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YEAR 12 BIOLOGY

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SAMPLE HSC EXAMINATION 1

Try to complete these papers as if they are the real thing. These are the instructions you need to follow in the HSC Exam:

General instructions

- Reading time: 5 minutes
- Working time: 3 hours
- Write using black pen.
- Draw diagrams using a pencil.
- For questions in Section II, show all relevant working in questions involving calculations.
- NESA approved calculators may be used.

Total marks: 100

Section I: 20 marks

Section II: 80 marks

- Attempt all questions.

Section I: 20 marks

Attempt Questions 1–20.

Allow about 35 minutes for this section.

1 What is the ultimate source of natural genetic variation?

- A** crossing over **B** meiosis
C recombinant DNA **D** mutation

2 During the 1854 cholera epidemic in London an English doctor, John Snow, methodically investigated the rate of cholera deaths in two neighbourhoods. The first was a site where water was drawn from a pump downstream from an area Snow suspected was contaminated with cholera. The second was a site where a pump supplied water upstream and away from the contaminated site. Five hundred deaths occurred in the neighbourhood of the downstream pump in ten days. No cases of cholera occurred in the neighbourhood upstream of the pump. Once the pump handle at the downstream site was removed, the water supply from that pump stopped and the number of cholera cases went down. Snow proposed that cholera was not spread by miasma but by contaminated water.

This case study is an example of:

- A** an early epidemiological study.
B an early study of non-infectious disease.
C a study of stream ecosystems.
D a study of microbiology.

3 Which of the following processes are all involved in the continuity of life?

- A** meiosis, DNA replication, binary fission, fertilisation
B homeostasis, osmoregulation, mitosis, implantation
C ovulation, budding, spore production, respiration
D excretion, circulation, hormone production, implantation

4 An infectious disease can be thought of as:

- A** an immune response.
B a non-communicable disease.
C a disruption to homeostatic mechanisms.
D a serious outbreak threat.

5 DNA is found:

- A** in the cell membrane.
B bound to proteins in chromosomes in the nucleus of eukaryotes.
C as unbound circular DNA in the cytosol of eukaryotes.
D in the mitochondria and chloroplasts of prokaryotic cells.

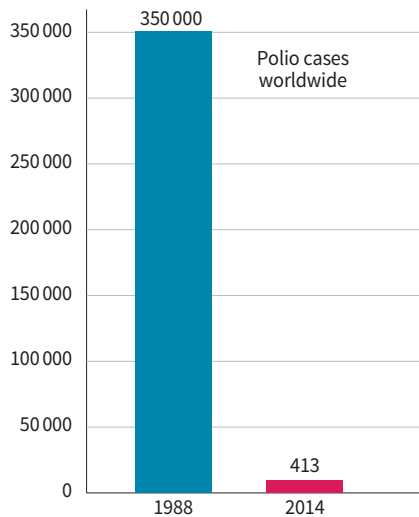
The following table provides WHO UNICEF data on the prevalence of a number of infectious diseases in the Southeast Asia region in the years 2012 to 2016.

The following graph shows polio cases worldwide in 1988 and 2014.

Analyse the data in the table and the graph to answer Questions 6 and 7.

Disease	2016	2015	2014	2013	2012
diphtheria	4016	2504	7666	4080	3953
measles	27 530	48 888	42 899	24 564	31 582
mumps	31 739	42 937	38 327	36 352	47 086
pertussis	43 141	29 813	54 953	37 602	45 847
polio	0	2	0	0	0
rubella	10 361	6515	9690	10 434	6877
encephalitis (Japanese)	3500	3320	2831	1356	282

Source: www.who.int/immunization/monitoring_surveillance/data/gsgloprofile.pdf



Source: <https://www.unicef.org.au/blog/news-and-insights/april-2016/this-infographic-proves-how-effective-vaccines-are>

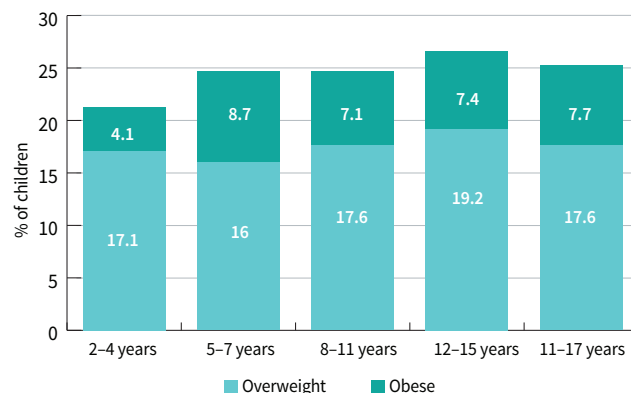
- 6 The prevalence of which disease shows a continually increasing trend from 2012 to 2016?
- A encephalitis B rubella
C measles D diphtheria
- 7 What is the most likely explanation for the prevalence of data for polio as compared to other diseases?
- A The disease was never prevalent in the Southeast Asia region.
B The disease was possibly prevalent until 2012 and then disappeared.
C The disease was prevalent but has been eliminated through monitoring control.
D The disease was prevalent but has been almost eliminated through immunisation.
- 8 Which of the following is a modern technique used in biotechnology?
- A mutation breeding
B the use of yeast to make bread
C the use of plasmids as vectors
D the use of a biological control to reduce prickly pear
- 9 What is the main cause of changes in allele frequency in the gene pool of a population?
- A natural selection B asexual reproduction
C gene expression D random segregation
- 10 Which of the following is an example of a chemical change that occurs in the cells and tissues of animals in response to the presence of pathogens?
- A Pathogens cause an increase in the diameter of blood vessels.
B Pathogens cause an increase in the permeability of blood vessels.
C Pathogens cause tissues at the site of an infection to become hot.
D Pathogens cause the production of cytokines to set up the inflammatory response.

- 11 Use the following table, which shows the inheritance of blood types in humans, to answer the question which follows.

Phenotype	Genotype
O	OO
A	AA, AO
B	BB, BO
AB	AB

A father has an O blood type and the mother has an A blood type. What are the possible blood types of their offspring?

- A O, A, B B A, B, AB
C A, O D AB, A
- 12 The following graph shows percentage rates of overweight and obesity for Australian boys and girls measured in the 2011 to 2012 *Australian Health Survey*. Use the information to answer the question which follows.



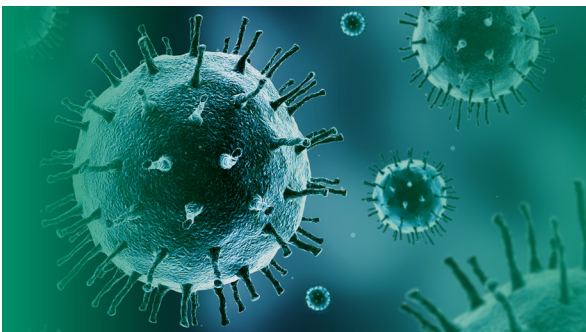
Source: *Australian Health Survey, 2011-12*

Which of the following statements provides a correct analysis of the data shown?

- A About one in four Australian children were overweight or obese, with the highest percentage in the 16-17 years age group.
B About one in four Australian children were overweight or obese, with the highest percentage in the 12-15 years age group.
C Rates of overweight are the same for all age groups.
D Rates of obesity are highest for the 16-17 years age group.
- 13 Which of the following is an example of a technology used to assist people with a visual disorder?
- A laser surgery B cochlear implant
C haemodialysis D nephrosis
- 14 What is an advantage of external fertilisation over internal fertilisation?
- A increased chance of fertilisation
B better suited to terrestrial environments
C facilitates widespread dispersal of zygotes
D fewer gametes produced

- 15 Which of the below is the correct sequence in polypeptide synthesis?
- A transcription, tRNA moves from the nucleus to ribosome in cytoplasm, translation
 - B transcription, mRNA moves from nucleus to ribosome in cytoplasm, translation
 - C translation, mRNA moves from the nucleus to ribosome in cytoplasm, transcription
 - D transcription, mRNA moves from ribosome in cytoplasm to the nucleus, translation
- 16 The 'Slip, Slop, Slap' campaign started in the 1980s in Australia with the aim of preventing skin cancer. Since then the incidence of the two most common forms of skin cancer has declined. This provides an example of:
- A an increased understanding of the genetics of skin cancer.
 - B the effectiveness of an educational campaign for a genetic disease.
 - C the effectiveness of an educational campaign for a disease caused by environmental exposure.
 - D the effectiveness of targeting specific populations.
- 17 Which of the following are all mutagens?
- A gamma rays, oncoviruses, alkylating agents
 - B radio waves, visible light, microwaves
 - C chlorophyll, progesterone, polypeptides
 - D vitamin A, ribonucleic acid, DNA polymerase
- 18 What is the most correct description of homeostasis?
- A Homeostasis involves a stimulus model in which change in the external or internal environment is detected and appropriate responses occur through neural pathways.
 - B Homeostasis involves a stimulus-response model in which change in the external or internal environment is detected and appropriate responses occur through hormones.
 - C Homeostasis involves a stimulus-response model in which change in the external or internal environment is detected and appropriate responses occur via negative feedback.
 - D Homeostasis involves a nerve pathway model in which change in the external or internal environment is detected and appropriate responses occur via negative feedback.

- 19 The image below represents which type of pathogen?



- A bacteria
- B prion
- C fungi
- D virus

- 20 Which of the following is a use of biotechnology in agriculture that could increase biodiversity?

- A genetic drift
- B gene flow
- C gene cloning
- D genetic erosion

Section II: 80 marks

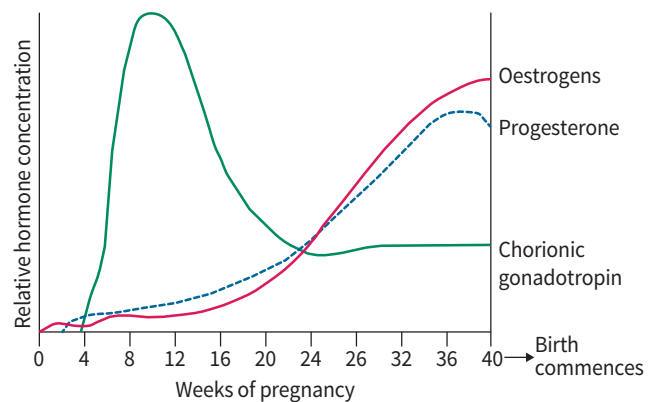
Attempt questions 21–32.

Allow about 2 hours and 25 minutes for this section.

Instructions:

- In the HSC Exam you will answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.

- 21 Briefly outline how population genetics has helped in understanding human evolution. (3 marks)
- 22 Construct a simple model to summarise plant and animal responses to infection. (4 marks)
- 23 Different pathogens have different modes of transmission. For four different types of pathogens that you classified in your study provide an example of the pathogen and the infectious disease that it causes and list each pathogen's mode of transmission. Construct a table to organise the answer. (4 marks)
- 24 Use the graph and your own analysis to explain the role of hormones in the progression of pregnancy and birth in mammals. (8 marks)

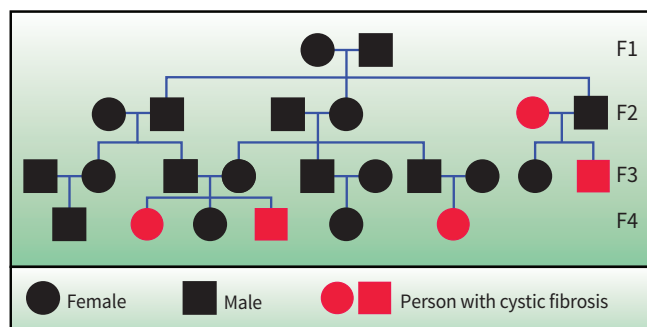


Source: By OpenStax College [CC BY 3.0 (<http://creativecommons.org/licenses/by/3.0/>)], via Wikimedia Commons

25 Construct a diagram and explain how the structure of DNA supports the process of DNA replication yet at the same time has allowed for point mutations to occur. (8 marks)

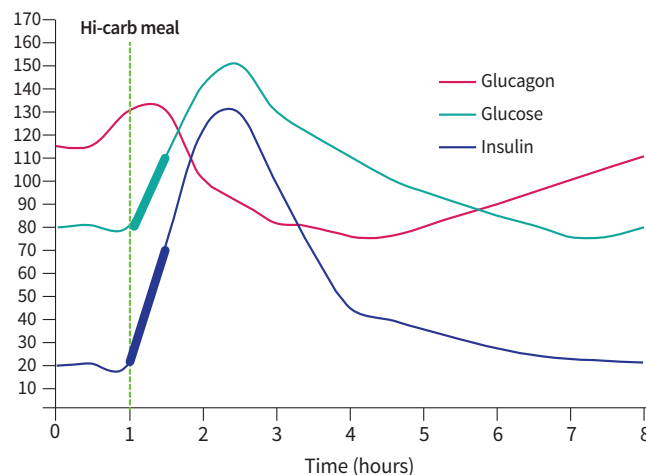
26 During your study you were asked to investigate the structure and function of proteins in living organisms. One approach to this task is to analyse diseases caused by faulty proteins. The following table provides some data about diseases associated with faulty proteins. Study the table and pedigree diagram below and then answer the questions which follow.

Symptoms	Cause/Defective protein
Cystic fibrosis	
fluids such as sweat, digestive juices and mucus are very thick often results in lung infections, digestive problems and a significantly reduced life expectancy	the protein cystic fibrosis transmembrane conductance regulator (CFTR) is defective, most commonly as a result of a loss of the amino acid phenylalanine at the 508th position on the protein the disease is inherited as autosomal recessive
Motor neurone disease	
muscle weakness, initially in hands or feet, followed by loss of speech, difficulty swallowing, muscle twitching, cramps, fatigue, weight loss, eventual paralysis and death about 10% of sufferers have inherited the condition but most cases arise without a known cause	nerves activating muscles degenerate Dr Justin Yerbury (a researcher and sufferer of the disease) believes that failure of proteins to be recycled within neurones results in protein accumulation to toxic levels; these proteins spread to adjacent neurones, progressing the disease



- Use the information from the table and your own research to explain the relationship between the structure and function of proteins. (3 marks)
- Describe the genetic change that would result in the inheritance of cystic fibrosis if neither parent in the first generation carried the allele for cystic fibrosis. (2 marks)
- Use the pedigree diagram to construct a Punnett square diagram to show the gametes and offspring of the F3 generation cross between the two cousins that produced three F4 offspring. (4 marks)

27 The graph below provides information about the homeostasis of blood glucose levels after a high carbohydrate meal. The black line is glucose, the blue line is insulin and the red line is glucagon. Study the graph and then answer the question that follows.



Interpret the graph to explain what happens to glucose levels, insulin levels and glucagon levels after the high carbohydrate meal. (6 marks)

- UNICEF estimates that about 3% of all babies in the world are born with genetic disorders.
 - What is a genetic disorder? Provide an example of the cause and effects of a genetic disorder that you have studied. (3 marks)
 - Provide one example of how genetic engineering could prevent genetic diseases and briefly outline an ethical concern associated with this genetic technique. (3 marks)

29 The following points provide information about some procedures that can be employed to prevent the spread of the infectious disease malaria. Malaria is widespread in the tropics and half of the world's population is potentially exposed to the disease. In 2015 there were approximately 212 million malaria cases and an estimated 429 000 malaria deaths.

- Pesticides are used in swampy areas to reduce the breeding of mosquitoes.
- Surface minnows released in waterways eat the mosquito larvae and reduce the mosquito population.
- People entering a malaria-infected area can take a course of chloroquine that interferes with the development of the parasite. A virulent form of the malaria protozoan is resistant to chloroquine.
- Education programs encourage the use of insect repellents, protective clothing and mosquito nets over bedding.
- A vaccine called PlasProtect consists of inactivated human malaria parasites which have been prevented from growing and causing a malaria infection. The vaccine is currently in early human trials.

- Artemisinin is a drug that has been used in Chinese medicine for 1500 years and is extracted from a wormwood shrub called *Artemisia annua*. It is grown by 100 000 small farmers in Asia and Africa and also extracted from wild plants in China. In combination with other drugs it is effective against multidrug resistant strains of the malaria protozoan.
 - A strain of yeast has been genetically modified to produce a precursor to artemisinin in order to ensure reliability and reduce the price of the drug. A 50 000-litre chemical reactor could provide sufficient quantities of the drug for the world though it remains more expensive than the naturally grown and extracted artemisinin.
 - CRISPR-Cas9 gene editing and gene drive technology could be combined to produce mosquitoes unable to carry the protozoan that would, when released, out-compete and eliminate the wild-type mosquito within a few generations.
- Use the information above to explain how social, economic and cultural contexts may influence biotechnology. (6 marks)
 - Construct a table to evaluate each procedure described. (8 marks)

30 The following predictions are about future developments in biotechnology. Read these and then answer the question that follows.

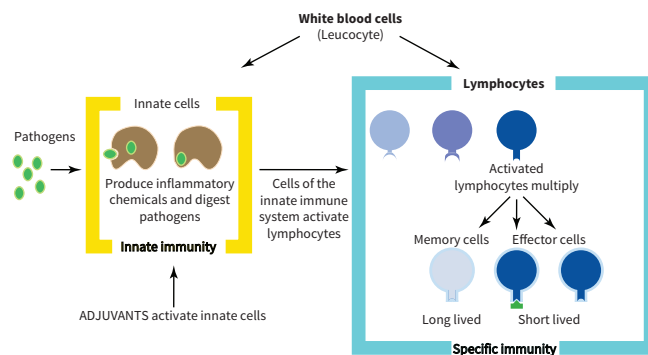
Personalised medicine becomes normal. Doctors use understanding of a person's genetic profile to predict which medicine will work best for them.

Gene therapy will be used to correct the impact of defective genes, reducing the problems of inherited disease.


Compare these statements with your own research into the future directions of biotechnology and the potential benefits for society of research using gene technologies.

(6 marks)

31 The diagram below comes from the Australian Academy of Science website and shows a model of how the human immune system responds to exposure to a pathogen. Interpret the model to answer the questions that follow.



Source: www.science.org.au/learning/general-audience/science-booklets/science-immunisation/1-what-immunisation

- In the diagram what does the image  represent? (2 marks)
- Briefly explain the difference between innate immunity and specific immunity. (2 marks)
- Name two types of lymphocytes and their function. (2 marks)
- Explain the part of the diagram that states: ADJUVANTS activate innate cells. (2 marks)

32 In your course work you investigated practical applications of STEM (science, technology, engineering and maths). Describe one practical application of STEM that is used in the treatment of a named non-infectious disease or disorder and briefly outline some advances in the technology that have improved the effectiveness of the treatment. (4 marks)

SAMPLE HSC EXAMINATION 2

Try to complete these papers as if they are the real thing. These are the instructions you need to follow in the HSC Exam:

General instructions

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Total marks: 100

Section I: 20 marks

Section II: 80 marks

- Attempt all questions.

Section I: 20 marks

Attempt Questions 1–20.

Allow about 35 minutes for this section.

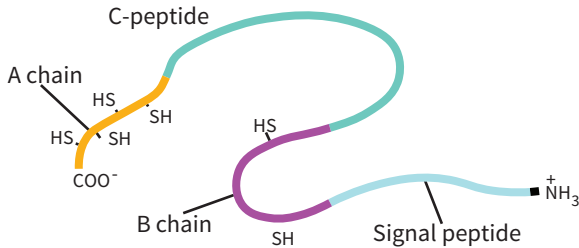
- 1 What is the term used when pathogens spread directly from host to host?
 - A vehicle transmission
 - B vector-borne transmission
 - C direct transmission
 - D fomite transmission
- 2 Which of the below is an example of the application of scientific knowledge to assist the reproduction of plants?
 - A cloning by embryo splitting
 - B sex reversal in sequential hermaphrodites
 - C propagation by tissue culture
 - D artificial insemination
- 3 Which of the following chemical changes occurs in the cells and tissues of plants in response to the presence of pathogens?
 - A reinforcement of the cell wall
 - B production of resistance peptides
 - C cytoplasmic streaming
 - D stomatal closure
- 4 What is a key factor in the difference between binary fission in bacteria with that in protists?
 - A Bacteria are unicellular and protists are multicellular.
 - B Bacteria reproduce sexually whereas protists reproduce asexually.
 - C Protists are much smaller than bacteria.
 - D Bacteria are prokaryotic and protists are eukaryotic.
- 5 Which of the following is an adaptation of a pathogen that facilitates its entry into a host?
 - A The outer surface of many microorganisms is composed of molecules that do not occur in their host.
 - B A pathogen causes an inflammation response.
 - C Some bacteria coat themselves with a thick polysaccharide capsule that is not recognised by phagocytes.
 - D Some macrophages have granules that contain anti-microbial enzymes.
- 6 What is the effect of genetic drift on the gene pool of a population?
 - A Alleles that support adaptation to the environment become more frequent.
 - B Alleles that cause disease are likely to be eliminated.
 - C Allele frequency changes because of random events.
 - D Allele frequency increases because of immigrants.
- 7 Binge drinking among teenagers and young adults is a community-wide problem. Binge drinking can increase the risk of chronic diseases later in life. You are asked to develop strategies for the prevention of binge drinking. What strategy could be most effective?
 - A raising funds to help fight diseases related to alcohol use at a young age
 - B education about supporting families with chronic diseases related to alcohol use at a young age
 - C a social marketing education campaign primarily targeting parents of teenagers
 - D a social marketing education campaign primarily targeting teenagers and young adults
- 8 What is a likely potential benefit for society of research into genetic technologies?
 - A increased life expectancy and better health
 - B reduced use of animals in biological testing
 - C reduced numbers of deleterious mutations occurring
 - D an expansion in worldwide biodiversity

9 Which of the following is an example of a chromosomal mutation?

- A frameshift mutation
- B aneuploidy
- C nucleotide substitution
- D nonsense mutation

The figure below represents the formation of insulin, which controls blood glucose levels. This figure may assist with your answers to Questions 10, 11 and 12.

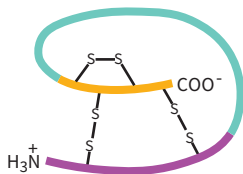
1 Preproinsulin



2 Membrane transport

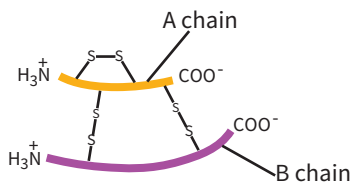
3 Cleavage of signal peptide

4 Disulfide bonds form



5 C-peptide is cleaved

6 Formation of the mature insulin molecule



10 What is the process that immediately precedes Step 1 in the figure above?

- A polypeptide synthesis
- B DNA replication
- C crossing over
- D chromosome translocation

11 Some people describe the hormone insulin as a 'key' that unlocks the cell to let glucose enter through the cell membrane. What is the best conclusion about the role of insulin?

- A Insulin is an enzyme that catalyses chemical reactions.
- B Insulin is a protein whose structure is important for its function.
- C Insulin is part of the cell membrane that attracts glucose.
- D Insulin reacts with glucose to release cellular energy.

12 What is the name of a non-infectious disease in which the body becomes resistant to the normal effects of insulin or gradually loses the ability to produce enough insulin?

- A gestational diabetes
- B type 2 diabetes
- C chronic disease
- D pre-diabetes

13 One way to assess the effectiveness of cloning is to:

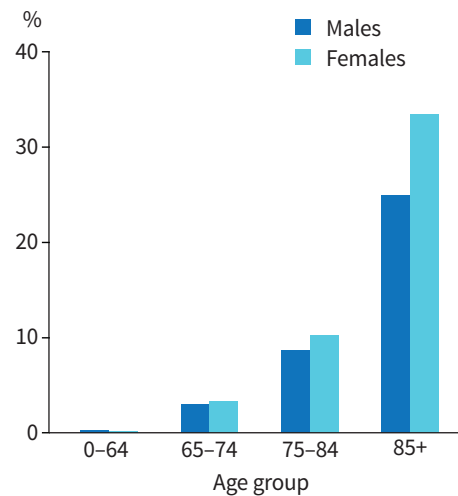
- A count the number of offspring.
- B screen for antibiotic resistance.
- C compare the number of attempts made with the number of genetically identical products.
- D determine the number of endangered species that have been saved.

14 What are the processes that cause variation during cell replication?

- A DNA replication and mutation
- B crossing over and random segregation
- C cytokinesis and chromatid replication
- D oncoviruses and electromagnetic radiation

15 The following graph provides epidemiological data of dementia in the Australian population. Dementia describes a syndrome characterised by the gradual impairment of brain function.

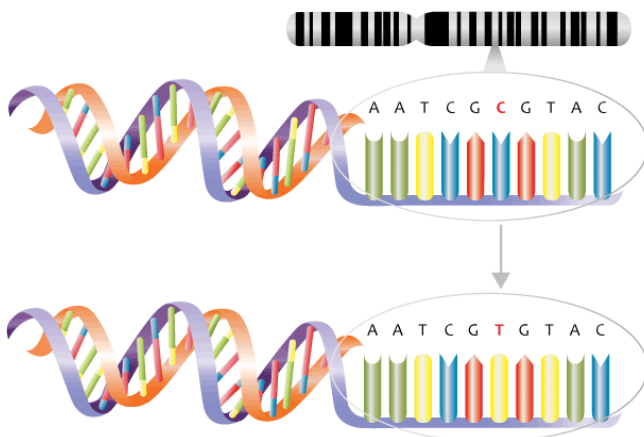
What is the graph an example of?



Source: Australian Institute of Health and Welfare 2016

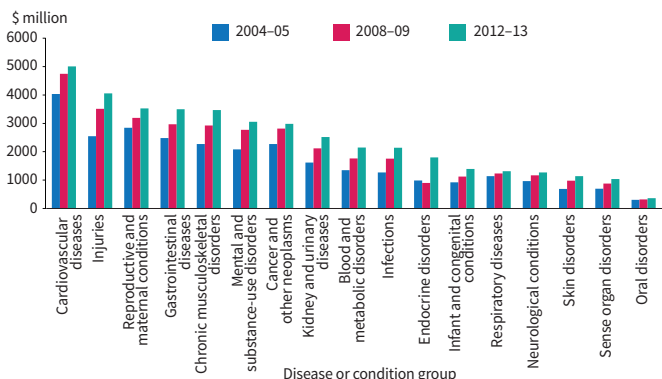
- A prevalence data
- B mortality data
- C incidence data
- D population aging data

- 16 What do the terms *antigen* and *antibody* mean?
- A Antigen refers to the invading microbe and the antibody is the pathogen.
 - B Antigen refers to the invading pathogen and the antibody is the protein that neutralises the pathogen.
 - C Antigen is the white blood cells that make antibodies that neutralise the pathogen.
 - D Antigens are toxins and antibodies help the toxins to work.
- 17 What does the figure below represent?



Source: image by NHS National Genetics and Genomics Education Centre (Flickr) [CC BY 2.0 (<http://creativecommons.org/licenses/by/2.0>)], via Wikimedia Commons

- A chromosomal mutation and a translocation
 - B nucleotide base deletion and a nonsense mutation
 - C nucleotide base insertion and a frameshift mutation
 - D nucleotide base substitution and a single nucleotide polymorphism
- 18 Which process is essential for the continuity of a species?
- A cell replication
 - B fertilisation
 - C implantation
 - D binary fission
- 19 In your study you investigated the economic costs and costs to productivity of diseases in populations. The following data shows Australian expenditure on patients admitted to hospital in 2004–05, 2008–09 and 2012–13. Study the data and answer the question which follows.



Source: AIHW disease expenditure database

What disease or condition group was responsible for a total expenditure of around \$13.8 million in the three time periods?

- A cancer
 - B cardiovascular disease
 - C muscular skeletal disorders
 - D respiratory disease
- 20 Which of the following diseases could be most easily prevented and kept out of Australia by quarantine?
- A sickle-cell anaemia
 - B smallpox
 - C lung cancer
 - D foot-and-mouth disease

Section II: 80 marks

Attempt questions 21–34.

Allow about 2 hours and 25 minutes for this section.

Instructions:

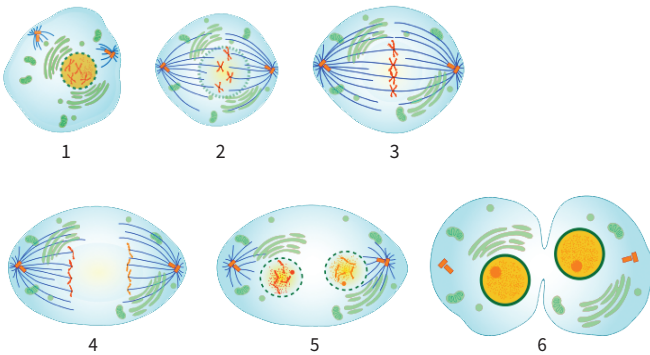
- In the HSC Exam you will answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.

- 21 Oils stored in the oil glands of leaves, such as eucalyptus oil, are examples of a preformed chemical defence of eucalyptus plants. Eucalyptus oil is also a traditional bush medicine used by Aboriginal people and is now used in a wide range of cleaning products and pharmaceuticals such as throat lozenges.
- a Explain the relationship between eucalyptus oil as a preformed defence in eucalypts and its use by Aboriginal people as a bush medicine. (2 marks)
 - b Briefly outline the contemporary application of Aboriginal protocols in the development of medicines in Australia. (2 marks)
- 22 Analyse the features of fertilisation and implantation in terms of how they contribute to continuity of species. (4 marks)
- 23 In 2008 about two million new worldwide cases of cancer were attributed to infectious agents such as certain viruses, bacteria and parasites. This equates to approximately 16% of all cancers worldwide. The proportion is higher in developing countries, where 23% of all cancers were attributed to infections, and lower in developed countries, where 7.4% of cancers were attributed to infectious spread. Study the table on the following page which details the number of new cancer types in 2008 that were attributable to infectious agents and then answer the questions that follow.

Cancer type	Number of new cancer cases	Number of new cancer cases attributed to infection in less developed regions	Number attributed to infection in more developed regions
stomach	870 000	470 000	180 000
liver	750 000	510 000	69 000
cervix/uterus	530 000	450 000	77 000
vagina	27 000	4100	7500

- What term is used to refer to numbers of new cases of a disease? (1 mark)
- Suggest why the proportion of new cases was higher in less developed regions. Justify your answer using information from the data. (2 marks)
- From your understanding of infectious and non-infectious diseases describe two strategies used to prevent cancers attributable to infection. (2 marks)

24 Study the figure below and answers the questions which follow.



Source: images by LadyofHats (own work, public domain), via Wikimedia Commons

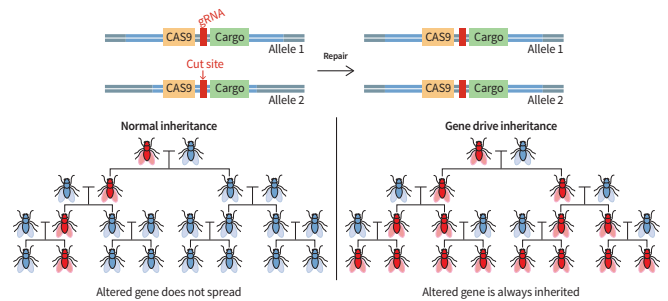
- Name the type of cell replication occurring in the figure above and describe a key process that you modelled in your studies for each of the numbered steps. (3 marks)
 - Name the other main type of cell division that you modelled and contrast the above processes and products with its processes and products. (2 marks)
- 25 Maintenance of homeostasis requires more than a simple reflex. The model below shows the more complex feedback mechanism required to maintain homeostasis.
- stimulus → receptor → afferent pathway → control centre → efferent pathway → effector → response → negative feedback

- Use the model to describe the negative feedback loop that maintains homeostasis for either temperature or glucose. (4 marks)

b Computer models of human thermoregulation responses have been developed for use in the design of clothing such as military suits. Simulating and modelling the thermoregulatory system also enables scientists to study the effects of extreme environments on the human body. From your understanding of trends and patterns in structural and physiological adaptations in endotherms that assist in thermoregulation describe some adaptations that would be considered in the design, simulations and modelling? (4 marks)

- 26 Construct diagrams to compare the structure and role of DNA with protein structure and function. (8 marks)
- 27 The World Health Organization has prepared a list of diseases that pose a serious threat of a global outbreak. The list includes the following diseases: Ebola (a fruit bat virus), Zika (a monkey virus), SARS (a bat virus), Lassa fever (carried by rats) and Nipah (a bat virus).
- What is the term for an outbreak of disease? (1 mark)
 - Briefly explain how these diseases have become a global threat. (2 marks)
 - Describe the key factors in the transmission of a disease during an outbreak. (2 marks)
 - Outline three current strategies that are used to predict and control outbreaks of disease. (3 marks)

28 The figure below demonstrates how gene drives (Cas9) and any linked alleles (Cargo) can 'take over' genetic control by cutting and repairing to insert the linked allele. Blue represents the mosquito with the wild allele and red represents the mosquito with the altered allele; that is, the gene drive and altered allele in the right-hand diagram. Study the figure and then answer the question that follows.



Source: image by Mariuswalter (own work), [CC BY-SA 4.0 (<https://creativecommons.org/licenses/by-sa/4.0/>)], via Wikimedia Commons

Compare the mechanism of gene drives with the normal inheritance pattern demonstrated in the figure. (6 marks)

- 29** In your study you conducted a practical investigation relating to microbial testing of water or food samples. Below is a summary of one technique used to investigate microbes in food samples. Read the procedure and then answer parts **a** and **b**.

Spread plate procedure

In the spread plate procedure sterile, melted nutrient agar is poured into a number of Petri dishes and allowed to cool. Small amounts of different food samples are placed on the nutrient agar. The lid is secured onto each Petri dish and the dishes incubated at a certain temperature for a specific period of time. Microbes may appear on the surface of the agar. Microbiologists can pick off samples of the microbes with a sterile inoculating needle or loop and use these samples to inoculate fresh nutrient agar plates.

- a** Outline experimental procedures that you would use to ensure that the investigation is valid. (2 marks)
- b** Outline the safety precautions that you would follow when carrying out this procedure. (2 marks)
- 30** Compare the processes, technologies and outcomes of DNA sequencing with DNA profiling. (6 marks)
- 31** A researcher is trying to develop new varieties of flowers by mutation breeding. Evaluate an example of each of the three different types of mutagens that might be considered to promote the mutant varieties. (6 marks)
- 32** Supporters of the use of growth hormones in the livestock industry list the benefits of increased productivity, reduced production costs and improved food affordability. Recombinant bovine growth hormone (rBGH) is a synthetically produced hormone that has been shown to increase milk yield between 10–15%. Australia, New Zealand and the European Union have banned the use of rBGH based on evidence that it increases the risk of health issues in cows and because of concerns regarding milk contamination. Countries such as the United States allow it.
- Use this information and your own investigations to answer the questions below.
- a** Outline the impact of social and economic contexts on biotechnology. (3 marks)
- b** Discuss the ethical uses of biotechnology. (2 marks)

- 33** In the early 1900s in Colorado a dentist named Frederick McKay started to investigate brown stains that were prolific on the teeth of locals. His investigation revealed that the individuals affected were resistant to tooth decay. He eventually traced the cause to high levels of fluoride that occurred in the water supply. Thirty years later the first pilot study into fluoridation was conducted in Grand Rapids. Fluoridation involves adding fluoride to drinking water. Children born after the fluoridation commenced showed a 60% decrease in the number of dental cavities and an improvement in oral health.

In your studies you analysed the role of epidemiology in understanding the incidence and prevalence of nutritional diseases and those caused by environmental exposure. Compare the results of one of your analyses with the case study described above. (5 marks)

- 34** Evaluate the effectiveness of a current technology that is used to assist with the effects of one of the following disorders: hearing loss, visual disorders or loss of kidney function. Describe future directions for further research and technological development in relation to the chosen disorder. (6 marks)

SAMPLE HSC EXAMINATION 1

Section I

- 1 **D.** Mutation results in the production of new alleles (the source of natural genetic variation). **A** and **B** are wrong because crossing over and meiosis produce new combinations of alleles but not new alleles. **C** is incorrect because recombinant DNA technology results from human intervention.
- 2 **A.** Snow's methods of gathering data, looking at relationships and hypothesising about causes of disease are part of epidemiological studies. **B** is wrong because cholera is an infectious disease. **C** is incorrect because it is not an ecosystem study. **D** is wrong because historically the definite links between microbes and bacterial infection had not been made in 1854.
- 3 **A.** All the processes in this option are involved in either sexual or asexual reproduction. **B** is wrong because homeostasis and osmoregulation are involved in metabolism, not reproduction. **C** is incorrect as respiration is essential for the release of energy in cells, not reproduction specifically. **D** is wrong because excretion and circulation are not directly involved in reproduction.
- 4 **C.** Infectious diseases cause a disruption to the body's homeostasis. **A** is wrong because the body responds to infectious disease through an immune response. **B** is wrong because non-communicable diseases are non-infectious diseases. **D** is incorrect because not all infectious diseases lead to serious outbreaks.
- 5 **B.** This option describes how DNA occurs in chromosomes. **A** is wrong because the cell membrane is a phospholipid bilayer embedded with proteins and cholesterol. **C** is incorrect because DNA is unbound in circular plasmids in prokaryotic cells, not eukaryotic cells. **D** is wrong because DNA occurs in mitochondria and chloroplasts in eukaryotic cells, not prokaryotic cells.
- 6 **A.** Encephalitis increases continually from 2012 to 2016. **B**, **C** and **D** are incorrect because the data shows that the pattern of prevalence of these diseases fluctuates between 2012 and 2016.
- 7 **D.** Polio has been almost eliminated through global immunisation programs as shown on the graph. **B** is not as accurate an answer as **D** (refer to the graph). The disease was prevalent in Southeast Asia so **A** is wrong. **C** is incorrect because monitoring is not going to almost eliminate diseases such as polio.
- 8 **C.** Modern biotechnology can involve the use of bacterial enzymes, plasmids as vectors and techniques including gel electrophoresis, bacterial transformations and the Polymerase Chain Reaction (PCR). **A**, **B** and **D** are wrong because these current techniques and applications of biotechnology have been used for either decades or centuries.
- 9 **A.** When selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction the frequency of an allele in a gene pool can change. This has been occurring throughout the course of evolution. **B** is wrong because asexual reproduction produces offspring genetically identical to parents. **C** is wrong because gene expression involves processes that convert the genotype into a phenotype of an organism and does not change alleles. **D** is incorrect because random segregation of homologous chromosomes does not confer advantage or disadvantage on any particular alleles or chromosomes.
- 10 **D.** Production of cytokines is a chemical change. The inflammatory response occurs quickly in animals in response to the presence of pathogens and produces both physical and chemical changes in the cells and tissues. **A**, **B** and **C** are examples of physical changes that occur in the cells and tissues of animals in response to the presence of pathogens.
- 11 **C.** Because **O** is recessive the father must have genotype **OO**. The mother could be **AO** or **AA**. The possible offspring would be **OO** or **OA**. **A**, **B** and **D** are wrong because neither parent carries the **B** allele so **B** or **AB** blood types are not possible.
- 12 **B.** The percentage for all age groups is about 25% (around one in four). The highest percentage is in the 12–15 years age group. **A** is partly correct but the highest percentage group is wrong. **C** is wrong because the rates are not exactly the same for all age groups. **D** is incorrect because the highest percentage is not in the 16–17 years age group.
- 13 **A.** Laser surgery is one type of technology used to correct visual disorders. **B** is wrong because cochlear implants are a technology used to assist with the effects of hearing loss. **C** is incorrect because haemodialysis is a technology used to assist with loss of kidney function. **D** is wrong because nephrosis is a disorder of the kidneys.
- 14 **C.** This option is correct as external fertilisation usually occurs in water and water currents can disperse gametes and zygotes. **A** is incorrect because there is greater loss of gametes so less chance of fertilisation. **B** is wrong because it is better suited to aquatic environments. **D** is wrong as generally far more gametes are produced and released.
- 15 **B.** This option correctly identifies that transcription occurs before translation and that transcription results in mRNA that travels from the nucleus to the ribosome. **A** is wrong because transcription does not produce tRNA. **C** is wrong because transcription occurs first. **D** is incorrect because mRNA moves *from* the nucleus not *to* the nucleus.
- 16 **C.** 'Slip, Slop, Slap' is an educational campaign that has been effective in reducing environmental exposure to the sun and therefore preventing skin cancer. **A** is wrong because, even though increased understanding of genetics is important, 'Slip, Slop, Slap' does not provide an example of this. **B** is incorrect because the campaign is aimed at preventing a disease caused by environmental exposure. **D** is wrong because the campaign targeted the entire Australian population.
- 17 **A.** This option correctly identifies physical, natural and chemical mutagens. **B** is wrong as it lists forms of electromagnetic radiation that are not mutagens. **C** and **D** are incorrect because they list biochemicals that are not mutagens.
- 18 **C.** Homeostasis involves a stimulus-response model in which change in the external or internal environment is detected and appropriate responses occur via negative feedback. **A** is wrong because homeostasis is stimulus and response, and involves more than neural pathways. **B** is wrong because homeostasis involves more than hormones. **D** is wrong because homeostasis involves more than a nerve pathway model.
- 19 **D.** The diagram is of a virus so options **A**, **B** and **C** are incorrect.

20 B. Gene flow is the increase in biodiversity of a population because of immigrants. This is not necessarily a good thing if it is, for example, a result of invasion of a natural ecosystem by a crop. **A** is incorrect because genetic drift relates to changes in allele frequency in a population due to random events. **C** is wrong because gene cloning creates copies of genes that are identical. **D** is wrong because genetic erosion is the decline of genetic diversity.

Section II

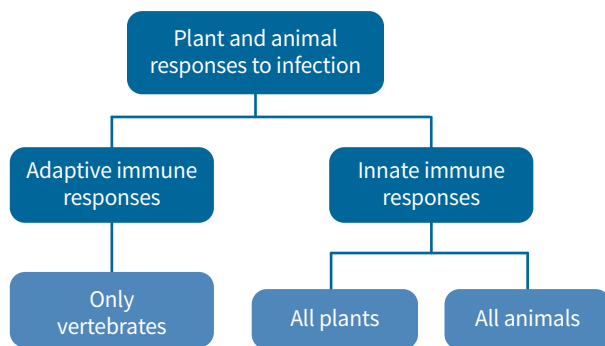
21 EM The question asks for a brief outline so you could consider using dot points to link population genetics to a better understanding of human evolution.

Population genetics investigates factors that influence the change of frequency of alleles over time and across locations and populations. Factors in human evolution include mutation, natural selection, genetic drift, gene flow and, particularly, migration. (✓)

Studies of DNA of ancestral groups such as Denisovans and Neanderthals have often relied on analysis and comparison of mitochondrial DNA which tends to be relatively well preserved and can be used as a biological clock because it is inherited through the maternal line. Fossils and archaeological remains in the Hohlenstein-Stadel cave in Germany could not be carbon dated but mitochondrial DNA put the fossilised bone to be about 124 000 years old. (✓)

Sudden reductions in population due to catastrophes such as the Toba super-volcano in Indonesia 70 000 years ago are believed to have reduced human diversity. (✓)

22 EM To answer this question you need to know that all plants and animals have an innate immune response to infections and vertebrates also have an adaptive immune response. Your model could be a flow diagram. Marks are given for the construction of the model (✓) (✓) and for correct information comparing plant and animal immune responses. (✓) (✓) A sample model is given below.



23 EM This is a simple recall question that asks you to organise your responses in a table. One mark (✓) is given for each correct answer for the four different types of pathogens. Note that this is a sample answer and you may have chosen other pathogens such as prions or fungi. Make sure you answer all parts of the question.

Type of pathogen	Example of disease it causes	Mode of transmission
bacteria	<i>Vibrio cholerae</i> causes cholera	indirect transmission through contaminated water
virus	flavivirus causes yellow fever	vector transmission by mosquitoes
protozoan	<i>Plasmodium falciparum</i> causes malaria	vector transmission by mosquitoes
macroparasite	tapeworms cause infection of the digestive tract	indirect transmission through undercooked food or water contaminated with tapeworm eggs and larvae

24 EM To answer this question you should first analyse the graph and the trends shown and outline the role of the three hormones in maintaining pregnancy. The drop in the level of progesterone is a clue to the explanation of the role of falling progesterone in triggering birth. The high mark value of this question indicates you need to explain thoroughly.

Progesterone is called the pregnancy hormone. It helps to facilitate the implantation of the embryo by maintaining the uterus lining. Other roles include the suppression of muscle contractions of the uterus. (✓) Falling levels of progesterone are part of the process that initiates birth. (✓)

A number of different forms of oestrogen are produced during pregnancy and they complement the role of progesterone. They prepare the body for birth by strengthening the smooth muscle of the uterus and initiating the development of mammary glands ready for milk production. (✓)

Oestrogens support progesterone in inhibiting the pituitary gland from its role in initiating ovulation and also by suppressing immune rejection. (✓)

Chorionic gonadotrophin is produced in high levels early in pregnancy and its levels fall in later stages. It helps to maintain the corpus luteum and hence levels of progesterone and oestrogens in the early stages of pregnancy. (✓) Chorionic gonadotrophin induces the production of the hormone relaxin that helps with expansion of maternal joints to allow room for the growing foetus. (✓)

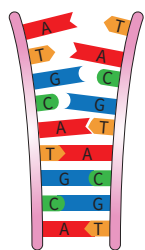
In addition to some of the oestrogens oxytocin is the hormone that orchestrates the contractions that result in birth. (✓) Relaxin helps with the expansion of the pelvis during birth but also facilitates the dilation of the cervix. (✓)

25 EM You need to identify the key components and structure of DNA, explain how replication occurs in relation to the structure and construct a diagram that summarises the key steps. You receive one mark for each of the two elements of the diagram. After you construct the diagram describe the changes that occur in point mutations in relation to the structure.

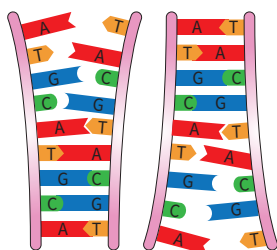
DNA is a polymer made up of nucleotide monomers. Each nucleotide contains a deoxyribose sugar joined to a phosphate and also joined to one of four nitrogenous bases: adenine and guanine are purine bases and thymine and cytosine are pyrimidine bases. (✓) The entire macromolecule consists of two chains of these nucleotides running in opposite directions and which are held together by hydrogen bonds between the nitrogen bases. (✓) Adenine attracts thymine and cytosine attracts guanine. The hydrogen bonds are not nearly as strong as the covalent bonds that hold each strand.

During DNA replication the sugar-phosphate backbones holding the nucleotides are peeled open when enzymes break the weak hydrogen bonds between the bases. (✓) The two single strands then become templates and, with the help of enzymes, the slotting in of matching nucleotides occurs so that two replicas of the original DNA are formed. (✓) Each molecule will reform into the double helix shown in the diagram that accompanies the question.

DNA unzips (before meiosis or mitosis)



Two DNA molecules forming



A point mutation is a mistake in one of the bases in a nucleotide of DNA. This can occur because of the action of a mutagen or if a mistake occurs during replication and the normal correction processes do not work. (✓) If the change is a substitution of one base for another there is only one change in the DNA molecule. If one additional nucleotide is inserted or a nucleotide deleted the whole of the following sequence of DNA will be altered. (✓)

- 26 a** **EM** You need to make clear connections between structure and function for the two listed diseases and other examples you have researched.

Cystic fibrosis is caused by a defective transport protein that impacts the functioning of membranes in a range of body organs. Change in the primary structure of the protein impacts on mucus secretions; that is, on protein functioning throughout the body. (✓)

Motor neurone disease is not well understood but the suggestion that protein levels can become toxic because of a failure to break down the proteins emphasises their importance in cell functioning. (✓)

Diseases such as prion diseases also demonstrate that the structure of proteins is critical to their proper functioning as defective proteins destroy the brain's structure and functioning. (✓)

- b** **EM** You need to identify and provide information about the cause of genetic change.

The genetic change is a point mutation (✓) and in the case of cystic fibrosis a single nucleotide polymorphism results in a substituted amino acid in the polypeptide. (✓)

- c** **EM** You need to demonstrate your ability to interpret a pedigree diagram to construct a Punnett square and clearly indicate the probability of the outcome.

Let C represent the allele for normal transmembrane protein and c the defective form that causes cystic fibrosis. Both parents must be heterozygous for cystic fibrosis. (✓)

Male gametes→	C	c
Female gametes↓		
C	CC	cC (✓)
c	Cc	cc (✓)

Offspring have a one in four probability of having cystic fibrosis and a one in two chance of being a heterozygous carrier. (✓)

- 27** **EM** To answer this question you need to understand the role of glucagon and insulin in maintaining homeostasis for glucose. Remember that the pancreas produces two hormones—insulin and glucagon—that regulate the amount of glucose in the blood. Insulin lowers blood glucose (blood sugar) levels by facilitating glucose transport from the blood into cells. Glucagon raises blood glucose levels by metabolising glycogen into glucose. When the system is functioning properly there is always some insulin and some glucagon being produced to create a balance between glucose release into the blood and glucose uptake into cells.

Very soon after a high carbohydrate meal glucose levels in the blood and insulin levels are higher. (✓) This rise is because the rise in glucose is detected by beta cells in the pancreas. These cells produce more insulin. (✓) When the glucose levels fall so do the insulin levels. (✓)

Before the meal glucagon levels are high because no glucose is being absorbed by the small intestine. (✓) At the 1.5-hour time point on the graph, when the glucose levels reach the high end of the normal glucose range, glucagon levels start to fall (✓) and continue to do so until glucose levels return back to the normal range of 70 to 110 mg/dl. At this point the glucagon concentration levels off and then slowly begins to rise again. (✓)

- 28 a** **EM** This question is straight recall but you need to make sure you answer all parts.

A genetic disorder is an inherited disorder or disease caused by genetic mutations passed down from parent(s) to offspring (✓); for example, Huntington's disease is disease caused by a faulty gene that makes an abnormal, toxic version of the Huntington protein. (✓) The toxic protein collects in the brain, causing damage to brain and nerve cells. (✓)

- b** **EM** This part of the question brings together your understanding of genetic techniques that can be used to prevent disease as well as your study of ethical issues. Make sure you answer both parts of the question; that is, choose an example of a genetic technique and provide one ethical concern for that technique.

Researchers are studying how genetic engineering can alter genes in human embryos to potentially eliminate risks of genetic diseases; that is, prevent genetic disorders from being passed from one generation to the next by genetically modifying the DNA of the embryo. (✓)

Ethical concerns are that the technology will be developed to manipulate human traits and alter the genetic sequencing of human embryos based on preference. This is sometimes called manipulating 'designer babies' and goes against the nature of heredity. (✓) Those opposed to the technology being used this way say that scientists should use the technology only for treating medical problems and not for choosing traits in embryos. (✓)

- 29 a** **EM** Demonstrate your understanding of social, economic and cultural contexts from the examples given for various approaches to managing malaria.

Social contexts include the many small farmers in Asia and collectors in China who rely on the natural source of the anti-malarial drug artemisinin (✓) and whose livelihoods are threatened by competition by the use of yeast and gene technology. (✓)

Economic contexts include the high and/or prohibitive costs of production of the anti-malarial drug artemisinin and the research and development costs of using gene drives and CRISPR-Cas 9 to develop mosquitoes that are unable to be vectors of the malarial parasite. (✓) Having patents or intellectual property rights that control the use of gene technologies could lead to situations in which the needed drugs were too expensive for populations in Asia and Africa. (✓)

Cultural contexts include belief systems that impact on the willingness to adopt medical interventions or the use of environmentally damaging pesticides. Without pesticides there would need to be increased emphasis on simple preventative measures such as mosquito nets or using minnows as biological controls. (✓) Some belief systems are opposed to the use of vaccines to prevent infectious disease. (✓)

- b **EM** The term *evaluate* means to make judgements based on criteria. In this question you need to evaluate the benefits or advantages and possible negative consequences and/or limitations of each procedure; that is, does it effectively prevent the spread of the disease malaria? In answering this part of the question it would be helpful to organise your answer in a table. One mark is given for the evaluation of each procedure.

Procedure described	Evaluation	
	Benefits/Advantages	Consequences/Limitations
pesticides	more available and affordable than other control methods	can have negative impacts on human health and the environment; resistance of mosquitoes to pesticides is a limitation
surface minnows	a cost-effective procedure	may have negative consequences on biodiversity
chloroquine	generally effective against some <i>Plasmodium</i> species and is safe for children and pregnant women and cheaper than some other treatments	protozoan resistance to the drug means that the virulent forms will survive to reproduce, which could result in an increase in the population of virulent form of protozoans
education programs	cost-effective forms of prevention and can have a greater reach and coverage than some other methods as well as targeting those communities at highest risk	availability of netting, insect repellent and protective clothing may be a problem in some regions, particularly rural and remote areas
vaccines	have been shown to be highly effective for the prevention, control and even eradication of some infectious diseases that were once common globally	the high cost of vaccines and community mistrust could be limiting factors, particularly in developing countries
artemisinin from natural sources	naturally occurring and traditionally used useful for supplementing treatment, especially where there are drug-resistant <i>Plasmodium</i> may be cost effective	affordability is an issue as supplies of the drug may be limited increasing production of artemisinin could be a solution but may impact negatively on farming areas and communities drug companies will use the plant for commercial gain without the informed consent of communities and without any benefits flowing back to communities that have traditionally used the plant
genetic engineering to produce the precursor of artemisinin	genetic engineering increases production of artemisinin and could make the treatment more affordable genetic engineering could also increase the amount of anti-malarial chemicals that the plant can produce	the drug is limited by its cost and availability
CRISPR-Cas9 gene editing and gene drive technology	engineering the genes of vectors such as mosquitoes can control the spread of diseases	the use of genetic engineering to control a disease vector raises ethical questions; for example, modified genes could escape the species boundary of the mosquito and cause problems in other species, leading to unforeseen ecological consequences

- 30 **EM** These predictions focus on the potential medical applications of biotechnology. As a comparison, possible directions in agricultural and industrial applications could provide contrasting ideas. Sample answers are also given for these two areas.

Medical applications of gene technologies, such as production of human insulin and other hormones and peptides, have been accepted more widely than applications in food production so it is reasonable to project that the more personalised approach to medicine described would ensue. (✓)

There may be more pressure on acceptance of GM food as the population grows and current agricultural practices result in environmental degradation. (✓) Crops could be grown that are more nutritional and in a much wider range of environmental conditions to address human food demand. (✓) Food could be produced in bioreactors so that natural environments can be conserved. (✓)

Industrial applications could see the further development of renewable energy resources and reduce greenhouse gases to better manage global warming. (✓) Waste could become a dated concept with all products and/or by-products being used in different ways. (✓)

- 31 **EM** The question tests your knowledge of how the human immune system responds to exposure to a pathogen. It requires recall of the innate and adaptive (specific) immune systems as well as vaccines.

- The image shows phagocytosis of a pathogen (✓) by a white blood cell called a macrophage. (✓)
- The innate immune system in the human body is the general defense system and is not specialised for specific pathogens. (✓) The specific immunity refers to the adaptive immune system, which acts specifically against certain antigens. (✓)
- B cells produce antibodies (✓) and T cells release certain chemicals or act as killer cells. (✓)
- Adjuvants are ingredients in vaccines. (✓) Adjuvants amplify immune responses by targeting the defence cells and chemicals of the innate defence system. (✓)

- 32 **EM** Make sure you name the practical application as well as the non-infectious disease or disorder it is used to treat. You could consider using dot points for your answer.

A cochlear implant or bionic ear is used to help people who have severe to profound hearing loss and/or damage to the inner ear or auditory nerve. (✓)

Cochlear implants work by wearing a sound processor behind the ear which has a microphone that picks up sounds in the person's environment. (✓) The sound processor then converts the sound into an electrical impulse that passes through the skin to a receiver surgically inserted and attached to the skull. The receiver relays the electrical impulse to an electrode array that has been surgically inserted into the cochlea to produce the sensation of sound at specific frequencies (pitches). (✓)

Improvements in cochlear implant technologies include applications that are compatible with iPods, iPhones and iPads. Hybrid technologies are being developed that combine a hearing aid and a cochlear implant in the one device. (✓)

SAMPLE HSC EXAMINATION II

Section I

- 1 **C.** Direct transmission is direct contact from one host to another. **A, B and D** are wrong because these are all indirect forms of transmission.
- 2 **C.** Tissue culture uses understanding of plant mitosis and sterile conditions to create large numbers of plant clones. **A, B and D** all relate to techniques that are used for animal reproduction.
- 3 **B.** One of the chemical responses of plants to the presence of pathogens is the production of specific receptors called resistance peptides that kill pathogens or stop them spreading. **A, C and D** are physical plant responses and therefore incorrect.
- 4 **D.** Bacteria are prokaryotic and lack a nucleus whereas protists are eukaryotic. Bacterial fission is different from mitosis. Mitosis is the basis of binary fission in protists. **A, B and C** are all incorrect statements.
- 5 **C.** If the bacterium is not recognised by phagocytes it is able to get past the body's first line of defence and enter into the bloodstream. **A** is incorrect because when a pathogen is composed of molecules that are different to the host's it will be recognised as non-self and an immune response will be triggered. **B** is incorrect because an inflammation response is designed to either kill the pathogen or prevent it from spreading. **D** is wrong because macrophages are part of the body's immune defence which prevent the entry of pathogens into the host.
- 6 **C.** Random drift causes changes in allele frequency because of events such as random mating. **A and B** relate to changes in frequency resulting from natural selection. **D** is wrong because gene flow is a result of immigrants bringing different alleles into a population.
- 7 **D.** The primary target for prevention needs to be teenagers and young adults. An education campaign through social media has been shown to be effective. **A and B** are wrong because they are not strategies for prevention. **C** is partly correct but the primary target needs to be the young people rather than the parents.
- 8 **A.** This option correctly identifies that better health and increased life expectancy are benefits for society that could reasonably be projected into the future. **B and D** are incorrect because they do not list benefits for society. **C** is wrong because genetic technologies will not directly eliminate mutagens though they may make screening and treating better.
- 9 **B.** Aneuploidy is an additional or missing chromosome, usually resulting from non-disjunction in cell replication. **A, C and D** are all examples of point mutations.
- 10 **A.** The diagram shows the transition from the polypeptide to the protein (insulin). **B and C** are incorrect because they are processes that occur in cell replication. **D** is wrong because the diagram represents a molecule, not a chromosome.
- 11 **B.** The structure of proteins is vital for their functioning. **A** is wrong because proteins have many roles in addition to being enzymes. **C and D** are wrong as they are not functions of hormonal proteins.
- 12 **B.** Type 2 diabetes is a disease in which the body becomes resistant to the normal effects of insulin or gradually loses the ability to produce enough insulin. **A** is wrong because gestational diabetes is a form that is first diagnosed during pregnancy. **C** is wrong because chronic disease is a general term for diseases that tend to be long lasting and persistent in their symptoms or development. **D** is incorrect because pre-diabetes refers to impaired glucose tolerance. This is a condition in which blood glucose levels are higher than normal but less than required for a diagnosis of diabetes.
- 13 **C.** Gene and whole organism cloning are gauged by the percentage success rate. **A** is wrong as it only refers to whole organism cloning. **B** is incorrect as antibiotic resistance is often linked to a cloned gene. Successful clones can be screened but the process does not work for whole organism cloning. **D** is wrong because it refers to only one possible application of whole organism cloning.
- 14 **B.** Sources of variation in cell replication are crossing over and random segregation (and mutation). **A** is wrong because it includes DNA replication and **C** is wrong because both processes result in replication. **D** is incorrect because it lists mutagens.
- 15 **A.** Prevalence is the number of cases or the proportion of cases in a population in a given time period. **B** is wrong because mortality refers to numbers of deaths. **C** is incorrect because incidence refers to the number of new cases in a specific time period. **D** is wrong because even though the number of cases of dementia is increasing—as a result of the number of older people as a proportion of the population increasing—this is not about population aging.
- 16 **B.** An antigen is any substance, microbe or pathogen that is usually foreign to an organism's own body and thus triggers an immune response. An antibody is a protein capable of interacting with a specific antigen. **A** is only partly correct and therefore not the best option: antigen does refer to the invading pathogen but the antibody is not the pathogen. **C** is wrong because antigens are not white blood cells and antibodies are mainly made by plasma cells or B cells. **D** is incorrect because even though antigens can refer to toxins produced by pathogens, antibodies attach to and neutralise toxins.
- 17 **D.** A single nucleotide base substitution in at least 1% of population is an SNP. **A** is wrong as the change is not large enough to be a chromosomal mutation. **B and C** are incorrect as the figure involves substitution as opposed to the insertion or deletion of a nucleotide.
- 18 **A.** Without cell replication multicellular organisms could not grow and unicellular organisms could not reproduce. **B and C** are wrong because they relate to sexual reproduction, which is not universal across all life forms. **D** is incorrect because it refers only to reproduction in bacteria and some fungi.
- 19 **B.** According to the graph, expenditure on cardiovascular disease totalled around 13.8 million dollars. All other diseases were less than that in terms of expenditure so options **A, C and D** are incorrect.

- 20 **D.** Foot-and-mouth disease is a disease in cattle that has been successfully kept out of Australia by quarantine. **A** is wrong because sickle-cell anaemia is a genetic disease. **B** is incorrect because smallpox has been controlled by vaccination. **C** is wrong because lung cancer is caused primarily by smoking and quarantine is ineffective in stopping smoking.

Section II

- 21 **a** **EM** The question asks you to relate two different understandings: plant responses to infections and Aboriginal bush medicines.

Eucalyptus oil contains antibacterial properties and is used by Eucalypts as a preformed chemical defence against the entry of pathogens. (✓) This makes it an effective bush medicine that has been traditionally used by Indigenous Australians. (✓)

- b** **EM** This is a recall question.

Aboriginal protocols are used in the development of medicines to ensure recognition and protection of Indigenous cultural and intellectual property (✓) and as guides to ethical practices and the equitable sharing of benefits that come from using bush medicines in the pharmaceutical industry. (✓)

- 22 **EM** You need to describe the key events in fertilisation and implantation and methodically examine them for their role in producing new generations of offspring.

Fertilisation is a key event in sexual reproduction because without the union of the male and female gametes offspring would not eventuate. If fertilisation failed across a species then the long-term continuity of that species would be at risk. (✓) Because it is a source of genetic diversity fertilisation is a key process contributing to the continuity of species. (✓)

Implantation is the process by which the embryo embeds in the lining of the uterus of placental and marsupial mammals to allow development of the foetus, making it essential for continuity of the species in these groups. (✓)

Species that reproduce asexually such as fungi (budding, spores), bacteria (binary fission) and protists (binary fission, budding) and plants reproducing vegetatively do not rely on either fertilisation or implantation for their asexual reproduction. The continuity of a species relies on genetic diversity so asexual reproduction may not provide enough diversity to support natural selection in a changing environment. (✓)

- 23 **a** **EM** This is a straight recall question.

The answer is incidence of disease. (✓)

- b** **EM** When answering this question make sure you justify or support your answer using the data provided.

The data shows that in developing countries the higher proportion was due to infections. (✓) This suggests that infections are more likely where there is poor sanitation and contaminated water, and where there are lower standards of health care and understanding of infectious agents. (✓)

- c** **EM** There are a number of ways to answer this question. Make sure the strategy is about prevention rather than treatment. Naming two strategies will result in two marks.

Examples include vaccination (e.g. vaccination against human papillomavirus (HPV) which causes cervical cancer), education campaigns to prevent transmission of the infectious agent, (✓) improved sanitation and clean water supplies to reduce the risks of infection, and community-wide screening programs to detect early signs of the cancer. (✓)

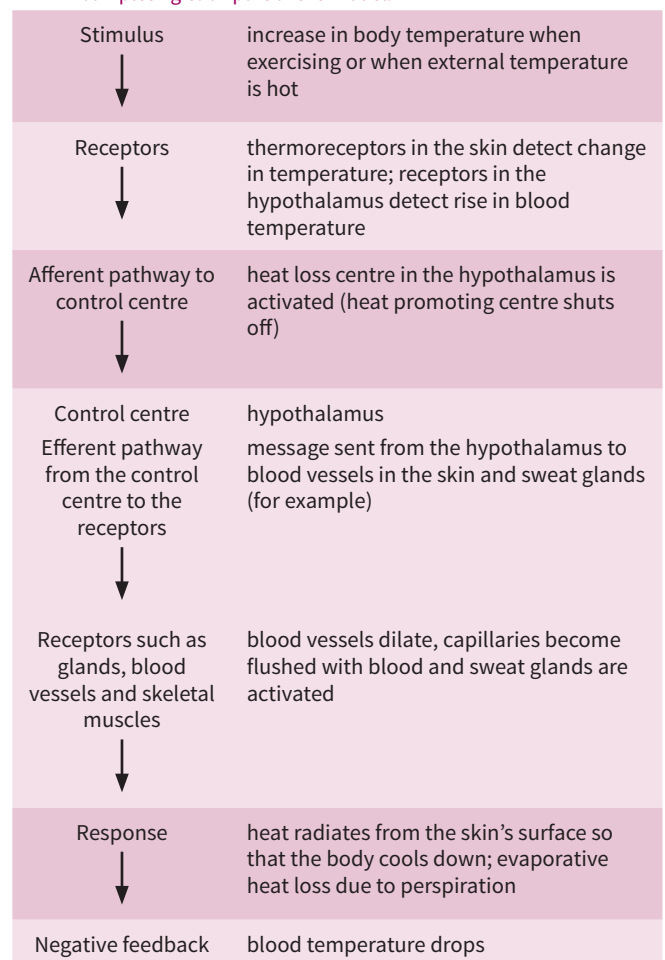
- 24 **a** **EM** You need to interpret the steps in the model of mitosis, identify key events represented and give information about the changes that are occurring.

- 1 DNA has replicated, nuclear membrane disappears, chromatids condense, joined by centromeres, centrioles form
- 2 centrioles move apart, joined by spindle fibres (✓)
- 3 chromatids joined to spindle at centromeres and are lined up along the 'Equator'
- 4 centrioles move apart and the chromatids separate, going to opposite poles (✓)
- 5 centrioles and spindles break down and the nuclear membrane starts to form
- 6 cytokinesis completes the mitosis cell division to divide cytoplasm between two cells (✓)

- b** **EM** This question requires that you identify meiosis as the other type of cell division and highlight how it differs from mitosis.

Mitosis, as described in part **a** above, is cell replication that results in two identical cells from the one parent cell. (✓) Meiosis is the cell division which results in the reduction of chromosome numbers by half. Genetic variation results from meiosis because of random segregation and crossing over. Meiosis results in four unique haploid cells from the one diploid parent cell. (✓)

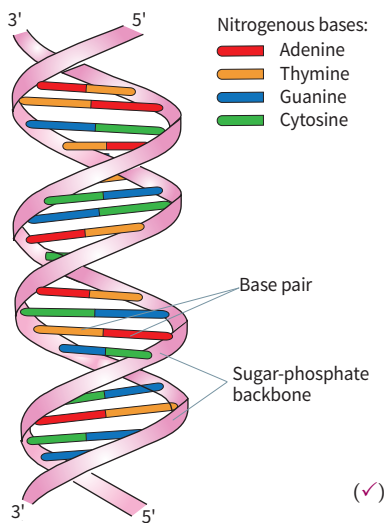
- 25 **a** **EM** This is a sample answer. Half a mark is given for correctly completing each part of the model.



- b** **EM** This is a higher-order question that asks you to apply your understanding of structural and physiological adaptations for thermoregulation. You need to know that humans are endotherms in order to answer this question correctly.

Adaptations considered would include structural and physiological adaptations that help control the exchange of heat with the environment. (✓) These include insulation or small surface area to minimise heat loss (✓) along with blood flow (✓); for example, reducing blood flow to extremities to keep the core of the body warm. (✓)

- 26** **EM** To answer this question you need to explain the structure and function of DNA, then the structure and function of proteins, and then outline the relationship between DNA and proteins. Diagrams should show the double helical structure of DNA and contrast that with the variable structure of proteins, such as the secondary (alpha and beta sheets), tertiary and quaternary arrangements.



DNA is the genetic code and the structure of the molecule has to ensure its replication and allow for the synthesis of polypeptides. (✓) DNA is a polymer made of nucleotide monomers in two strands running in opposite directions. The four bases on the nucleotides are arranged in specific pairs held together by hydrogen bonds. During polypeptide synthesis each triplet of bases is the code for the insertion of a specific amino acid in a sequence that forms a polypeptide. (✓) The double helical shape encloses the base pairs as a form of protection from mutagens in order to ensure stability of the code.



Proteins are complex polymers made up of various numbers of polypeptide chains. Each polypeptide chain consists of up to 20 different amino acids (monomers) forming the primary structure. (✓) The amino acids interact with each other, forming beta sheets and alpha helices at various places along a polypeptide which results in its secondary structure. These may fold together to form the tertiary structure (as shown in the diagram). Finally, a protein may form from at least one or more polypeptide chains interacting together. (✓)

Compared with DNA, protein structures are much more varied. Some may be long and can interact together, such as actin and myosin which bring about muscle contraction. Other proteins have a specific shape to interact with other molecules in order to bring about chemical changes (enzymes). Other proteins store and transport (e.g. haemoglobin) while others control entry into cells, provide mechanical support, control metabolism (hormones) or recognise foreign substances (antibodies). The structures of proteins suit their many purposes. (✓)

- 27** **a** **EM** This is a straight recall question. You could answer with either epidemic or pandemic.

An epidemic is the rapid spread of infectious disease to a large number of people in a particular population in a relatively short period of time. (✓) A pandemic is the rapid global spread of infectious disease. (✓)

- b** **EM** Make sure you relate your answer to mobility. Note: The diseases in the question are all zoonotic diseases; that is, diseases that can spread between animals and humans.

The speed and volume of the mobility of individuals and human population movement is unprecedented in human history. Given the speed of travel it is possible for an infected individual to travel the globe within the incubation period of a disease, thereby causing an exponential increase in contacts. (✓)

Global changes in land and animal use have significantly increased the risk of zoonotic diseases in humans. Increases in human population make it easier for diseases to spread and bring more people in closer contact with other animals. (✓)

- c** **EM** Many factors can contribute to the spread of disease during an epidemic. Sample answers are provided. Consider using dot points for your answer. One mark is given for each correct point. Note: More information is given below than you would need to provide to obtain two marks.

Transmission of a disease during an epidemic is usually rapid. Key factors that increase exposure to pathogens and cause the spread of disease are:

- a continual source of the disease; for example, a reservoir such as a contaminated water supply
- environmental factors such as changes in climate
- loss of healthcare systems and shortage of medical supplies; for example, as a result of civil war
- natural disasters such as flooding, which can damage sewerage system infrastructure
- an increase in the amount of the pathogen or new strains of the pathogen that can be spread from animals to humans
- introduction of the pathogen into an area where the pathogen has not been before; for example, because of deforestation
- slow responses by health agencies at the start of the epidemic.

- d** **EM** As with part c, consider using dot points for your answer. One mark is given for each correct point.

- Modelling with computers is used to predict future occurrences of disease along with projecting and simulating how a disease will progress and spread. Modelling can also simulate the effects of possible interventions. (✓)
- Restriction measures include travel restrictions and increased quarantine surveillance. (✓)
- Event-based surveillance systems can systematically scan a multitude of informal sources; for example, news reports, online newspapers, social media and internet-based searches can all assist in ensuring a rapid response to outbreaks. (✓)

- 28 EM** You need to interpret the pedigree diagram showing normal inheritance of a mutation and compare it with that showing the pattern of inheritance with the added gene drive.

Using the pedigree diagram for normal inheritance it is apparent that the normal or wild type allele is recessive (✓) and the fly with the altered allele was heterozygous dominant meaning that half of its offspring showed the phenotype for the altered allele. (✓) This pattern of inheritance predicts that 12.5% of offspring will have the altered allele in the third generation as demonstrated in the pedigree diagram. (✓)

With the gene drive inheritance shown in the figure all offspring of the parents with altered alleles have the altered allele in their phenotype. (✓) This means that even when the offspring mate with wild-type flies all offspring have the altered allele. This is because the gene drive 'edits' the allele on the other homologous chromosome, converting it to the altered allele. (✓) As the altered allele attached to the gene drive always becomes homozygous it is always passed on to the offspring. In the offspring the gene drive makes the allele homozygous and so on through generations. (✓)

- 29 a EM** This is a straight recall question which demonstrates your understanding of scientific method. Validity involves designing your investigations to use independent, dependent and controlled variables to ensure a valid procedure. Below is a sample answer.

I would ensure controlled variables; that is, the factors that are kept constant during the procedure. This would include having the same amount of agar in each Petri dish, ensuring the same temperature for each Petri dish (✓) and having the same amount of food sample and the same time for incubation. (✓)

- b EM** This is a straight recall question which demonstrates your understanding of safe work practices and managing the risks associated with inoculating nutrient agar plates and growing microbes. One mark is given for each correct procedure. Your answer could have included any two of the points below.

Safe work practices and risk management include:

- the use of protective clothing; for example, enclosed shoes, masks, lab coat, gloves and protective eyewear
- sterilising flaming transfer loops, wires or needles immediately before and after transfer of samples
- ensuring the correct labelling of all samples
- thorough cleaning of work surfaces
- washing hands thoroughly before leaving the laboratory
- autoclaving agar plates at the end of the investigation to ensure harmful microbes are destroyed.

- 30 EM** The answer is given below as an explanation but you may find that that the use of dot points or a table will help with the three aspects of comparing DNA sequencing with profiling.

DNA sequencing enables mapping of species genomes by determining the order of the nucleotide bases on all DNA in an organism (✓) while DNA profiling uses the unique genetic make-up of individuals for analysis of crime scene samples, unidentified remains and confirming family relationships. (✓)

DNA profiling relies on comparing sections of non-coding DNA that are highly variable in length; that is, variable number tandem repeats (VNTRs) and short tandem repeats (STRs). Particular enzymes called nucleases break the DNA from the sample into these fragments. (✓) DNA sequencing also uses enzymes and involves breaking fragments at particular nucleotide bases that are identified in some way or by synthesising fragments from a single DNA strand that acts as a template. (✓)

Both DNA sequencing and DNA profiling have used technologies such as the polymerase chain reaction to increase the quantity of DNA being analysed along with electrophoresis for separation and comparison of the lengths of the DNA fragments. (✓) Both DNA sequencing and DNA profiling have undergone dramatic improvements in the technologies applied and reductions in the time taken to complete the processes. (✓)

- 31 EM** The key to answering this question is to identify the types of mutagens—chemical, electromagnetic and natural—and make judgements as to how they could be used to best promote mutations in plants.

Gamma rays are a high-energy, high-frequency, short wavelength form of ionising electromagnetic radiation. (✓) Gamma rays can be sourced from radioisotopes such as potassium-40. Gamma rays have been shown to produce mutations in both seeds and pollen, and have successfully been used in the production of mutant rice lines. Gamma rays often result in chromosome aberrations and safety precautions must be used when handling radioisotopes. (✓)

Chemical mutagens used in plant breeding are often the alkylating agents such as ethyl methanesulfonate (EMS). (✓) These agents add alkyl (hydrocarbon chains) to the bases of DNA, causing changes such as base substitutions, but are generally much easier and safer to handle than gamma rays. (✓)

Natural mutagens include certain viruses that are known to induce point mutations (insertions, deletions and substitutions) in DNA, particularly in mammalian cells. (✓) Transposable elements such as transposons, retrotransposons and retroviruses are mutagens that could be classified as natural because they are self-replicating segments of DNA that excise and/or insert themselves within the genome. Transposable elements have an advantage in mutation breeding of plants because the changes they promote are not random; that is, there are places where they are more likely to insert themselves or replicate. (✓)

- 32 a EM** You need to present ideas on how the social and economic benefits flowing to certain individuals and groups will impact on the support and use of biotechnology.

The acceptance and use of biotechnology is influenced by social contexts. Some individuals and groups in society have concerns regarding animal welfare, the use of chemicals in the environment and the methods used in food production. These can restrict the acceptance of some applications of biotechnology. (✓) Some groups may fear the impact of altering natural processes in animals by the use of rBGH or be concerned that food labelling may not accurately describe what they are purchasing and whether the food contains high levels of hormones. (✓)

Farmers who can afford rBGH and benefit from it may support its use whereas others who cannot afford it or have concerns for animal health may oppose it. (✓)

Economic and social contexts interact. If societal pressures reduce sales of a product, thereby making it not economically viable, then the application of the specific biotechnology becomes defunct. (✓)

- b EM** Arguments about what is ethically right or wrong with the uses of biotechnology need to be developed in your response to this question.

Ethical uses of biotechnology are about ensuring that benefits to society and the environment outweigh any harm, particularly to societal groups or animals that may not have any choice about the applications of biotechnology. (✓) An ethical use of biotechnology could be the development of biofuels that reverse the impact of global warming. Other uses could include more effective bioremediation of land or the protection or restoration of damaged ecosystems such as coral reefs. (✓)

- 33 EM** When you compare the studies and results show how they are similar and how they are different. Remember that prevalence measures the number or proportion of cases in a population at a given time.

The sample study chosen for this answer is the epidemiology of vitamin D deficiency, a nutritional disease caused by insufficient exposure to the sun, often as a result of the use of sunscreen, skin pigmentation and clothing habits. Vitamin D is a fat-soluble vitamin needed for calcium maintenance, bone health and homeostasis. (✓) Deficiency is related to diseases such as osteoporosis, hypertension, diabetes and cancer. Deficiency is measured by levels of the blood serum 25(OH)D. (✓)

Available prevalence data shows that vitamin D deficiency is a global problem, particularly in girls and women from Middle Eastern countries but also in adults in many European, South American and African countries. One billion people worldwide—about 15% of the population—are vitamin D deficient or insufficient. (✓)

Epidemiological studies play a role in reducing the prevalence of non-infectious diseases or disorders. The benefits of epidemiological studies are evident in both the fluoridation and vitamin D deficiency studies. McKay's study led to targeted public health intervention that reduced tooth decay and improved oral health. (✓) Epidemiological studies of vitamin D deficiency allow scientists to identify risk factors, target those populations that need to be screened, and determine the resources needed for health care: in this case diet supplementation to at-risk populations. Studies have shown that vitamin D3 supplements are more effective in raising 25(OH)D levels than vitamin D supplements. (✓)

- 34 EM** You only need to choose one disorder. When you evaluate effectiveness consider the value of the technology and other factors such as the extent to which it assists with the effects of the disorder, as well as its cost and affordability. Make sure you answer both parts of the question: you need to describe and evaluate a current technology and describe a possible future research and technology. The sample answer provided relates to visual disorders.

Example of current technology: the visual disorder is cataracts, which are the world's leading cause of blindness. Cataracts are caused when proteins in the lens clump together, making the lens cloudy and blocking and distorting the light entering the eye. (✓)

Surgery can easily restore normal sight. Cataract surgery is an example of a highly effective technology as the treatment is simple. It is one of the most frequently performed surgeries in the world and takes less than 30 minutes. Once the cloudy (opaque) natural lens is replaced with a clear artificial lens it is not possible to develop another cataract. The cost in developing countries is about \$15 to \$100 (✓) and the major challenge is to get the treatment to those who need it. (✓)

Example of future technology: the visual disorder is retinitis pigmentosa, a disease in which photoreceptor cells in the retina die because of a gene mutation and vision dims from the outside to form a tunnel of light. (✓) Disorders of the retina are harder to treat than disorders of the lens. A bionic eye that uses a microchip containing thousands of photodiodes (to replace the function of the photoreceptor cells) has been developed and is currently in the trial stage. The microchip is implanted among dead photoreceptor cells in the retina's macular region, allowing the optic nerve to pick up electrical signals. (✓) The technology requires high costs for research and development and the surgery is complex. Another drawback is that the implant does not restore full vision and the patient must learn to interpret the new visual data. (✓)