From rock to living systems

Phosphorus cycles through minerals, soil, water and organisms. Track the same element between stores; it is transferred and reused, not created by weathering or feeding.

1. FOLLOW THE MAIN TRANSFERS

Phosphorus-bearing minerals	Weathering →	Phosphate in soil or water
Dissolved phosphate	Assimilation →	Phosphorus in producers
Phosphorus in food	Feeding →	Phosphorus in consumers
Organic phosphorus in remains and waste	Decomposition →	Inorganic phosphate available for reuse

2. WHY ORGANISMS NEED PHOSPHORUS

Phosphorus is part of DNA and RNA, ATP and phospholipids in cell membranes. Animals obtain it through their diet; plants absorb dissolved phosphate. Decomposers can release phosphate from organic material, making it available for another round of uptake.

Phosphorus is the element; phosphate is a chemical form containing phosphorus and oxygen. Organic phosphorus occurs in carbon-containing biological molecules. These labels describe forms, not different elements.

Reservoir interactions: College Board, ERT-1.F.1-2.
Biological roles and transfers: OpenStax, Biology 2e 46.3.
Plant uptake, decomposition and fertilizers: University of Minnesota Extension.

Scope: College Board AP Environmental Science CED (2025), Topic 1.6, p. 41.

Slow release can limit growth

The major reservoirs are phosphorus-bearing rocks and ocean sediments. Much of this phosphorus is not immediately accessible to organisms.

1. THE LONG GEOLOGICAL RETURN

Sediments
Particles and remains settle

→

Sedimentary rock
Burial and rock formation

→

Exposed rock
Uplift and exposure

Weathering of exposed rock releases phosphate again. This geological return is slow compared with uptake and recycling through a local food web; not all phosphorus follows the burial route.

2. NO MAJOR GASEOUS PHASE

Unlike carbon and nitrogen, phosphorus has no significant atmospheric gas reservoir in the standard cycle. Dust and aerosols can still transport phosphorus-containing particles. "No major gas phase" does not mean no phosphorus ever enters the air.

3. WHY PHOSPHORUS CAN BE LIMITING

Rocks release phosphorus slowly, so the usable supply can be small. A shortage can constrain producer growth, especially in freshwater and some terrestrial ecosystems. A large total store does not guarantee a large available supply.

4. KEEP THE PROCESSES DISTINCT

Weathering can release phosphate from rock. Erosion transports material; sedimentation deposits it. Uptake moves phosphate into organisms; decomposition can return it.

Major stores, atmospheric contrast and limitation: College Board, ERT-1.F.2-3.
Sedimentation, uplift and atmospheric particles: OpenStax, Biology 2e 46.3.

Scope: College Board AP Environmental Science CED (2025), Topic 1.6, p. 41.

Useful nutrient, harmful excess

Application link: human activity can move phosphorus from slow geological stores into fields and waterways much faster than natural weathering alone.

1. PEOPLE REDISTRIBUTE PHOSPHORUS

Phosphate rock is mined and processed into fertilizers. Manure also supplies organic and inorganic phosphorus. These inputs can support crops, but adding phosphorus is useful only when its supply limits growth; other constraints can remain.

2. FOLLOW THE ROUTE INTO WATER

Rainfall and irrigation runoff can carry dissolved phosphorus and phosphorus attached to eroded soil particles into streams and lakes. Agricultural losses and wastewater can add nutrients beyond what the receiving ecosystem can absorb.

3. EXCESS LOADING CAN DRIVE EUTROPHICATION

More nutrients reach the water

↓ Where nutrients limit growth, algae may grow rapidly.

More organic matter is broken down

↓ Decomposer respiration consumes dissolved oxygen.

Oxygen becomes too scarce

Fish and other aquatic animals may be stressed or die.

Phosphorus is often limiting in fresh water, but it is not the only possible limiting factor.

4. REDUCE LOSSES AT THE SOURCE

Match fertilizer to crop needs. Reduce soil erosion and use vegetated buffers to intercept runoff.

Runoff and prevention: US EPA, Sources and Solutions: Agriculture.
Nutrient enrichment and oxygen loss: US EPA, Nutrient Pollution.

Scope: College Board AP Environmental Science CED (2025), Topic 1.6, p. 41.