10.1
The development of classification systems
The earliest classification systems were based on visual similarities between organisms. Advances in our understanding of the biological or genetic make-up of organisms has provided evidence for how organisms are linked. This information informs revisions to the system of classification which is used.

Summary Questions
1 Any 2 appropriate reasons. For example: Enables scientists to share information / makes communication easy (1); provides information about an organism, based on members of the same group (1); allows accurate identification of an organism (1).
2 Ligers cannot reproduce to produce more ligers therefore they are not a species (1). Both lions and tigers reproduce to produce fertile offspring, therefore they are species (1).
3 a Phylum (1); b Erithacus (1); c rubecula (1)
4 Both parents are members of the same genus (Rubus) (1) but different species (ursinus and idaeus) (1). Two different species cannot produce fertile offspring / according to the taxonomic classification system the loganberry should not be fertile (1).

10.2
Summary Questions
1 Any two from: Plants have chloroplasts / chlorophyll, whereas fungi do not (1); plants are autotrophs, whereas fungi are heterotrophs (1); fungi may be unicellular, plants are always multicellular (1); fungi store food as glycogen, whereas plants store food as starch (1); plant cell walls are composed of cellulose, whereas fungi cell walls are composed of chitin (1) Or other suitable example.
2 a Prokaryote (1). b Fungi (1). c Protoctista (1)
3 Any three from: Advances in biological techniques have identifies large differences in composition (1); ribosomes/rRNA differ (1); cell walls differ – peptidoglycan not found in archaea (1); old classification does not show correct phylogeny (1).
4 Any six from: Living organisms classified into two kingdoms based on major differences in characteristics (1) for example, those that moved and ate (animals) and those that didn’t (plants) (1); scientific advances/use of microscope allowed smaller details to be observed (1); organisms divided into five kingdoms (1); Plants, animals, fungi, protoctista, prokaryotes (1); Advances in science allowed DNA and proteins to be studied (1); Provided evidence for evolutionary relationships (1); Three domain system proposed (1); Relevant scientists mentioned (Linnaeus, Whittaker, Woese) (1).

10.3
How do you interpret phylogenetic trees?

Summary Questions
1 Historical classification systems based on physical characteristics / niche occupancy, whereas phylogeny based on evolutionary relationships (1).
2 It takes into account evolutionary relationships that might not be obvious by just looking at characteristics (1); it forms a continuous tree so organisms do not have to be forced into groups (1); is not hierarchical therefore different groups on the tree are represented according to their evolutionary position – and can thus be compared (1).

3 a (snakes (1)
b They have become extinct / not present in the world today (1); they are placed along the timeline at the point they existed in time (1).
c Bird and crocodile branches are closer together than bird and turtle (1); birds shared a common ancestor with dinosaurs. This organism shared a common ancestor with the crocodiles (the common ancestor with turtles is much further back in history) (1).

10.4 Evolutionary embryology
Very unlikely that an embryo could form a fossil, as it is made up only of soft tissue (only in rare cases, such as encasement in tar or resin, are bodily tissues preserved).

Summary Questions

1 A diagram used to show evolutionary relationships between organisms (1); the closer the branches of the tree the closer the evolutionary relationships (1).

2 **Advantages** (2): for example – radioisotopes can be used to date fossils / changes can be tracked over time / chronological order apparent in rock strata. **Disadvantages** (2): for example – many organisms decompose quickly before they have a chance to fossilise/destroyed by volcanoes/ destroyed by earthquakes.

3 **1 mark for scientist, 1 mark for contribution (max 6)**
Lyell – suggested that fossils were actually evidence of animals that had lived millions of years ago.
Hutton – proposed theory of uniformitarianism.
Darwin – came up with theory of evolution by natural selection through observations in Galapagos islands / jointly published theory.
Wallace – came up with theory of evolution by natural selection in Borneo/jointly published theory.

4 Any **three from:** Study of similarities and differences in proteins and nucleic acid/DNA of an organism (1); changes in highly conserved molecules can help identify evolutionary links (1); such as cytochrome C / ribosomal RNA (1); species that are closely related have the most similar DNA and proteins /distantly related have far fewer similarities. (1)

10.5 Studying variation in identical twins

1 They have no genetic variation therefore all variation is the result of the environment.

2 They have been exposed to greater amount on environmental influences.

3 Eye colour is determined solely by genes as both identical, ear piercing determined solely by environment as they have opposite results, mass and height controlled by a combination of both genetic and environmental factors as results vary, mass controlled more by the environment than height as greater variation shown.

Summary Questions

1 Interspecific variation is differences between individuals of different species whereas intraspecific is differences between individuals of the same species (1).

2 a Any **two suitable examples**, e.g., scar, tattoo, dyed hair (1)
b Any **two suitable examples**, e.g., eye colour, blood group, lobed, or lobeless ears (1)

3 Caused by a combination of genetics and the environment (1). Genes determine the natural colour of hair and texture, e.g. curly/straight (1). Environment affects final appearance, e.g. if hair is cut, dyed, or lightened by sunlight (1).

4 Any **3 from:** Individuals produced by asexual reproduction are clones/genetically identical to parents (1); no fertilisation so no mixture of genetic material (1); meiosis does not take place/ no production of gametes (1); DNA can only be altered as a result of mutation (1).

10.6 Flagella length variation in *Salmonella*

1 2.4 μm
2 0.49
3 1.91—2.89 μm (68% of population will fall within standard deviation of the mean).
4 Continuous variation, the length of flagella can take any value within a range.

Summary Questions
1 *Continuous* – b, c (1). *Discontinuous* – a, d (1)
2 Characteristics which show discontinuous variation are purely controlled by genetics/no environmental influence (except scars/tattoos just environment) (1). Normally controlled by a single gene (1). Characteristics which show continuous variation are controlled by a combination of genetic and environmental causes (1). Controlled by a number of genes/polygenes (1).
3 *Any two from*: The values of a characteristic which shows discontinuous variation fall into discrete categories (1) if a mean is calculated it may produce a value which does not fit into a category (1) many of the characteristics do not have a numerical value (1).
4 *Any four from*: Continuous variation (1) as controlled by both genetic and environmental causes (1). Normal distribution (1) very few rabbits would be extremely large or extremely small (1) most would be within one standard deviation of the mean (1).

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(2) – 1 mark for each ranked column correct
∑ d² = 4.5 (1)

\[ r = 1 - \frac{6 \sum d^2}{n(n^2 - 1)} \] (1)
\[ r = 1 - \frac{(6 \times 4.5)}{(8 \times 63)} \] (1)
\[ r = 0.946 \] (1)

b df=6 (1); \( p = 0.946 > 0.881 \) therefore >99% confidence. Therefore there is very little (<0.1%) likelihood that the null hypothesis is true (1).

10.7

Classification of giant pandas
1 Giant pandas have: a large body mass, shaggy fur, a pseudo-thumb, the ability to climb
2 Student’s own answer. Any conclusion drawn should be consistent with the evidence available: for example, a student may conclude that the giant panda is a panda, due to the similarities in its teeth, snout and paws to the red panda.
3 The molecular sequence of a particular molecule is compared, by looking at the order of DNA bases or at the order of amino acids in a protein. Species that are closely related have similar DNA and proteins, whereas those that are distantly related have far fewer similarities.

Summary Questions
1 *Anatomical* – camouflage, sharp canine teeth (1); *Physiological* – melanin production, production of toxins (1); *Behavioural* – migration, courtship dance (1).
2 Analogous structures are structures that have adapted to perform the same function but have a different origin whereas homologous structures appear superficially different but have the same underlying structure (1).
3 a Insect and bird wing – both have evolved to fly to escape predators/hunt for food (1).

4 2 marks for named adaptation and suitable explanation. 2 marks for correctly naming the adaptation as behavioural/anatomical/physiological.

5 They have analogous structures – anatomical features that perform the same function in different organisms, but have a different origin (1). 

Any two from: Both burrow through soft soil to find insects (1). Both have a streamlined body shape, and modified forelimbs for digging (1). Both have velvety fur which allows smooth movement through the soil (1).

10.8

Anolis lizards

1 When few individuals of a species colonise a new area their offspring initially experience loss in genetic variability, resulting in individuals that are physically and genetically different from their source population (1).

2 Have no lizard populations.

3 Area covered in scrub/short vegetation, short hind limbs provide stability to walk along narrow perches.

4 Any four from: released pairs of lizards on islands with no lizards but the same vegetation; measured genetic variation; measured hind leg length; hind leg length shortened over time providing evidence for natural selection; founder effect would produce random leg length.

5 Decreases fitness of population and their ability to survive and reproduce, as a result of less variation, increased chance of recessive disorders.

Summary Questions

1 Any three from: availability of light / water / nutrients / carbon dioxide / space, risk of being eaten, disease, ability to cross-pollinate, or other suitable example (1).

2 Variations exist within a population (1); those with the best characteristics survive AND reproduce (1); characteristics are passed onto their offspring through genes (1).

3 A mutation occurred / existed in the mosquitoes DNA which made them DDT resistant (1) these organisms survived exposure to DDT and reproduced (1); mutation which caused resistance is passed onto their offspring (1); frequency of the DDT-resistant allele increases in the population (1).

4 Any six from (or other appropriate examples):

Flavobacterium digests nylon waste (1); positive – used to clean up factory waste (1); bacteria e.g. MRSA – antibiotic resistance (1); negative – no longer killed using current medical treatment (1); sheep blowfly – insecticide resistant (1); negative – no longer killed by insecticide so increased sheep death (1).