Student Number _ _ Student Name _____



Caringbah High School
Biology: HSC Course
PRACTICE Trial 2021

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams and graphs using pencil
- NESA approved calculators may be used

Total marks:
100

This paper has two parts, Part A and Part B

Part A – 20 marks

- Attempt Questions 1-20
- Allow about 35 minutes for this part

Part B – 80 marks

- Attempt Questions 21-37
- Allow about 2 hour and 25 minutes for this part

Section I

20 marks

Attempt Questions 1 – 20.

Allow about 35 minutes for this section.

Use the multiple-choice answer sheet provided for Questions 1 – 20.

1 The secretion of specific hormones is carefully regulated during the ovulation cycle to prepare the uterus for the implantation of an embryo. After ovulation the corpus luteum enlarges and starts to secrete hormones X and Y.

If fertilisation and implantation occur, the pregnancy is controlled by hormone Y, which is secreted from the corpus luteum in the first three months and later from the placenta.

Hormone Z controls birth by causing coordinated contractions of uterine muscles.

What are hormones X, Y and Z respectively?

A. Oestradiol, oxytocin, progesterone
B. Oxytocin, oestradiol progesterone
C. Oestradiol, progesterone, oxytocin
D. Prolactin, progesterone, oxytocin

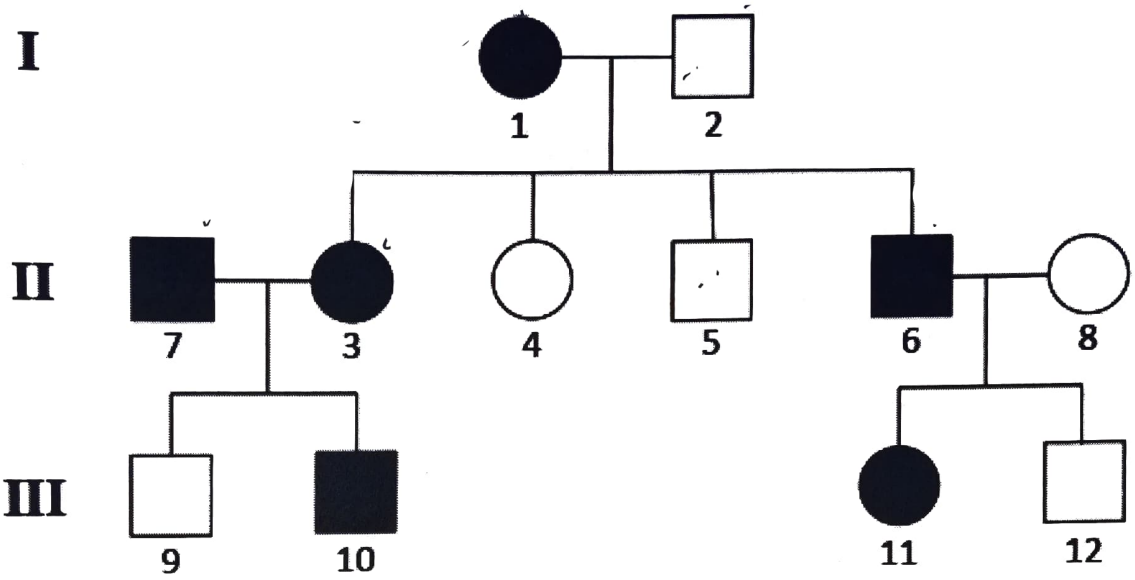
2 A geneticist compared the sequences of two genes (I and II) from a bacterium. Gene I contained 32% cytosine and Gene II contained 14% cytosine. Which of the following statements about the chemical makeup of the genes can be deduced from these data?

A. Gene I contained 32% adenine.
B. Gene II contained 36% adenine.
C. No conclusion can be drawn as the base pairing in bacterial DNA is not the same as in eukaryote DNA.
D. Gene I contained more thymine than Gene II.

3 Several responses of the immune system result in the perforation of specific cells and subsequent rupture of the cells due to the inflow of extracellular fluid. This process can be directly caused by:

A. both T-cells and B-cells
B. mast cell activity
C. T-cells and mast cells
D. complement action

4 It is often difficult to draw conclusions about the inheritance of traits in humans as there may be more than one possible explanation for the observed phenotypes over several generations. At best a researcher might only be able to rule out specific possibilities. Which of the following statements can the researcher conclude based on the following pedigree?



A. The researcher could reliably conclude that this trait is autosomal dominant.
B. Individual II 3 must be heterozygous.
C. The trait could be recessive.
D. The researcher could rule out the possibility that the trait is sex-linked because there are equal numbers of males and females who show the trait.

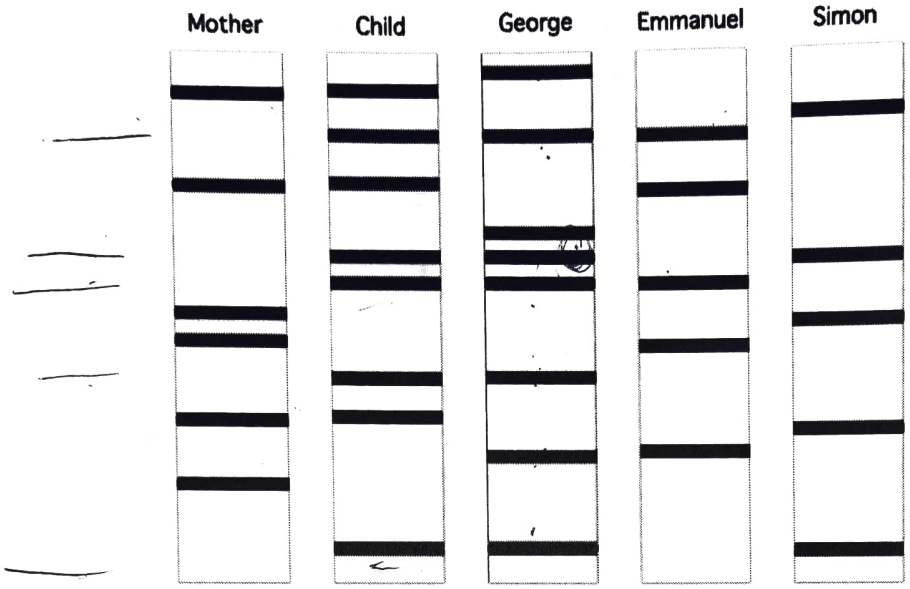
5 Homologous chromosomes:

A. are present in pairs in all cells.
B. have identical alleles.
C. contain only coding regions of DNA.
D. can exchange sections during meiosis.

6 The process by which scientists remove a gene from one species and insert it into another is best described as:

A. biotechnology.
B. genetic engineering.
C. gene therapy.
D. artificial insemination.

7 DNA profiling can be used to test for paternity. Three men (George, Emmanuel and Simon) were tested to determine the paternity of a child and the following banding patterns were produced.



Which individual could you conclude is the most likely to be the father from these data?

A. George
B. Emmanuel
C. Simon
D. None of the three men, as none of their profiles exactly matches that of the child.

8 Emmanuel has been playing the saxophone in jazz and rock bands since his high school days and now, in his fifties, has noticed that he has difficulty hearing, especially the higher-pitched notes of his jazz vocalist. Which of the following most likely explains his hearing loss?

A. Damage to the cochlear hair cells
B. Damage to the inner ear bones
C. Stress relating to his possible impending paternity suit
D. Damage to his Eustachian tubes from playing the saxophone.

9 The table below illustrates the chromosomes in a single somatic cell from four different individuals from the same plant species.

			
I	II	III	IV

Which of the following statements is correct?

A. Image II is an example of polyploidy and is due to duplication and translocation of chromosomes.

B. The normal chromosome number for this species is represented by image IV and is $n = 8$.

C. Image I is an example of trisomy as the chromosome number is divisible by 3.

D. Image II and III are examples of aneuploidy.

10 Antibodies:

A. are ineffective against bacterial pathogens.

B. are produced in an individual to confer passive immunity.

C. are involved in stimulating the complement system.

D. are produced by phagocytes following the initial infection by a pathogen.

11 Which of the following lists only non-infectious diseases?

A. Malaria, diabetes, polio

B. Diabetes, cystic fibrosis, food poisoning

C. Asthma, influenza, hepatitis

D. Cystic fibrosis, scurvy, haemophilia

12 The table below illustrates the genetic code.

Table of mRNA codons and associated amino acids

UUU, UUC: phe	UCU, UCC, UCA, UCG: ser	UAU, UAC: tyr	UGU, UGC: cys
UUA, UUG: leu		UAA: stop	UGA: stop
		UAG: stop	UGG: trp
CUU, CUC, CUA, CUG: leu	CCU, CCC, CCA, CCG: pro	CAU, CAC: his	CGU, CGC, CGA, CGG: arg
		CAA, CAG: gln	
AUU, AUC, AUA: ile	ACU, ACC, ACA, ACG: thr	AAU, AAC: asn	AGU, AGC: ser
AUG: met		AAA, AAG: lys	AGA, AGG: arg
GUU, GUC, GUA, GUG: val	GCU, GCC, GCA, GCG: ala	GAU, GAC: asp	GGU, GGC, GGA, GGG: gly
		GAA, GAG: glu	

The following DNA sequence is part of the gene coding for an enzyme in a species of yeast.

ACG CCA GTG ACA CTG GAT

Researchers have identified several strains of this yeast in their laboratory that have undergone changes to this sequence. Three examples of such changed sequences are given below:

I ACG CCA GTG ACA GCT GGA

II ACG GGG GTG ACA CTG GAT

III ACG CCA GTG ACT CTG GAT

Which of the following statements is correct?

A. The amino acid sequence coded by the original DNA sequence is thr pro val thr leu asp.

B. Sequence I would result in a frameshift mutation and is the least likely to affect the synthesis of the enzyme.

C. Sequence II is the most likely to affect the synthesis of the enzyme as it contains the most base changes.

D. Sequence III has introduced a stop codon so no functional gene product will be synthesised.

13 Restriction endonucleases are used in molecular biology to:

A. splice exons out of pre-RNA before translation.
B. attach DNA primers to target DNA during the polymerase chain reaction.
C. prepare DNA fragments for electrophoresis.
D. splice DNA into plasmids for gene duplication.

14 A population of laboratory rats in a medical research institute was suffering from an unknown disease. Researchers isolated three suspected pathogens (which they labeled I, II and III) from affected rats and carried out a biochemical analysis to determine which classes of organic compounds were present in the three suspects. Their results were as follows:

	I	II	III
DNA	✗	✗	✓
RNA	✗	✓	✓
protein	✓	✓	✓
lipid	✗	✓	✓
carbohydrate	✗	✗	✓

Which of the following could the researchers conclude from these results?

A. Neither I nor II could be pathogens as they do not contain DNA.
B. I could not be a pathogen as it contains no nucleic acid.
C. III could be a fungus.
D. II and III are both cellular pathogens.

15 Once isolated, the researchers carried out a series of investigations, using a population of healthy rats, to establish that one of the suspected pathogens was indeed the cause of the disease. The scientist who is credited with devising this procedure is:

A. John Snow
B. Robert Koch
C. Robert Ross
D. Louis Pasteur

16 *Frankliniella occidentalis* (below) is a small thrip that is known to infect plants of the genus *Pelargonium* (geraniums) with a virus (the pelargonium flower-break virus). Symptoms caused by the virus include white streaks on flowers, discoloration of leaves and reduced plant growth. The virus is transmitted by thrips moving virus-infected pollen from plant to plant. It infects the plant through wounds made by the thrips as they feed on the plant tissues.



The thrip, *Frankliniella occidentalis*.

But all is not lost for geranium growers. A nematode in the genus *Heterorhabditis* is known to infect the thrips and once inside it releases a bacterium that rapidly kills the thrip. The nematode is being investigated as a potential biological control agent.

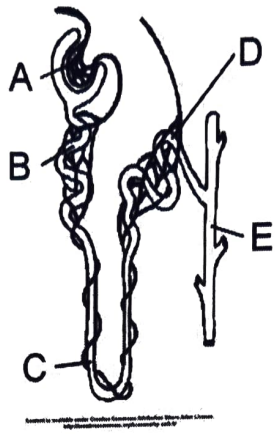
Based on this information, which of the following descriptions CANNOT be accurately applied to *F. occidentalis* and *Heterorhabditis*:

A. pathogens
B. hosts
C. vectors
D. macroparasites

17 Insulin is released in response to various physiological processes in the body relating to glucose homeostasis. One of the actions of insulin is to:

A. increase uptake of glucose into muscle and fat cells.
B. decrease conversion of glucose to fat in fat cells.
C. increase excretion of glucose in the urine.
D. increase blood glucose concentration.

18 The following diagram shows a single nephron from a kidney. Physiological processes at various points are mediated by hormones to control how much water and solutes are excreted by the kidney.



Which of the following statements is correct?

A. ADH acts at C to increase the permeability of the membrane to water so that more water will be excreted by the kidney.

B. ADH acts at C to decrease the permeability of the membrane to water so that more water will be excreted by the kidney.

C. ADH acts at E to increase the permeability of the membrane to water so that less water will be excreted by the kidney.

D. ADH acts at E to increase the permeability of the membrane to water so that more water will be excreted by the kidney.

19 In an epidemiological study of disease, incidence is defined as:

A. the total number of people suffering from the disease.

B. the number of new cases of the disease occurring in a specific time interval.

C. the number of localities where the disease has occurred.

D. an estimate of the number of people infected based on knowledge of what percentage of people who are ill report to a doctor or hospital.

20 Each of the evolutionary phenomena listed below is more likely to affect gene frequencies in small populations compared to large populations. Which of these processes **requires** a small population for it to have any impact?

A. Genetic drift

B. Natural selection

C. Mutation

D. Sexual selection

Question 21. (5 marks)

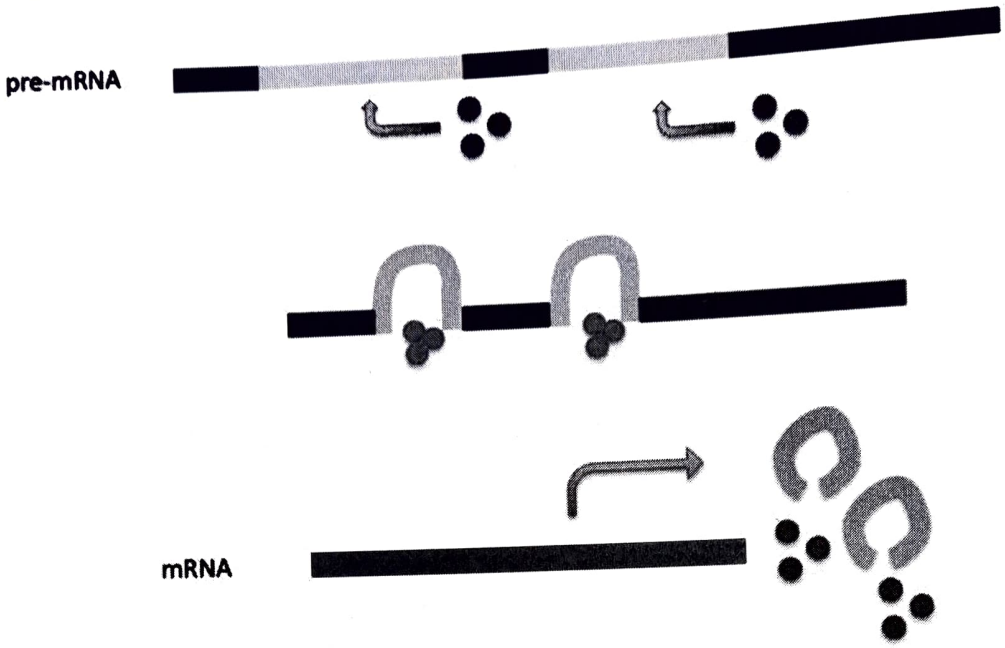
Environment has a significant effect on many aspects of an organism's phenotype and function.

(a) Discuss an example of how the environment influences phenotype. **2 marks**

(b) Some species of animals, plants and fungi alternate between sexual and asexual forms of reproduction. Explain why a population would switch from asexual to sexual reproduction, with reference to the differences between the two types of reproduction and the specific advantage that each type has under particular environmental conditions. **3 marks**

Question 22. (3 marks)

The diagram below illustrates a process that occurs in eukaryote cells.



(a) Identify the black and grey regions of the pre-mRNA and explain the role this process plays in eukaryote cells. **2 marks**

(b) Explain why this process is unique to eukaryote cells and does not occur in prokaryotes. **1 mark**

Question 23. (4 marks)

Researchers reported in 2013 on a child suffering from mitochondrial encephalomyopathy, which they were able to determine was caused by a mutation in the anticodon region of the tRNA coding for tryptophan.[1] The symptoms affected all major organs of the child's body.

Using your knowledge of the role of tRNA in cell function, discuss the potential impact this mutation would have on normal cell function.

4 marks

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[1] Roos, S. *et al.* (2013) A novel mitochondrial tRNA Arg mutation resulting in an anticodon swap in a patient with mitochondrial encephalomyopathy. *European Journal of Human Genetics 21*: 571–573

Question 24. (6 marks)

(a) Draw a cell with $2n = 4$ at Metaphase of mitosis and a second cell with $2n = 4$ at Metaphase I of meiosis. Explain how the differences between the two influence the genetic makeup of the daughter cells in each case. **4 marks**

(b) Using specific examples, describe the types of mutations that can result from errors that occur during meiosis. **2 marks**

Question 25. (2 marks)

The sex of birds is determined by the ZW chromosome system: males have two Z chromosomes and females have a Z and a W chromosome. The shape and colour of the tail feathers of a certain species of bird was found to be controlled by two gene loci.

The gene for tail shape is on the Z chromosome and the two alleles (Z^F and Z^S) of this gene show incomplete dominance. The phenotypes, expressed as the size of the tail feathers, are:

- Males that are homozygous for the allele Z^F have large tail feathers
- Males that are homozygous for the allele Z^S have small tail feathers
- Males that are heterozygous and females that carry one Z^F allele have medium-sized tail feathers
- Females that carry the Z^S allele have no tail feathers

The gene for feather colour is on an autosomal chromosome and the two alleles (B and Y) also show incomplete dominance. The phenotypes are:

- Birds that are homozygous for B have black feathers
- Birds that are homozygous for Y have yellow feathers
- Birds that are heterozygous have brown feathers

What would be the phenotype ratio of the offspring of a cross between a male bird with medium-sized yellow feathers and a female bird with medium-sized black feathers? Show your working. **2 marks**

BBZ^FW = Medium black female

YYZ^WZ^F = Medium yellow male.

100% = BX (brown).

	Z^F	W
Z^S	Z^SZ^F	Z^SW
Z^F	Z^FZ^F	Z^FW

Phenotype 1: 100% Brown feathers.

Phenotype 2: 50% medium, 25% no feathers, 25% large.

(2:1:1)

Question 26. (5 marks)

Artificial insemination is a process used in agriculture to control certain characteristics in populations of farmed animals. Using specific examples, describe the process and evaluate the benefits of this application and its potential impact on biodiversity. **5 marks**

Question 27. (5 marks)

The term cloning is used to refer to copying a gene (gene cloning) and to copying an entire organism (whole animal cloning).

(a) Name and briefly describe two different processes that can be used to clone a gene. **2 marks**

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(b) Describe the process of whole animal cloning and discuss some of the ethical issues associated with its application. **3 marks**

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Question 28. (5 marks)

(a) Using examples, describe three different ways by which infectious diseases can be transmitted. For each example, include the name of the disease, the causative agent and the mode of transmission. **3 marks**

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(b) For one of the diseases described in (a), explain how specific adaptations of the pathogen responsible facilitate the transmission of the disease between hosts. **2 marks**

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Question 29. (3 marks)

Describe a plant disease of agricultural significance, including the symptoms resulting from infection and what processes have been used to prevent or control it. **3 marks**

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Question 30. (3 marks)

A number of diseases are caused by either over-consumption or a lack of certain nutrients in the diet. Name and describe the cause, symptoms and treatment of one such nutritional disease. **3 marks**

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Question 31. (6 marks)

Viral infections have always been difficult to treat so the development since 1960 of antiviral drugs has been of great benefit.

(a) Why has it been difficult to treat viral infections? **2 marks**

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(b) Describe at least two mechanisms by which modern antiviral drugs destroy viruses. **2 marks**

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(c) Our immune system is capable of destroying viruses. Which cells are responsible and how do they function? **2 marks**

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Question 32. (9 marks)

Populations of the Tasmanian devil have been declining dramatically over the past 20 years due to the devastating impact of devil facial tumour disease (DFTD), as outlined in a recent paper:

> "Although cancer rarely acts as an infectious disease, a recently emerged transmissible cancer in Tasmanian devils (*Sarcophilus harrisii*) is virtually 100% fatal. Devil facial tumour disease (DFTD) has swept across nearly the entire species' range, resulting in localized declines exceeding 90% and an overall species decline of more than 80% in less than 20 years." (Epstein *et al.*, 2016, p1) [2]

(a) The DFTD cancer cells first arose in mutated Schwann cells surrounding the neurons of a single individual and are now being transmitted between devils through bites. This is one of only a very small number of cases in which cancer is known to be infectious. What are the more common causes of cancer? **1 mark**

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(b) The DFTD cancer cells evade the devil's immune system by destroying their own MHC molecules. Explain why destroying the cancer cells' MHC molecules prevents the immune system from detecting them. **1 mark**

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(c) Were the DFTD cancer cells the result of a somatic or a germ-line mutation? Explain your answer. **2 marks**

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Question continues over page.

[2] Epstein, B, *et al.* (2016) Rapid evolutionary response to a transmissible cancer in Tasmanian devils. *Nature Communications* | DOI: 10.1038/ncomms12684

(d) The Tasmanian research team has provided some hope that the disease may be halted and the devil population saved from extinction. By comparing over 90,000 single nucleotide polymorphisms (SNPs) between pre- and post-infection populations, they have discovered two genomic regions that contain genes related to immune function and these genes appear to be undergoing strong selection.

Explain the advantages of using SNP sequences in genetic analyses. **2 marks**

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(e) Work is now proceeding on the development of a vaccine, using killed DFTD tumour cells. How will injecting devils with killed tumour cells provide immunity to the disease? **3 marks**

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Question 33. (8 marks)

In 1997, Dr Holger Jannasch of the Woods Hole Oceanographic Institution, Massachusetts, wrote: "I decided early that a medical profession was not for me, because I aspired to study microbes as allies, not as enemies." [3]

Many people even today only think of microorganisms such as viruses, fungi and bacteria as pathogenic but there are also many instances in which particular types provide us with major benefits.

(a) Discuss some of the impacts, both negative and positive, that microorganisms have on human health. **3 marks**

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[3] Jannasch, H.W. (1997) Small is Powerful: Recollections of a Microbiologist and Oceanographer. *Annu. Rev. Microbiol. 51*:1–45

(b) Outline some of the ways that microorganisms have been used in agriculture and industry to benefit society. **5 marks**

Question 34. (3 marks)

The progression of cancer in a patient is classified into different stages:

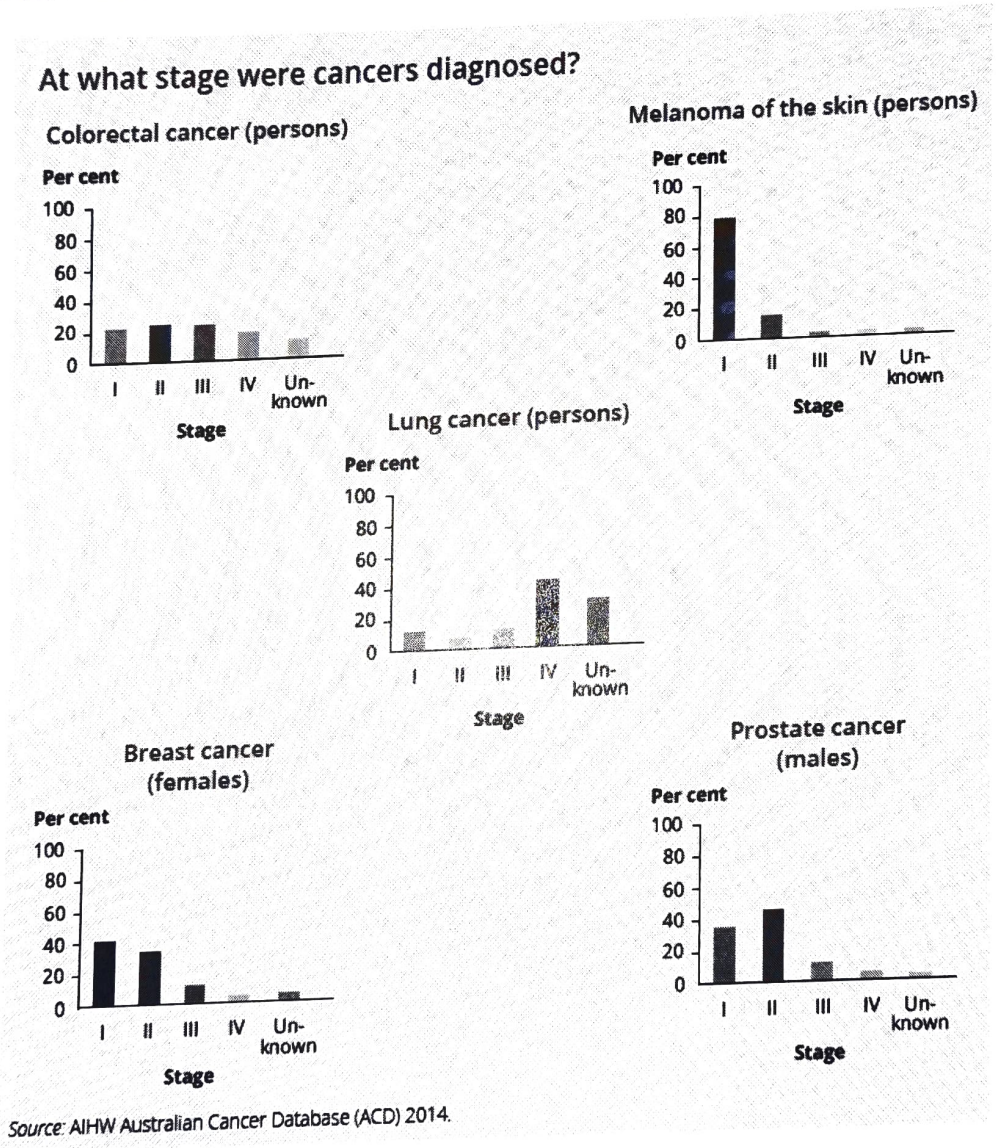
Stage I: the cancer is small and only in one area. Also called early stage cancer.

Stage II: the cancer has grown but has not spread.

Stage III: the cancer has grown into nearby tissues or lymph nodes.

Stage IV: the cancer has undergone metastasis. Also called advanced cancer.

The following graphs[4] indicate at what stage different types of cancers were diagnosed in Australia in 2011.



Source: AIHW Australian Cancer Database (ACD) 2014.

Question continues over page.

[4] Australian Institute of Health and Welfare (2019) Cancer in Australia: In brief 2019. Cancer series no. 122. Cat no. CAN 126. Canberra: AIHW. (Reprinted under Creative Commons Licence and with the written permission of the AIHW.)

1 mark

(a) What is meant by the term metastasis?

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2 marks

(b) Suggest possible reasons for the differences between the graphs.

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Question 35. (4 marks)

Spectacles and contact lenses have long been prescribed for a variety of visual disorders.

(a) Describe one such visual disorder and explain how spectacles are designed to correct the disorder. **2 marks**

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(b) Discuss how more recent technology has been used to replace spectacles and contact lenses for this, or any other, visual disorder. **2 marks**

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Question 36. (4 marks)

Plants have evolved a variety of adaptations for controlling both temperature and water balance.

(a) You are probably familiar with how much more pleasant it is to walk on grass in bare feet than on a concrete footpath on a hot day. Explain why the grass is cooler on your feet than the footpath. **2 marks**

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(b) Describe at least two structural adaptations for reducing water loss in named Australian plants. **2 marks**

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Question 37. (5 marks)

Using specific examples, evaluate the potential of genetic technologies for the prevention or control of non-infectious disease. **5 marks**

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