar graph to represent the results of the chewing experiment conducted by the scientists at Harvard University. (5)

2.2.2 Explain clearly what the scientists concluded from their chewing investigation about human evolution. (5)

2.3 From all the information provided, describe ONE other evolutionary development in the skulls of hominids as seen in the diagrams on page 7 and explain the importance of this development. (3)

2.4 Use the information in the graph on page 8 and your own knowledge to answer the following questions:

2.4.1 How long ago did *Australopithecus africanus* live? (1)

2.4.2 Which species of hominid on the graph is represented by the fossil 'Lucy'? (1)

2.4.3 Explain the evolutionary link between tool development and brain size as described in the text. (2)

2.4.4 How are the earlier tools different to the more modern stone tools? (1)

2.4.5 Name a hominid that lived about 500 000 years ago and probably cooked its food. (1)

2.5 2.5.1 Describe the difference in the teeth and lower jaws seen in the image on page 8. (2)

2.5.2 How do these differences support the information given about the change in diets of our human ancestors? (2)

2.6 2.6.1 Which of the hominids mentioned in the text migrated into Europe from Africa? (1)

2.6.2 Briefly describe ONE of the theories for the migration of modern humans across the world. (2)

[30]

QUESTION 3

The benefits of selective breeding for the production of more desirable plants and animals outweigh the disadvantages of these breeding methods.

Using the source material provided as well as your own knowledge, discuss your opinion on the above statement in the form of a 2½ – 3 page essay.

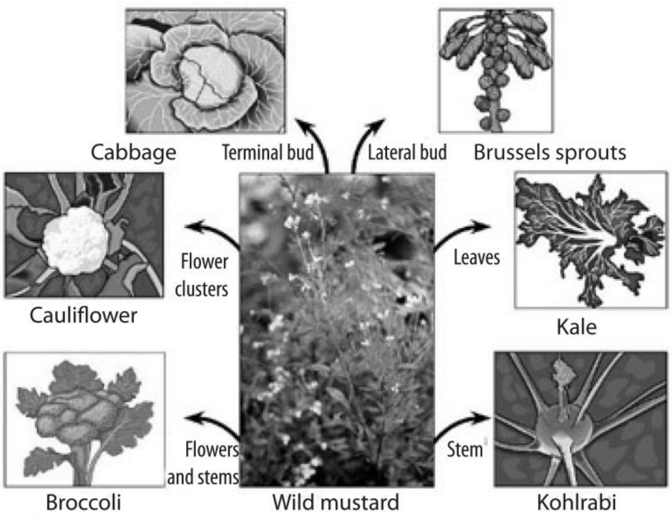
[40]

To answer this question you are expected to:

- Read the source material carefully and present a debated argument to illustrate your point of view.
- Select relevant information from sources A to H below.
- It is important to integrate your own relevant biological knowledge.
- Take a definite stand on the question and arrange the information to best develop your argument.
- Write in a way that is scientifically appropriate and communicates your point of view clearly.
- **Provide** a clear **plan** of your essay before you start writing. Note that the plan will be marked as part of the assessment of this question.

SOURCE A Humans have manipulated the genetic traits in species for thousands of years.

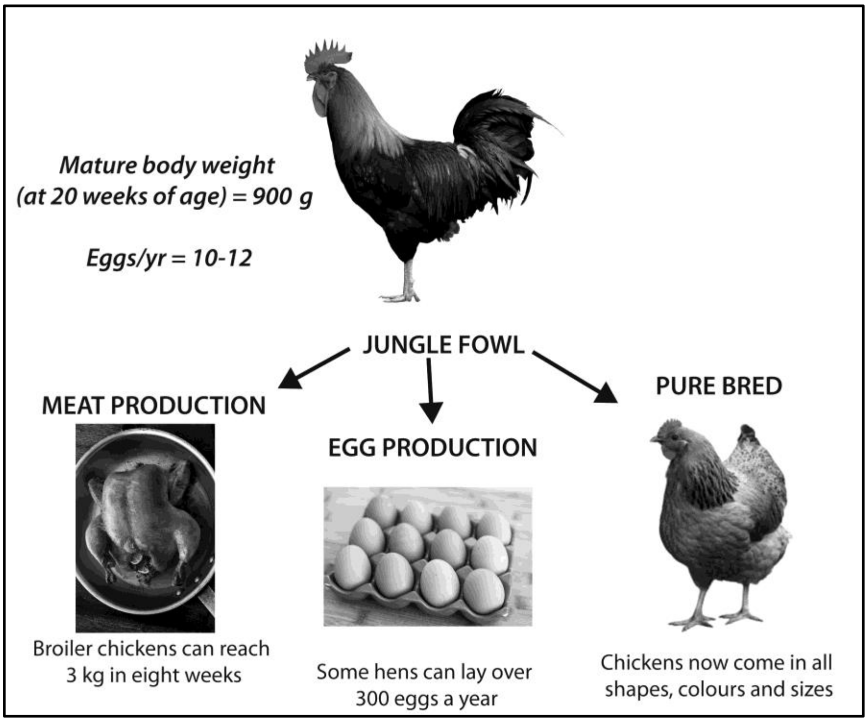
Selective breeding can be described as an animal or plant born with a desired trait, and bred by a farmer to produce more organisms with that trait. Selective breeding is why we have so many varieties of the cabbage-like plants; e.g. cabbage, kale, broccoli, cauliflower, and Brussels sprouts.



As shown in this image, each of these plants is a variation or cultivar of wild mustard (*Brassica oleracea*). Each cultivar was bred for thousands of years for specific features; cauliflower and broccoli were bred for their ability to produce flowering heads. The features seen in each cultivar were the results of naturally-occurring genetic differences found in the genome.

[Adapted from: <http://study.com/academy/lesson/genetic-manipulation-definition-pros-cons.html>]

SOURCE B **Results of generations of genetic selection of the Red Jungle Fowl to create specific-purpose chicken breeds.**
Source: Jacquie Jacob, University of Kentucky



All breeds of chickens around today are descended from the Red Jungle Fowl of Southeast Asia. Generations of genetic selection have developed breeds specialising in specific characteristics, as illustrated in the diagram. For example, the mature weight of the Red Jungle Fowl is only about 900 grams, whereas today's chicken breeds developed specifically for meat production can reach a market weight of 3 kilograms in only eight weeks. Similarly, while the sexually mature Red Jungle Fowl hen lays 10 to 12 eggs during the breeding season, hens from chicken breeds developed specifically for egg production lay year-round and can produce more than 300 eggs in a year.

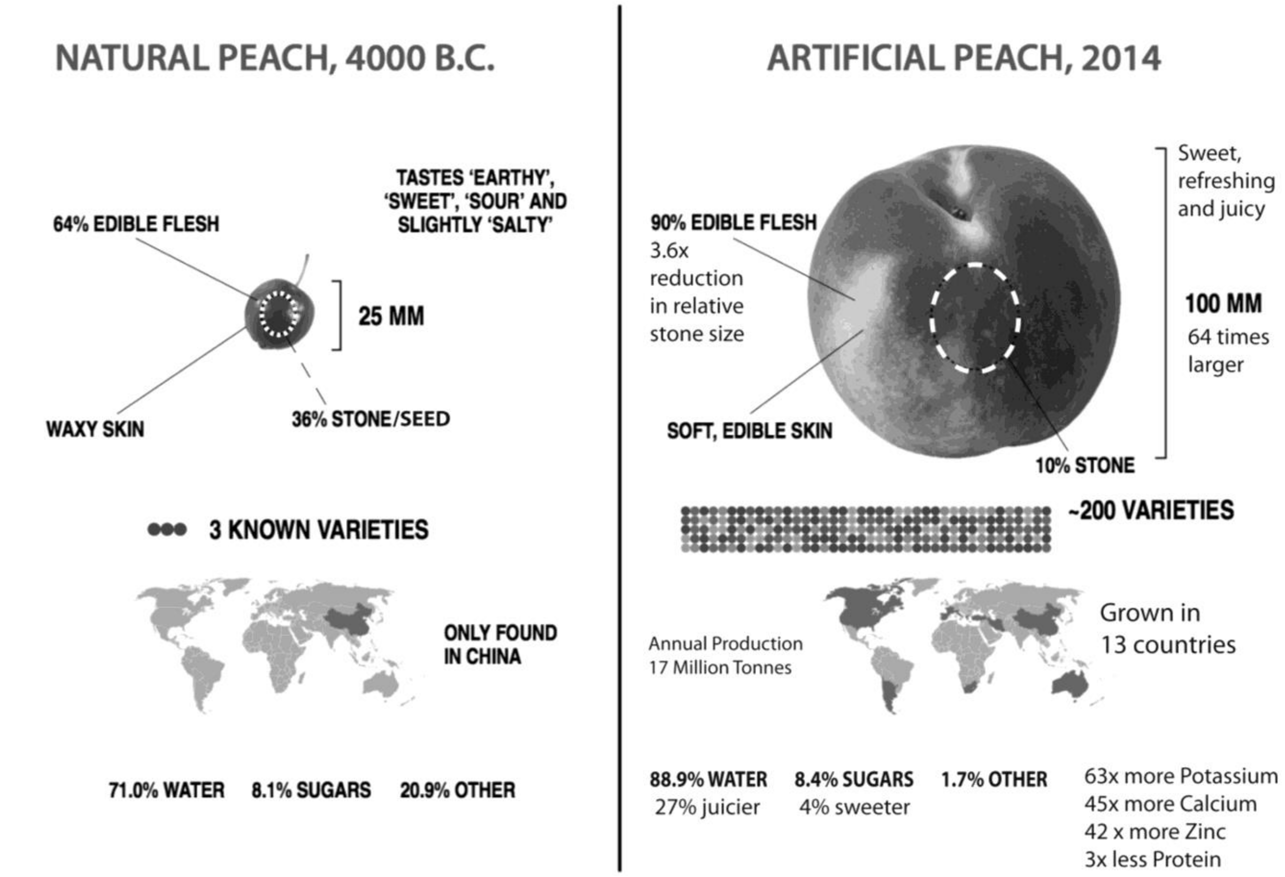
[Adapted from: <http://articles.extension.org/pages/65355/which-chicken-breed-is-best-for-small-and-backyard-poultry-flocks>]

SOURCE C **Then vs. Now: Our favourite foods before and after selective breeding.**

INTERNATIONAL
FOOD INFORMATION
COUNCIL FOUNDATION

Food Insight

Your Nutrition and Food Safety Resource



[Adapted from: <http://www.foodinsight.org/foods-before-now-gmo-biotechnology>]

SOURCE D **How the 'Poison Potato' impacted the GMO debate.**
Maggie Koerth-Baker | October 4, 2013

In the late 1960s, researchers from the US Department of Agriculture (USDA), Penn State University and the Wise Potato Chip Company collaborated to breed the "Lenape" potato. This new breed soon became hugely popular with potato chip manufacturers, due to the fact that it had the perfect combination of sugar and starch to produce the thin, crispy golden-brown potato chips that we know today.

But the Lenape potato's biggest legacy might be its impact on the GMO debate.

Credit: Evan-Amos, via Wikimedia Commons

After the new breed was introduced, the USDA found that it contained heightened levels of *solanine, an alkaloid chemical that helps protect the potato against pests that is also slightly toxic and harmful to humans.

The Lenape potato shows that risk and uncertainty is not just associated with genetically modified crops, but crops that come from conventional breeding as well. There is actually a lot more risk and uncertainty with conventional breeding, than there is with genetic modification (GM). That's because, with GM, you're mucking about with a single gene. There are a lot more genes in play with conventional breeding, and a lot more ways that surprising genetic interactions could come back to haunt you.

[*Solanine poisoning causes gastrointestinal and neurological disorders. Symptoms include nausea, diarrhoea, vomiting, stomach cramps, burning of the throat, headaches and dizziness. Hallucinations, loss of sensation, and paralysis, fever, jaundice, dilated pupils and hypothermia have been reported in more severe cases. In large quantities, solanine poisoning can cause death.]

[Adapted from: <https://www.geneticliteracyproject.org/2013/10/04/potato-chips-dangerously-delicious/>]

SOURCE E Back from the dead? First quagga project sales reach record prices at auction.

On Friday the 17th of March 2017, three unusual-looking plains zebras sold at auction for an astonishing R1 740 000 – R580 000 each.

According to Mike Gregor, Chairman of the Quagga Project, "typically it is difficult to even find a buyer for plains zebra. But these animals are far from typical. Nothing like this has ever been offered for sale before and with this money we can finally begin to right a terrible wrong inflicted on the quagga a hundred and fifty years ago."

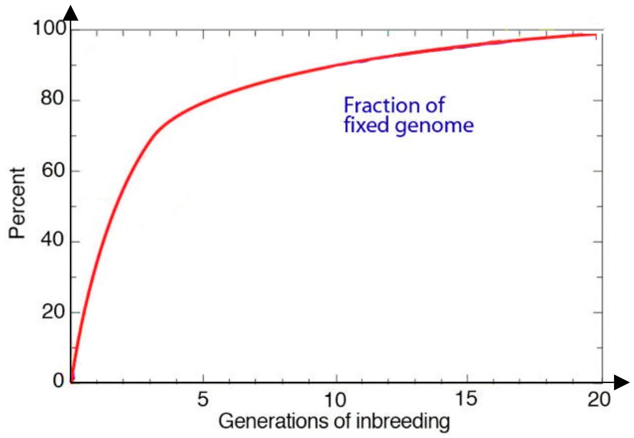
Decades of selective breeding, rigorous attention to the defining characteristics of the lost quagga, and an exhausting, collective effort have persuaded wildlife specialists that the 'extinct' quagga is indeed on the way back.

- The quagga is an extinct, less-stripy cousin of the African plains zebra.
- The animal disappeared from South Africa in the 1880s due to over-hunting.
- But scientists are using a selective breeding programme to bring it back.

They are selecting for specific genetic traits in order to breed animals which resemble the quagga as closely as possible.

[Adapted from: <https://quaggaproject.org/>]

SOURCE F Effect of inbreeding on homozygous alleles



The graph shows the cumulated effect of inbreeding on homozygosity across the first 20 generations. After 20 generations, it has been calculated that 98,7% of the loci are present in a homozygous state and this increases to 99,98% after 40 generations.

[Adapted from: <http://nfs.unipv.lectures/files/inbred_congenic.html>]

SOURCE G Pedigreed pets

Plant and animal breeders usually employ controlled mating to increase the frequency of desirable traits and to reduce genetic variation in a population. In effect, they try to guide the direction of evolution by preventing some individuals from mating and encouraging others to do so. By doing this, in a sense they are acting in the place of nature in selecting winners and losers in the competition for survival. This method has been used to develop purebred varieties of laboratory mice, dogs, horses, and other pets and farm animals.

Ancient (left) and modern bulldog (right) skulls compared to illustrate how breeders have altered the skull and jaw in 300 years. The concentrated repetition of aberrant mutations of the cranium and 'upper' jaw (maxilla) has resulted in this defect.

Darwin stated the following on observing the trends in bulldog breeding:
"Some of the peculiarities characteristic of the several breeds of dog have arisen suddenly, and, though strictly inherited, may be called ***'monstrosities'****; for instance, the shape of the head and the under-hanging jaw in the* ***bulldog****. A peculiarity suddenly arising, and deserving to be called a* ***'monstrosity'****, may be increased and fixed by man's selection".*
(Charles Darwin, 'The Variation of Animals and Plants under Domestication', Vol. 1, London, 1875)

[Adapted from: <http://www.gaiaresearch.co.za/bbgaiabulldogreport.html>]

SOURCE H **Animals are not ours to eat, wear, experiment on, use for entertainment, or abuse in any other way.**
People for the Ethical Treatment of Animals.

These 'mutant' cattle aren't monsters – they're victims

They're called Belgian blue bulls, and the reason they look so bulky is because of a naturally occurring mutation called "double muscling," which occurs when the animals lack a certain protein that regulates muscle growth. While double muscling is natural, the way the mutation has been kept going is not. The meat industry selectively breeds animals who exhibit this mutation to produce bigger animals and, therefore, more meat.

This comes at a high price for the animals. Because of their abnormally large size, Belgian blue cattle often endure many serious health problems:

- Pregnancies are very difficult, and the animals almost always require C-sections to deliver their calves.
- Once the calves are born, they may have a number of birth defects, including enlarged tongues, which can make it difficult – or even impossible – for them to feed.
- They may also suffer from cardio-respiratory, bone, and joint problems, among other ailments.
- All this can mean a very uncomfortable existence for these animals and often leads to a premature death.

[Adapted from: <http://www.peta.org/blog/belgian-blue-cattle/>]

Total: 100 marks