

EXTENDED ANSWER QUESTIONS

Each Extended Answer is worth 10 marks.

PART A Questions

39. 2012:37
Protein synthesis involves two stages, **transcription and translation**. Describe the main steps in each of these processes.
40. 2013:38
Describe, using scientific terminology, the main steps involved in DNA replication in a living cell.
41. 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.
42. 2016:36a
Describe the structure of DNA and the main steps in DNA replication in a cell.
43. 2016:36b
Describe the process of meiosis and explain how this process produces genetic variation.
44. 2017:36a
Chymosin is an enzyme produced by nursing calves to assist with the digestion of milk. Humans also use chymosin to make cheese. Traditionally, chymosin for cheesemaking was obtained from the stomach of calves that had been killed for their meat. It is now obtained from genetically-modified microorganisms.
Describe how recombinant DNA technology can be used to genetically modify bacteria to produce chymosin and the advantages of obtaining chymosin for cheesemaking in this way.

PART B Questions

45. 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.
46. 2016:37a
Describe how a cell produces an enzyme.

Continuity of life on Earth

- life has existed on Earth for approximately 3.5 billion years and has changed and diversified over time
- evidence for the theory of evolution includes
 - comparative genomics (molecular evidence)
 - the fossil record
 - comparative anatomy and embryology
- evolutionary relationships between groups can be represented using phylogenetic trees
- mutation is the ultimate source of genetic variation as it introduces new alleles into a population
- natural selection occurs when selection pressures in the environment confer a selective advantage on a specific phenotype to enhance its survival and reproduction; this results in changes in allele frequency in the gene pool of a population
- in addition to environmental selection pressures, sexual selection, mutation, gene flow and genetic drift can contribute to changes in allele frequency in a population gene pool
- speciation and macro-evolutionary changes result from an accumulation of micro-evolutionary changes over time
- selective breeding (artificial selection) through the intentional reproduction of individuals with desirable characteristics results in changes in allele frequencies in the gene pools over time
- differing selection pressures between geographically isolated populations may lead to allopatric speciation
- populations with reduced genetic diversity face increased risk of extinction

MULTIPLE-CHOICE QUESTIONS

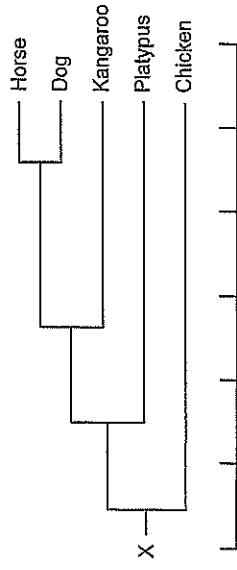
1. Which one of the following statements about the gene pool is most accurate? (2012:02)
 - (a) The gene pool contributes to biodiversity.
 - (b) Mutation decreases the size of the gene pool.
 - (c) Genetic drift increases the size of the gene pool.
 - (d) Natural selection causes random changes in the gene pool.

2. Alleles are alternative forms of (2012:16)
 - (a) an amino acid.
 - (b) a chromosome.
 - (c) a gene.
 - (d) a protein.

3. Which of the following statements about evidence for evolution is correct? (2012:17)
 - (a) The embryos of both humans and fish have tails.
 - (b) The wings of insects and birds are homologous.
 - (c) Organisms produce hundreds of different types of amino acid.
 - (d) Soft-bodied organisms are common in the fossil record.

4. Which one of the following most probably evolved through sexual selection? (2012:18)
 - (a) antibiotic resistance in bacteria
 - (b) courtship displays in birds
 - (c) high reproduction rate in marine fish
 - (d) milk yield in dairy cows

The next 2 questions refer to the phylogenetic tree below.



5. What does X represent? (2013:14)
 - (a) the ancestor of birds but not mammals
 - (b) the oldest known fossil vertebrate
 - (c) the very first mammal to evolve
 - (d) the common ancestor of all five named animals

6. The label for the scale at the bottom of the phylogenetic tree should be (2013:15)
 - (a) 'Time before the present'.
 - (b) 'Rate of natural selection'.
 - (c) 'Number of species'.
 - (d) 'Classification level'.

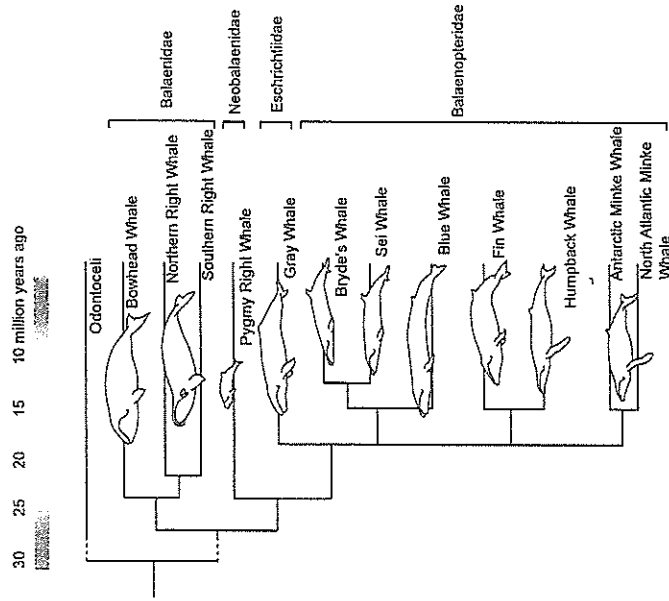
7. Some strains of disease-causing bacteria have evolved resistance to the antibiotics that were once used to treat the disease. This evolution has been driven by (2013:19)
 - (a) artificial selection.
 - (b) natural selection.
 - (c) genetic drift.
 - (d) genetic engineering.

8. (2013:21)

Scientists have determined that a huge number of species became extinct about 250 million years ago. Which of the following types of evidence would they have used to determine this?

- (a) biochemical
- (b) embryological
- (c) fossil
- (d) genetic

The next two questions relate to the following phylogenetic tree, which shows the relationships among some whale species.



9. (2014:13)

On the basis of the information contained in the phylogenetic tree, which of the following pairs of whale species are most closely related?

- (a) Sei Whale and Bryde's Whale
- (b) Blue Whale and Fin Whale
- (c) Bowhead Whale and Humpback Whale
- (d) Pygmy Right Whale and Northern Right Whale

10. (2014:14)

Approximately how long ago did the Antarctic Minke Whale and North Atlantic Minke Whale diverge?

- (a) 30 million years ago
- (b) 20 million years ago
- (c) 15 million years ago
- (d) 10 million years ago

11. (2014:18)

A biologist kept a culture of vinegar flies in the laboratory. The biologist only allowed those flies with a relatively large number of bristles on their abdomen to breed. He did this for several generations and at the end of the study found that, on average, the number of abdominal bristles in the vinegar flies in the culture had increased. The increase in the number of abdominal bristles in the flies was due to

- (a) natural selection.
- (b) artificial selection.
- (c) gene flow.
- (d) genetic drift.

The next question relates to the calculation of the running speed of the extinct dinosaur *Tyrannosaurus rex*.

12. (2014:28)

A biologist wanted to calculate the running speed of *Tyrannosaurus rex* but needed to know the dinosaur's foot length to make the calculation. Which of the following types of evidence would provide the best estimate of foot length in *Tyrannosaurus rex*?

- (a) comparative anatomy
- (b) comparative biochemistry
- (c) embryology
- (d) fossil

13. (2015:03)

Meiosis usually involves

- (a) crossing over and mutation.
- (b) mutation and random mating.
- (c) crossing over and independent assortment.
- (d) independent assortment and random mating.

14. (2015:08)

Most of the bacteria in a population are killed by an antibiotic, but a few cells survive to reproduce and produce the next generation. Compared to those in the previous generation, the bacteria in the next generation are likely to be

- (a) more susceptible to mutation.
- (b) less susceptible to mutation.
- (c) more susceptible to the antibiotic.
- (d) less susceptible to the antibiotic.

15. (2016:11)

In mitosis, a parent cell usually produces

- (a) four daughter cells, each of which has the same number of chromosomes as the parent cell.
- (b) four daughter cells, each of which has half the number of chromosomes as the parent cell.
- (c) two daughter cells, each of which has the same number of chromosomes as the parent cell.
- (d) two daughter cells, each of which has half the number of chromosomes as the parent cell.

16. (2016:14)

Which of the following is an example of a macroevolution?

- (a) The frequency of an allele in a weed population increased from 5% to 50%.
- (b) Pea plants in nutrient-rich soil grew faster than pea plants in nutrient-poor soil.
- (c) A species of elephant evolved into two new species.
- (d) Black rats fed on warfarin poison evolved resistance to this poison.

17. (2016:18)

The first known life forms on Earth were a type of

- (a) bacteria that evolved approximately 3.5 billion years ago.
- (b) bacteria that evolved approximately 3.5 million years ago.
- (c) protozoan that evolved approximately 3.5 billion years ago.
- (d) protozoan that evolved approximately 3.5 million years ago.

18. (2016:19)

The first known life forms on Earth were discovered from

- (a) comparative genomics.
- (b) comparative anatomy.
- (c) laboratory experiments.
- (d) the fossil record.

19. (2016:21)

Artificial selection is the

- (a) intentional reproduction of individuals with desirable characteristics that changes the frequency of alleles in the selected line.
- (b) intentional reproduction of individuals with desirable characteristics that does not change the frequency of alleles in the selected line.
- (c) unintentional reproduction of individuals with desirable characteristics that changes the frequency of alleles in the selected line.
- (d) unintentional reproduction of individuals with desirable characteristics that does not change the frequency of alleles in the selected line.

The next two questions relate to the information below.

A biologist measured the amount of genetic diversity in five populations of the Australian platypus. The amount of genetic diversity in each population is indicated by the diversity index. Values of the diversity index range from 0 (no diversity) to 1 (maximum diversity).

Population	Diversity index
Central Victoria	0.597
Northwestern Tasmania	0.606
King Island	0.032
Kangaroo Island (wild)	0.419
Kangaroo Island (sanctuary)	0.431

20. (2016:23)

On the basis of the information in the table, which of the following platypus populations is at the greatest risk of extinction due to genetic factors?

- (a) Kangaroo Island (wild)
- (b) Kangaroo Island (sanctuary)
- (c) Northwestern Tasmania
- (d) King Island

21. (2016:24)

Which of the following processes could introduce a new allele into a platypus population?

- (a) genetic drift
- (b) natural selection
- (c) mutation
- (d) meiosis

22. (2016:28)

Two species of tortoises live on separate islands. These two species evolved from a common ancestor by allopatric speciation. The likely order of events in the speciation, from first to last, would have been

- (a) natural selection, reproductive isolation, geographical isolation.
- (b) natural selection, geographical isolation, reproductive isolation.
- (c) geographical isolation, natural selection, reproductive isolation.
- (d) geographical isolation, reproductive isolation, natural selection.

23.

Which of the following processes causes a random loss of alleles from a population?

(2016:29)

- (a) genetic drift
- (b) mutation
- (c) natural selection
- (d) gene flow

24.

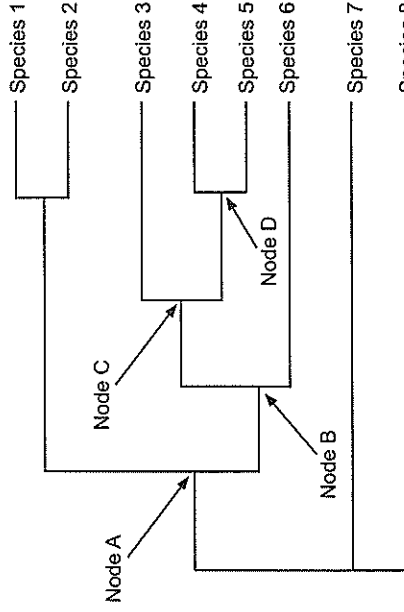
(2017:03)

The woolly mammoth was a large mammal that became extinct approximately 4000 years ago. Reduced genetic diversity associated with a small population size contributed to the extinction of this species and was probably due to

- (a) artificial selection.
- (b) natural selection.
- (c) mutation.
- (d) genetic drift.

The next question relates to the information below.

The following phylogenetic tree shows the evolutionary relationships among eight plant species.



25.

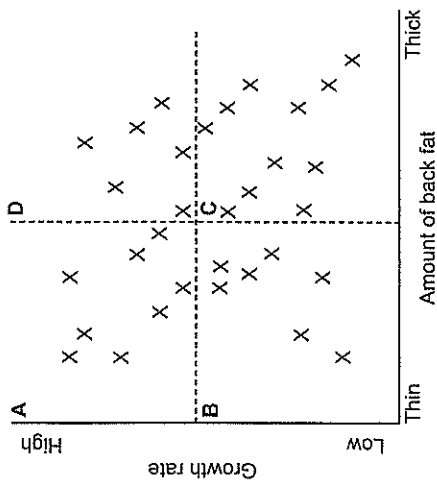
(2017:06)

Which node (branch point) in the phylogenetic tree represents the most recent common ancestor of species 3, 4, 5 and 6?

- (a) Node A
- (b) Node B
- (c) Node C
- (d) Node D

The next question relates to the diagram below.

A biologist measured the growth rate and the thickness of back fat in a group of pigs. The results are shown in the diagram, where each 'X' represents one pig. The biologist divided the pigs into four groups (A, B, C and D) according to their growth rate and thickness of back fat, as shown in the diagram.



26. (2017/20)
The biologist wants to use selective breeding to produce pigs with a high growth rate and thin back fat. The best animals to select for breeding for this purpose are those in group

- (a) A.
- (b) B.
- (c) C.
- (d) D.

SHORT ANSWER QUESTIONS

27. [12 marks] (2012/34)
(b) Humans have used artificial selection (selective breeding) to modify the characteristics of plants and animals for many years.

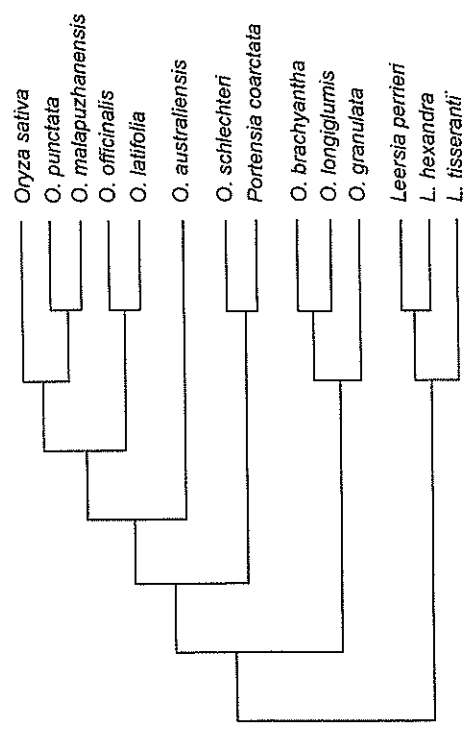
Outline how artificial selection can be used to increase drought resistance in rice. [4]

- (d) Describe two advantages and two disadvantages of using recombinant DNA technology to modify the characteristics of plants and animals compared to artificial selection techniques. [4]

Advantages:

Disadvantages:

- (e) The Asian rice plant is a member of the genus *Oryza*, which also includes a number of species of wild rice. The following phylogenetic tree shows the evolutionary relationships between the Asian rice (*O. sativa*) and some of the wild species in the *Oryza* and other related genera.



CONTINUED NEXT PAGE

30. [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.

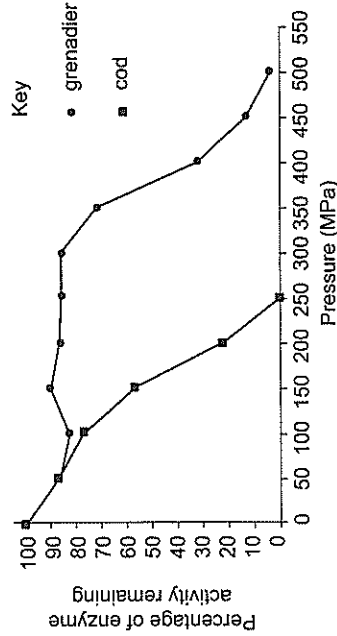
(d) The population of Enderby Island Cattle on Enderby Island was started from about nine individuals and remained small for the entire time that the cattle were on the island. The allele frequencies in this population are therefore likely to have been changed by genetic drift. Explain how genetic drift changes the allele frequencies in a population. [4]

(e) In most cattle breeds the bulls are much larger and more muscular than the cows. Is this likely to be due to natural selection, artificial selection or sexual selection? Explain your answer. [4]

31. [4 marks]

(2014:35)

A biologist investigated the relationship between the activity of the lactate dehydrogenase (LDH) enzyme and external pressure in two species of fish (grenadier and cod) in a controlled experiment. The results are shown in the following graph.



(e) The composition of the LDH enzymes of the grenadier and cod differ with respect to at least 21 amino acids. Name the evolutionary process that is the source of differences in the amino acid composition of molecules and explain how this process leads to such differences.

32.. [8 marks]

(2015:34)

(d) (i) Define the term 'gene pool'.

[1]

(ii) State one major similarity between the processes of natural selection and genetic drift.

[1]

(iii) State one major difference between the processes of natural selection and genetic drift.

[2]

(e) (i) Define the term 'gene flow'.

[1]

(ii) Explain the importance of barriers to gene flow in the process of speciation.

[3]

33. [4 marks]

(2016:31)

(a) Name and describe the process by which a bacterial cell reproduces.

34. [4 marks]

(2016:34)

(e) Many strains of bacteria that cause diseases in humans are evolving resistance to antibiotics. Explain how a disease-causing strain of bacterium can evolve resistance to an antibiotic used to treat the associated disease.

.35. [16 marks]

(2017:34)

(a) Indicate the order in which the following life forms first evolved: eukaryotic cells, prokaryotic cells, land plants and marine animals. [4]

First (Oldest): _____

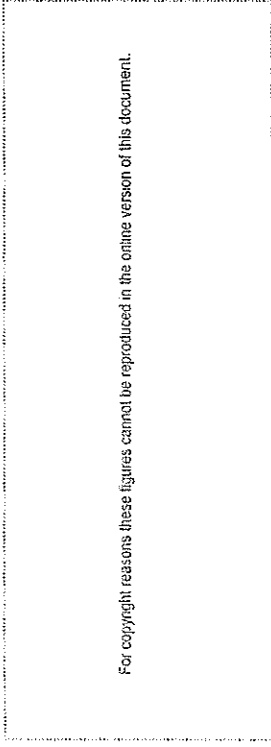
Second: _____

Third: _____

Fourth: _____

(b) Distinguish between microevolution and macroevolution. Include a specific example of each in your answer. [4]

Male red-collared widowbirds have very long tail feathers. In order to investigate the evolution of these feathers, a biologist cut the feathers of some male widowbirds and compared the mating success and body condition of these males to those of males with uncut, long tail feathers (control males). Figure 1 below shows the body condition index (where higher values indicate better condition) of the males with experimentally shortened feathers and the control males during the breeding season when the males were maintaining a territory. Figure 2 shows the mean number of active nests for the two types of male. This reflects the number of females that each male was able to attract to his territory.



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(d) Suggest a plausible explanation for the evolution of long tail feathers in the male widowbirds. [5]

- (e) Large numbers of Australian herring inhabit estuaries on the south coast of Western Australia. The genetic compositions of the groups of individuals in the different estuaries are the same.

Provide a plausible explanation for why this is so. [3]

EXTENDED ANSWER QUESTIONS

Each Extended Answer is worth 10 marks.

PART A Questions

- 36. 2016:37b
Explain how an advantageous allele can arise and then spread through a population.
- 37. 2017:37a
Describe the process of allopatric speciation.
- 38. 2017:37b
Explain how fossils, comparative anatomy, comparative embryology and comparative genomics can each provide evidence for the theory of evolution.

PART B Questions

- 39. 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.

40. 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.

41. 2015:41

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

- (c) one mark each for any 3 of the following mRNA: (3)
- made up of a single strand of nucleotides
 - the chain of nucleotides is shorter than the DNA molecule
 - uracil replaces thymine in the chain
 - start and stop codons are present in the chain
 - there is a coding region made up of codons between the starting and stop codons
- (d) one mark for each of the following (4)
- tRNA combines with a specific amino acid
 - tRNA carries its amino acid to a ribosome on which mRNA is located
 - tRNA's anticodon finds its matching codon on the mRNA template
 - the amino acid forms a peptide bond with its adjacent amino acid while the tRNA detaches from the amino acid and moves away from the ribosome
- (e) one mark each for any 4 of the following (4)
- the radiation contaminated area may show a dangerously high background radiation count
 - high radiation levels are likely to damage some DNA molecules in the birds that live in the area as radiation exposure has a cumulative effect
 - if damage occurs to DNA in the barn swallows' gametes
 - this may cause mutations in the offspring of those barn swallows that have been exposed in the contaminated areas
 - uncontaminated areas will not show dangerous levels of radiation and will therefore have a lower incidence of abnormalities
- 38 (2017:33) (4 marks)
- (d) One mark for each of the following
- Cross a large number (e.g. several thousand) of fruit flies from a frequently sprayed orchard with a large numbers of fruit flies from the laboratory
 - Allow the F1 generation to interbreed and observe the proportion of resistant and non-resistant offspring in the F2 generation
 - If the F2 generation shows an approx. ratio of - resistant : non-resistant = 3 : 1 this suggests that the resistant gene is dominant
 - If the F2 generation shows an approx. ratio of - resistant : non-resistant = 1 : 3 this suggests that the non-resistant gene is dominant

Extended Answer Questions
PART A

- 39 (2012:37) (10 marks) (max 5)
- Transcription: Any five of:
- 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:
- 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 (10 marks)
- 40 (2013:38) First 5 dot points - 1 mark each (max 5)
- Description (1)
- 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 synthesise 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

- 41 (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
- 42 (2016:36a) (10 marks) (4)
- DNA structure - 1 mark for any 4 of the following points
- Molecule chain of nucleotides
 - Each nucleotide consists of a nitrogen base, a sugar molecule and a phosphate group
 - Four types of bases - adenine, thymine, cytosine and guanine
 - Most DNA consists of two complimentary strands of DNA
 - Two strands form a double helix
 - Strands are held together by weak hydrogen bonds
 - Adenine bonds to thymine, cytosine bonds to guanine across the strands

43 (6)

- Replication - 1 mark for any 6 of the following points
- Replication of each chromosome occurs in the middle stages of interphase
 - DNA molecule unzips along its entire length separating its two complementary strands
 - Each single DNA strand becomes a template/ process is semi-conservative as each new DNA molecule has one original strand
 - Enzyme helicase is used to separate strands
 - Free nucleotides in the nucleoplasm move to complementary bases along each single strand
 - Enzyme polymerase is used to join the complementary bases along each strand
 - Hydrogen bonds between the complementary bases are weak - but their sum total provides sufficient stability
 - Along the leading strand (5' to 3') this joining process is continuous, along the lagging strand (3' to 5') it is discontinuous

44 (2016:36b) (10 marks) (7)

- Process of meiosis - 1 mark for any 7 of the following points
- Chromosomes replicate during interphase
 - Meiosis involves two divisions, before each division the nuclear membrane breaks down
 - In the first division diploid cell has homologous chromosomes that form pairs
 - Spindles attach to each pair
 - Pairs are separated moving to opposite poles of the cell
 - Cell divides into two, each cell containing one chromosome of each homologous pair
 - In second division new spindles form
 - Spindles separate chromatids that move to opposite poles of each cell
 - Both cells divide forming a total of 4 cells
 - Each new cell (gamete) contains half the number of chromosomes as the parent cell - each is haploid

45 (2016:37a) (10 marks) (3)

- How meiosis produces genetic variation - 1 mark for any 3 of the following points
- Crossing over - chromosomes exchange genetic material during the first division
 - Nondisjunction - some chromosomes/chromatids fail to separate during the first or second cell division
 - Random assortment of chromosomes as they form pairs during the prophase of first division
 - Mutations in the parent cells (or germ cells) that form gametes

46 (2017:36a) (10 marks) (8)

- One mark each for any 8 of the following
- In recombinant gene technology a DNA fragment is integrated into DNA to which it does not normally belong
 - To produce chymosin (main enzyme in rennet) the gene which codes for this protein is removed from calf DNA
 - The DNA fragments containing the target gene are removed using a specific restriction enzyme
 - The DNA fragments are amplified using PCR
 - DNA fragments containing the target DNA are then spliced using ligase into bacterial plasmid DNA molecules
 - The plasmid molecule is cut using the same specific restriction enzyme
 - The bacteria are incubated to produce millions of copies, each time a bacterium divides its DNA is replicated
 - Each bacterium has the capacity to produce chymosin which can be extracted for use in cheese making
 - The chymosin is then purified - other proteins are removed

One mark each for any two of the following

- The advantages include
- The process enables extracts containing almost pure chymosin to be produced
 - No need to slaughter calves to produce cheese
 - Less likelihood of contamination of chymosin by other harmful bacteria
 - More economical process and more cheese can be produced

PART B

45 (2013:41) (10 marks) (1) (4)

Crossing-over

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

Randomly/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).

46 (2016:37a) (10 marks) (2) (4)

- 1 mark for any 2 of the following points
- Enzymes are a type of protein - therefore the production of an enzyme is the same as protein synthesis
 - Production takes place in two stages - transcription followed by translation
 - Transcription takes place on chromosomal DNA in the nucleus of eukaryotic cells, translation occurs in the cytoplasm on ribosomes

Transcription

- 1 mark for any 4 of the following points (4)
- DNA unzips along part of its length
 - Free nucleotides in the nucleoplasm bond to one side of the exposed DNA molecule
 - RNA polymerase speeds up this bonding
 - Uracil replaces thymine in molecule formed
 - The molecule formed is called mRNA
 - mRNA detaches from the DNA - sections of the molecule called introns which do not code for amino acids are removed by enzymes
 - mRNA moves through a nuclear pore to a ribosome

Translation

- 1 mark for any 4 of the following points (4)
- Transfer RNA (tRNA) molecules which have three nucleotides called anticodons transport particular amino acids from the cytoplasm to their corresponding codons along the mRNA molecule
 - mRNA forms a template for the synthesised protein so the order and number of amino acids used is correct
 - Polymerase promotes the bonding of the nucleotides in the codons and matching anticodons
 - Adjacent amino acids delivered by the tRNA molecules form peptide bonds
 - When complete the long chain of amino acids detaches from the mRNA - a protein/peptide is formed

Chapter 2: Continuity of life on Earth

Multiple Choice Questions

1 (2012:02)	(a)	2 (2012:16)	(c)	3 (2012:17)	(a)	4 (2012:18)	(b)
5 (2013:14)	(d)	6 (2013:15)	(a)	7 (2013:19)	(b)	8 (2013:21)	(c)
9 (2014:13)	(a)	10 (2014:14)	(c)	11 (2014:18)	(b)	12 (2014:28)	(d)
13 (2015:03)	(c)	14 (2015:08)	(d)	15 (2016:11)	(c)	16 (2016:14)	(c)
17 (2016:18)	(a)	18 (2016:19)	(d)	19 (2016:21)	(a)	20 (2016:23)	(d)
21 (2016:24)	(c)	22 (2016:28)	(c)	23 (2016:29)	(a)	24 (2017:03)	(d)
25 (2017:06)	(b)	26 (2017:20)	(a)				

Short Answer Questions

27 (2012:34) (b) Any four of: (12 marks) (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

(d) Advantages Any two of: (max 2)

- Much faster result/artificial selection may take decades/centuries/don't have to wait for natural mutations to occur
- Allows the retention of other desirable characteristics of the best varieties of the species
- Able to use the best genes available/genes from other species – not just the best in the species

Disadvantages Any two of: (max 2)

- May become a weed due to success in dry conditions
- May upset natural food webs by suddenly becoming a food source for native animals
- May crossbreed with nearby non-recombinant crops/related native species to contaminate them
- Complicated/specialised process/expensive
- Not always successful
- Effects/consequences not fully understood/ethical issues/allergic reactions

(e) (i) *O. officinalis* (1)

- The *O. officinalis* branch is closer to *O. sativa* than the *O. australiensis* branch/share a more recent common ancestor

(ii) Yes/Supports the argument (1)

- The *Portensia* branch is in the middle of a number of *Oryza* branches instead of outside them. (1)

28 (2012:35) (e) Any four of: (4 marks)

- Prevents development of resistance
- Natural selection of resistant SWD
- If used in successive years the survivors will produce more and more offspring that are resistant
- If a new one is used the previous year's survivors will have no advantage
- Variation exists in genetics of original population
- It takes several generations for resistance to become significant

29 (2013:31) (e) (i) (1 mark each point – max 4) (6 marks) (4)

- Females begin reproduction at an earlier age/males begin reproduction at a later age
- Females are reproductively successful over a longer period of their lives (2–14 years)/males have a shorter reproductive life (8–12 years)
- Females produce only one offspring per year/males can produce many more/up to 17
- During their lifetime, each male produces more offspring/each female produces fewer offspring
- Reproductive success is limited in young seals, both male and female (especially male)

(ii) (1 mark each point – max 2) (2)

- Any one of: (max 1)
- Large males compete successfully against other males
- Large males preferred as a mate by the females
- Any one of: (max 1)
- Large males have more offspring
- Increase of frequency of genes for large males

30 (2014:34) (d) (8 marks) (4)

- Genetic drift occurs when population size is limited/small
- It is random/chance event
- Some individuals may have more offspring than others so allele frequency increases
- Some individuals may die so there is a decrease in allele frequency for alleles they possess

(e) (4)

- Must have sexual selection (1)
- Acts on organisms ability to obtain a mate
- And successfully copulate/mate
- Males will compete for access to the females/larger more muscular more successful
- Females choose which bull to mate with/choose best mate/best genes for offspring

31 (2014:35) (e) (4 marks)

- The process is mutation (must have this) (1)
- Change in DNA code
- Changes RNA code when copied
- Change in amino acid sequence during translation
- Thus different phenotypes arise due to different proteins being synthesised

32 (2015:34) (d) (i) (8 marks)

Gene pool definition: The total number of genes of every individual in an interbreeding population. (1)

- Any one of the following differences (difference MUST be related): (2)
- Genetic drift occurs when population size is limited/small (1) Natural selection can occur in any population size (1)
- GD – It is random/chance/unpredictable event (1) NS is not random/trait becomes more common because it offers an advantage (1)

(e) (i) Alleles are added to or subtracted from a gene pool due to movement/death of fertile individuals or gametes (1)

(ii) Barriers such as geographical or behavioural (1)

- Prevent interbreeding of members of the same species/ breeding populations (1)
- Such that the separated populations adapt and evolve in different environments (1)
- Speciation occurs due to different selection pressures (1)

33 (2016:31) (a) Binary fission (4 marks) (1)

- any 3 of the following for 1 mark each (3)
- DNA replicates
- Replicated DNA move to opposite poles of cell
- Cell divides
- Each half contains a copy of the DNA

- 34 (2016:34) (4 marks) (4)
- (e) any 4 of the following for 1 mark each
- Bacteria show variation within each strain
 - A proportion of a bacterium population normally have a resistance to any particular antibiotic
 - When an antibiotic is applied to bacteria many will die but those bacteria with a resistance may survive
 - The survivors reproduce in favourable conditions, a greater proportion of the population will have a resistance to the antibiotic
 - If the same antibiotic is used to control these bacteria a smaller proportion die i.e. the antibiotic has a diminished potency

- 35 (2017:34) (16 marks) (4)
- (a) One mark for each of the following (in order)
- First: prokaryotic cells
 - Second: eukaryotic cells
 - Third: marine animals
 - Fourth: land plants
- (b) One mark for each of the following (students may use other examples)
- Microevolution involves only small changes in a population
 - e.g. small but different changes in allele frequencies in two populations that have only recently become separated
 - Macroevolution involves major change
 - e.g. when two species develop from one species - the original population - one species is split into two (or more) reproductively isolated populations over a long period of time - two (or more) species develop

- (d) One mark for any five of the following points.
- Female birds of this species are attracted to male birds which have longer tail feathers. This characteristic is sexually selected
 - Within a territory a male with long tail feathers will attract more females than a male with shorter tail feathers
 - Males with longer tails establish more nests within their territories
 - Males with longer tails produce more offspring during the breeding season than their shorter tailed competitors
 - The proportion of offspring with longer tail feathers therefore increases with each succeeding generation
 - The proportion of alleles for long tail increases with each generation while the proportion of alleles for short tail decreases

- (e) Any one of the following explanations is acceptable. One mark for each point
- The herring populations are not reproductively isolated
 - There is some movement and interbreeding between the groups
 - An exchange of genes occurs between the groups so that allele frequencies remain the same
- Or
- The populations have only recently become separated
 - Each population has not had sufficient time to adapt to its particular environment
 - The proportion of different alleles therefore represents the frequencies of the original parent population
- Or
- The herring populations remain isolated in estuaries during their maturation period
 - At a particular time of the year mature fish in each population move out of each estuary and congregate with other populations to breed away from the estuaries - there is one gene pool
 - Juveniles eventually move back to estuaries to grow and develop

Extended Answer Questions
PART A

- 36 (2016:37b) (10 marks) (2)
- How alleles arise
- 1 mark for each of the following points
 - New alleles arise by mutations - random changes to a gene/ genes/ chromosomes
 - Mutations are caused by mutagens - chemicals e.g. *Syngathetic musin (2,4-d and 2,4,5-)*, used as herbicides), rapid temperature changes and radiation

- How alleles spread through a population
- 1 mark for any 8 of the following points
- If the mutation is in a germ cell/gamete it may be inherited
 - As mutations are random changes they are mostly neutral or harmful, very few mutations are useful
 - Natural selection removes harmful mutations
 - Most mutations are recessive and therefore harmful mutations are hidden by (unmutated) normal genes - as generally genes occur in pairs
 - A rare advantageous mutation will be naturally selected
 - Any organism that inherits a useful gene may have an advantage over others in its population
 - Its chances of survival and reproduction may be increased
 - Some of its offspring will acquire the advantage
 - In turn they will survive and reproduce at a greater rate than those that do not possess the advantageous trait
 - Gradually the proportion of individuals within the population that have the gene will increase and the frequency of the gene within the population therefore increases

- 37 (2017:37a) (10 marks) (10)
- Allopatric speciation
- One mark each for the following points
- Allopatric speciation is the evolution of two (or more) species from one original species.
 - Initially there is one species with considerable genetic biodiversity.
 - It exists as one gene pool.
 - The population is divided into two by the formation of a barrier between them (or a small group is separated from the parent population).
 - The barrier does not allow interbreeding between the two populations - they are 'reproductively isolated'.
 - Different natural selection pressures within each environment change the gene frequencies within each population differently.
 - In several generations the two separated gene pools become two sub species.
 - Mutations that are advantageous in each environment are naturally selected but not shared by the reproductively isolated gene pools.
 - The populations become progressively less alike.
 - Over many generations, if the barrier was removed, the gene pools become so different that interbreeding between individuals from each population would be impossible because their DNA is incompatible. The two gene pools now represent two separate species.

- (Note: Students may use clear annotated diagrams to illustrate this process)
- 38 (2017:37b) (10 marks) (8) (2)
- Must have 2 points from each of the four areas below then any other 2 points
- Fossils
- Fossils - the remains or imprints of organisms that have lived in the past
 - Fossils can be used to compare living populations with their ancestors
 - Fossils indicate changes to the anatomy of species, usually gradual change
- Comparative anatomy
- Closely related organisms have similar structures
 - E.g. the three body parts of insects, i.e. head, thorax and abdomen indicate that all insects have diverged from a common ancestor

- Homologous structures – structures which in embryos may look the same but as different species develop, become different and develop different functions.
 - E.g. forelimbs of vertebrates – legs for walking in most mammals, wings for flying in birds – homologous structures indicate common ancestors
- Comparative embryology**
- Embryology: in the vertebrate group all the embryos are very similar in that they have pharyngeal folds (or gill slits), a post-anal tail and a very similar shape
 - This suggests that they have many genes in common
 - They therefore have a relatively recent common ancestor
- Comparative genomics**
- Genomics – the area of genetics involved in studying genomes, DNA sequencing and its use in biology
 - Comparison of organisms' DNA, genes and nucleotide sequences enables scientists to more accurately construct phylogenetic trees and to determine how closely related species are to one another, that is to determine whether or not they have a recent common ancestor
 - Knowledge of the genes in related organisms can help understand which alleles have been naturally selected and which have disappeared in particular populations
 - Biochemistry: comparisons of blood proteins, DNA and other compounds within the body of animals and plants, enables links to be drawn
 - The observation that all organisms contain DNA suggests a connection between all organisms that may be traced to the beginning of life on earth
 - E.g. the similarity of DNA in the primate group indicates that they evolved from a common ancestor (approximately 65 million years ago)

PART B

- 39 (2012:40) (10 marks)
- Any ten of:
- Genetic variation exists within a species
 - Variation is due to gene mutation
 - Variation is due to reproductive processes/ non disjunction/crossing over/independent assortment
 - There is an excessive amount of reproduction with each new generation
 - Fish, isolated in caves
 - Selection pressure now exists
 - Those with the best genetic adaptations are most likely to survive and reproduce
 - Establish the link between reduction in vision and increase in other senses as being advantageous in dark/ cave environment
 - More energy available for other senses
 - Their offspring will inherit the favourable genes
 - Gene frequency of favourable genes will increase
 - If a population is reproductively isolated, speciation can occur
 - After many generations/a lot of time all/most members of the species are eyeless
 - Eyeless population may no longer be able to interbreed with surface population

- 40 (2014:41) (10 marks)
- Any 10 points for one mark each, but must refer to speciation, not just natural selection, otherwise only maximum of 5 marks.
- speciation has occurred
 - mutations occur within populations
 - causes variation
 - isolation/migration occurs separating ancestral/original species from others
 - due to geographical isolation/oceans
 - no gene flow occurs
 - two different gene pools are created
 - environmental conditions differ in different regions
 - selection pressures/forces act on different populations
 - some adapt/have characteristics/phenotypes that are favourable
 - competition occurs for food/space/resources
 - only the strongest survive and reproduce

- passing on favourable alleles/increasing incidence of favourable phenotypes
- speciation occurs as species become too different/cannot reproduce
- to produce fertile offspring/interbreed

41 (2015:41) (10 marks)

- Fossils**
- Any 5 points for one mark each.
- Fossils are any preserved remains of a living organism
 - Provide direct evidence of past life on earth
 - Usually preserved in rocks of different ages so that they can be aged/time scale can be studied
 - Fossils show how much, or how little, organisms have changed over time.
 - Demonstrates progressive changes in the structures of animals and plants as they adapt to different/changing environments
 - Can provide evidence of the environment/climate in the past eg fossilised pollen grains, plants and coprolites (fossilised faeces)
- 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 (2012:15)	(c)	2 (2013:17)	(b)	3 (2013:20)	(a)	4 (2014:27)	(b)
5 (2015:10)	(d)	6 (2017:25)	(a)				

Short Answer Questions

- 7 (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
- 8 (2012:34) (4 marks)
- (a) Crossing over
- Involves exchange of DNA segments/alleles/sections of chromatid between homologous chromosomes
 - 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)