Five processes, different jobs

Nitrogen changes chemical form as it cycles. Identify the starting material, the product and the process; the names are not interchangeable.

1. NITROGEN FIXATION

N_2 → NH_3 / NH_4^+

Certain microbes convert nitrogen gas to ammonia; in soil water, much becomes ammonium.

2. ASSIMILATION

NH_4^+ or NO_3^- → Organic nitrogen

Plants take up inorganic nitrogen and incorporate it into molecules such as amino acids.

3. AMMONIFICATION

Organic nitrogen → NH_4^+

Decomposers break down nitrogen-containing remains and waste, releasing ammonium.

4. NITRIFICATION

NH_4^+ → NO_2^- then NO_3^-

Nitrifying microbes oxidize ammonium to nitrite, then nitrate. This pathway requires oxygen.

5. DENITRIFICATION

NO_3^- → N_2

In oxygen-poor conditions, bacteria reduce nitrate to nitrogen gases, returning nitrogen to air.

READ THE ARROWS AS TRANSFORMATIONS

These are simplified changes in nitrogen form, not balanced chemical equations. Not every atom must pass through every process in this order.

Five processes and fixation: College Board, ERT-1.E.1-2; OpenStax, Biology 2e 46.3.
Oxygen conditions and soil transformations: University of Minnesota Extension.

Scope: College Board AP Environmental Science CED (2025), Topic 1.5, p. 40.

Abundant in air, limited for growth

The atmosphere is the largest reservoir in the nitrogen cycle studied here. A large store does not mean its nitrogen is directly available to most organisms.

1. WHY NITROGEN CAN LIMIT PRODUCTION

Nitrogen is needed for proteins and nucleic acids. Most plants cannot use nitrogen gas directly, even though it is abundant in air. Fixation supplies biologically available nitrogen; shortages of usable nitrogen can limit primary production.

2. TRACK NITROGEN INTO AND OUT OF FOOD WEBS



Death and waste supply organic nitrogen to decomposers. Ammonification returns ammonium to soil or water; renewed uptake recycles it through organisms.

3. MICROBES PROVIDE ACCESS

Nitrogen-fixing bacteria may live freely or in legume root nodules. The plant supplies sugars and a habitat; its bacterial partners provide fixed nitrogen. The bacteria, not the plant itself, perform fixation.

4. COMPARE THE RESERVOIRS

Other stores include biomass, soil organic matter, dissolved ions and sediments. Many active pools exchange nitrogen quickly; some organic matter and sediments retain it longer.

Availability and reservoirs: College Board, ERT-1.E.3-4.
Food-web transfers and symbiotic fixation: OpenStax, Biology 2e 46.3.

Scope: College Board AP Environmental Science CED (2025), Topic 1.5, p. 40.

Inputs, losses and downstream effects

Application link: changing the supply or movement of usable nitrogen affects both plant growth and the wider ecosystem. More nitrogen is not always better.

1. HUMAN INPUTS INCREASE AVAILABLE NITROGEN

Industrial fixation combines nitrogen gas with hydrogen to make ammonia for fertilizers. Manure also supplies nitrogen. Extra inputs can support crops, but unused nitrogen may leave the field and affect other ecosystems.

2. MOVEMENT IS NOT A CHEMICAL CONVERSION

Nitrate dissolves in water and can leach below roots toward groundwater. Runoff can carry nutrients to surface waters. These are transfers between places; nitrification and denitrification change nitrogen into different forms.

3. TRACE A NUTRIENT-POLLUTION PATHWAY

Excess nutrients reach water

↓

Nitrogen and phosphorus can stimulate excess algal growth.

More organic matter is decomposed

↓

Decomposer respiration uses dissolved oxygen.

Oxygen supply falls below demand

Fish and other aquatic animals may be stressed or die.

Nutrients sustain aquatic life; excess loading disrupts it. This is a cycling application.

KEEP THE TWO "NITRI-" PROCESSES DISTINCT

Nitrification: NH_4^+ to NO_3^- | Denitrification: NO_3^- to N_2

Fertilizer inputs and nitrate transport: University of Minnesota Extension.
Excess nutrients and oxygen loss: US EPA; OpenStax, Biology 2e 46.3.

Scope: College Board AP Environmental Science CED (2025), Topic 1.5, p. 40.