INTERNATIONAL SECONDARY CERTIFICATE EXAMINATION
NOVEMBER 2022

BIOLOGY: PAPER II

SOURCE MATERIAL BOOKLET FOR QUESTIONS 1, 2 AND 3

QUESTION 1

Read the information below. Use this information, as well as your own knowledge, to answer Question 1 on pages 2–5 of the question paper.

Hunter syndrome occurs almost exclusively in males. The syndrome progressively worsens as the person ages, affecting many different parts of the body. However, the rate of progression varies among affected individuals.

Figure 1.1 – Symptoms of Hunter syndrome

[Adapted: <https://www.ykhoa.org>]

There are two types of Hunter syndrome, called the severe and mild types. While both types affect many different organs and tissues as described above, people with severe Hunter syndrome also experience a decline in intellectual function and a more rapid disease progression. Individuals with the severe form begin to lose basic functional skills between the ages of six and eight. The life expectancy of these individuals is 10 to 20 years. Individuals with mild Hunter syndrome also have a shortened lifespan, but they typically live into adulthood and their intelligence is not affected. Heart disease and airway obstruction are major causes of death in people with both types of Hunter syndrome.

Hunter syndrome is a condition that is inherited in an X-linked pattern. The IDS gene responsible for this condition is located on the X chromosome. The normal version of the IDS gene codes for an enzyme that breaks down a waste molecule found in all cells. Hunter syndrome results from various mutations in this gene, resulting in various alleles that do not code for a working version of this enzyme. In males, one copy of the gene in each cell is sufficient to cause the condition, whereas a female must be homozygous for Hunter syndrome to have the disorder. A characteristic of X-linked inheritance is that fathers cannot pass X-linked traits to their sons.

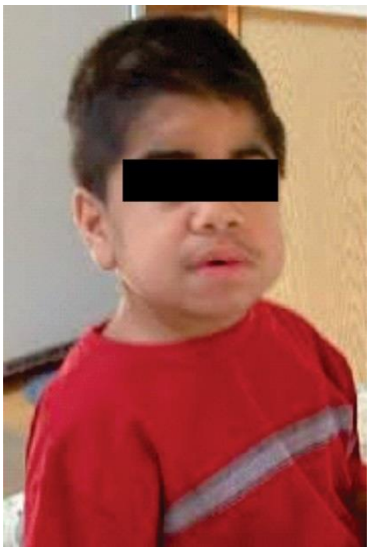


Figure 1.2 – A boy with Hunter syndrome

[Source: OMICS International]

One of the mutations in the IDS gene is a substitution mutation where thymine replaces cytosine at position 200 of the gene.

[Adapted: <https://www.ghr.nlm.nih.gov>]
[Adapted: Zhang, H., Jing, L., Zhang, X. & Wang, Y. 2011. Synonymous Variation in a Female Create Exonic Splicing. PLOS 2011]

Sanger sequencing: The chain termination method

In order to check whether a person has inherited the allele for Hunter syndrome, DNA is extracted from a cell and the gene is sequenced.

Regions of DNA can be sequenced using a method called **Sanger sequencing**. Sanger sequencing was developed by the British biochemist Fred Sanger and his colleagues in 1977.

In the Human Genome Project, Sanger sequencing was used to determine the sequences of many fragments of human DNA.

Figure 1.3 – A Sanger sequence

[<https://www/sites.google.com>]

Sanger sequencing involves making many copies of a gene. Its 'ingredients' are similar to those needed for DNA replication, or for polymerase chain reaction (PCR).

The free nucleotides are labelled with a coloured dye – a different colour for each type of nucleotide. The method involves using these free nucleotides to make many copies of the gene to be sequenced and the identity of the nucleotides making up the sequence can be worked out using the colour patterns that result.

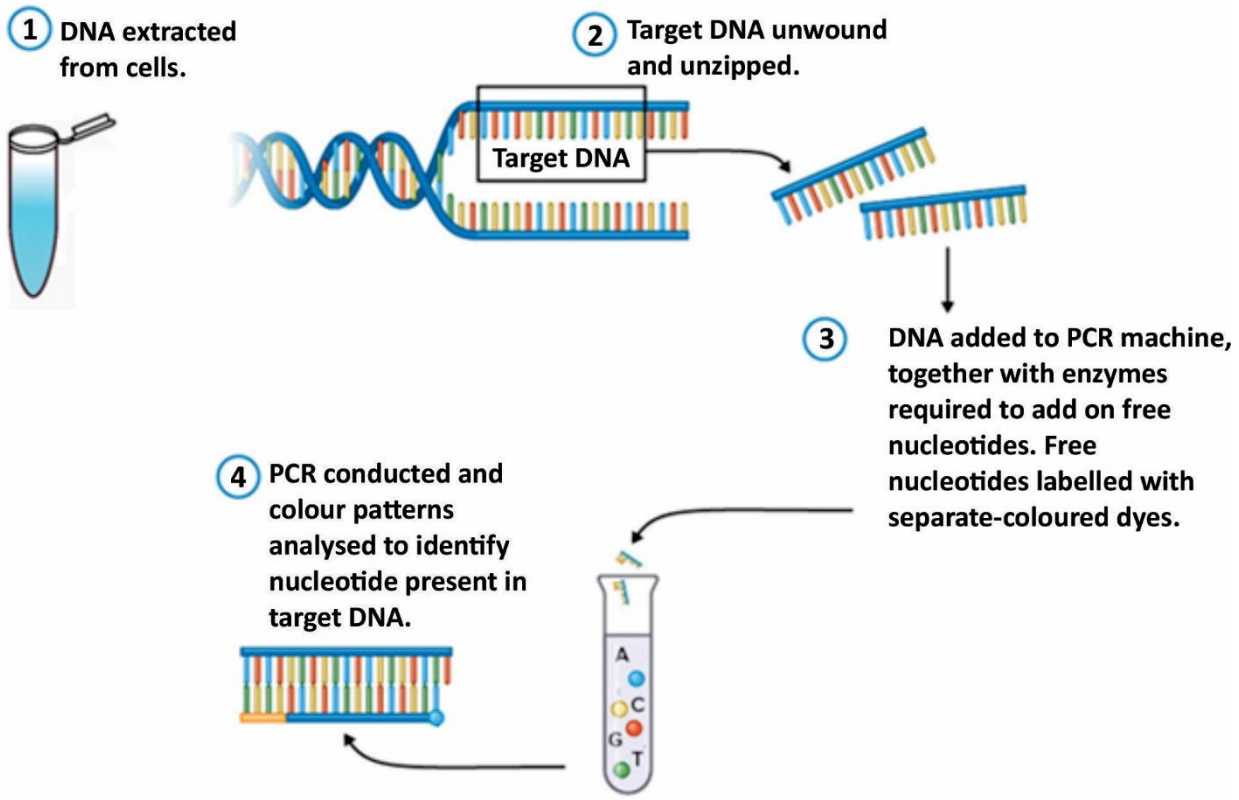


Figure 1.4 – Process of Sanger sequencing

[Adapted: <https://images.squarespace-cdn.com>]
[Adapted: <https://encrypted-tbn0.gstatic.com>]

[Adapted: <https://www.khanacademy.org>]

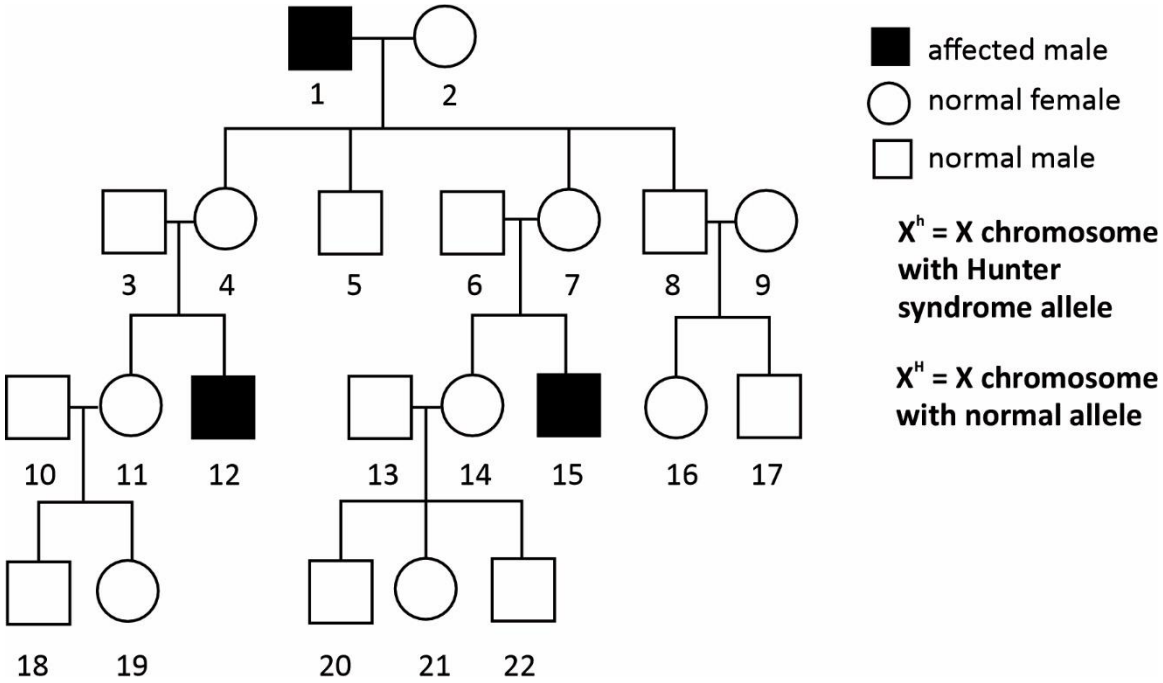


Figure 1.5 – Pedigree of a family with Hunter syndrome.

[Adapted: <https://www.autumnmarcita.files.wordpress.com>]

QUESTION 2

Read the information below. Use this information, as well as your own knowledge, to answer Question 2 on pages 6–8 of the question paper.

Scientists settled a century-old family drama using DNA from postcards

In 1885, Abshir Elmidihoud, a young Somalian man, left home in search of new opportunities. After finding a new job in South Africa, Abshir fell in love with Susan, the 17-year-old European daughter of his boss. He was subsequently fired. But that was just the beginning of this family drama.

Susan ran away from home to be with Abshir and found a place to stay in the home of Dube Sibanda, a chieftain in a remote rural village. In 1887, she gave birth to a son named Philip. Susan stated that Philip was Dube's baby.

Susan remained in contact with Abshir and saw a lot of him. Susan eventually left Dube and went to live with Abshir. Abshir adopted the one-and-a-half-year-old Philip as his son. Abshir and Susan went on to have another son, named David.

Fast forward to May 2017, when Alvina Adams, a forensic geneticist at the University of Cape Town, was approached with an unusual request. Abshir's descendants wanted to verify that Abshir (and not Dube) was Philip's true father.

Ever since the efforts and discoveries of scientists like Watson, Crick, Wilkins and Franklin in the 1940s and 1950s, researchers have been able to use DNA to establish family relationships.

After looking through various family possessions for something that might have DNA from the family members, Adams found some postcards that had been sent by Abshir and Dube that might hold their DNA in the remnants of the saliva used to paste the stamps.

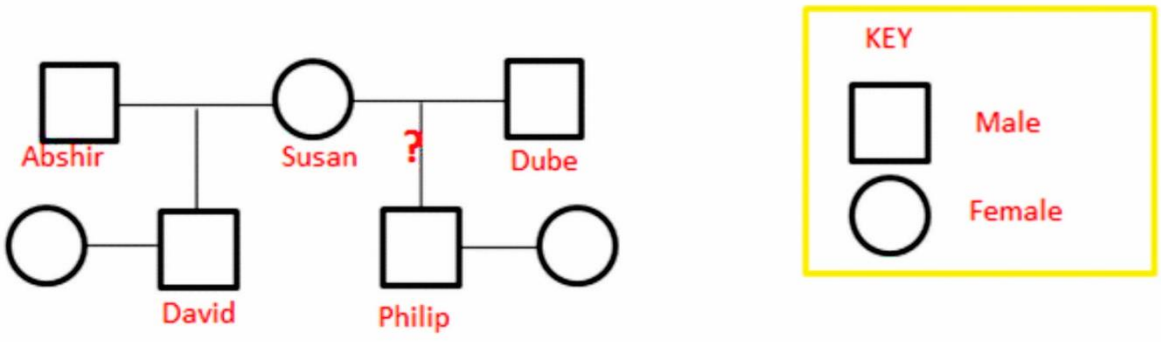


Figure 2.1 – Family tree showing the possible relationships between Elmidihoud / Sibanda family

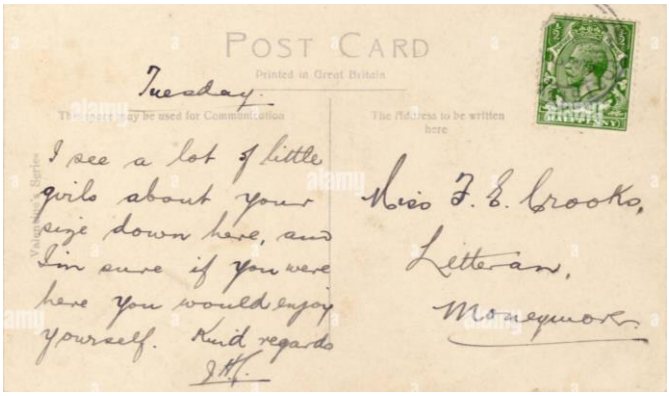


Figure 2.2 – An example of a postcard with stamp attached

[<https://c8.alamy.com>]

The scientists compared the DNA found under the stamps from Abshir and Dube with the DNA found on postcards sent by Philip and David. Analysis of the Y chromosome was used in each case to trace ancestry.

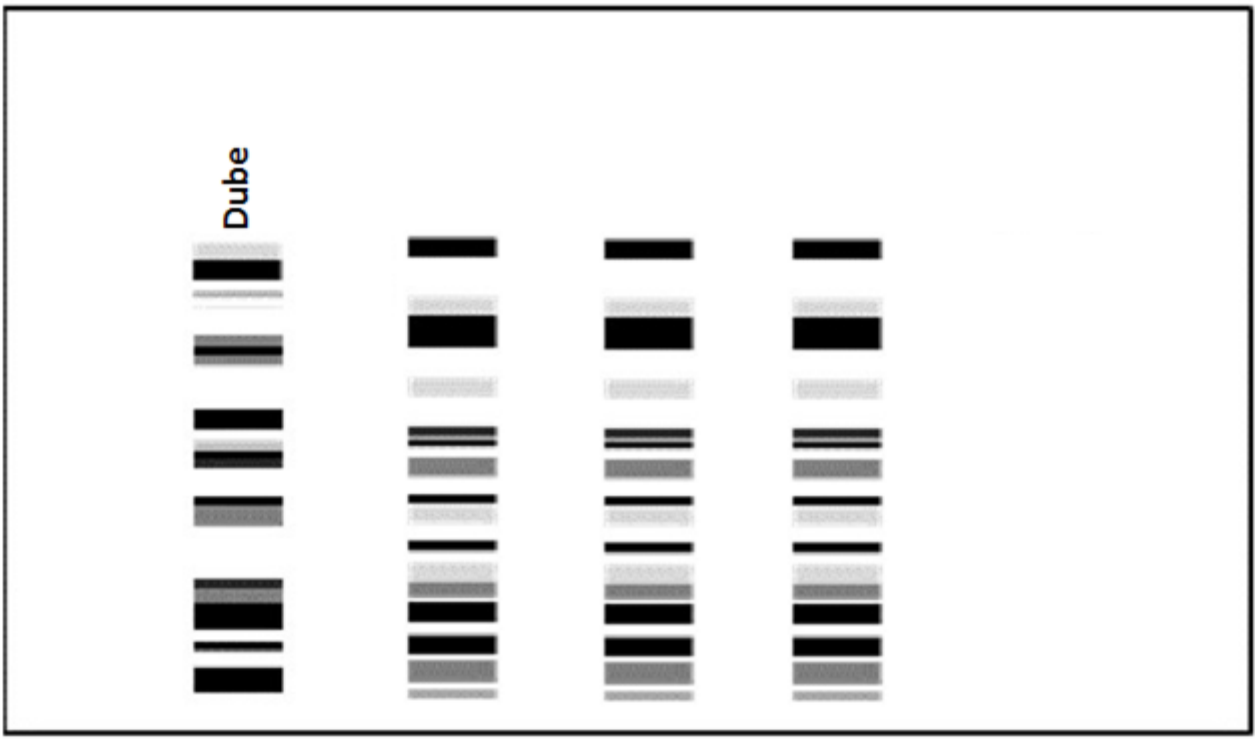


Figure 2.3 – DNA profile made using a sample from Dube (labelled) and DNA profiles made using samples taken from Philip, Abshir and David (in no particular order).

[Adapted: <https://slidetodoc.com>]

The increase in accuracy and efficiency of DNA analysis has led to the establishment of companies that specialise in offering services, such as the one below, to trace ancestry and test paternity. They advertise that they are able to trace ancestry using DNA found on personal items such as stamps, hairbrushes or coffee cups.

Figure 2.4 – Advertisement for 'Family Tree DNA' – a company set up to trace ancestry.

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

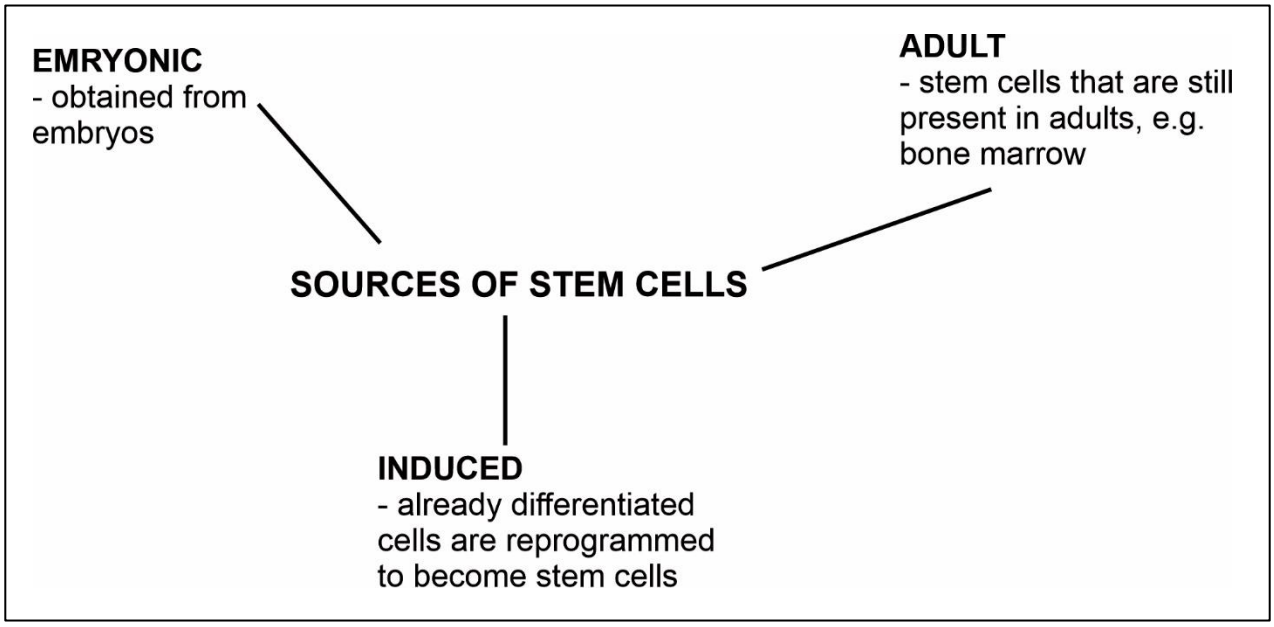
[Adapted: Haas, C., Körner, C. & Sulzer, A. 2022. 19th century family saga re-told by DNA recovered from postcard stamps. *Forensic Science International* 330:111129]

SECTION B

QUESTION 3

Read the information on stem cell research below and use it and your own knowledge to complete the essay in Question 3 on page 9 of the question paper.

SOURCE A Types of stem cell used in research



SOURCE B Arguments in favour of and against embryonic stem cells

CONS – the main objection is to using embryos left over from in vitro fertilisation to harvest stem cells, and destroying the embryos after harvesting the stem cells.

- Embryos have the potential for life.
- Many people believe that embryos have a soul and dignity that should be preserved.
- Stem cell research constitutes murder.
- Embryonic stem cells tend to grow quickly. Their fast growth and reproduction have the potential for growing out of control and this could eventually form life-threatening cancerous tumours.
- The possibility of transplanted stem cells differentiating into the wrong type of tissue in the recipient's body with unknown consequences is yet another danger.
- The stem cells could result in unwanted immune responses and allergies.

PROS – the main argument is that excess embryos not used by people for in vitro fertilisation need to be destroyed anyway, so why not use them for valuable research?

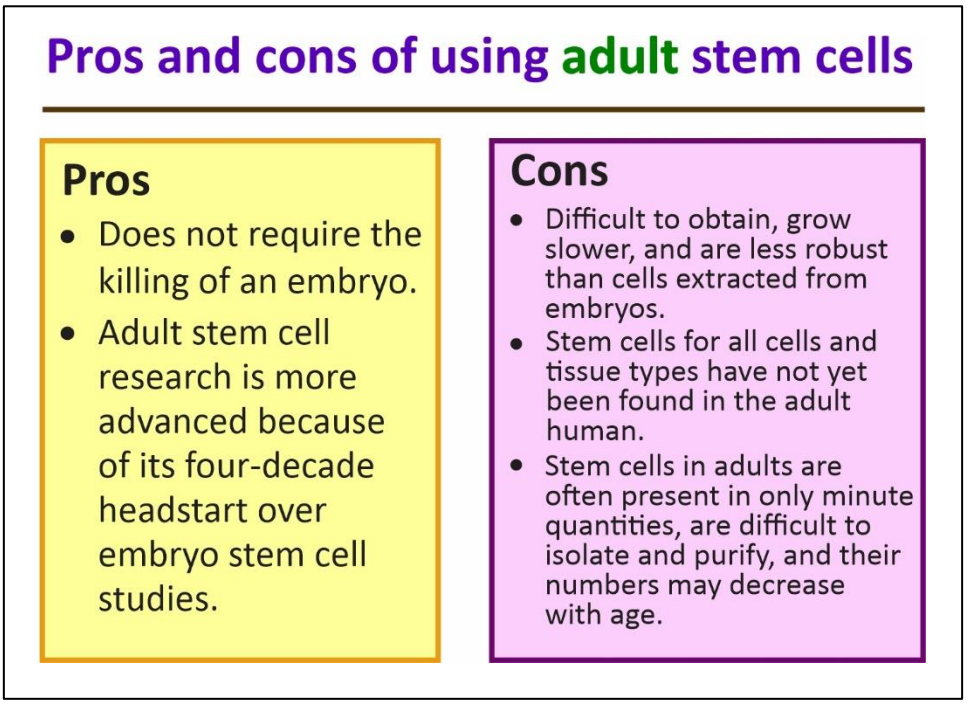
- Stem cell research has the potential to minimise the suffering of people with many different diseases.
- Stem cells can teach us how cells become different from one another.
- We will be able to grow replacement organs and prolong the life of people with disease.
- Embryos cannot survive outside the womb and cannot be regarded as life.
- More than a third of embryos do not implant after conception and that is much more than will be used in stem cell research.
- Embryos are not humans, the life of *Homo sapiens* only begins when the heartbeat develops during the 6th week of pregnancy, or when the brain begins developing activity, at about 7–8 weeks after conception.

[Adapted: <https://www.answers.com>]
[Adapted: Herberts, C. A., Kwa, M. S. G. & H. P. H. Hermsen. 2011. Risk factors in the development of stem cell therapy. *J. Transl. Med.* 9:29.]

Pros and cons of using induced stem cells

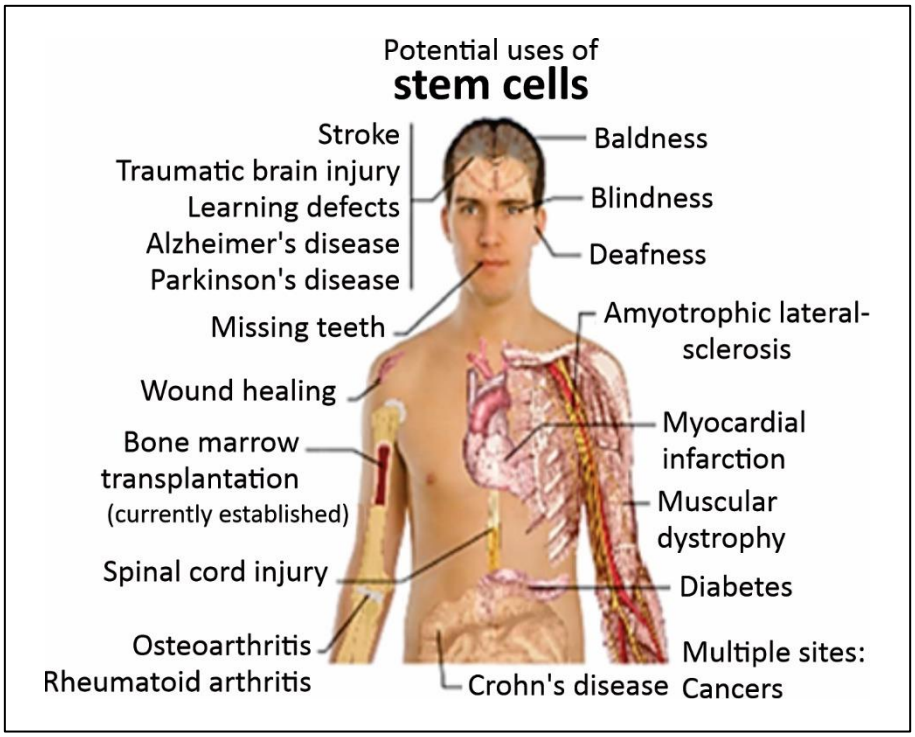
Pros	Cons
• Easy to source.	• Can form tumours more easily than embryonic stem cells do.
• Can be made from patient's own cells – therefore no problem with immune rejection.	• Sometimes reprogramming the cell does not work, cells could retain some characteristics of original cell.
• No ethical problems.	• Induced stem cells could transmit viruses to the recipient.

[Adapted: <https://www.salve.digication.com>]

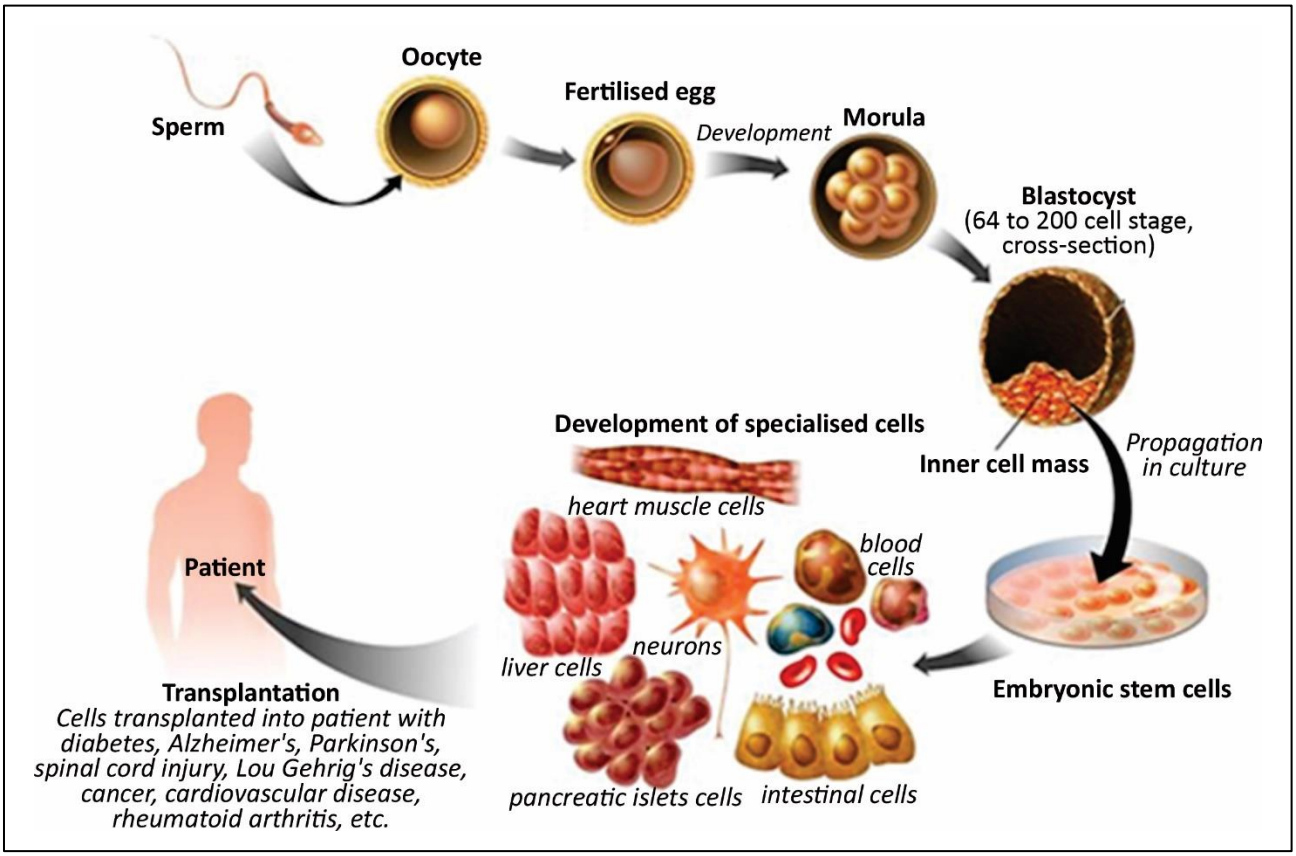


[Adapted: <http://www.images.slideplayer.com>]

SOURCE C Potential uses of stem cells



[<https://www.biologyresources.com>]



[<http://www.2.bp.blogspot.com>]

SOURCE D How safe is stem cell treatment?

Three people are nearly blind after getting a stem cell treatment

Three women in their 70s and 80s who enrolled in a stem cell trial to treat age-related macular degeneration, caused by deterioration of the most sensitive part of the retina, were left with severe vision loss following the treatment they received in a trial.

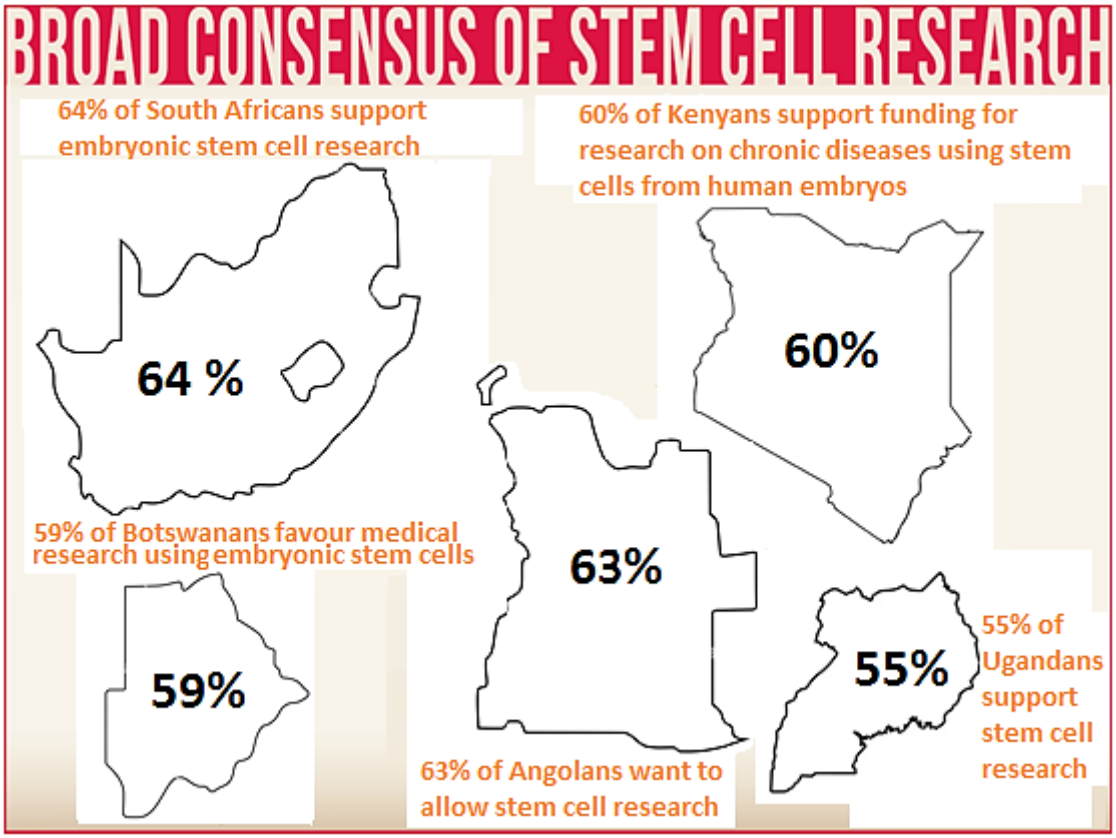
The women each had liposuction to remove fat tissue, and the fat cells were processed to extract stem cells that they were told would develop into cells that would replace the diseased ones in their eyes.

Instead, the injected solution caused inflammation, infection and detached retinas in all three women. Within days of receiving the treatment, all three patients went to hospital with vision loss, severe infections and bleeding.

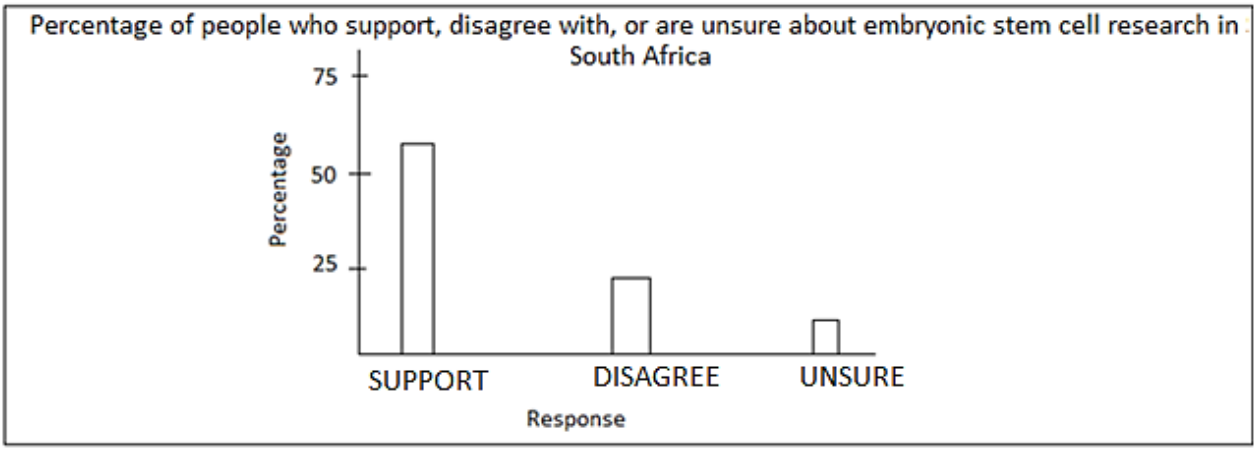
[Adapted: <https://www.time.com>]

SOURCE E Different religious and ethical views concerning stem cell research

[<https://www.stemcellprosandcons.weebly.com>]



[Adapted: <https://www.pewtrusts.org>]



[Adapted:<https://www.s-media-cache-ak0-pinimg.com>]

1. JUDAISM

Permitted (and encouraged as opposed to wasting the embryo) as long as the embryo has not already implanted into a womb as it does not have the status of a living organism. Should be used for life-saving purposes.

[Rabbi Levi Halperin. Institute for Science and Jewish Law]

2. BUDDHISM

Not acceptable – human life begins at conception – the new being has the karmic identity of a recently deceased individual.

3. CATHOLICISM

Not permitted under any circumstances – considered to be murder of a living human.

RELIGIOUS VIEWS

4. ISLAM

Permitted to save a life – embryo not considered a living entity if it has not implanted.

5. HINDUISM

Generally not permitted – life starts at conception. However, there are other branches that accept it.

6. BAPTIST

Not permitted – human life begins at fertilisation.

[Adapted: <https://www.embryo-ethics.smd.qmul.ac.uk>]

SOURCE F Case studies

Michael J Fox, the Hollywood actor stricken by Parkinson's disease, has pleaded with American voters not to restrict research into stem cell technology in an emotional interview.

Since retiring from acting after being diagnosed with the disease, Fox has become an outspoken campaigner for stem cell research. Fox is best known for his role in Back to The Future.

'Unfortunately, American senator Jim Talent opposes expanding research. Senator Talent even wanted to criminalise the science that gives us a chance for hope.'

[Adapted: <https://www.telegraph.co.uk>]

When Carol Mulumba was just three weeks old she was diagnosed with sickle cell anaemia – a hereditary blood disorder common in Black, Asian, Middle Eastern and Mediterranean heritage. Sickle cells can cause many problems: the cells do not move as freely through the blood vessels and can cause blockages that result in severe pain.

The only cure currently being researched for sickle cell anaemia is a stem cell transplant. Speaking about the transplant, Carol said:

'A month after my transplant, testing showed that I was cured of sickle cell disease! I don't have pain anymore. After my transplant, I started a brand-new life and I'm now a normal and healthy 13-year-old. All kids with sickle cell disease should be able to start a new life too.'

[Adapted: <www.cells4life.com>]