NUTRIENT CYCLING

Content Statements:

C4.2.15 Primary production as accumulation of carbon compounds in biomass by autotrophs

C4.2.16 Secondary production as accumulation of carbon compounds in biomass by heterotrophs

C4.2.17 Constructing carbon cycle diagrams

C4.2.18 Ecosystems as carbon sinks and carbon sources

C4.2.19 Release of carbon dioxide into the atmosphere during combustion of biomass, peat, coal, oil and natural gas

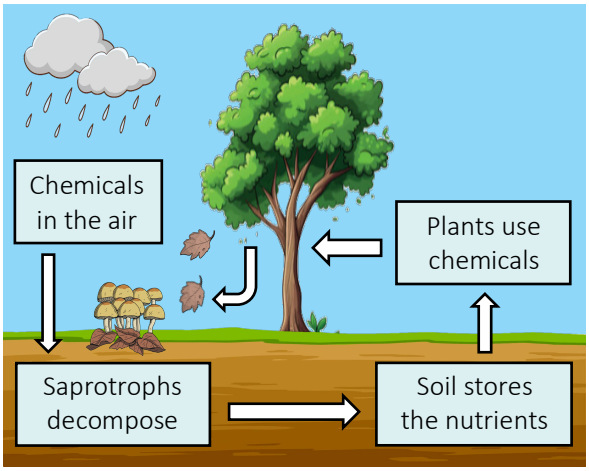
C4.2.20 Analysis of the Keeling Curve in terms of photosynthesis, respiration and combustion

C4.2.21 Dependence of aerobic respiration on atmospheric oxygen produced by photosynthesis, and of photosynthesis on atmospheric carbon dioxide produced by respiration

C4.2.22 Recycling of all chemical elements required by living organisms in ecosystems

NUTRIENT CYCLES

Nutrients refer to substances required by an organism for survival and include elements such as carbon, phosphorus and nitrogen. The supply of chemical elements on Earth is finite – hence, they are continuously **recycled**. Autotrophs obtain inorganic nutrients from the environment and then incorporate them into carbon compounds. A heterotroph will ingest these compounds as part of their diet and use them for growth or repair. When an organism finally dies, saprotrophs will decompose the remains and release the chemical elements back into the surrounding environment.



BIOMASS

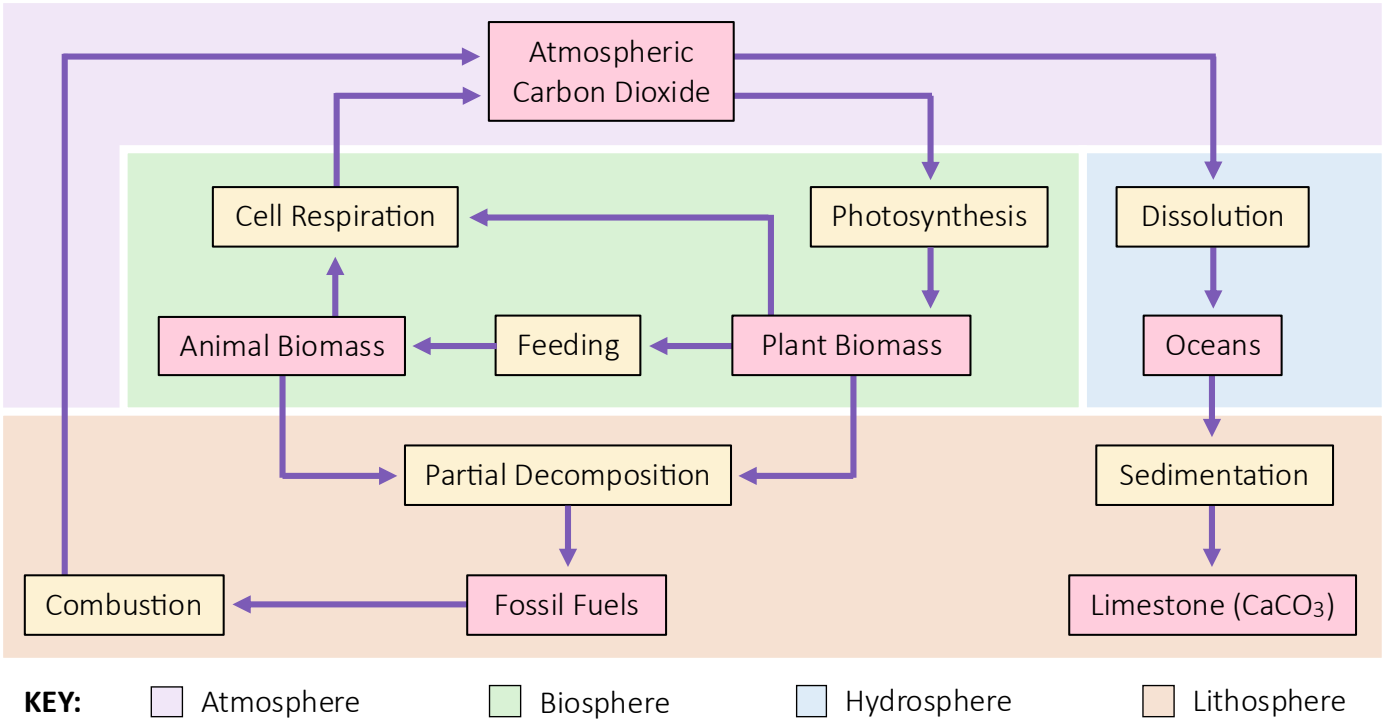
Biomass is the total mass of a group of organisms – consisting of all carbon compounds contained within cells and tissues. Biomass increases when organisms grow or reproduce and is lost during cell respiration (the carbon compounds are converted into carbon dioxide and water). Different biomes (habitats) vary in their capacity to accumulate biomass due to distinct environmental conditions. For example, biomes with more sunlight will accumulate biomass faster (as a consequence of higher relative rates of photosynthesis).

PRODUCTIVITY

The rate of biomass generation in an ecosystem is called production and is expressed in units of mass per area per time (g m^{-2} day^{-1}). **Primary production** is the accumulation of carbon compounds in biomass by *autotrophs* (producers), whereas **secondary production** describes the accumulation of carbon compounds in biomass by *heterotrophs* (consumers). Secondary production is primarily driven by the transfer of organic compounds via feeding and is always lower than primary production due to the loss of biomass during cell respiration. Herbivores typically have lower secondary productivity than carnivores because all vegetation contains cellulose – which is harder to digest than meat and so more biomass becomes lost via excretion.

CARBON CYCLE

Carbon is an essential component of the organic compounds that form the structure of cells and the carbon cycle describes the exchange of carbon within ecosystems between **sources** and **sinks**. Carbon exists within the atmosphere as carbon dioxide (and methane) and is incorporated into living tissue via photosynthesis. The carbon compounds can be transferred via feeding and is released (as CO_2) via cell respiration. Decaying organisms release carbon dioxide during decomposition, but undigested organic material may accumulate within the lithosphere and form fossil fuels. The ocean acts as a giant carbon sink and the dissolved CO_2 will form carbonate ions that contribute to shells or coral ($CaCO_3$) or undergo sedimentation to form limestone.



CARBON FLUXES

The process of carbon transfer between a carbon source and a sink is known as a **carbon flux**. Global fluxes are very large and are measured in gigatonnes. Two of the most significant fluxes are photosynthesis and cell respiration. If photosynthesis exceeds respiration there is a net uptake of carbon dioxide, while excess respiration causes the release of carbon dioxide. Carbon can accumulate within the soil when organisms are only partially decomposed after death (due to *acidic* or *anaerobic* conditions). This organic matter will gradually form fossil fuels – such as peat, coal, oil and natural gas. Fossil fuels may be used in **combustion** reactions to fuel human industry. This releases carbon dioxide into the atmosphere, raising concentrations.

KEELING CURVE

The Keeling curve is a daily record of global atmospheric CO_2 concentrations (measured at Mauna Loa Observatory since 1958). A number of trends are apparent based on the curve:

- Carbon dioxide concentrations fluctuate annually (lower in the summer months as more light for photosynthesis)
- Global trends conform to northern hemisphere patterns (it contains a greater majority of the planet's land mass)
- Atmospheric carbon dioxide levels are steadily increasing (by combustion) to be at the **highest levels** ever recorded