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| **Topic 5: Evolution and biodiversity (12 hours)** | | | |
| **Essential idea:** There is overwhelming evidence for the evolution of life on Earth. | | | |
| **5.1 Evidence for evolution** | | | |
| **Nature of science:**  **5.1.NOS1** Looking for patterns, trends and discrepancies—there are common features in the bone structure of vertebrate limbs despite their varied use. (3.1) | | | Pg.244 |
| **Understandings:** | | **Theory of knowledge:**  • Evolutionary history is an especially challenging area of science because experiments cannot be performed to establish past events or their causes.  There are nonetheless scientific methods of establishing beyond reasonable doubt what happened in some cases. How do these methods compare to those used by historians to reconstruct the past?  **Utilization:**  Syllabus and cross-curricular links:  Physics  Topic 7.1 Discrete energy and radioactivity  Geography  Part 1.3 Patterns in environmental quality and sustainability/Biodiversity and change  Environmental systems and societies  Topic 4 Biodiversity in ecosystems | |
| **5.1.U1** Evolution occurs when heritable characteristics of a species change. | Pg.242 |
| **5.1.U2** The fossil record provides evidence for evolution. | Pg.242 |
| **5.1.U3** Selective breeding of domesticated animals shows that artificial selection can cause evolution. | Pg.243 |
| **5.1.U4** Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function. | Pg.244-245 |
| **5.1.U5** Populations of a species can gradually diverge into separate species by evolution. | Pg. 246 |
| **5.1.U6** Continuous variation across the geographical range of related populations matches the concept of gradual divergence. | Pg.247 |
| **Applications and skills:** | |
| **5.1.A1** Application: Development of melanistic insects in polluted areas. | Pg.247-248 |
| **5.1.A2** Application: Comparison of the pentadactyl limb of mammals, birds, amphibians and reptiles with different methods of locomotion. | Pg.245-246 |

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| **Topic 5: Evolution and biodiversity (12 hours)** | | | |
| **Essential idea:** Gene pools change over time. | | | |
| **10.3 Gene pools and speciation** | | | |
| **Nature of science:**  **10.3.NOS1** Looking for trends and discrepancies—patterns of chromosome number in some genera can be explained by speciation due to polyploidy (3.1) | | | Pg.461 |
| **Understandings:** | | **Theory of knowledge:**  • Punctuated equilibrium was long considered an alternative theory of evolution and a challenge to the long established paradigm of Darwinian gradualism. How do paradigm shifts proceed in science and what factors are involved in their success?  **Utilization:**  • Many crop species have been created to be polyploidy. Polyploidy increases allelic diversity and permits novel phenotypes to be generated. It also leads to hybrid vigour.  Syllabus and cross-curricular links:  Biology  Topic 5.1 Evidence for evolution | |
| **10.3.U1** A gene pool consists of all the genes and their different alleles, present in an interbreeding population. | Pg.455 |
| **10.3.U2** Evolution requires that allele frequencies change with time in populations. | Pg.455 |
| **10.3.U3** Reproductive isolation of populations can be temporal, behavioural or geographic. | Pg.458-459 |
| **10.3.U4** Speciation due to divergence of isolated populations can be gradual. | Pg.460 |
| **10.3.U5** Speciation can occur abruptly. | Pg.461 |
| **Applications and skills:** | |
| **10.3.A1** Application: Identifying examples of directional, stabilizing and disruptive selection. | Pg.456 |
| **10.3.A2** Application: Speciation in the genus *Allium* by polyploidy. | Pg.462 |
| **10.3.S1** Skill: Comparison of allele frequencies of geographically isolated populations. | Pg.459-460 |
| **Guidance:**  • Punctuated equilibrium implies long periods without appreciable change and short periods of rapid evolution. |  |

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| **Topic 5: Evolution and biodiversity (12 hours)** | | | |
| **Essential idea:** The diversity of life has evolved and continues to evolve by natural selection. | | | |
| **5.2 Natural selection** | | | |
| **Nature of science:**  **5.2.NOS1** Use theories to explain natural phenomena—the theory of evolution by natural selection can explain the development of antibiotic resistance in bacteria. (2.1) | | | Pg.256 |
| **Understandings:** | | **Theory of knowledge:**  • Natural Selection is a theory. How much evidence is required to support a theory and what sort of counter evidence is required to refute it? | |
| **5.2.U1** Natural selection can only occur if there is variation among members of the same species. | Pg.250 |
| **5.2.U2** Mutation, meiosis and sexual reproduction cause variation between individuals in a species. | Pg.250 |
| **5.2.U3** Adaptations are characteristics that make an individual suited to its environment and way of life. | Pg.250-251 |
| **5.2.U4** Species tend to produce more offspring than the environment can support. | Pg.251 |
| **5.2.U5** Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring. | Pg.252 |
| **5.2.U6** Individuals that reproduce pass on characteristics to their offspring. | Pg.252 |
| **5.2.U7** Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species. | Pg.252-253 |
| **Applications and skills:** | |
| **5.2.A1** Application: Changes in beaks of finches on Daphne Major. | Pg.254-255 |
| **5.2.A2** Application: Evolution of antibiotic resistance in bacteria. | Pg.257 |
| **Guidance:**  • Students should be clear that characteristics acquired during the lifetime of an individual are not heritable. The term Lamarckism is not required. |  |

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| **Topic 5: Evolution and biodiversity (12 hours)** | | | |
| **Essential idea:** Species are named and classified using an internationally agreed system | | | |
| **5.3 Classification of biodiversity** | | | |
| **Nature of science:**  **5.3.NOS1** Cooperation and collaboration between groups of scientists—scientists use the binomial system to identify a species rather than the many different local names. (4.3) | | | Pg.259 |
| **Understandings:** | | **International-mindedness:**  • There are international codes of nomenclature and agreements as to the principles to be followed in the classification of living organisms.  **Theory of knowledge:**  • The adoption of a system of binomial nomenclature is largely due to Swedish botanist and physician Carolus Linnaeus (1707–1778). Linnaeus also defined four groups of humans, and the divisions were based on both physical and social traits. By 21st-century standards, his descriptions can be regarded as racist. How does the social context of scientific work affect the methods and findings of research? Is it necessary to consider the social context when evaluating ethical aspects of knowledge claims? | |
| **5.3.U1** The binomial system of names for species is universal among biologists and has been agreed and developed at a series of congresses. | Pg.259 |
| **5.3.U2** When species are discovered they are given scientific names using the binomial system. | Pg.260 |
| **5.3.U3** Taxonomists classify species using a hierarchy of taxa. | Pg.260 |
| **5.3.U4** All organisms are classified into three domains. | Pg.260-261 |
| **5.3.U5** The principal taxa for classifying eukaryotes are kingdom, phylum, class, order, family, genus and species. | Pg.261 |
| **5.3.U6** In a natural classification, the genus and accompanying higher taxa consist of all the species that have evolved from one common ancestral species. | Pg.262-263 |
| **5.3.U7** Taxonomists sometimes reclassify groups of species when new evidence shows that a previous taxon contains species that have evolved from different ancestral species. | Pg.263-264 |
| **5.3.U8** Natural classifications help in identification of species and allow the prediction of characteristics shared by species within a group. | Pg.264 |
| **Applications and skills:** | |
| **5.3.A1** Application: Classification of one plant and one animal species from domain to species level. | Pg.262 |
| **5.3.A2** Application: Recognition features of bryophyta, filicinophyta, coniferophyta and angiospermophyta. | Pg.266 |
| **5.3.A3** Application: Recognition features of porifera, cnidaria, platylhelmintha, annelida, mollusca, arthropoda and chordata. | Pg.267 |
| **5.3.A4** Application: Recognition of features of birds, mammals, amphibians, reptiles and fish. | Pg.268 |
| **5.3.S1** Skill: Construction of dichotomous keys for use in identifying specimens. | Pg.265 |
| **Guidance:**  • Archaea, eubacteria and eukaryote should be used for the three domains.  • Members of these domains should be referred to as archaeans, bacteria and eukaryotes.  • Students should know which plant phyla have vascular tissue, but other internal details are not required.  • Recognition features expected for the selected animal phyla are those that are most useful in distinguishing the groups from each other and full descriptions of the characteristics of each phylum are not needed.  • Viruses are not classified as living organisms. |  |

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| **Topic 5: Evolution and biodiversity (12 hours)** | | | |
| **Essential idea:** The ancestry of groups of species can be deduced by comparing their base or amino acid sequences. | | | |
| **5.4 Cladistics** | | | |
| **Nature of science:**  **5.4.NOS1** Falsification of theories with one theory being superseded by another—plant families have been reclassified as a result of evidence from cladistics. (1.9) | | | Pg.275 |
| **Understandings:** | | **Theory of knowledge:**  • A major step forward in the study of bacteria was the recognition in 1977 by Carl Woese that *Archaea* have a separate line of evolutionary descent from bacteria. Famous scientists, including Luria and Mayr, objected to his division of the prokaryotes. To what extent is conservatism in science desirable? | |
| **5.4.U1** A clade is a group of organisms that have evolved from a common ancestor. | Pg.269 |
| **5.4.U2** Evidence for which species are part of a clade can be obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein. | Pg.270 |
| **5.4.U3** Sequence differences accumulate gradually so there is a positive correlation between the number of differences between two species and the time since they diverged from a common ancestor. | Pg.271 |
| **5.4.U4** Traits can be analogous or homologous. | Pg.271 |
| **5.4.U5** Cladograms are tree diagrams that show the most probable sequence of divergence in clades. | Pg.272 |
| **5.4.U6** Evidence from cladistics has shown that classifications of some groups based on structure did not correspond with the evolutionary origins of a group or species. | Pg.274 |
| **Applications and skills:** | |
| **5.4.A1** Application: Cladograms including humans and other primates. | Pg.272 |
| **5.4.A2** Application: Reclassification of the figwort family using evidence from cladistics. | Pg.275-276 |
| **5.4.S1** Skill: Analysis of cladograms to deduce evolutionary relationships. | Pg.273  Dbqs 273-274 |