Higher Biology Unit 3 Sustainability and Interdependence

Learning Outcomes

Key Area 1: Food supply, plant growth and productivity

1a: Food Supply

- Food security is the ability of human populations to access food of sufficient quality and quantity.
- Human population growth has increased the demand for food and the concern for food security
- Food production must be sustainable
- Food production must not degrade the natural resources needed for agriculture
- All food production depends on photosynthesis
- The area to grow crops is limited
- Crop production is limited by factors that affect plant growth
- Crop production can be increased by breeding and growing higher-yielding cultivars, the use of fertilisers and by protecting crops from pests, disease and competition
- Breeders seek to develop crops with higher nutritional values, resistance to pests and diseases, as well as those that can thrive in particular environmental conditions.
- Livestock animals produce less food per unit area than crop plants due to the loss of energy between trophic levels
- Livestock production is possible in habitats unsuitable for growing crops

Higher Biology Unit 3 Metabolism and Survival
Learning Outcomes

1b: Photosynthesis

- Photosynthesis captures light energy to produce carbohydrates
- Light energy is absorbed by photosynthetic pigments to generate ATP and for photolysis
- Photosynthetic pigments absorb light of specific wavelengths. Each pigment absorbs a different range of wavelengths of light.
- Light that is not absorbed by pigments undergoes transmission and reflection
- The absorption spectrum shows the range and extent to which light wavelengths are absorbed by a pigment
- The action spectrum shows the rate of photosynthesis of a plant across a range of light wavelengths
- Chlorophyll a and chlorophyll b are the main photosynthetic pigment in green plants
- Carotenoids such as carotene and xanthophyll extend the range of wavelengths absorbed by photosynthesis
- Carotenoids pass energy to chlorophyll
- Absorbed energy excites electrons in pigment molecules
- Excited electrons release their energy as they pass through electron transport chains
- Energy released by the electrons generates ATP production by ATP synthase
- Absorbed energy is also used in photolysis, in which water molecules are split into hydrogen and oxygen
- Hydrogen is transferred to the coenzyme NADP forming NADPH and oxygen is evolved
- In the carbon fixation stage (Calvin Cycle) the enzyme RuBisCo fixes carbon dioxide by attaching it to ribulose bisphosphate (RuBP) to produce an intermediate compound called 3-phosphoglycerate (3PG)
- The 3-phosphoglycerate (3PG) is phosphorylated by ATP and combined with hydrogen from NADPH to produce glyceraldehyde-3-phosphate (G3P)
- G3P is used for the synthesis of glucose and to regenerate RuBP
- Glucose produced can be used as a substrate for respiration, synthesised to starch or cellulose or passed to other biosynthetic pathways
- These biosynthetic pathways can lead to the formation of a variety of metabolites such as DNA, protein and fat

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Learning Outcomes

Key Area 2: Plant and Animal Breeding

- Plant and animal breeding is used to improve crops and animal stock to support sustainable food production
- Desirable qualities in improved organisms include higher food yields, higher nutritional values, increased resistance to pests and diseases, resistance to harsh growing conditions and characteristics that assist rearing and harvesting
- Plant field trials are carried out to compare different cultivars or treatments they receive, or to evaluate GM crops
- In field trials, the number of replicates involved must take account of the variability within the sample
- In field trials, the treatments must be randomised to eliminate bias when measuring treatment effects
- In field trials it is important to make sure the treatments selected will allow valid comparisons to be made
- Animals are naturally outbreeding
- Certain plants and animals can be inbred for several generations until the population is true breeding for the desired type due to elimination of heterozygotes
- Inbreeding can produce individuals homozygous for unwanted, deleterious recessive alleles
- Inbreeding depression is the name given to the accumulation in individuals of homozygous recessive alleles that are deleterious (harmful)
- In animals, cross-breeding individuals from different breeds can produce a new F1 cross-breed population with improved characteristics
- Parent breeds can be maintained and cross-bred to produce the desired individuals when needed.
- Cross-breeding of different inbred plant lines can produce a relatively uniform heterozygous crop in the F1 generation
- F1 hybrids often have increased vigour and yield
- Plants with increased vigour may have increased disease resistance or increased growth rate
- As a result of genome sequencing, organisms with desirable genes can be identified and used in breeding programmes
- Single genes can be inserted into the genomes of crop plants creating GMO plants with improved characteristics.

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Learning Outcomes

Key Area 3&4: Crop Protection and Animal Welfare

- In agriculture, **weeds compete** with crops while **pests and disease** organisms **damage** them, reducing their productivity
- Annual plant weeds have rapid growth, a short life cycle, high seed output and long-term seed viability
- Perennial weeds have competitive adaptations such as storage organs and vegetative reproduction
- Most crop pests are invertebrate animals such as insects, nematode worms and molluscs
- Crop plant diseases can be caused by fungi, bacteria and viruses, which are often carried by invertebrate animals
- Weeds, pests and diseases can be controlled by cultural means such as **ploughing, weeding and crop rotation.**
- Selective herbicides can target broad-leaved species
- Systemic herbicides enter the plant's transport system and are **effective against weeds with underground storage organs by preventing regeneration**
- Fungicides can often be more effective when applied protectively, based on disease forecasts, than when treating a diseased crop
- Pestidices can be **toxic** to animal species or be **persistent** and so **accumulate** or become **magnified** in food chains
- Crop plants can become **resistant** to pesticides through natural selection
- Biological control of pests involves the use of their natural predators, parasites or diseases
- Risks with the use of biological control occur when the control agent escapes into the wider environment and becomes an invasive species, parasitise, prey on or be a pathogen of other species.
- Integrated pest management (IPM) combines cultural, chemical and biological controls
- Provision of animal welfare in livestock production raises issues of costs, benefits and ethics
- Poor welfare of livestock can be indicated by stereotypic and misdirected behaviour or failure of sexual or parental behaviour and altered levels of activity

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Learning Outcomes

Key Area 5: Symbiosis

- Symbiosis is an intimate relationship that has coevolved between members of two different species
- Parasites benefit in terms of energy or nutrients and their hosts are harmed by the loss of these resources
- Parasites often have limited metabolism and cannot survive out of contact with their hosts
- Parasites can be transmitted to new hosts using direct contact, resistant stages and vectors
- Some parasitic life cycles have evolved to include secondary hosts.
- In mutualism, both partner species benefit in an interdependent relationship
- Examples of mutualism include cellulose-digesting microbes in the guts of herbivores and photosynthetic algae in the polyps of coral

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Learning Outcomes

Key Area 6: Social Behaviour

- Many animals live in social groups and have behaviours such as social hierarchies, cooperative hunting and cooperative defence, which are adaptations to group living
- Cooperative hunting can benefit subordinate animals as well as dominant animals
- By cooperative hunting, subordinate animals might gain more food than by hunting alone
- Altruistic behaviour harms the donor individual but benefits the recipient
- In social animals, reciprocal altruism often occurs
- In reciprocal altruism, altruistic behavioural roles are later reversed
- Altruism often occurs between related individuals (kin)
- In kin selection, the donor benefits in terms of increased chances of survival of genes they share with the recipient's offspring
- In social insects, such as bees, wasps, ants and termites, only certain individuals contribute to reproduction
- Most members of a colony of social insects are workers, who cooperate with close relatives to raise offspring related to them (kin selection)
- In primates there is a long period of parental care during which offspring can learn complex social behaviours
- To reduce unnecessary conflict, social primates use ritualistic display and appeasement behaviours which include grooming, using submissive or aggressive facial expressions and body postures and through sexual presentation
- In monkeys and apes, alliances form between individuals, which are often used to increase social status within the group

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Learning Outcomes

Key Area 7: Components of Biodiversity

- Genetic diversity, species diversity and ecosystem diversity are measurable components of overall biodiversity.
- Genetic diversity is represented by the number and frequency of all the alleles in a population
- Species diversity comprises the number of different species in an ecosystem (the species richness) and the proportion of each species present in the ecosystem (the relative abundance)
- Ecosystem diversity refers to the number of distinct ecosystems within a defined area
- A community with a dominant species has less species diversity than one with the same species richness but no particularly dominant species

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Learning Outcomes

Key Area 8: Threats to Biodiversity

- Humans have exploited certain species in the past and in some cases populations have remained large enough to recover
- Small populations can show the bottleneck effect, by which they have lost so much genetic diversity that evolutionary response to environmental change is not possible
- Small populations tend to inbreed and so their low genetic diversity leads to poor reproductive rates
- Habitat fragments typically support lower species richness than larger areas of the same habitat
- Habitat fragments suffer from degradation at their edges, which can further reduce their size
- Edges of habitat fragments can be invaded by edge species adapted to habitat edges at the expense of interior species
- Habitat fragmentation can be remedied by linking isolated fragments with habitat corridors, which allow species to feed, mate and eventually recolonise the fragments following local extinctions
- Introduced species are non-native species that have been intentionally or accidentally moved by humans to new geographic locations
- Naturalised species are introduced species that have become established in native communities
- Invasive species are naturalised species that have spread rapidly, eliminating native species by out-competing them, hybridising (breeding) with them or preying on them
- Invasive species might be free of predators, parasites, pathogens or competitors that would limit their populations in their native habitats