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| **Topic 4: Ecology (12 hours)** |
| **Essential idea**: The continued survival of living organisms including humans depends on sustainable communities. |
| **4.1 Species, communities and ecosystems** |
| **Nature of science:****4.1NOS1** Looking for patterns, trends and discrepancies—plants and algae are mostly autotrophic but some are not. (3.1) | Pg.203-204 |
| **Understandings:** | **International-mindedness:**• The need for sustainability in human activities could be discussed and the methods needed to promote this.**Utilization:**Syllabus and cross-curricular links:GeographyPart 2A: Fresh water-issues and conflictsEnvironmental systems and societiesTopic 2.1 Species and populations**Aims:**• **Aim 6:** It would be best for students to obtain data for the chi-squared test themselves, to give first-hand experience of field work techniques. |
| **4.1.U1** Species are groups of organisms that can potentially interbreed to produce fertile offspring. | Pg. 202 |
| **4.1.U2** Members of a species may be reproductively isolated in separate populations. | Pg. 202 |
| **4.1.U3** Species have either an autotrophic or heterotrophic method of nutrition (a few species have both methods). | Pg. 203 |
| **4.1.U4** Consumers are heterotrophs that feed on living organisms by ingestion. | Pg.205 |
| **4.1.U5** Detritivores are heterotrophs that obtain organic nutrients from detritus by internal digestion. | Pg.205 |
| **4.1.U6** Saprotrophs are heterotrophs that obtain organic nutrients from dead organisms by external digestion. | Pg.205 |
| **4.1.U7** A community is formed by populations of different species living together and interacting with each other. | Pg.206 |
| **4.1.U8** A community forms an ecosystem by its interactions with the abiotic environment. | Pg.210 |
| **4.1.U9** Autotrophs obtain inorganic nutrients from the abiotic environment. | Pg.210 |
| **4.1.U10** The supply of inorganic nutrients is maintained by nutrient cycling. | Pg.211 |
| **4.1.U11** Ecosystems have the potential to be sustainable over long periods of time. | Pg.211-212 |
| **Applications and skills:** |
| **4.1.S1** Skill: Classifying species as autotrophs, consumers, detritivores or saprotrophs from a knowledge of their mode of nutrition. | Pg. 206 dbqs-204 |
| **4.1.S2** Skill: Setting up sealed mesocosms to try to establish sustainability. (Practical 5) | Pg.212 |
| **4.1.S3** Skill: Testing for association between two species using the chi-squared test with data obtained by quadrat sampling. | Pg.207-208 |
| **4.1.S4** Skill: Recognizing and interpreting statistical significance | Pg.209 -210 dbqs-209 |
| **Guidance:**• Mesocosms can be set up in open tanks, but sealed glass vessels are preferable because entry and exit of matter can be prevented but light can enter and heat can leave. Aquatic systems are likely to be more successful than terrestrial ones.• To obtain data for the chi-squared test, an ecosystem should be chosen in which one or more factors affecting the distribution of the chosen species varies. Sampling should be based on random numbers. In each quadrat the presence or absence of the chosen species should be recorded. |  |

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| **Topic 4: Ecology (12 hours)** |
| **Essential idea:** Ecosystems require a continuous supply of energy to fuel life processes and to replace energy lost as heat. |
| **4.2 Energy flow** |
| **Nature of science:****4.2.NOS1** Use theories to explain natural phenomena—the concept of energy flow explains the limited length of food chains. (2.2) | Pg.217 |
| **Understandings:** | **International-mindedness:**• The energetics of food chains is a factor in the efficiency of food production for the alleviation of world hunger.**Utilization:**Syllabus and cross-curricular links:BiologyTopic 2.8 Cell respirationTopic 2.9 PhotosynthesisPhysicsTopic 2.3 Work, energy and powerTopic B.2 ThermodynamicsEnvironmental systems and societiesTopic 2.3 Flows of energy and matter |
| **4.2.U1** Most ecosystems rely on a supply of energy from sunlight. | Pg.213 |
| **4.2.U2** Light energy is converted to chemical energy in carbon compounds by photosynthesis. | Pg.215 |
| **4.2.U3** Chemical energy in carbon compounds flows through food chains by means of feeding. | Pg.215 |
| **4.2.U4** Energy released from carbon compounds by respiration is used in living organisms and converted to heat. | Pg.215- 216 |
| **4.2.U5** Living organisms cannot convert heat to other forms of energy. | Pg.216 |
| **4.2.U6** Heat is lost from ecosystems. | Pg.217 |
| **4.2.U7** Energy losses between trophic levels restrict the length of food chains and the biomass of higher trophic levels. | Pg.217- 218 |
| **Applications and skills:** |
| **4.2.S1** Skill: Quantitative representations of energy flow using pyramids of energy. | Pg.218 |
| **Guidance:**• Pyramids of number and biomass are not required. Students should be clear that biomass in terrestrial ecosystems diminishes with energy along food chains due to loss of carbon dioxide, water and other waste products, such as urea.• Pyramids of energy should be drawn to scale and should be stepped, not triangular. The terms producer, first consumer and second consumer and so on should be used, rather than first trophic level, second trophic level and so on.• The distinction between energy flow in ecosystems and cycling of inorganic nutrients should be stressed. Students should understand that there is a continuous but variable supply of energy in the form of sunlight but that the supply of nutrients in an ecosystem is finite and limited. |  |

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| **Topic 4: Ecology (12 hours)** |
| **Essential idea:** Continued availability of carbon in ecosystems depends on carbon cycling |
| **4.3 Carbon cycling** |
| **Nature of science:****4.2.NOS1** Making accurate, quantitative measurements—it is important to obtain reliable data on the concentration of carbon dioxide and methane in the atmosphere. (3.1) | Pg. 228 |
| **Understandings:** | **Utilization:**Syllabus and cross-curricular links:PhysicsTopic 8.1 Energy sourcesChemistryTopic C.2 Fossil fuelsTopic C.5 Environmental impact—global warming**Aims:**• **Aim 8:** The ethical implications of diverting crops such as maize from a food to a fuel crop could be considered. |
| **4.3.U1** Autotrophs convert carbon dioxide into carbohydrates and other carbon compounds. | Pg. 220 |
| **4.3.U2** In aquatic ecosystems carbon is present as dissolved carbon dioxide and hydrogen carbonate ions. | Pg.221 |
| **4.3.U3** Carbon dioxide diffuses from the atmosphere or water into autotrophs. | Pg.221 |
| **4.3.U4** Carbon dioxide is produced by respiration and diffuses out of organisms into water or the atmosphere. | Pg.222 |
| **4.3.U5** Methane is produced from organic matter in anaerobic conditions by methanogenic archaeans and some diffuses into the atmosphere or accumulates in the ground. | Pg.222-223 |
| **4.3.U6** Methane is oxidized to carbon dioxide and water in the atmosphere. | Pg.223 |
| **4.3.U7** Peat forms when organic matter is not fully decomposed because of acidic and/or anaerobic conditions in waterlogged soils. | Pg.223-224 |
| **4.3.U8** Partially decomposed organic matter from past geological eras was converted either into coal or into oil and gas that accumulate in porous rocks. | Pg.224-225 |
| **4.3.U9** Carbon dioxide is produced by the combustion of biomass and fossilized organic matter. | Pg.225 |
| **4.3.U10** Animals such as reef-building corals and mollusca have hard parts that are composed of calcium carbonate and can become fossilized in limestone. | Pg.225-226 |
| **Applications and skills:** |
| **4.3.A1** Application: Estimation of carbon fluxes due to processes in the carbon cycle. | Pg.227 |
| **4.3.A2** Application: Analysis of data from air monitoring stations to explain annual fluctuations. | Pg.228 dbq’s 227 |
| **4.3.S1** Skill: Construct a diagram of the carbon cycle. | Pg.226 |
| **Guidance:**• Carbon fluxes should be measured in gigatonnes. |  |

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| **Topic 4: Ecology (12 hours)** |
| **Essential idea:** Concentrations of gases in the atmosphere affect climates experienced at the Earth’s surface. |
| **4.4 Climate change** |
| **Nature of science:****4.4.NOS1** Assessing claims—assessment of the claims that human activities are producing climate change. (5.2) | Pg.236 |
| **Understandings:** | **International-mindedness:**• Release of greenhouse gases occurs locally but has a global impact, so international cooperation to reduce emissions is essential.**Theory of knowledge:**• The precautionary principle is meant to guide decision-making in conditions where a lack of certainty exists. Is certainty ever possible in the natural sciences?**Utilization:**Syllabus and cross-curricular links:PhysicsTopic 8.2 Thermal energy transferGeographyPart 1.3 Patterns in environmental quality and sustainability/Atmosphere and changeEnvironmental systems and societiesTopic 7.2 Climate change—causes and impacts**Aims:**• **Aim 7:** Databases can be used to analyse concentrations of greenhouse gases.• **Aim 8:** There are interesting parallels between humans that are unwilling to reduce their carbon footprint and cheating in social animals. When the level of cheating rises above a certain level, social behaviour breaks down. |
| **4.4.U1** Carbon dioxide and water vapour are the most significant greenhouse gases. | Pg.229- 230 |
| **4.4.U2** Other gases including methane and nitrogen oxides have less impact. | Pg. 230 |
| **4.4.U3** The impact of a gas depends on its ability to absorb long wave radiation as well as on its concentration in the atmosphere. | Pg.230 |
| **4.4.U4** The warmed Earth emits longer wavelength radiation (heat). | Pg.231 |
| **4.4.U5** Longer wave radiation is absorbed by greenhouse gases that retain the heat in the atmosphere. | Pg.231-232 |
| **4.4.U6** Global temperatures and climate patterns are influenced by concentrations of greenhouse gases. | Pg.234 |
| **4.4.U7** There is a correlation between rising atmospheric concentrations of carbon dioxide since the start of the industrial revolution 200 years ago and average global temperatures. | Pg.235 |
| **4.4.U8** Recent increases in atmospheric carbon dioxide are largely due to increases in the combustion of fossilized organic matter. | Pg.235 |
| **Applications and skills:** |
| **4.4.A1** Application: Threats to coral reefs from increasing concentrations of dissolved carbon dioxide. | Pg.238 |
| **4.4.A2** Application: Correlations between global temperatures and carbon dioxide concentrations on Earth. | Pg.232-233 |
| **4.4.A3** Application: Evaluating claims that human activities are not causing climate change. | Pg.237 |
| **Guidance:**• Carbon dioxide, methane and water vapour should be included in discussions.• The harmful consequences of ozone depletion do not need to be discussed and it should be made clear that ozone depletion is not the cause of the enhanced greenhouse effect. |  |