NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2013

LIFE SCIENCES: PAPER I

Time: 2½ hours 150 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 13 pages and a yellow Answer Booklet of 8 pages (i – viii). 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.

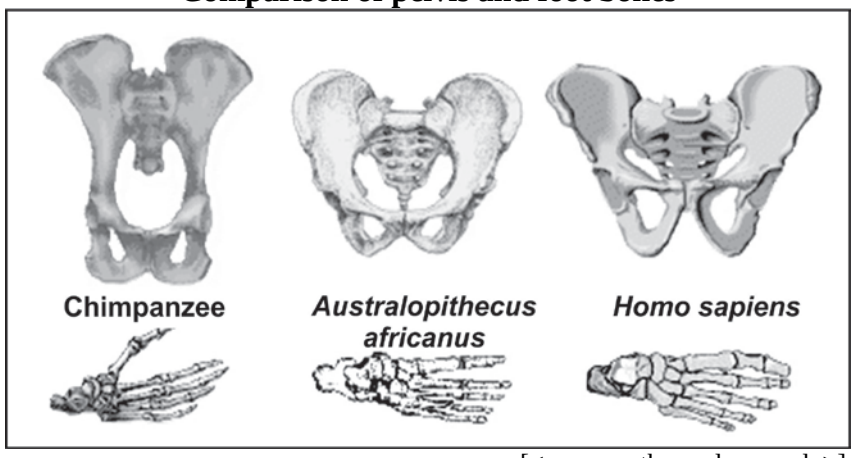
6. Use the total marks that can be awarded for each of Questions 1, 2, 3 and 4 as an indication of the detail required.

7. It is in your own interest to write legibly and to present your work neatly.

QUESTION 2

2.1 Study the diagram below showing the pelvic and foot bones of three primates.

Comparison of pelvis and foot bones



[<www. anthro.palomar.edu>]

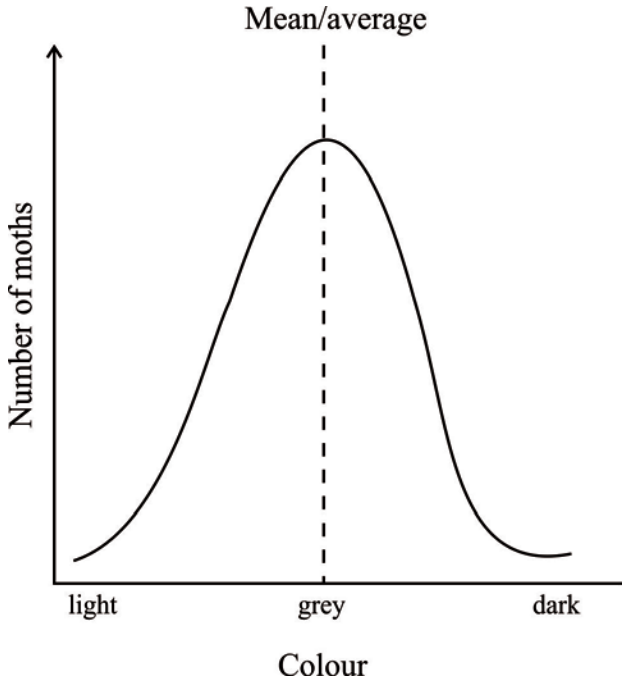
2.1.1 Which ONE of the above organisms is not bipedal? (1)

2.1.2 Describe TWO observable features of this named organism in Question 2.1.1 that support your answer. (4)

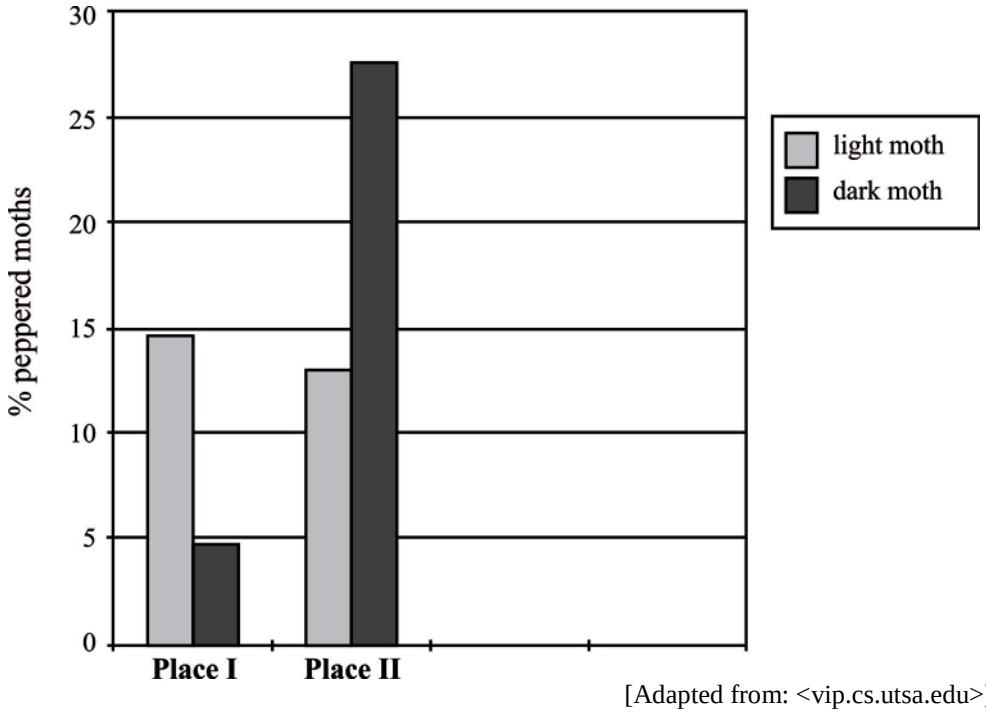
2.1.3 Explain fully the importance of bipedalism in the evolution of modern humans. (5)

2.2 The theory of natural selection was used to explain the observed variation in the colour of peppered moths in Britain. Use the graph below and on page 3 to help you answer the questions that follow.

A. Graph showing the colour of peppered moths before the Industrial Revolution in the 1800s in Britain



B. The proportion of different coloured peppered moths in two different places, I and II, in 1950 in Britain



[Adapted from: <vip.cs.utsa.edu>]

2.2.1 What was the most common phenotype of the peppered moth before the Industrial Revolution in Britain? (1)

2.2.2 What is the cause of the different phenotypes of these moths? (2)

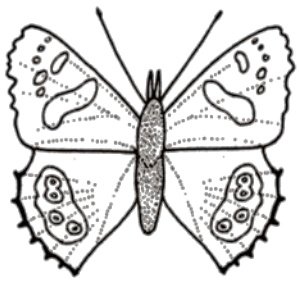
2.2.3 Use the information in the bar graph B to answer these questions.

(a) Which place has the greater percentage of dark moths? (1)

(b) Is Place I likely to be an industrial area or open countryside? Give a reason for your answer. (3)

2.3 The Red Admiral butterfly is found in New Zealand. A subspecies is found on the Chatham Islands to the west of New Zealand. Although a subspecies may interbreed with the original species, they often do not due to isolation. The New Zealand mainland species has a lower wing structure that is different from that of the Chatham Island subspecies as can be seen from the diagram below. It is suspected that many years ago rising sea levels cut off the Chatham Islands.

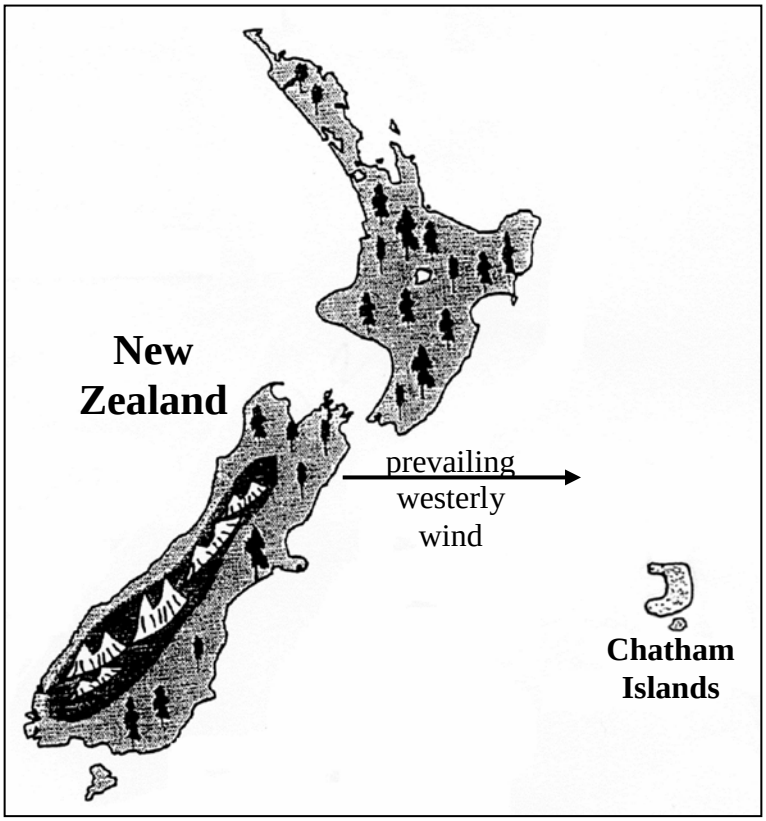
Mainland species



Chatham Islands subspecies

Butterflies are drawn to scale.

Map showing position of Chatham Islands in relation to the New Zealand mainland



[Adapted from: <nzbutterfly.info>]

Using the information provided and your knowledge, answer the following questions.

2.3.1 Give a brief description of ONE other example of the formation of a new species that you studied that has taken place in a similar way to the Red Admiral butterfly. (3)

2.3.2 Explain how gene flow has influenced the evolution of the two groups of butterflies. (3)

2.3.3 In your opinion, how did the mainland Red Admiral butterfly originally colonise Chatham Islands? (2)

2.4 'Natural selection can be bad news for humans.'

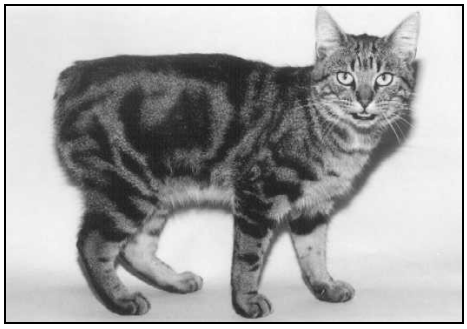
Discuss the validity of this statement by referring to the development of antibiotic resistance in bacteria. (5)

[30]

QUESTION 3

Certain genes are essential for normal development. Mutations in these genes may become lethal if an individual inherits two of the genes. An example of this is the gene found in cats which controls development of the spine. Individuals that inherit two of the mutated genes die before birth. Heterozygous cats with one normal gene (M) and one mutated gene (m) are normal in development, but have no tail. Tailless cats are named *Manx* cats as seen in the image below.

PHOTOGRAPH OF A TYPICAL MANX CAT



Geneticists conducted breeding experiments with two Manx cats to determine the percentage of Manx kittens born with no tails. Below is a table of their results.

	OFFSPRING	
	Kittens with tails	**Manx kittens**
First litter of offspring	2	5
Second litter of offspring	2	3
Total number of offspring	**4**	**8**

3.1 3.1.1 (a) State the genotype of a Manx cat. (1)

(b) From the table of results, determine the percentage of Manx kittens born to the two Manx cats. (1)

(c) Explain TWO procedures that the scientists would have implemented in their breeding program to ensure the success of their experiment. (4)

3.1.2 (a) Draw a genetic cross or Punnett diagram to illustrate the breeding experiment between two Manx cats. (4)

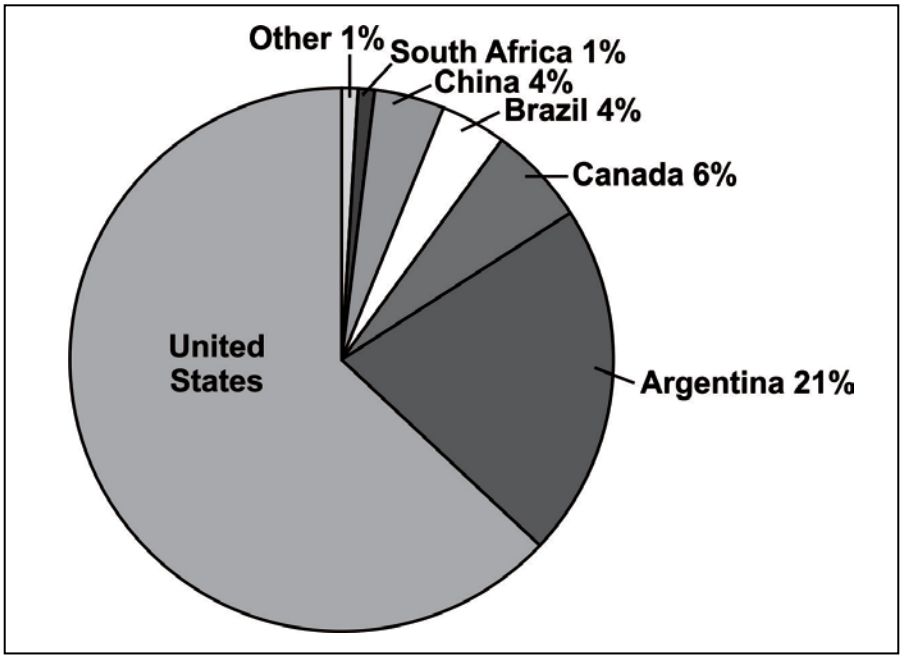
(b) On your Punnett diagram or genetic cross, label the genotype of the kittens with the lethal gene combination that would die before birth. (1)

3.1.3 Do you think that these types of experiments on animals are useful to scientists who study human disorders? Give a well-explained scientific reason for your opinion. (2)

3.2 Explain what the Human Genome Project (HGP) is and discuss its impact on society. (5)

3.3 The graph below shows the countries that grow 99% of the world's genetically modified (GM) crops. It has been predicted that during the next few years we will see an exponential increase in GM product development.

Graph showing the percentage of global GM crop production in one year



[Adapted from: <www.bioenergysite.com>]

3.3.1 What is a genetically modified organism (GMO)? (2)

3.3.2 (a) Suggest a reason why the United States plants the most GM crops. (1)

(b) Calculate the percentage of GM crops produced by the United States. Show all your working. (2)

3.3.3 Genetic engineering of crops is a highly controversial technology. There are environmental and economic reasons that are put forward by both supporters and those who oppose GM crops.

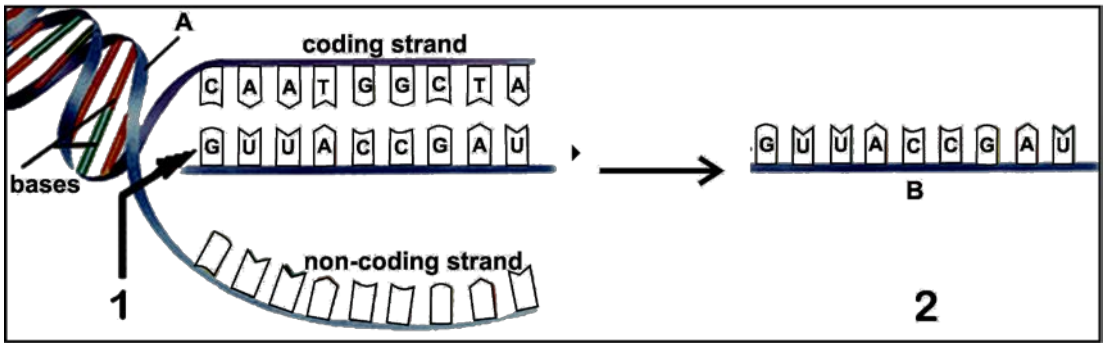
(a) List TWO advantages and TWO disadvantages of GM crops. (4)

(b) In your opinion should South Africa plant more GM crops? Give a well explained reason in a short response. (3)

[30]

QUESTION 4

4.1 The following diagram shows part of a cellular process.



[Adapted from: <www.odec.ca/projects>]

4.1.1 Name the specific process shown in the diagram sequence above. (1)

4.1.2 What is the end result of the whole process in the cell's cytoplasm? (1)

4.1.3 A and B are both nucleic acids found in living cells. Draw a table to illustrate ONE difference in structure and ONE difference in function between the two types of nucleic acid, A and B, shown above. (5)

4.1.4 Describe the role of molecule B in the whole process named in Question 4.1.2 above. (3)

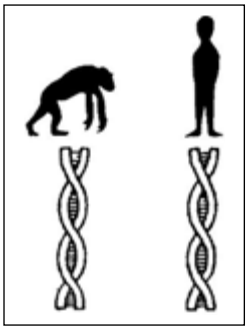
4.1.5 Briefly describe ONE scientific process that could be used to analyse the DNA of humans. (2)

4.2 A geneticist conducted an investigation to determine how similar the nucleotide sequence of chimpanzee's DNA is to that of human DNA.

Background Information

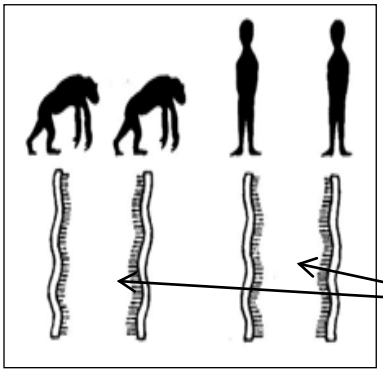
In double-stranded DNA, complementary ('matching') nitrogenous bases are joined by weak hydrogen bonds. Heating the DNA breaks these bonds and 'melts' the DNA into two separate strands. The more base-pairs in double-stranded DNA that are complementary, the higher the temperature that is required to melt the DNA. Normal double-stranded DNA (with perfectly matching strands) has the highest melting point of 85 °C.

EXPERIMENTAL PROCEDURE



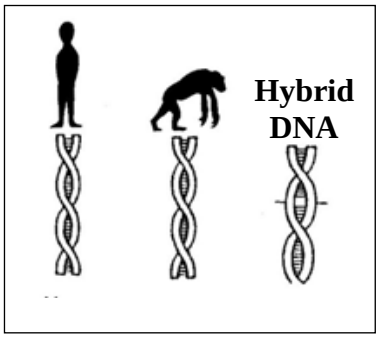
Step 1

Equal-sized samples of DNA were taken from some chimpanzee cells and some human cells.



Step 2

The two DNA samples were mixed and heated and all the DNA melted at 85 °C.



Step 3

During cooling, the single strands of DNA will re-join in one of three ways.

1. *Some join back into normal double-stranded chimp DNA*
2. *Some join back into normal double-stranded human DNA*
3. *But some strands of human and chimp DNA form 'hybrid DNA'*

Hybrid DNA

'melting' of DNA at 84 °C

Step 4 *The hybrid DNA was isolated and heated again.*

Step 5 *The temperature at which the hybrid DNA melted was measured.*

*The '**melting**' temperature is a measure of how similar the two strands are in the hybrid DNA.*

[Adapted from: <evolution.berkeley.edu>]

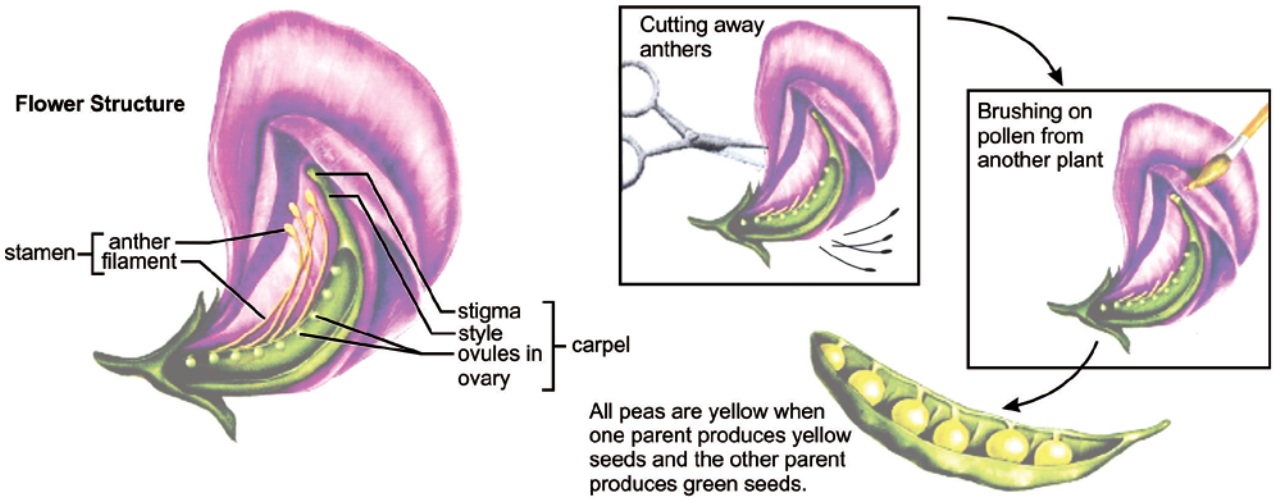
4.2.1 Why was the 'melting point' of DNA considered to be important in this investigation? (1)

4.2.2 What reasonable deduction can be made from the results of this investigation? (2)

4.2.3 In your own words explain clearly what is meant by 'hybrid DNA' in this investigation. (3)

4.2.4 Describe TWO other types of scientific evidence, other than DNA similarities, that scientists could use to prove evolutionary relationships between humans and primates. (4)

4.3 The following diagram is an example of Gregor Mendel's pea breeding experiments.



Trait	Characteristics *Dominant	Characteristics *Recessive	F_2 Results* Dominant	F_2 Results* Recessive
Stem length	Tall	Short	787	277
Pod shape	Inflated	Constricted	882	299
Seed shape	Round	Wrinkled	5,474	1,850
Seed colour	Yellow	Green	6,022	2,001
Flower position	Axial	Terminal	651	207
Flower colour	Purple	White	705	224
Pod colour	Green	Yellow	428	152

[<http://www.southtexascollege.edu>]

4.3.1 Explain clearly why Mendel cut away the anthers from the pea flowers. (2)

4.3.2 What was the approximate F_2 ratio produced in Mendel's breeding experiments? (1)

4.3.3 Mendel used the scientific approach in his experiments. Using information from the diagram and your own knowledge, explain his important contributions to our understanding of modern genetics? (5)

[30]

QUESTION 5

Do you think that humans have the right to exploit animals for medical products?

- 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 G 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

Humans often think of themselves as superior to other animals (not to mention plants, fungi, bacteria and so on) and therefore having the right to exploit other organisms for their own benefit. However, there has been a growing trend in recent years to challenge the human-centred (anthropocentric) view of our relationship with other species.

[Biological Science; *Taylor et al. 1997*]

SOURCE B WHAT IS BIOPHARMING?

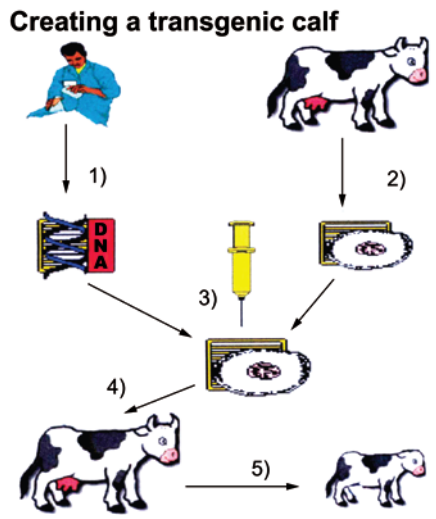
Producing therapeutic proteins in transgenic farm animals is called 'biopharming'. Currently, research groups around the world are investigating whether transgenic animals such as goats, cattle, pigs, rabbits and chickens can be used to produce therapeutic proteins. Animal pharming, the process of using transgenic animals to produce human drugs, is staking its claim in a lucrative world market. Transgenic animals are animals which have been genetically transformed by splicing and inserting foreign human genes into their chromosomes. The inserted gene, when successful, enables an animal to make a certain pharmaceutical protein in its milk, urine, blood, sperm, or eggs, or to grow rejection-resistant organs for transplant.

Global demand continues to grow for human proteins and vaccines. These proteins serve numerous therapeutic purposes such as treatments for cystic fibrosis, haemophilia, osteoporosis, arthritis, malaria, and HIV. Transgenic animals can also produce antibodies that target certain diseases which are used in vaccine development.

Transgenic animals are costly to produce and they have high value. The cost of making one transgenic animal ranges from $20,000 to $300,000, and only a small portion of the attempts succeed in producing a transgenic animal, e.g. in mice 5% – 30% of transgenic embryos survive and in cows and sheep only 1% – 5%. An American firm that clones transgenic calves for human pharmaceutical production estimated that one transgenic animal can produce, in its lifetime, $200 to $300 million worth of pharmaceuticals.

[Adapted from: European Commission, Use of Transgenic Animals in the Manufacture of Biological Medicinal Products for Human Use, 2004]

SOURCE C CREATING A TRANSGENIC CALF



(1) A human gene responsible for producing a desired protein is isolated in a laboratory.

(2) An animal is given hormonal treatment to produce a large number of ova (egg cells), and the ova are collected from the oviduct.

(3) The human gene is inserted into the fertilised egg via micro injection. DNA is injected into the fertilised embryo.

(4) The transgenic embryo is placed in a surrogate host which gives birth to the transgenic animal.

(5) The offspring is tested for the new gene.

[<www.avigenics.com>]

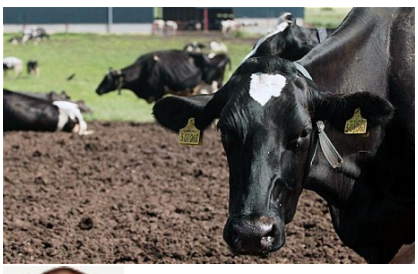
SOURCE D TABLE OF BIOPHARMING PRODUCTS CURRENTLY IN DEVELOPMENT

Animal	Medicinal product/drug	Use
Sheep	Alpha 1 anti trypsin	Deficiency leads to emphysema
Sheep	CFTR	Treatment of cystic fibrosis
Sheep, pig, goat, cow	Tissue plasminogen activator; fibrinogen; antithrombin	Treatment of thrombosis; wound healing
Sheep, pig, cow	Factor VIII, IX clotting factors	Treatment of haemophilia
Goat	Glutamic acid decarboxylase	Treatment of type 1 diabetes
Goat	Pro542	Treatment of HIV
Cow	Collagen I, Collagen II	Tissue repair, treatment of rheumatoid arthritis

[Adapted from: <www.aphis.usda.gov>]

SOURCE E NUTRITIONAL SUPPLEMENTS

Scientists have created genetically modified cattle that produce 'human' milk for allergic and malnourished babies.



By Richard Gray, Science Correspondent of the UK Telegraph. 2 April 2009

The scientists have successfully introduced human genes into 300 dairy cows to produce milk with the same properties as human breast milk.

- Human milk contains high quantities of key nutrients that can help to boost the immune system of babies and reduce the risk of infections.
- Milk from herds of genetically modified cows could provide an alternative to human breast milk and formula milk for babies, which is often criticised as being an inferior substitute.

SOURCE F OPINIONS

Biotechnology is a tremendous power. It represents the power to quickly, precisely and intentionally alter life. It could be used to achieve many benefits that would receive broad public support, it could also, potentially, be used to achieve goals that would inspire public fear. It is the intentional alteration of life that makes biotechnology a social issue.

– *Jennifer Espey, 'Socioethical Implications of Biotechnology' Consumer Connection*

Every living thing on the planet is built from the same types of molecules, and at the molecular level of life, every living thing functions in fundamentally the same way, whether a human, a goldfish, a maple tree, or an earthworm. Biotechnology operates at that molecular level of life.

– *Eric Grace, 'Biotechnology Unzipped' Trifolium Books*

Genetic engineering is responsible for a skyrocketing increase in the numbers of animals being used in laboratory experiments, and is likely to have drastic long term ill-effects in the animals themselves.

– *Catherine Willett, a science policy advisor for People for the Ethical Treatment of Animals*

The potential human health benefits justify tinkering with nature's plan. If a transgenic animal produces a great cancer therapy, I won't hear anyone saying, 'You shouldn't do that'.

– *Origen Biotherapeutics scientist working on stem cell lines, Marie Cecile Van de Lavoir*

SOURCE G CONCERNS ABOUT THE WELFARE OF TRANSGENIC ANIMALS

- Transgenic sheep which produce growth hormone grow leaner meat and put on mass more quickly. However, they are more prone to infection, tend to die young and the females are infertile.
- Even more side effects were noted in other animals than with sheep, including arthritis, gastric ulcers, heart and kidney disease.
- Transgenic technologies have their potential to cause pain.
- Handling and restraint can be distressful to farm animals but are essential for almost all genetic engineering procedures.
- Embryo collection and transfer present a range of animal welfare issues depending on the species used. In sheep, goats, and pigs these manipulations involve surgical or invasive procedures.

[Biological Science, *Taylor et al. 1997*]

Total: 150 marks