



NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2014

LIFE SCIENCES: PAPER I

Time: 2½ hours

150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

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

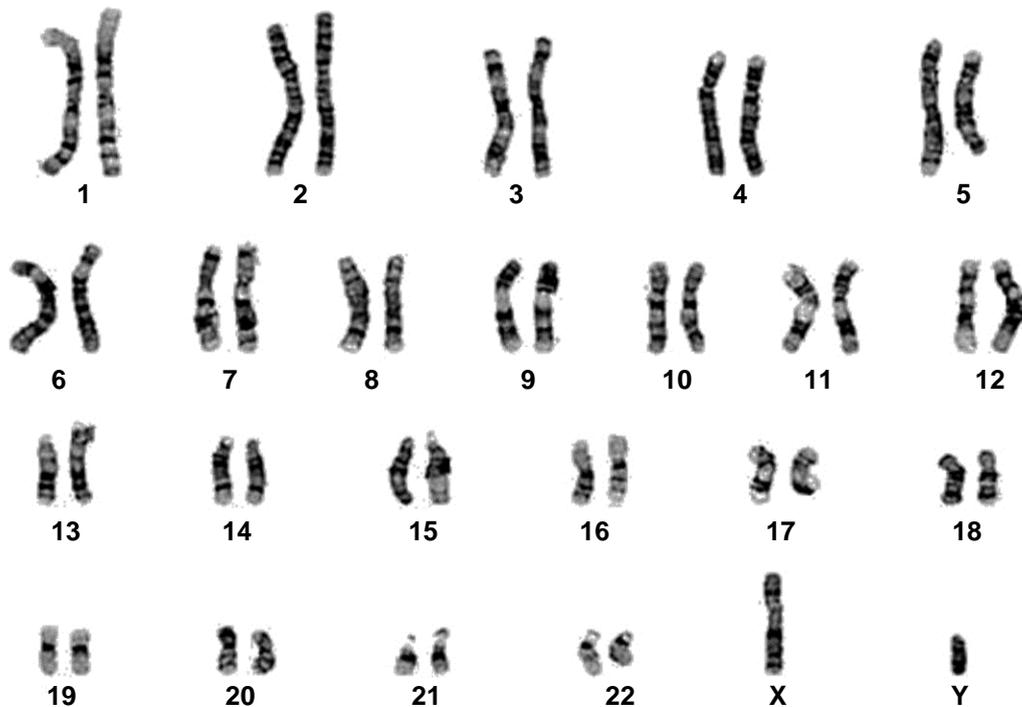
2.1 Use the information below and your own knowledge to answer the following questions.

Cri-du-chat is one of the most common human disorders caused by a type of mutation, named a deletion, on chromosome 5. The name 'Cri-du-chat' is French for 'cry of the cat'.

Symptoms:

- Poorly developed larynx leading to catlike cry
- Babies have a small head and chin, round face, a fold of skin over the eyes and the eyes are widely set
- Health problems include heart defects, hearing and sight problems, respiratory problems and poor muscle tone
- Difficulty in walking and talking correctly
- Severe mental retardation

Karyotype of an individual with Cri-du-chat



[Adapted: <<http://teacherweb.com>>]

- 2.1.1 Is this karyotype from a male or female individual? Give a reason for your answer. (2)
- 2.1.2 Describe how and why the appearance of chromosome 5 on the karyotype above indicates that this individual has Cri-du-chat syndrome. (2)
- 2.1.3 List THREE phenotypic outcomes in a person with Cri-du-chat. (3)
- 2.1.4 Do you think that the parents of a child with Cri-du-chat should seek genetic counselling before having another baby? Provide reasons to support your opinion. (4)
- 2.1.5 Briefly explain the scientific term 'deletion mutation' when it is referred to in general and state how a deletion changes a genotype. (2)

2.2 Describe an example of a beneficial mutation that led to an evolutionary change. (3)

2.3

FUR FROM A FLUFFY WHITE CAT USED IN MURDER TRIAL

Cat fur easily sticks to clothing and many surfaces. The genetic material in cat fur obtained from a crime scene has the potential to link perpetrators, accomplices, witnesses and victims.

Police found cat fur on the jacket of Douglas Beamish who was accused of murdering Shirley Duguay. The fur was the only forensic evidence in the case and was genetically linked to the victim's cat, 'Snowball'. It helped to convict Beamish of murder.

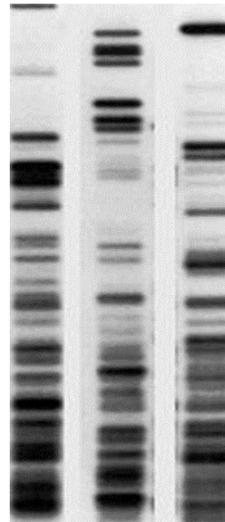
[Adapted: <news.discovery.com>]

A. Genetic profile of fur taken from suspect's jacket

B. Genetic profiles of 'Snowball' and two other cats in the neighbourhood

Cat fur on jacket

1 2 3



[<www.genetool.nlm.gov>]

(Diagrams in A and B not to the same scale)

2.3.1 Which of the cats' profiles, 1, 2 or 3, in B, belongs to 'Snowball'? Give a reason for your choice. (2)

2.3.2 Why do you think the crime investigators also included samples from the cats in Douglas Beamish's neighbourhood? (2)

2.3.3 (a) What is the 'genetic material' referred to in the text above? (1)

(b) Name ONE other type of body tissue/cell that could be used in obtaining forensic evidence. (1)

2.4 Use the information below and your own knowledge to answer the following questions.

A new 'cat' database in America is analysing mitochondrial DNA (mtDNA) which is useful in forensics due to two properties:

- It has a high mutation rate making comparisons easier
- Its genes exist in large amounts

It is an extensive database which could be widely used by criminal investigators.

2.4.1 Do you think South Africa should establish a DNA database for cats for forensic or other use? Give TWO well explained reasons for your opinion. (4)

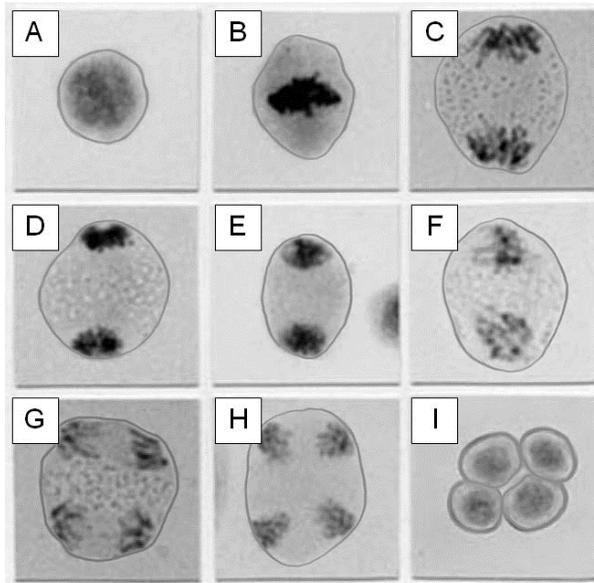
2.4.2 (a) Explain what (mitochondrial) mtDNA is. (2)

(b) State two properties of mtDNA that make it useful in forensics. (2)

[30]

QUESTION 3

3.1 Study the micrographs of a cell undergoing meiosis. They are shown in the correct sequence.



[<<http://www4.nau.edu/biology>>]

3.1.1 Give a visible reason for identifying meiosis in the cells seen above. (1)

3.1.2 State a correct term used to describe each of the following cells:
(Note: names of phases not required)

(a) the cell at A (1)

(b) the cells at I (1)

3.1.3 State the letter of a micrograph on the previous page where the following events would be occurring:

- (a) a cell in which DNA replication would be taking place (1)
- (b) a cell undergoing meiosis I where the chromosomes have **just** reached the opposite poles (1)

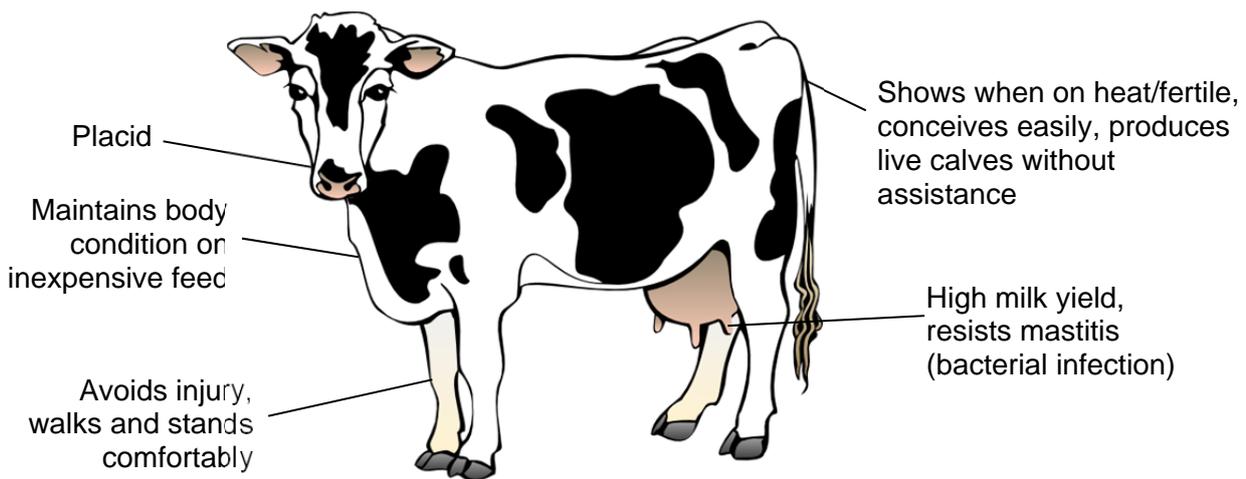
3.1.4 Discuss how meiosis brings about genetic variation in a species and explain why genetic variation can be described as the 'lifblood of evolution'. (6)

3.2

Cattle are selected by humans on the basis of desirable traits, e.g. quantity of milk produced, muscle mass. Scientists call this the 'genetic gain', i.e. the gain towards the most desirable phenotype. Some of the traits humans have selected for are shown in the diagram below.

A more direct way of breeding the best dairy cattle is by scientists finding genetic markers of desired characteristics through DNA analysis and selling commercially produced semen with these selected traits.

The Perfect Dairy Cow



[Adapted: <<http://www.greenup.com.au/>>]

3.2.1 (a) Most of the genetic improvements in dairy cattle have come about by traditional breeding methods of farmers. State a biological term used for the traditional breeding method performed by farmers to improve their herds. (1)

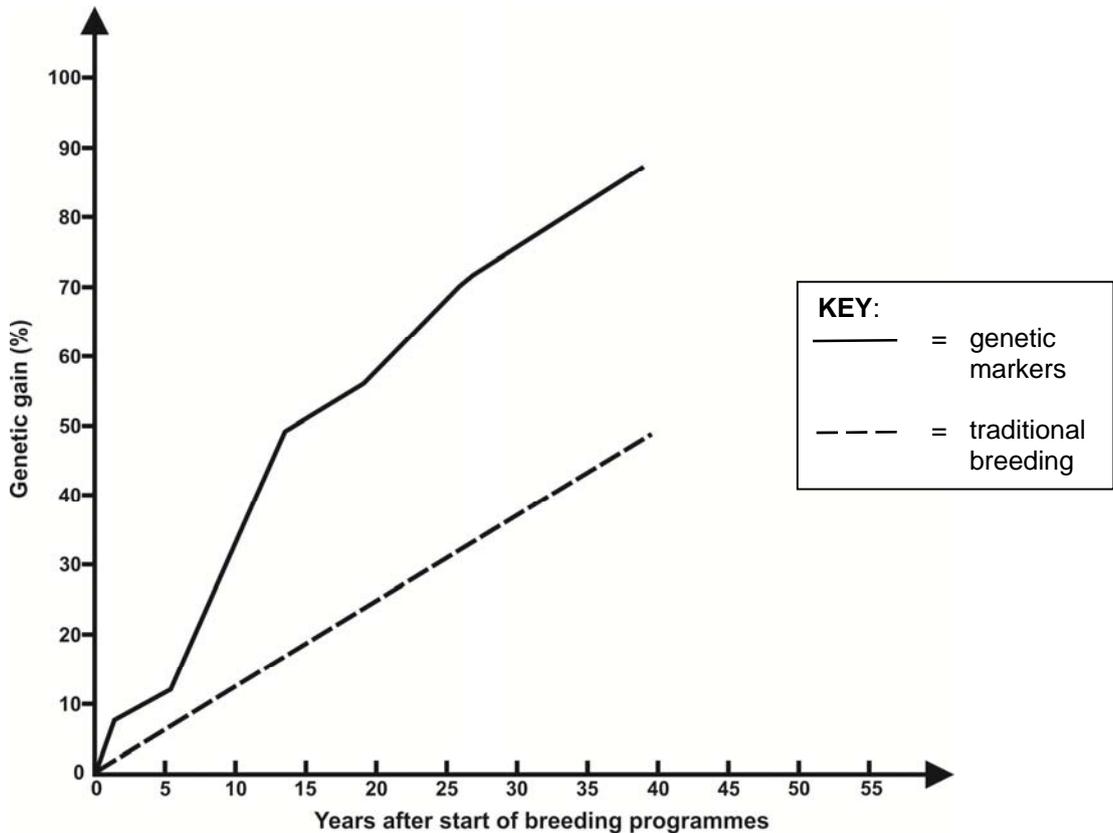
(b) What is meant by 'traits' in the text? (1)

3.2.2 List TWO features mentioned, other than milk production and muscle mass, that farmers might select in dairy cattle. (2)

3.2.3 Draw up a table of TWO clear differences between natural selection as defined by Darwin, and the traditional dairy breeding method you mentioned in Question 3.2.1 (a). (5)

3.2.4 An investigation comparing the two methods of achieving the perfect dairy cow started 35 years ago. The graph below illustrates the different results achieved from the breeding investigations.

Graph comparing the genetic gain from farmers' breeding programmes to the use of genetic markers



[Adapted: *Breeds of Livestock*, Oklahoma State University and Genetics Australia; 2001]

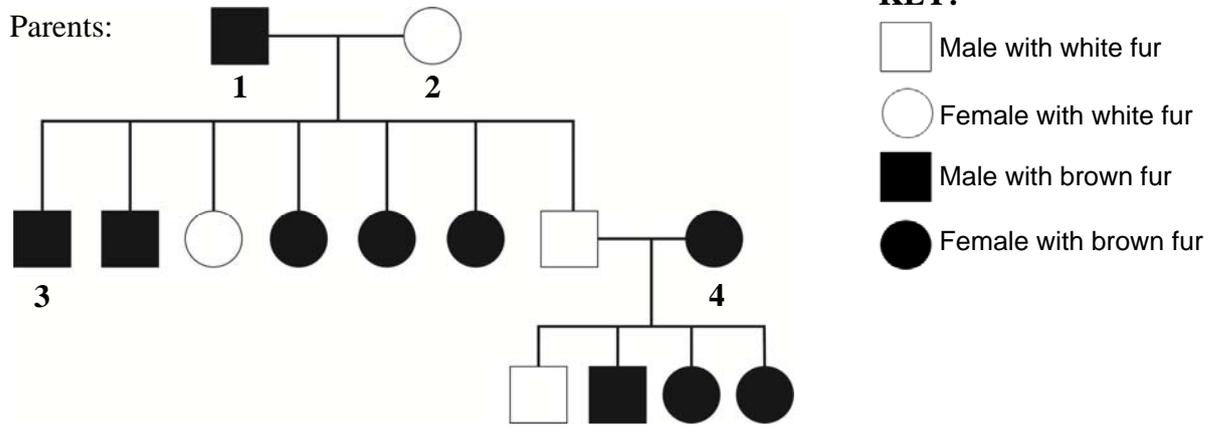
- (a) From the graph determine the difference in genetic gain after 30 years between traditional breeding and the use of genetic markers in dairy cattle. Show your working. (3)
 - (b) Use information on the graph to predict how many years it will take, from the start of the breeding programmes, to achieve the perfect dairy cow (100%) with the use of genetic markers. (1)
- 3.2.5 Why is it important that dairy breeding in South Africa has focussed on producing the 'perfect cow'? (2)
- 3.2.6 Explain the disadvantages associated with the breeding of highly pedigreed pets, e.g. dogs. (4)

[30]

QUESTION 4

4.1 Brown coat colour (B) in wild rabbits is determined by a dominant gene. A mutation in some rabbits caused a recessive gene for white coat colour (b).

Family tree showing a cross between a Heterozygous Brown Rabbit and a Homozygous White Rabbit

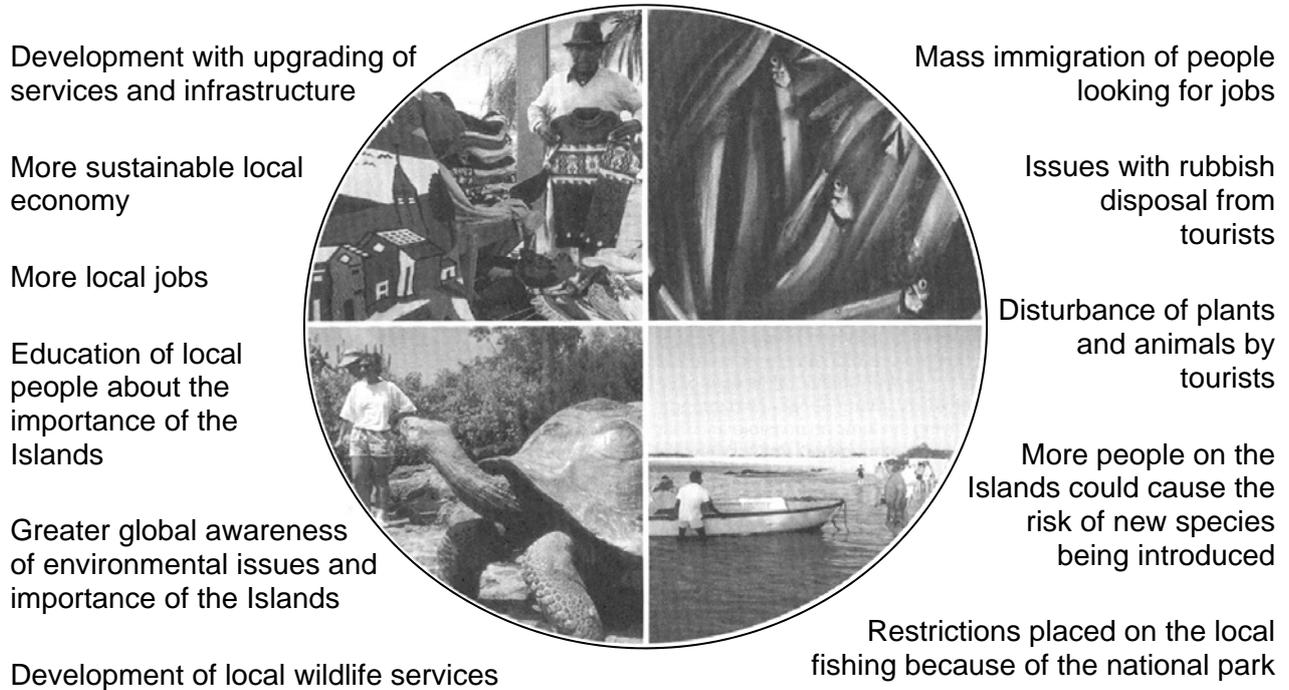


- 4.1.1 State the genotypes and genders (sexes) of both parents 1 and 2. (4)
- 4.1.2 (a) What is the phenotypic ratio for coat colour of the first generation of rabbits born to the parents? (2)
- (b) Explain why rabbit number 4 would be heterozygous for brown coat colour. (3)
- 4.1.3 Name the type of gametes (egg cells or sperm cells) produced by rabbit number 2 and state which alleles for fur colour are present in the gametes. (2)
- 4.1.4 (a) What is a possible environmental cause of a mutation such as the one which resulted in white fur? (1)
- (b) Explain a possible disadvantage of white fur in wild rabbits. (2)
- 4.1.5 (a) Suggest a reason why white coat colour might be more popular with pet shop owners. (1)
- (b) How could this preference for white fur negatively affect the gene pool of pet rabbits? (2)

4.2 Read the information below on ecotourism in the Galapagos Islands.

- 97% of the Galapagos Islands have been declared a national park
- Tourism is a major contributor to the economy
- More than 80 000 tourists travel through this ecologically sensitive area each year
- Since Charles Darwin's work on the Islands it remains a unique place for scientists to conduct research and work on evolutionary principles

Aspects of Ecotourism to the Galapagos Islands



[<www.geographyteachers.com>]

- 4.2.1 Describe ONE of the important observations that Charles Darwin made on the Galapagos Islands and explain how it contributed to his theory of evolution. (4)
- 4.2.2 Do you think the general public should be allowed to tour the Galapagos Islands? Justify your answer using facts from the text above. (4)

4.3 Use the information below to construct a flow diagram of the colonisation of the Galapagos Islands by plants.

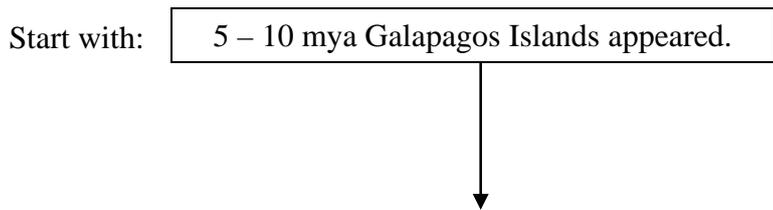
Five to ten million years ago, the underwater Galapagos volcanoes appeared for the first time in the middle of the Pacific Ocean. Those volcanic islands had no plant or animal life. All organisms that are now native to the islands must have originally arrived through some form of long-distance dispersal.

There are many grasses and ferns, but plants with heavier seeds are quite scarce because they would have had a more difficult time travelling by wind. Birds likely brought with them hitch-hiking plant seeds that were attached to their feathers or feet, or even in their guts.

Those plant species that were initially most successful were those of the 'weedy' variety with good tolerances for a variety of environmental conditions.

Many plants rely on insects or animals for pollination, and the chance of both a plant and its pollinator arriving to the islands together was unlikely. This can explain why there are so few showy flowering plants, but there are many wind-pollinated plants on the islands at present.

[Adapted: <<http://www.galapagos.org>>]



(5)
[30]

QUESTION 5

Collaboration (working together) amongst scientists has been a feature of many important scientific findings.

Is there any benefit in scientists working together to find out more about the evolution of modern humans (*Homo sapiens*)?

Read the source material carefully and present a debated argument to illustrate your point of view.

To answer this question you are expected to:

- Select relevant information from Sources A to H below. Do not attempt to use all the detail provided.
- Integrate your own relevant biological knowledge. However, do not write an essay based solely on your own 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.

Write an essay of not more than 1½ to 2 pages to answer the question.

[20]

SOURCE A **Is *Australopithecus sediba* the Most Important Human Ancestor Discovery Ever?**

By Kate Wong April 24, 2013

RECONSTRUCTION OF *AUSTRALOPITHECUS SEDIBA*, BASED ON REMAINS FROM THREE INDIVIDUALS FOUND AT THE SITE OF MALAPA IN SOUTH AFRICA



[Image: Courtesy of Lee R. Berger and the University of the Witwatersrand]

Three years ago researchers added a new branch to the human family tree: *Australopithecus sediba*, a nearly two-million-year-old relative from South Africa. By all accounts it was a dazzling find – two partial skeletons, an adult female and young male. Any time human fossils, especially skeletons, are found it's a big deal, because such remains are so incredibly rare. *A. sediba* may just be the most important hominin (modern humans and their extinct relatives) discovered yet.

The way Berger and his collaborators are studying the finds and sharing what they learn represents a real difference to the cloak-and-dagger (secretive) manner in which palaeoanthropological investigations often work. Berger has made the project open access, with a policy of granting permission to any palaeoanthropologist who asks to see the original fossils. This can only improve the quality of the science that comes out of the project and may well inspire other teams to be more forthcoming with their own data.

At the end of the day we need loads of fossils, artifacts and DNA from different times and places to piece together the full story of our origins.

[Adapted: @Scientific American, a blog where several senior editors and managers will provide you with up-to-date updates on everything that is new at *Scientific American*]

SOURCE B **COLLABORATION IN SCIENCE**

PRESS RELEASE

2012-10-08

THE NOBEL ASSEMBLY AT KAROLINSKA INSTITUTE

has today decided to award

THE NOBEL PRIZE IN PHYSIOLOGY OR MEDICINE 2012

jointly to

John B. Gurdon and Shinya Yamanaka

for the discovery that mature stem cells can be reprogrammed to become pluripotent

- * **Sir John B. Gurdon** – Gurdon is currently at the Gurdon Institute at Cambridge University
- * **Shinya Yamanaka** – Yamanaka is currently Professor at Kyoto University, where he directs the Centre for Stem Cell Research and Application

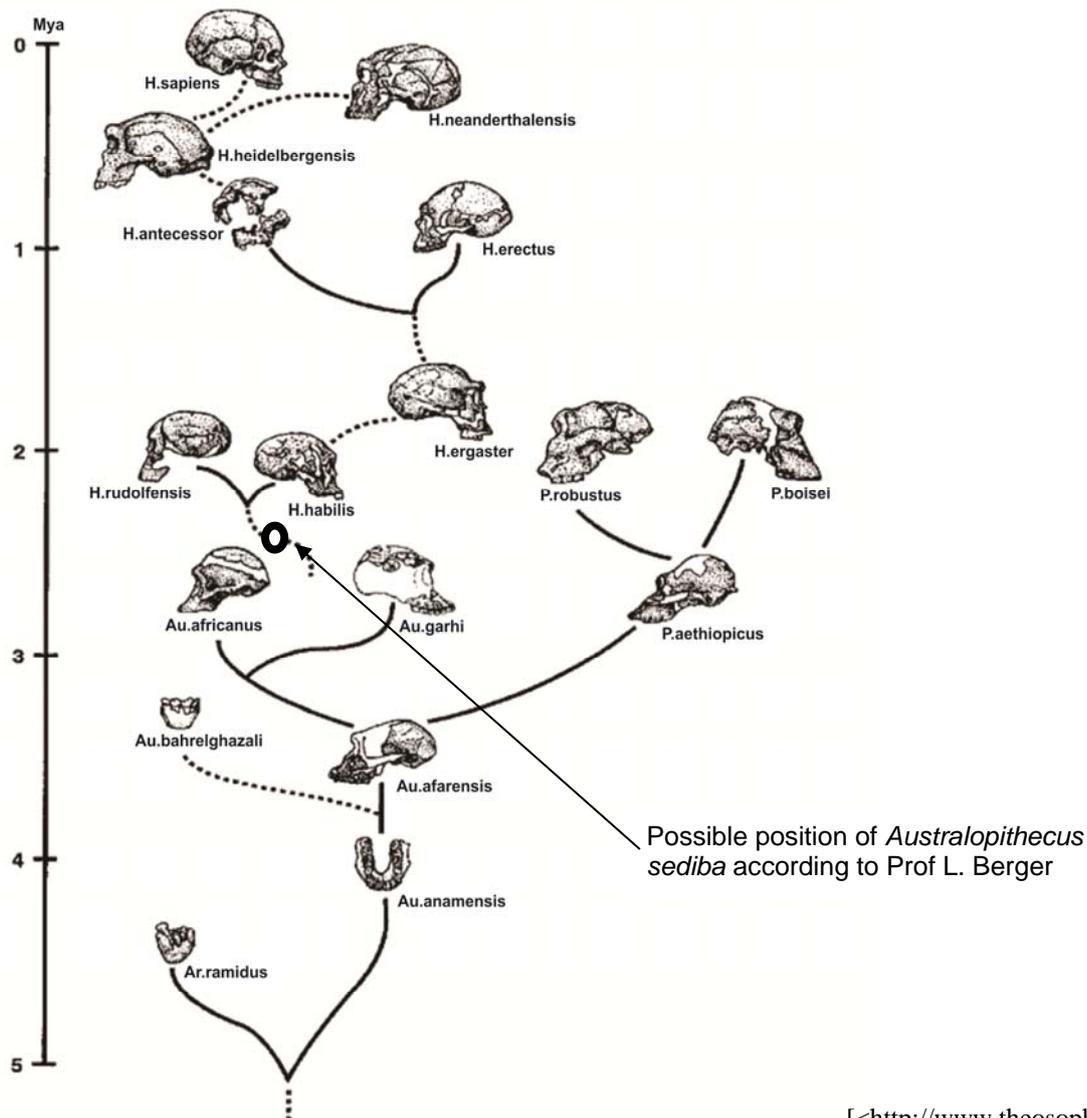
SOURCE C RELIABILITY OF EARLY FOSSIL FINDS

How reliable are palaeoanthropological finds and their interpretations? There are limitations – discoveries are fairly rare and have often been made under questionable circumstances, especially in the early days. As soon as something is dug up and taken elsewhere, essential elements are destroyed and one is dependent on the testimony of the discoverers. Sometimes early field research methods were extremely unscientific, but the resulting finds were taken seriously. When a certain discovery fits the currently ruling theory it will be accepted without much scrutiny. If something does not fit the pattern, it is either ignored or attacked and rejected, but not always on valid grounds.

[Adapted from: <www.theosophy-nw.org>]

SOURCE D HOMINID FAMILY TREE SHOWING A POSSIBLE LINE OF DESCENT

Reasonably well known relationships are indicated by solid lines; less secure relationships are indicated by dotted lines.



[<http://www.theosophy-nw.org 2013>]

SOURCE E THE NATURE OF SCIENCE**SCIENCE IN THE REAL WORLD**

Science is logical and objective – mostly. But let us get real ...

Hypothesis-test-revise is an idealised view of science. Like learning to drive, we all know what we should do, but after our test do we all drive perfectly?

Scientists are human too. The majority are honest, conscientious, hard-working and fair. Some, a tiny minority, cheat: they make things up, or fudge figures.

But scientists also tend to be attached to their own theories.

Science has many safety checks:

Peer review

Scrutiny of research by other experts before findings are published.

Whistle blowing

If researchers suspect foul play, they can raise their concerns with authorities.

Regulation

There are many forms of regulation that scientists must adhere to – from their employers (e.g. universities), ethical committees and national laws.

Objectivity

Experiments should be objective – another scientist should be able to carry out the same research in the same way and get the same findings.

Replication

It is usually not enough for one group of scientists to report findings. These are often treated with caution until a second group has found the same thing.

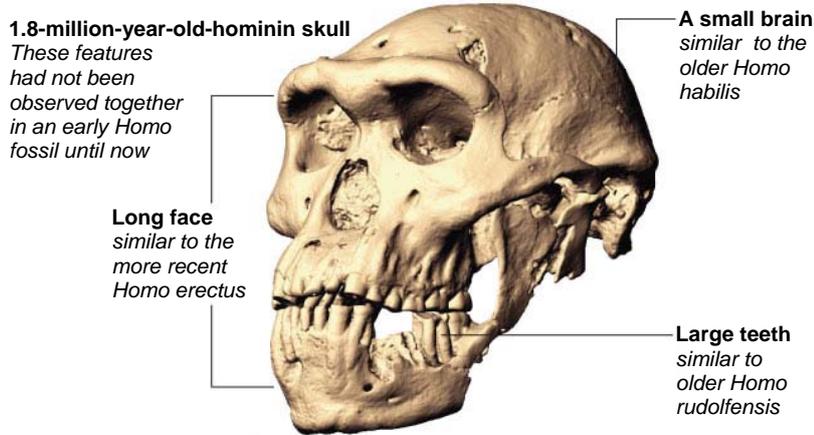
Testability

A good scientific theory is testable. If it cannot be tested, it is of little use in science.

[Adapted: <www.wellcomescience.ac.uk>]

SOURCE F NEWLY FOUND SKULL CAUSES DEBATE ON HUMAN HISTORY

A 1.8-million-year-old skull blends features of a number of early human species



Hominid bones located in Georgia could rule out *Australopithecus sediba* as a human ancestor. The five hominid fossils could remove a number of African hominid species from the tree of human evolution and rule out *Australopithecus sediba* as a possible human ancestor.

The Dmanisi skulls – hailed by international and local palaeo-scientists as 'spectacular' – cast doubt on the prevailing story of human evolution.

The blend of features suggests early humans were one species that had diverse facial and cranial characteristics.

This skull's features resemble those of both earlier and later humans. Photograph courtesy Georgian National Museum



[Source: <<http://news.nationalgeographic.com>>2013]

SOURCE G OPINIONS OF SCIENTISTS

'Hominid bones located in Georgia could rule out *Australopithecus sediba* as a human ancestor.'

Professor Lee Berger said that it is a pity that comparisons of *Australopithecus sediba* were not included in the study of the new hominid fossils before the announcement was made.

Caley Orr (Midwestern University) and Dean Falk (palaeoanthropologist); both think that the new theory erasing the other *Homo* species is intriguing, but believe that more specimens and additional research are needed to fully validate it.

It does not matter who finds hominid fossils or proposes new theories on hominid evolution. There is much work to be done – the important goal is to find as many hominid fossils in the shortest possible time. Only then can we work on completing the hominid family tree.
(ADJ Taylor – palaeoanthropologist; NSW University)

[Adapted: <<http://evolutionnews.org>>]

SOURCE H THE REWARDS IN SCIENCE

Curiosity may drive people into science, but then reality quickly sinks in. To be successful, today's scientists must often be self-promoting entrepreneurs whose work is driven not only by curiosity but by personal ambition, political concerns, and quests for funding.

[Adapted: <<http://www.nytimes.com>>]

Perhaps the most difficult barriers to effective collaboration (working together) in science are concerns about authorship of results and ownership of ideas or data. Some scientists avoid collaboration altogether because of a fear that their contributions will go unrecognised.

[Adapted: <<http://www.huffingtonpost.com/science>>]

Billionaires with big ideas are privatising American Science

President Obama believes in using science 'to grow the American economy' and presented 'the next great American project': a \$100 million initiative to probe the mysteries of the human brain. "We can't afford to miss scientific opportunities while the rest of the world races ahead," President Obama said. "I don't want the next job-creating discoveries to happen in China or India or Germany. I want them to happen right here." "For better or worse," said a political analyst at the American Association for the Advancement of Science, "the practice of science in the 21st century is becoming shaped more by the particular interests of individuals with huge amounts of money." For example, many are financing hunts of dinosaur bones.

[Adapted: <<http://nytimes.com>>]