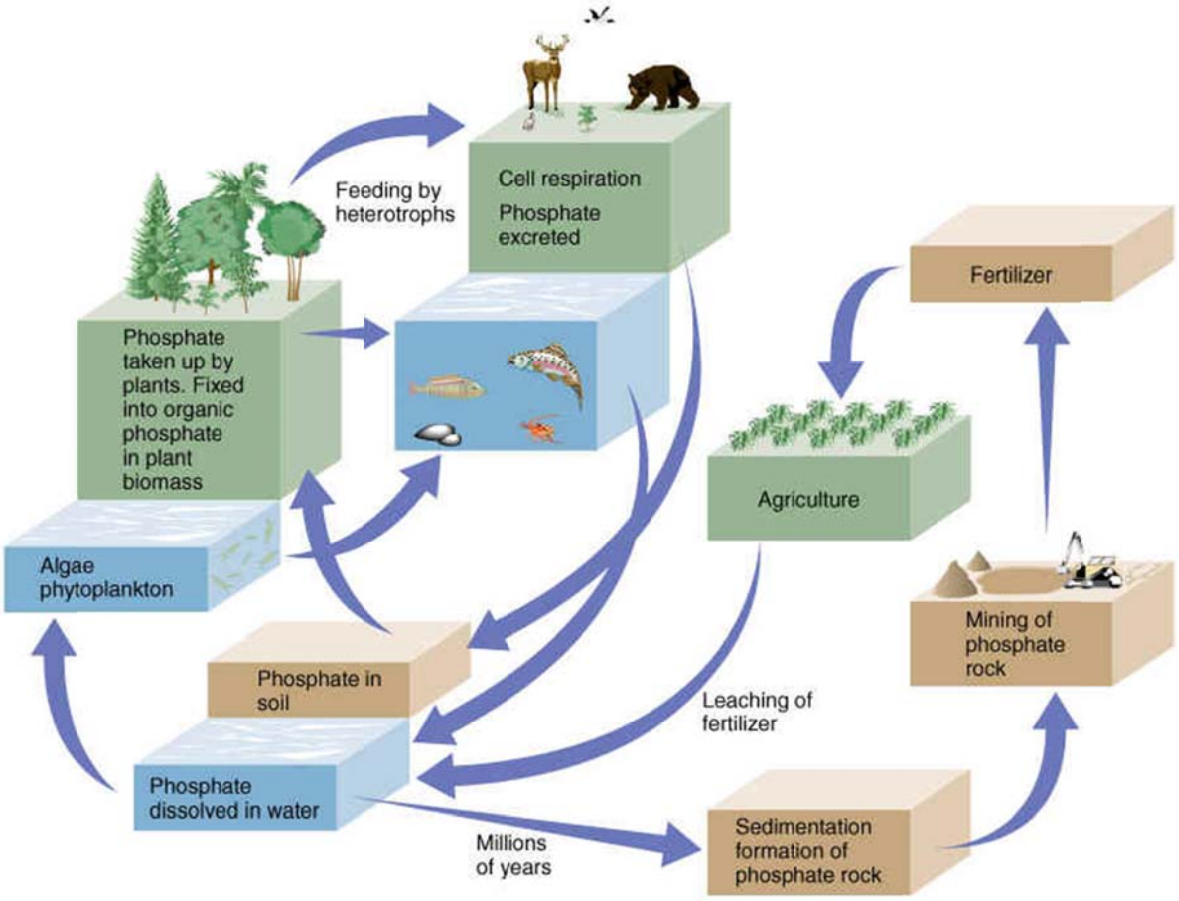
Attachment A: Phosphorus Cycle



Phosphorus in the Biosphere

Phosphorus has a key role in DNA and ATP, two of life's most important molecules. DNA (deoxyribonucleic acid) carries the genetic code of all living things, and ATP (adenosine triphosphate) carries the chemical energy that powers the activity of every living cell. In addition, phosphorus is essential in the composition of bones and teeth, which are intricate frameworks of proteins and the mineral apatite.

The **phosphorus cycle** is the biogeochemical cycle that describes the movement of phosphorus through the lithosphere, hydrosphere, and biosphere. Unlike many other biogeochemical cycles, the atmosphere does not play a significant role in the movement of phosphorus, because phosphorus and phosphorus-based compounds are usually solids at the typical ranges of temperature and pressure found on Earth.

The production of phosphine gas is allowed only in specialized, local conditions. Low phosphorus (chemical symbol, P) availability slows down microbial growth, which has been shown in studies of soil microbial biomass. Soil microorganisms act as sinks and sources of available P in the biogeochemical cycle. However, the major transfers in the global cycle of P are not driven by microbial reactions. Further studies need to be performed for integrating different processes and factors related to gross phosphorus mineralization and microbial phosphorus turnover in general.

The guano of birds, insects and bats circulates phosphorus more widely in the biosphere, but some always gets away into the ocean. Seabirds and salmon bring phosphorus back to the land. A small trickle of phosphorus is buried in the seafloor to roughly balance what enters the cycle from igneous rocks.

Phosphates move quickly through plants and animals; however, the processes that move them through the soil or ocean are very slow, making the phosphorus cycle overall one of the slowest biogeochemical cycles.

Unlike other cycles of matter compounds, phosphorus cannot be found in air as a gas. This is because at normal temperature and circumstances, it is a solid in the form of red and white phosphorus. It usually cycles through water, soil and sediments. Phosphorus is typically the limiting nutrient found in streams, lakes and fresh water environments. As rocks and sediments gradually wear down, phosphate is released. In the atmosphere phosphorus is mainly small dust particles.

Initially, phosphate weathers from rocks. The small losses in a terrestrial system caused by leaching through the action of rain are balanced in the gains from weathering rocks. In soil, phosphate is absorbed on clay surfaces and organic matter particles and becomes incorporated (immobilized). Plants dissolve ionized forms of phosphate. Herbivores obtain phosphorus by eating plants, and carnivores by eating herbivores. Herbivores and carnivores excrete phosphorus as a waste product in urine and faeces. Phosphorus is released back to the soil when plants or animal matter decomposes and the cycle repeats.

The availability of organic phosphorus to support microbial, plant and animal growth depends on the rate of their degradation to generate free phosphate. There are various enzymes such as phosphatases, nucleases and phytase involved for the degradation. Enzymatic hydrolysis of organic phosphorus is an essential step in the biogeochemical phosphorus cycle, including the phosphorus nutrition of plants and microorganisms and the transfer of organic phosphorus from soil to water bodies. Many organisms rely on the soil derived phosphorus for their phosphorus nutrition.

Phosphorus supplementation strategies for pastoral regions

All classes of stock grazing in phosphorus deficient areas will benefit from phosphorus supplements during the wet season (about 10 g/head/day for breeders and 5 g/day for others).

Supplementing phosphorus to dry stock in energy and protein deficient circumstances will accentuate rather than correct a weight loss situation. Therefore do not feed phosphorus to dry animals when they are losing weight. However, lactating cows will sometimes benefit from phosphorus during the dry (4 g/head/day), particularly if protein or non-protein nitrogen is given at the same time.

Phosphate supplements

Phosphorus can be provided in dry or roller licks, or added to water. Suitable sources of phosphate include mono ammonium phosphate (MAP), diammonium phosphate (DAP) and dicalcium phosphate (DCP). Both MAP and DAP have the advantage of providing some non-protein nitrogen, while the high calcium content of DCP might be counterproductive in some pastoral situations,

Rock phosphate is not recommended. It contains less available phosphorus than the alternatives, is insoluble in water and is relatively unpalatable. Some sources also contain potentially toxic impurities such as fluorine and cadmium.