Heredity

Chapter 1

- continuity of life requires the replication of genetic material and its transfer to the next generation through processes, including binary fission, mitosis, meiosis and fertilisation
- DNA is a helical double-stranded molecule that occurs bound to proteins in chromosomes in the nucleus, and as unbound circular DNA in the cytosol of prokaryotes, and in the mitochondria and chloroplasts of eukaryotic cells
- the structural properties of the DNA molecule, including nucleotide composition and pairing and the hydrogen bonds between strands of DNA, allow for replication
- the genetic code is a base triplet code; genes include 'coding' and 'non-coding' DNA, and many genes contain information for protein production
- protein synthesis involves transcription of a gene into messenger RNA in the nucleus, and translation into an amino acid sequence at the ribosome
- proteins, including enzymes and structural proteins, are essential to cell structure and functioning
- the phenotypic expression of genes depends on the interaction of genes and the environment
- mutations in genes and chromosomes can result from errors in DNA replication or cell division, or from damage by physical or chemical factors in the environment
- variations in the genotype of offspring arise as a result of the processes of meiosis, including crossing over and random assortment of chromosomes, and fertilisation, as well as a result of mutations
- frequencies of genotypes and phenotypes of offspring are determined by patterns of inheritance, including dominance, autosomal and sex-linked alleles, multiple alleles and polygenes
- DNA sequencing enables mapping of species genomes; DNA profiling identifies the unique genetic makeup of individuals
- recombinant DNA technology and DNA identification technologies are applied in agriculture and environmental conservation

MULTIPLE-CHOICE QUESTIONS

1. *(2010:07)*

Protein synthesis and energy release in a eukaryotic cell involve respectively

(a) endoplasmic reticulum and ribosomes.

(b) mitochondria and contractile vacuoles.

(c) ribosomes and mitochondria.

(d) Golgi bodies and mitochondria.

The next two questions relate to the following information.

Analysis of the complete genome of an amoeba (a small, single-celled eukaryote) shows that it contains 14% thymine.

2. *(2010:08)*

The percentage of adenine in the genome of this amoeba is likely to be

(a) 14%.

(b) 28%.

(c) 36%.

(d) 72%.

3. *(2010:09)*

The percentage of cytosine in the genome of this amoeba is likely to be

(a) 14%.

(b) 28%.

(c) 36%.

(d) 72%.

4. *(2011:04)*

The complementary DNA codon (base triplet) for ATG is

(a) TAC.

(b) GTA.

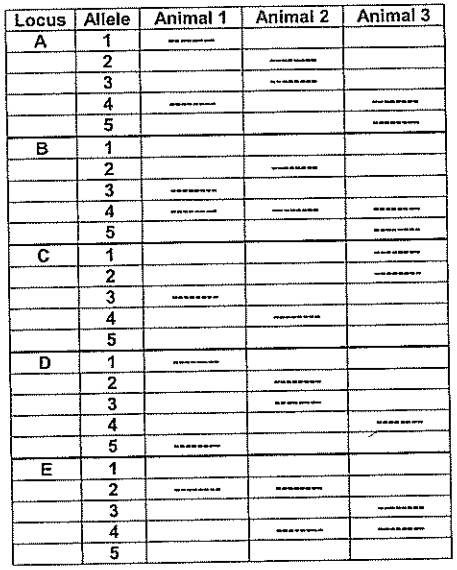
(c) TUC.

(d) GCA.

The next 2 questions refer to the following information.

In the technique of genetic profiling, each DNA profile represents several loci (gene positions) on a pair of homologous chromosomes. If an animal is heterozygous at a particular locus, two bands are seen in the DNA profile. If it is homozygous, only one band is seen.

DNA profiles for three animals are shown below.



Locus	Allele	Animal 1	Animal 2	Animal 3
A	1			
	2			
	3			
	4			
	5			
B	1			
	2			
	3			
	4			
	5			
C	1			
	2			
	3			
	4			
	5			
D	1			
	2			
	3			
	4			
	5			
E	1			
	2			
	3			
	4			
	5			

5. *(2011:14)*

At how many loci is Animal 2 homozygous?

(a) 1

(b) 2

(c) 3

(d) 4

6. *(2011:15)*

If Animal 1 mated with Animal 3 and produced a single offspring, the offspring

(a) must be homozygous at locus A.

(b) may be homozygous at locus D.

(c) could be either homozygous or heterozygous at locus C.

(d) must be heterozygous at locus E.

7. *(2012:01)*

If 20% of the nucleotides in a DNA fragment contain cytosine, what percentage will be thymine?

(a) 20

(b) 30

(c) 40

(d) 50

8. *(2013:16)*

Which of the following occurs during protein synthesis?

(a) RNA molecules are converted to DNA molecules.

(b) Ligase unwinds DNA molecules.

(c) Restriction enzymes cut DNA molecules.

(d) RNA polymerase binds to DNA molecules.

9. *(2013:18)*

In gel electrophoresis

(a) positively charged DNA fragments move toward the negatively charged electrode.

(b) large DNA fragments move more rapidly than small DNA fragments because they have a greater electrical charge.

(c) the gel is porous and acts like a sieve, allowing some fragments to pass through the pores more easily than others.

(d) the DNA fragments are mixed evenly with the gel material before it solidifies.

10. *(2013:22)*

Which of the following techniques can be used to study the activity of many genes at the same time?

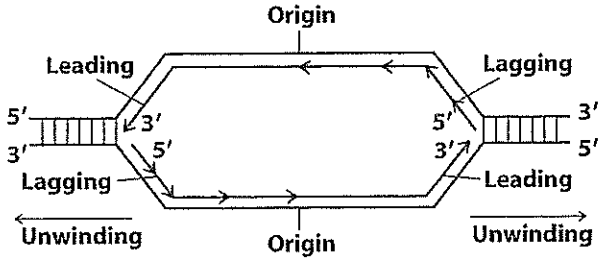
(a) gel electrophoresis

(b) polymerase chain reaction

(c) gene cloning

(d) DNA microarrays

The next question refers to the diagram below, which shows a cell process.



11. *(2014:01)*

This process is

(a) crossing over.

(b) DNA replication.

(c) transcription.

(d) meiosis.

12. *(2014:04)*

A eukaryotic cell will have more

(a) chromosomes than genes.

(b) chromosomes than alleles.

(c) alleles than genes.

(d) genes than alleles.

13. *(2014:11)*

Translation occurs on or in

(a) golgi vesicles.

(b) nuclei.

(c) lysosomes.

(d) ribosomes.

14. *(2014:17)*

Which of the following processes describes the exchanges of alleles between homologous chromosomes?

(a) mutation

(b) independent assortment

(c) crossing over

(d) random mating

15. *(2014:22)*

The sequence of bases in a strand of DNA is ATCGAGC. The sequence of bases in a mRNA molecule synthesised from this strand will be

(a) ATCGAGC.

(b) TAGCTCG.

(c) UAGCUCG.

(d) TUCGAGC.

16. *(2015:10)*

In gene cloning, the main purpose of plasmids is to

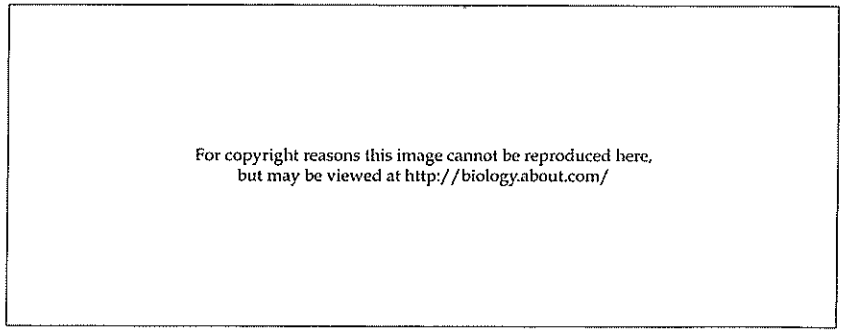
(a) identify the gene for cloning.

(b) extract the desired gene from a donor organism.

(c) produce many copies of the desired gene.

(d) introduce the desired gene into a recipient organism.

The next three questions relate to the diagram below, which shows a cell process.



17. *(2015:22)*

The process shown in the diagram is

(a) transcription.

(b) translation.

(c) DNA repair.

(d) DNA replication.

18. *(2015:23)*

The feature labelled X is a molecule of

(a) protein.

(b) DNA.

(c) tRNA.

(d) mRNA.

19. *(2015:24)*

The function of the feature labelled Y is to

(a) carry the genetic code from the DNA to the site of protein synthesis.

(b) encode the sequence of amino acids in a protein chain.

(c) transfer amino acids to the growing peptide chain during protein synthesis.

(d) correct errors in the sequence of amino acids in a protein chain.

SHORT ANSWER QUESTIONS

20. **[20 marks]** *(2010:22)*

(a) DNA and RNA are important in cellular functioning.

(i) List **two (2)** structural differences between DNA and RNA. [2]

_____

_____

(ii) Name the major function performed by [2]

tRNA _____

mRNA _____

CONTINUED NEXT PAGE

(b) Describe, without molecular detail, the difference between *transcription* and *translation*. [4]

(c) Describe briefly, at the molecular level, the process of protein synthesis. [4]

(d) Give brief definitions of

(i) restriction enzymes. [2]

(ii) gel electrophoresis. [2]

DNA profiling is proving useful in many areas of science.

(e) (i) Define 'DNA profiling'. [2]

(ii) Describe an example of the application of DNA profiling in environmental conservation. [2]

21. [8 marks] *(2011:21)*

DNA is an information-carrying molecule that is essential to all organisms and has many functions.

(a) Describe, with the aid of a labelled diagram, the basic structure of DNA. [4]

CONTINUED NEXT PAGE

(b) In terms of DNA structure, explain why different alleles of a gene produce different proteins. [4]

22. [4 marks] *(2012:34)*

(c) Humans are now using recombinant DNA technology to modify the characteristics of plants and animals.

Outline how recombinant DNA technology can be used to increase drought resistance in rice.

23. [11 marks] *(2013:31)*

(a) Describe the relationship between DNA, genes and chromosomes. [3]

Parts (b) and (c) refer to the table below. It provides data on the number of chromosomes, amount of DNA and amount of time taken for meiosis to occur in germ cells of selected plant and animal species.

Species	Number of chromosomes	Amount of DNA (picograms)	Duration of meiosis (days)
Plants			
Triticum aestivum (wheat)	42	54	1
Secale cereale (rye)	14	29	2
Allium cepa (onion)	16	54	4
Lilium longiflorum (lily)	24	106	8
Trillium erectum (wake-robin)	10	120	11
Animals			
Drosophila melanogaster (fly)	8	0.085	4
Locusta migratoria (locust)	24	13	8
Triturus viridescens (amphibian)	24	49	12
Mus musculus (mouse)	40	5	13
Homo sapiens (human)	46	6	24

(b) (i) The data in the table indicate that germ cells with larger chromosome numbers do not necessarily contain more DNA. Provide a possible reason for this. [1]

(ii) What do the data in the table suggest about the relationship between the amount of DNA in a germ cell and the duration of meiosis in the plant species? [2]

CONTINUED NEXT PAGE

(c) (i) The data in the table suggest that the duration of meiosis might be slower in animals than plants. What aspects of the data suggest this? Quote data from the table to support your answer. [3]

(ii) Despite your answer above, the data in the table do not allow for reliable conclusions to be drawn about the relative duration of meiosis in plant and animal species. Give **two** possible reasons for this. [2]

24. **[4 marks]** *(2013:34)*

(c) Many proteins are produced in the ribosomes within the cytoplasm of a cell.

How does messenger RNA determine the sequence of amino acids during protein synthesis?

25. **[4 marks]** *(2013:35)*

Dry land salinity is a major problem in Australian agricultural areas and especially in south-western Australia.

(e) A plant species was found that was able to grow in soils with a salt concentration well in excess of 100 g/L. The species is not suitable for revegetation of saline agricultural areas because it is poisonous to farm animals.

Summarise how recombinant DNA techniques could be used to take advantage of this plant's salt resistance in other, more suitable species.

26. **[13 marks]** *(2015:34)*

(a) Indicate whether each of the following statements about DNA replication is true or false by circling the correct answer. Give a reason for your answer.

(i) The base sequence of a newly-synthesised strand of DNA is identical to that of the template strand from which it was synthesised. [2]

True False

Reason: _____

(ii) DNA replication is called 'semi-conservative' because the wrong base is sometimes added to the newly-synthesised strand of DNA. [2]

True False

Reason: _____

CONTINUED NEXT PAGE

(b) Polymerase Chain Reaction (PCR) is an important method in biotechnology.

(i) What is PCR used to do? [2]

(ii) State **three** reagents (ingredients) that are required for PCR. [3]

One: _____

Two: _____

Three: _____

(c) (i) Distinguish between a gene and an allele. [2]

(ii) Distinguish between a dominant allele and a recessive allele. [2]

EXTENDED ANSWER QUESTIONS

PART A Questions

27. 2012:37
Protein synthesis involves two stages, **transcription** and **translation**. Describe the main steps in each of these processes.

28. 2013:38
Describe, using scientific terminology, the main steps involved in DNA replication in a living cell.

29. 2014:38
A biologist used DNA data to investigate the relationship between red and gray wolves. Describe how the technique of gel electrophoresis could be used to compare the DNA of these two species.

PART B Questions

30. 2013:41
Genetic variation is a prerequisite for evolution. Mutation is one source of genetic variation and meiosis is another. Name and describe the **two** ways in which meiosis produces genetic variation.

26. 2012:40

Evolution can be regressive, where a characteristic that is no longer required is lost and the energy saved is diverted to other functions. Fish in the genus *Astyanax* provide an excellent example of regressive evolution. Some of the fish in this genus possess eyes and live in surface streams, whereas others live deep in underground caves and have degenerative eyes (called 'eyeless'). The cave-dwelling fish, however, have other improved sensory systems. For example, the number of taste buds in the cave-dwelling fish is much greater than in the surface-dwelling fish.

Explain how the evolutionary process has resulted in the cave-dwelling forms of *Astyanax* becoming eyeless.

27. 2014:41

The Galapagos Islands are made up of many islands. Different islands have their own unique species of Darwin's finch (a type of bird). The different species have their own songs, food preferences and beak shapes. The different species evolved from one ancestral species that colonised each of the islands and then specialised.

Use your knowledge of the evolutionary process, to explain how one ancestral species has given rise to the different species of Darwin's finch on each island.

28. 2015:41

Explain how fossils and the embryology of vertebrates can each provide evidence for evolution.

Science as a human endeavour

Chapter **3**

- transgenic organisms have been engineered for desirable traits, including resistance, faster growth rate, greater product quality and yield, and tolerance to adverse environmental conditions
- using transgenic organisms may have adverse effects on genetic diversity and the environment, including
  - the effects on non-target organisms
  - more rapid evolution of pesticide-resistant species
  - the possibility of gene flow from crop species to weed species resulting in the emergence of 'super weeds'
- biotechnology can be used in environmental conservation for
  - monitoring endangered species
  - assessing gene pools for breeding programs
  - quarantine
- technological developments in the fields of comparative genomics, comparative biochemistry and bioinformatics have enabled identification of further evidence for evolutionary relationships
- conservation planning to maintain viable gene pools includes consideration of
  - biogeography
  - reproductive behaviour
  - population dynamics

MULTIPLE-CHOICE QUESTIONS

1. *(2011:01)*

A species of marine fish has 144 chromosomes in its gametes. How many chromosomes would be found in its body cells?

(a) 36

(b) 72

(c) 144

(d) 288

2. *(2011:05)*

The enzyme DNA polymerase

(a) produces a complementary DNA strand from an RNA template.

(b) enables DNA to be repaired and joins DNA fragments together.

(c) adds nucleotides to template DNA to produce a complementary strand.

(d) cuts DNA at a specific base sequence recognition site.

3. *(2012:15)*

The enzyme DNA polymerase

(a) unwinds DNA by breaking the bonds between base pairs.

(b) breaks DNA up into separate nucleotides.

(c) adds nucleotides to a newly forming DNA strand.

(d) cuts DNA at specific recognition sites.

4. *(2013:17)*

In which order do the three stages of polymerase chain reaction (PCR) occur?

(a) annealing, denaturation, extension

(b) denaturation, annealing, extension

(c) extension, annealing, denaturation

(d) annealing, extension, denaturation

5. *(2013:20)*

Which of the following is a transgenic organism?

(a) a bacterium that has been modified to produce human insulin

(b) a mule that is a cross between a donkey and a horse

(c) an alga that has been introduced into an area in which it did not previously exist

(d) a mosquito with two pesticide resistant alleles at a gene

6. *(2014:27)*

Polymerase chain reaction (PCR) is an artificial method of

(a) DNA repair.

(b) DNA replication.

(c) transcription.

(d) translation.

7. *(2015:10)*

In gene cloning, the main purpose of plasmids is to

(a) identify the gene for cloning.

(b) extract the desired gene from a donor organism.

(c) produce many copies of the desired gene.

(d) introduce the desired gene into a recipient organism.

SHORT ANSWER QUESTIONS

8. **[12 marks]** *(2011:21)*

DNA is an information-carrying molecule that is essential to all organisms and has many functions.

(c) Two techniques that are used in DNA technology are polymerase chain reaction (PCR) and DNA microarrays (chips).

(i) Explain briefly the purpose of polymerase chain reaction (PCR). [2]

(ii) State **two (2)** purposes of the DNA microarray technique. [2]

CONTINUED NEXT PAGE

(d) One of the most important uses of recombinant DNA technology in agriculture is pest control in crops.

(i) The main process used in this area is gene cloning. Explain briefly the role of restriction enzymes and plasmids in this process. [2]

(ii) In recent years farmers and biologists have expressed concerns about the ethics of using gene cloning in agricultural pest control. [2]

Discuss **one (1)** concern that has been raised in this area.

(e) Apart from pest management in agriculture, describe **two (2)** other uses of recombinant DNA technology. [4]

9. [5 marks] *(2012:31)*

Scientists genetically modified male and female mice so they were able to produce a specific human enzyme called IKKbeta in their fat tissue.

The scientists conducted an experiment in which they fed two groups of mice on the same high fat diet. One of the groups was genetically modified, while the other was not. The mice all started at the same weight and after 22 weeks on the diet, the average weight of the modified mice was 38 g and of the unmodified mice was 45 g. There was no significant difference between males and females.

(e) Before the gene that produces the IKKbeta enzyme could be introduced to mouse DNA it had to be cloned. Describe the steps that were used in the process of cloning the IKKbeta gene.

10. [4 marks] *(2012:34)*

Genetic recombination in eukaryotes occurs via several processes including crossing over and independent assortment of chromosomes during meiosis.

(a) Describe each of these processes and explain briefly how they produce genetic variation.

Crossing over:

CONTINUED NEXT PAGE

Independent assortment:

11. [4 marks] *(2012:35)*

Spotted Wing Drosophila (SWD), a type of fruit fly, is a pest in many fruit crops. These flies are often caught in traps that are baited with wine and/or vinegar to attract them.

(b) Polymerase chain reaction and gel electrophoresis were used to study genetic diversity in SWD.

Explain how the technique of gel electrophoresis separates DNA fragments of different sizes.

12. [3 marks] *(2013:31)*

(d) Evolution, at the species level, is driven by a small number of processes.

Name the evolutionary process that produces

(i) new alleles. [1]

(ii) random changes in allele frequencies. [1]

(iii) adaptive changes in allele frequencies. [1]

13. [8 marks] *(2014:34)*

Enderby Island Cattle existed on Enderby Island, south of New Zealand, for over 80 years. This breed of cattle is of interest because of its ability to survive cold conditions. Biologists want to isolate the genes that allow the Enderby Island Cattle to survive in cold conditions and transfer them to other cattle breeds.

(a) (i) What is the term used to describe a species that contains a gene that has been artificially introduced from another species? [1]

(ii) Explain how DNA microarrays can be used to identify the genes that promote cold tolerance in the Enderby Island Cattle. [2]

(iii) DNA microarray technology is relatively new. What is the main advantage of this technology? [1]

(b) A variety of techniques, including restriction enzymes, would be used to transfer a gene from an Enderby Island cow into another cattle breed.

(i) What are restriction enzymes? [2]

CONTINUED NEXT PAGE

(ii) What role would restriction enzymes play in the process of transferring a gene from one organism to another? [2]

EXTENDED ANSWER QUESTIONS

PART A Questions

14. 2015:38

Artificial selection and transgenesis (the production of transgenic organisms) are two methods that humans use to change the features of plants or animals. Describe how artificial selection and transgenesis can each be used to change the features of plants or animals.

UNIT 4

SURVIVING IN A CHANGING ENVIRONMENT

Chapter 1: Heredity

Multiple Choice Questions

1 (2010.07)	(c)	2 (2010:08)	(a)	3 (2010.09)	(c)	4 (2011:04)	(a)
5 (2011:14)	(a)	6 (2011:15)	(d)	7 (2012:01)	(b)	8 (2013:16)	(d)
9 (2013:18)	(c)	10(2013:22)	(d)	11 (2014:01)	(b)	12(2014:04)	(c)
13 (2014:11)	(d)	14(2014:17)	(c)	15 (2014:22)	(c)	16(2015:10)	(d)
17 (2015:22)	(b)	18(2015:23)	(d)	19 (2015:24)	(c)		

Short Answer Questions

20 (2010:22) **(20 marks)**

(a) 1 mark/dot point (1 max for DNA and 1 max for RNA)

(i) DNA
Double helix strand
Contains the base thymine
• Deoxyribose sugar
RNA
Single helix strand
Contains the base uracil
• Ribose sugar **(max 2 marks)**

(ii) tRNA
Acts as a transport molecule for amino acids
Carries the correct amino acids to the mRNA
Translation
mRNA
Binds to the ribosome and initiates protein synthesis
Determines the amino acid sequence of the protein
• Carries code from the DNA in the nucleus to the cytoplasm
• Transcription **(max 2 marks)**

(b) 1 each (2 max): Must specify clearly which is transcription and which is translation
Any two for Transcription of:
• Process in which a mRNA copy is made from the DNA /gene or sequence or segment
• in DNA is copied to mRNA /creates/involves RNA
• occurs in the nucleus of eukaryotes (but don't need eukaryote for the mark) **(max 2 marks)**
Any two for Translation of:
• Process in which the assembly of the protein/polypeptide occurs from amino acid sequences
• Involves the instruction for the creation of the protein
• occurs in the ribosome/in the cytoplasm
• tRNA carries the correct amino acid to the mRNA **(max 2 marks)**

(c) Any four: 1 each *(An annotated diagram could be used to answer this question)*
• Transcription
• DNA unzipped
• mRNA copies the nucleotide sequence inside the nucleus
• mRNA moves from within the nucleus to the cytoplasm/cytosol/ribosome **(max 2 marks)**

Translation
• tRNA carries the appropriate amino acids to join the polypeptide chain
• tRNA contains an anti-codon that allows the correct sequence to be formed
• mRNA carries the code for the formation of the protein
• Polypeptide is formed on the ribosome
• Polypeptide is released into the cytoplasm **(max 2 marks)**

(d) (i) Restriction enzymes:
• act as molecular scissors
• that recognise specific sequences in DNA

- and cut the DNA at this point
- different restriction enzymes recognise different sequences and bases (max 2 marks)

(ii) Gel electrophoresis:
- sample is placed into agarose/gel
- proteins/DNA move in an electrical current passed through the gel
- smaller protein/DNA pieces moving through the gel at a faster rate than larger ones/separates DNA pieces
- forming bands representing different segments of protein/DNA (max 2 marks)

(e) Each dot point is 2 marks, the division between marks indicated by /.

(i) 'DNA profiling'
- A genetic tool used to compare and contrast DNA sequences of
- different individuals. (max 2 marks)

(ii) Example
- to determine if animals are bred in captivity/or stolen from the wild.
- Establish zoo data base as a reference guide/for captive breeding/for determining whether animals were wild-born or captive-born.
- Track migration routes for animals.
- Identifying inbreeding in populations/identify discrete populations/ Identify DNA profiles of organisms suitable for translocation
- Definitive species identifications to identify threatened species/sub-species/identify wildlife smuggling
- Identify parasites and diseases/better treat disease in wildlife populations/screen for genetic disease (max 2 marks)

21 (2011:21) (8 marks)

(a) Any 4 of the following attached to a suitable diagram (max 4, max 2 if no diagram shown) (4)
- Contains 4 nitrogenous bases/adenine, thymine, cytosine, guanine
- Bases are paired: adenine with thymine; guanine with cytosine
- Backbone of de-oxyribose sugar and a phosphate group correctly shown on diagram
- These make up nucleotides
- In the form of a double helix/double stranded
- Very long molecule/has tens of thousands of pairs
- Hydrogen bonds

(b) 1 mark each (max 4) (4)
- Sequence of bases/nucleotides codes
- This coding is for amino acid sequence/protein structure
- Each amino acid is coded for by 3 nucleotides/bases/triplet codes/codons
- The alleles have different base sequences/nucleotide sequences/triplet codes/codons

22 (2012:34) (4 marks)

(c) Any four of:
- Identify drought tolerant genes in other species
- Genes are extracted
- These genes are cloned in bacteria
- Insert genes into the chromosomes of rice plants
- Drought tolerance is transferred to the rice plant

23 (2013:31) (11 marks)

(a) Any three of: 1 mark each (max 3) (3)
- Both chromosomes and genes are made of DNA
- A chromosome is a long length of DNA/contains many genes
- A gene is a short section of DNA/chromosome

(b) (i) Any one of: (max 1) (1)
- Chromosomes contain different amounts of DNA
- When present in large numbers, the chromosomes may contain little DNA/be small
- When present in small numbers, the chromosomes may contain a lot of DNA/be large
- Chromosome fusion/fission gives same amount of DNA but different chromosome number

(ii) 1 mark each – max 2 (2)
- The more DNA in a cell, the longer the duration of meiosis
- with the exception of bread wheat/except in bread wheat where the duration is shorter than expected (based on the amount of DNA)

(c) (i) Any two of: (1 mark each – max 2) (2)
- It was much slower in the amphibian compared to wheat and onion (all of which had about the same amount of DNA)
- The average duration in the animal species was much longer than in the plant species/the average duration in the plant species was much shorter than in the animal species
- In most of the animal species it took longer than 8 days whereas in most of the plant species it took less than 8 days
- Any accurate numerical quote from the data (1)

(ii) Any two of: (1 mark each – max 2) (2)
- Included a very small number of species/small sample size/need to include more species
- No data for plant and animal species with identical amounts of DNA/most of the plant and animal species had different amounts of DNA
- (Possible) lack of controlled conditions (when taking the measurements)

24 (2013:34) (4 marks)

(c) First three points and one from last list (4)
- The nucleotide sequence of mRNA is in triplets/3's/3 bases (1)
- These three bases/triplets are called codons (1)
- Each mRNA base triplet/codon determines one amino acid (1)

Plus any one of
- Ribosome joins amino acids together/polypeptide chain formed
- Start codon is AUG/all proteins start as methionine
- tRNA carries amino acids to the mRNA
- tRNA contains anticodons which are complementary to the codons (1)

25 (2013:35) (4 marks)

(e) Any four of the following in logical sequence (detail not required) – max 2 if sequence is not correct (4)
- identify the gene/s responsible for salt tolerance
- extract the gene/s from the donor plant (using restriction enzymes)
- insert the gene/s into a vector/plasmid (same restriction enzyme)
- introduce vector to a host/bacterial cell (for cloning/increasing number of genes)
- introduce gene to target species
- salt tolerance becomes part of the target species' genotype

26 (2015:34) (13 marks)

(a) (i) False (1) (2)
Bases are complimentary to the template so a mirror 'image' (1)

(ii) False (1) (2)
Semiconservative involves each of the two daughter molecules having an old strand from the original DNA and one newly made strand. Wrong base implies mutation (1)

(b) (i)
- To amplify/make multiple copies of DNA (1)
- For DNA profiling to test for genetic disorders/DNA fingerprinting/investigating extinct species (1)

(ii) (3)
- Segment of DNA to be copied (1)
- Single stranded DNA primers (1)
- Heat stable DNA polymerase/Taq polymerase (1)

(c) (i)
- Gene – section of DNA that codes for a protein/contains code for synthesis of a polypeptide (2)
- Allele – form of a gene for a particular characteristic having the code for a particular phenotype

(ii)
- Dominant – allele expressed by a heterozygote that masks another allele (2)
- Recessive – allele not expressed in the heterozygote/hidden due to the expression of the dominant allele

Extended Answer Questions

PART A

27 (2012:37) **(10 marks)**

Transcription: Any five of: **(max 5)**

- DNA unwinds
- RNA polymerase
- attaches to DNA at a specific region/promoter region/5'
- DNA code is used as a template
- only one strand of DNA is transcribed (antisense strand)
- free nucleotides used to form mRNA
- mRNA forms complementary strand to DNA
- difference is uracil instead of thymine attached to adenine
- transcription stops at terminator sequence on DNA strand
- RNA polymerase/enzyme then detaches from DNA/releases mRNA
- mRNA transported/moves (from nucleus) to cytoplasm

Translation: Any five of: **(max 5)**

- mRNA transported/moves (from nucleus) to cytoplasm (if not awarded above)
- mRNA binds to ribosome
- Bases in groups of 3 per codon
- start codon (mRNA)
- tRNA recognises codon on mRNA
- tRNA contains an anti-codon
- tRNA binds to site on ribosome/P site
- and brings amino acid with it
- a peptide bond forms between the amino acids
- tRNA is released to continue the process

amino acid chain forms a polypeptide/protein

28 (2013:38) **(10 marks)**

First 5 dot points – 1 mark each (max 5)

Description

- The double-stranded DNA unwinds/unzips (1)
- The enzyme DNA polymerase synthesizes the new DNA strand/molecule. (1)
- Each of the two DNA strands/molecules is copied/acts as a template/becomes half of the new DNA molecule. (1)
- The new strand/molecule is complementary to the original/template strand. (1)
- The enzyme ligase joins the stretches of DNA together. (1)

Plus any five of (1 mark each – max 5) (5)

- The DNA (double helix) unwinds at a particular location/the replication fork.
- The DNA strands are coated with a protein (called SSB – single strand binding proteins) that prevents the two strands from re-annealing/keeps the strands separate
- The nucleotides on each strand are now exposed and unpaired/the nucleotide sequence of the exposed strands is copied
- Free nucleotides, present in the nucleoplasm are attached to their complementary bases
- Adenine pairs with thymine, cytosine pairs with guanine
- An enzyme (helicase) unwinds the DNA/facilitates this
- DNA polymerase can only extend a (pre-existing) nucleic acid chain/DNA polymerase cannot synthesis from scratch
- DNA strands have a direction and synthesis only occurs in one direction/DNA synthesis occurs in a 5' to 3' direction.
- One strand is synthesized continuously (leading strand)/one strand is synthesized in short pieces (lagging strand).
- Primers are necessary/Synthesis begins at primers
- Primers are short pieces of RNA/are synthesized by the enzyme primase

29 (2014:38) **(10 marks)**

1 mark for each point (max 10 points)

- DNA is extracted from each species
- DNA is cut into fragments
- Using restriction enzymes
- The same/corresponding fragments from each species
- Are loaded into the gel (wells) at the negative end of the chamber
- An electric current is passed through the gel
- DNA is a large negatively charged molecule
- Moves from negative electrode/terminal to positive electrode
- Different fragments move at different rates
- Small fragments move faster than larger fragments
- This forms specific patterns of bands
- DNA is treated with dye that shows up under UV light
- Thus the DNA of the two species can be compared

PART B

30 (2013:41) **(10 marks)**

Crossing-over (1)

Plus any four of the following – 1 mark each (max 4) (4)

- In the early stages of meiosis/in prophase I/during reduction division
- Chromosomes pair/synapse/attached at chiasmata
- They then exchange/swap sections of DNA/chromatids
- Recognition that the process involves homologous chromosomes/homologous sequence exchange (must mention the word homologous)
- This creates chromosomes with new combinations of alleles/genes (resulting in genetic variation)

Random/independent assortment (1)

Plus any four of the following – 1 mark each (max 4) (4)

- During metaphase I/during reduction division
- Chromosomes align in the centre of the cell
- Chromosomes then move/segregate to different poles
- Recognition that the alignment of the chromosomes is random/the segregation/separation of the chromosomes is random with respect to parental origin
- Recognition that homologous chromosomes move/separate to different poles

(After segregation) the poles/gametes contain a mix of chromosomes from each 'parent' (resulting in genetic variation).

Chapter 2: Continuity of life on Earth

Multiple Choice Questions

1 (2011:02)	(c)	2 (2012:02)	(a)	3 (2012:16)	(c)	4 (2012:17)	(a)
5 (2012:18)	(b)	6 (2013:14)	(d)	7 (2013:15)	(a)	8 (2013:19)	(b)
9 (2013:21)	(c)	10 (2014:13)	(a)	11 (2014:14)	(c)	12 (2014:18)	(b)
13 (2014:28)	(d)	14 (2015:03)	(c)	15 (2015:08)	(d)		

Short Answer Questions

16 (2012:34) **(12 marks)**

(b) Any four of: **(max 4)**

- Genetic variation exists in rice population
- Expose rice to drier conditions
- Select/breed with those that survive the longest
- Their favourable genes are passed to the next generation
- Repeat the process for several generations to produce drought tolerant strain

Embryology of vertebrates

Any 5 points for one mark each.

- Comparative embryology compares the embryos of different species
- And shows the relationship between different species of animals/vertebrates
- Early stages of many vertebrates embryos appear very similar for example they all have gill slits/ notochord/tail
- This suggests a common ancestor embryos sometimes have structures that are inappropriate for their adult form but that show their relatedness to other animals.
- The more similarities in later embryonic forms of different vertebrates demonstrates that they had a more recent common ancestor

Chapter 3: Science as a human endeavour

Multiple Choice Questions

1 (2011:01)	(d)	2 (2011:05)	(c)	3 (2012:15)	(c)	4 (2013:17)	(b)
5 (2013:20)	(a)	6 (2014:27)	(b)	7 (2015:10)	(d)		

Short Answer Questions

8 (2011:21) **(12 marks)**

(c) (i) Any 2 of the following (max 2) (2)
- Amplifies/replicates/duplicates/copies DNA
- Allows analysis of samples of DNA that were previously too small for analysis

(ii) Any 2 of the following (max 2) (2)
- Determine the presence of genes
- Determine the sequence of genes/nucleotides
- Detect change in the expression/activity levels of genes
- Assess genome content in – different cells of an individual/members of the same species.
- Check the identity of organisms in food/domestic animal feed

(d) (i) Any of the following – must have reason
- Restriction enzymes: Cuts the segment of DNA required (1)
- Plasmids: Acts (as a vector) to carry the gene into the host cell (1)

(ii) Any 1 of the following to include the concern and why it is a concern. 2 marks for 1 dot point
- Resistant crops may pass on genes to closely related weed species (1) making the weed resistant to herbicides (1).
- An increase in resistance in insect pest populations (1) could make crops more vulnerable to insect pests (1).
- Foods with transplanted genes (1) may cause allergic reactions (1).
- Resistant crops may pass on genes (1) contaminating nearby organic/non-genetically modified crops (1).
- Affects natural food web/ecosystems/biodiversity in area (1) insects affected maybe important food sources for native animals (1).

(max 2 marks)

(e) Any 2 of the following chosen from any area. (4)
2 marks for each dot point for reason (1) and explanation (1)
Agriculture:
- Change in pigmentation in commercial flowers (1) for ornamental purposes (1)
- Protection of fruit/strawberries against freezing/frost (1) Spraying genetically engineered bacteria onto the fruit (1)
- Recombinant growth hormone genes for farm animals (1) to improve milk yield/produce leaner meat (1)
- Delay in the ripening of fruit (1) so they have a longer shelf life/can be transported further. (1)
- Enhancing/altering the flavour (1) and nutritional content (1) of foods.
- Inserting new genes increases survival (1) in unfavourable conditions (e.g. salinity) (1)

Medicine:
- Production of hormones (insulin/growth hormone) (1) to replace those that are deficient (1)
- Production of vaccines (1) for prevention of infectious diseases (1)
- Creation of proteins (1) to produce medications (blood clotting factor VIII/erythropoietin) (1)
- Prenatal diagnosis (1) of human genetic diseases (1)

Environment:
- Control of feral pests (e.g. rabbit) (1) by reducing fertility (1)
- Bioremediation (1)/to break down toxic chemicals/oil/heavy metals (1)
- Production of ethanol (1) from plant wastes (1)

9 (2012:31) **(5 marks)**

(e) Gene cloning

Any five of:
- Restriction enzymes cut the DNA
- Plasmid also cut by restriction enzymes
- DNA inserted using DNA ligase
- Plasmids inserted into cells/vector
- Cells multiply
- Multiple copies of gene made

10 (2012:34) **(4 marks)**

(a) Crossing over
- Involves exchange of DNA segments/alleles/sections of chromatid between homologous chromosomes (1)

Crossing over
- Each chromosome can be a blend of maternal and paternal DNA/creates new combinations of alleles (1)

Independent assortment
- Random combinations of maternal and paternal chromosomes
- chromosomes align randomly
- independently on each side of equator (1)

Independent assortment
- Produces a very large range of variation in gametes (1)

11 (2012:35) **(4 marks)**

(b) Any four of:
- DNA fragments have a small electric charge
- DNA fragments are (able to move when) placed in a gel
- A weak electric field is applied to the gel
- This pulls the fragments to one end of the gel
- Fragments move at different rates depending on size
- Smallest fragments move faster/further/offer less resistance
- Separates fragments into a unique pattern for that species

12 (2013:31) **(3 marks)**

(d) (i) • Mutation (1)
(ii) • Genetic drift/Random genetic drift/bottleneck/founder effect (1)
(iii) • Natural selection/selection/ sexual selection (1)

13 (2014:34) **(8 marks)**

(a) (i) Transgenic (1)
(ii) • Collect cell samples from Enderby Island Cattle and another breed not cold tolerant (1) (2)
• Use DNA microarray to measure gene expression in both samples/ identify genes expressed in E.I. cattle but not in other breed (1)
(iii) • Much faster than other technologies (1) (2)
• Able to test for the presence and/or expression of thousands of different genes at the same time (1)

(b) (i) • Proteins/enzymes that recognise specific/short nucleotide sequences (2)
• Cut DNA only at specific recognition site
• Act as molecular scissors (1)
(ii) • Recognises the sequence of bases and cuts gene/isolates the gene (2)
• Cuts same sequence in plasmid/vector to insert gene

Extended Answer Questions
PART A

14 (2015:38) **(10 marks)**

Artificial Selection

1 mark for each point (max 5 points)
- Artificial selection is the process by which humans use animal and plant breeding to selectively develop particular phenotypic traits (features/characteristics)
- by choosing which animal or plant males and females will sexually reproduce and have offspring together.
- involves the breeder or experimenter applying a known amount of selection to a single phenotypic trait by examining the chosen trait/feature
- and choosing to breed only those that exhibit higher or increased signs of that trait
- such that the trait is more common throughout the stock.
- techniques such as inbreeding, linebreeding, and outcrossing are used.

Transgenesis

1 mark for each point (max 5 points)
- transgenic species is a species that has genes from another species added to its genetic code/DNA
- the gene for the required characteristic/feature/trait is isolated
- it can be injected into the nuclei of egg cells or early embryo to become part of the DNA
- thus the resulting offspring has the desired trait
- it can be achieved by using plasmids from bacteria
- the selected section of DNA (that codes for the trait) is isolated from the donor cell
- and inserted into the plasmid to produce recombinant plasmids
- these are introduced into bacteria that reproduce to produce clones of the desired gene

Chapter 4: Homeostasis

Multiple Choice Questions

1 (2010:03)	(d)	2 (2010:04)	(b)	3 (2010:05)	(a)	4 (2011:08)	(c)
5 (2011:10)	(b)	6 (2011:11)	(d)	7 (2011:20)	(a)	8 (2012:09)	(b)
9 (2012:10)	(d)	10 (2012:11)	(a)	11 (2012:13)	(d)	12 (2012:14)	(b)
13 (2012:24)	(c)	14 (2013:02)	(a)	15 (2013:03)	(b)	16 (2013:10)	(b)
17 (2013:11)	(a)	18 (2013:12)	(c)	19 (2014:03)	(d)	20 (2014:16)	(d)
21 (2014:21)	(b)	22 (2014:30)	(d)	23 (2015:01)	(b)	24 (2015:02)	(a)
25 (2015:09)	(b)	26 (2015:14)	(d)	27 (2015:18)	(a)	28 (2015:19)	(c)
29 (2015:20)	(d)	30 (2015:28)	(a)	31 (2015:30)	(d)		

Short Answer Questions

32 (2011:24) **(10 marks)**

(a) (i) 1 mark each definition (2)
• A feature/characteristic that enables an organism to survive in its (particular) environment.
(ii) • physiological/functional

(b) Any 2 of the following: 1 mark for the adaptation and 1 mark for the explanation (4)
- Waxy/thick cuticle on surface of leaf – Waterproof/reflects heat so less evaporation (2)
- Leaf shape is narrow/cylindrical – Reduces the surface area for water loss (2)
- Hairs on leaves/tomentum – Absorb less/reflect more heat than smooth leaves/decrease rate of evaporation (2)
- Stems flatten and become leaf like (cladodes/phyllodes) and leaves reduced to spines – Cladodes lose less water than similar sized leaves (2)
- Succulent leaves – For storing water (2)
- Stomata only on the lower epidermis – Less exposed to direct heat radiation (2)
- Depressed/sunken stomata – Water vapour trapped (2)
- Stomata open at night – Carbon dioxide stored overnight (2)
- Closing of stomata in the middle of the day/open for only short periods during drought – Open when sunlight but lower temperatures. (2)
- Deciduous in the dry season – No leaves to lose water from (2)
- Rolling of leaves in dry conditions – Reduced number of stomata exposed to the dry conditions/inner surface stomata not exposed (2)
- Leaves hang vertically – Less surface area exposed to radiant heat (2)

(c) (i) 1 mark each (2)
A – stomatal pore/stomata/stoma/stomate
B – guard cell
(ii) 1 each (max 2) (2)
During the daytime:
- Chloroplasts in B photosynthesise
- Glucose levels rise in B/guard cells
- Increase in osmotic pressure in B/guard cells.
- Potassium ions are pumped into B/guard cells
- Water enters structure B/guard cells/B/guard cells becomes turgid
- A/stomata opens due to uneven thickness of walls of B/guard cells/thickened inner walls of B/guard cells causes A/stomata to open

33 (2011:25) **(20 marks)**

(a) Advantage 1 mark: Explanation 1 mark (2)
- Allows excess heat to be radiated/conducted out of body – Explain in terms of efficient evaporative cooling
- Can withstand high temperatures without overheating – Allows increased conduction/convection/radiation
- Allows rapid heat loss through radiation/conduction – Reduces energy needed for cooling

Disadvantage 1 mark: Explanation 1 mark (2)
- Can lead to rapid dehydration – Allows increase evaporation
- Can cause overheating if exposed to the sun – Increased heat absorption due to conduction/convection/radiation
- Can lose heat during the cold desert night – Increase conduction/convection/radiation

(b) Any 4 of the following: 1 each (4)
- Carbon dioxide
- Oxygen
- Wastes
- Salts/ions
- pH
- Sugar levels

(c) Marks awarded for complexity of feedback loop:
- Correctly draws a negative feedback model – Correct sequence – show relationships – all six components (4)
- Correctly draws – negative feedback model with five components in correct sequence to show relationships (3)
- Draws a negative feedback model with four components correctly labelled and show relationships (2)
- Draws a negative feedback model with three components labelled in correct order to show relationships (1)