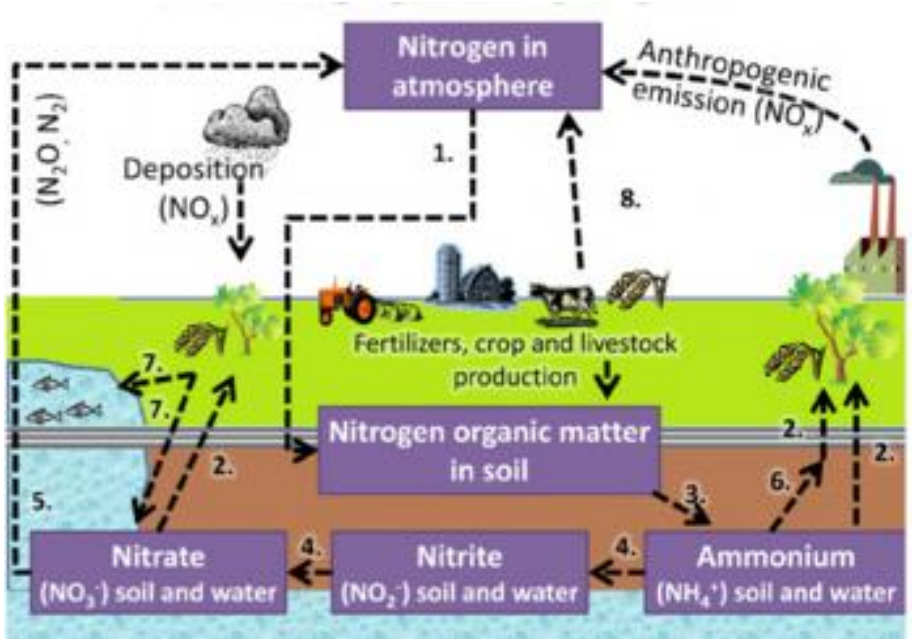
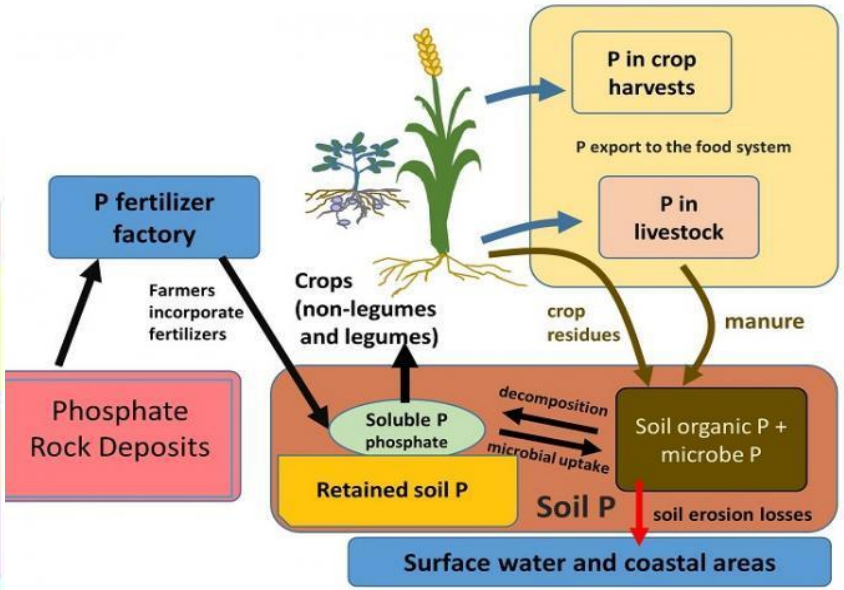
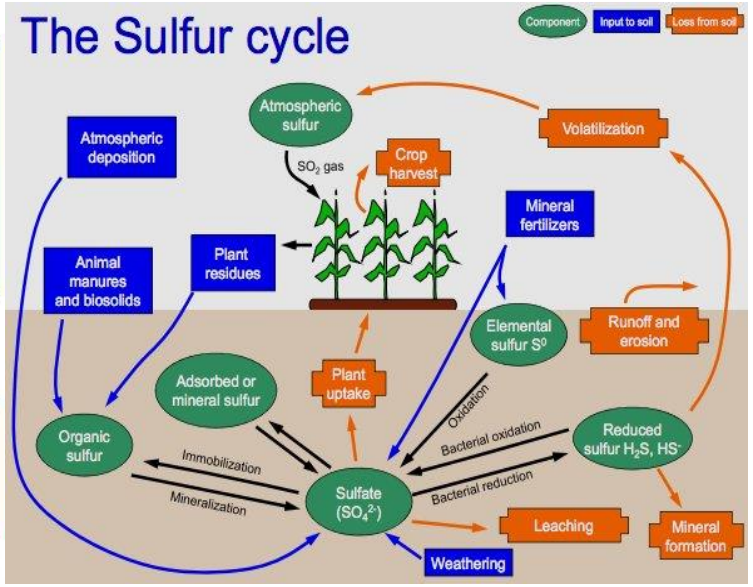
Nitrogen-Phosphor and Sulphure Cycles







AQSE06 Soil Biology
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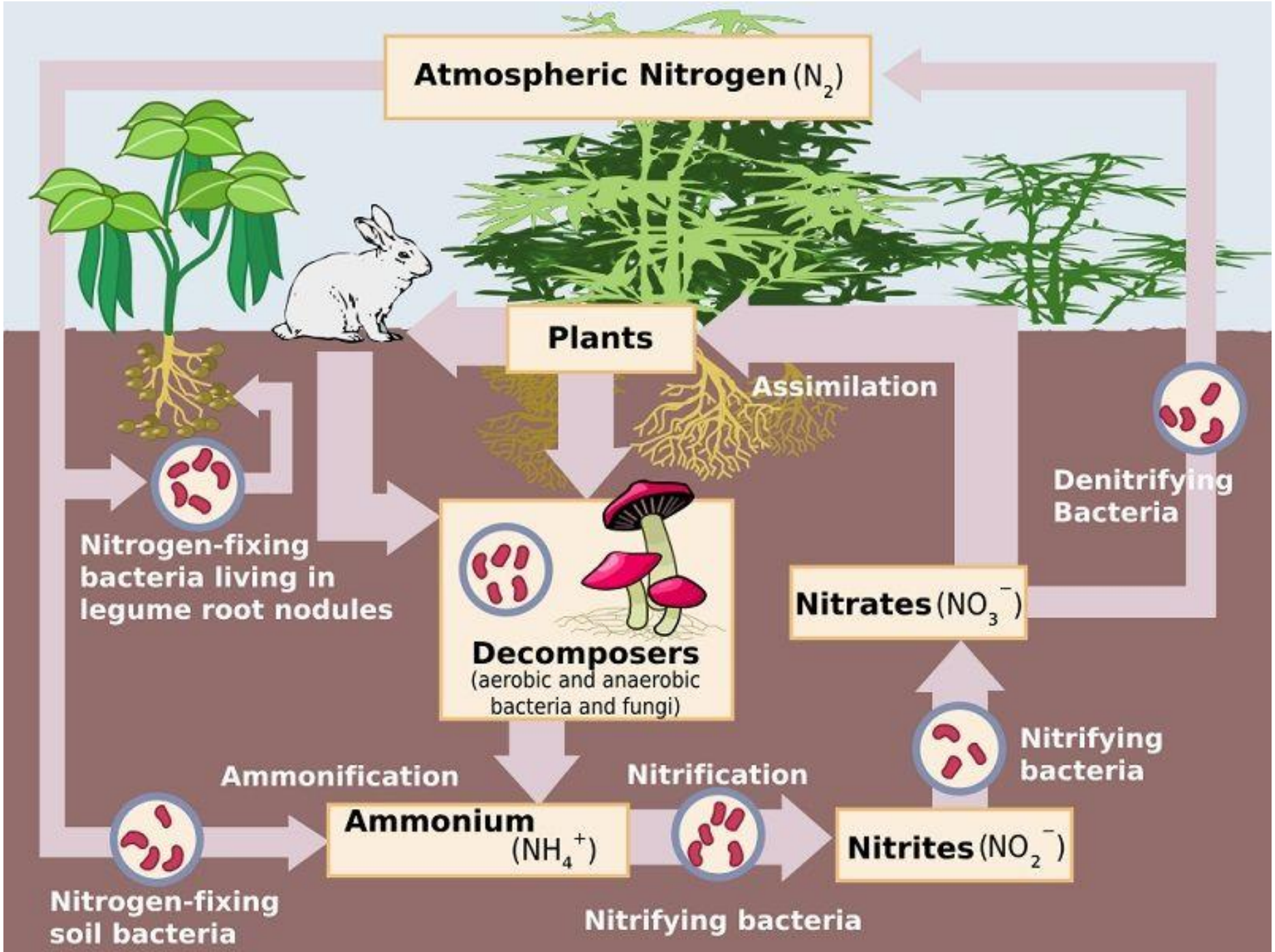
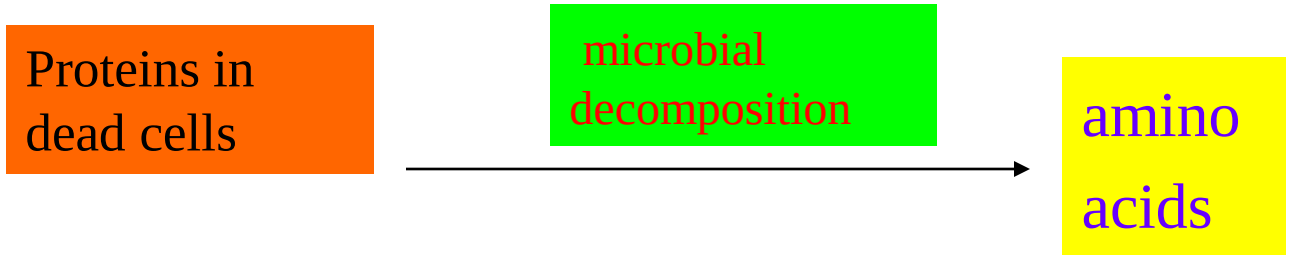
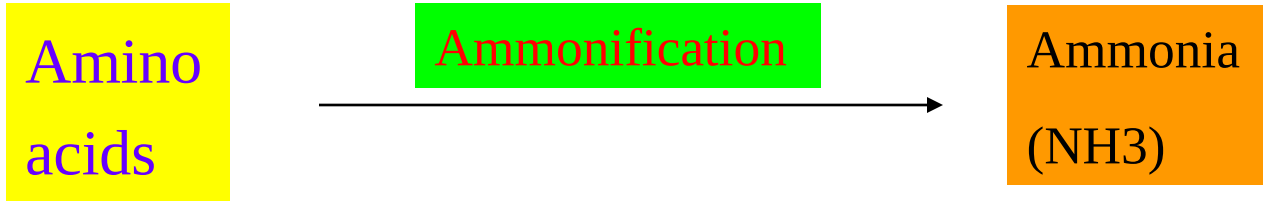

Atmospheric Nitrogen (N_2)
Plants
Assimilation
Denitrifying Bacteria
Nitrogen-fixing bacteria living in legume root nodules
Decomposers
(aerobic and anaerobic bacteria and fungi)
Nitrates (NO_3^-)
Nitrifying bacteria
Ammonification
Nitrification
Ammonium (NH_4^+)
Nitrites (NO_2^-)
Nitrogen-fixing soil bacteria
Nitrifying bacteria



Almost all of the nitrogen in the soil consists of organic molecules (mostly proteins). When a living organism dies, the microbial decomposition process converts proteins into amino acids.



Amino groups of amino acids are converted into ammonia (NH3). This phenomenon known as amonification is carried out by some bacteria and fungi.

Key Processes and Prokaryotes in the Nitrogen Cycle

Processes	Example organisms
Nitrification ($NH_4^+ \rightarrow NO_3^-$)	
$NH_4^+ \rightarrow NO_2^-$	*Nitrosomonas*
$NO_2^- \rightarrow NO_3^-$	*Nitrobacter*
Denitrification ($NO_3^- \rightarrow N_2$)	*Bacillus, Paracoccus, Pseudomonas*
N_2 Fixation ($N_2 + 8H \rightarrow NH_3 + H_2$)	
Free-living	
Aerobic	*Azotobacter* Cyanobacteria
Anaerobic	*Clostridium*, purple and green bacteria
Symbiotic	*Rhizobium* *Bradyrhizobium* *Frankia*
Ammonification (organic-N $\rightarrow NH_4^+$)	
	Many organisms can do this
Anammox ($NO_2^- + NH_3 \rightarrow 2N_2$)	*Brocadia*

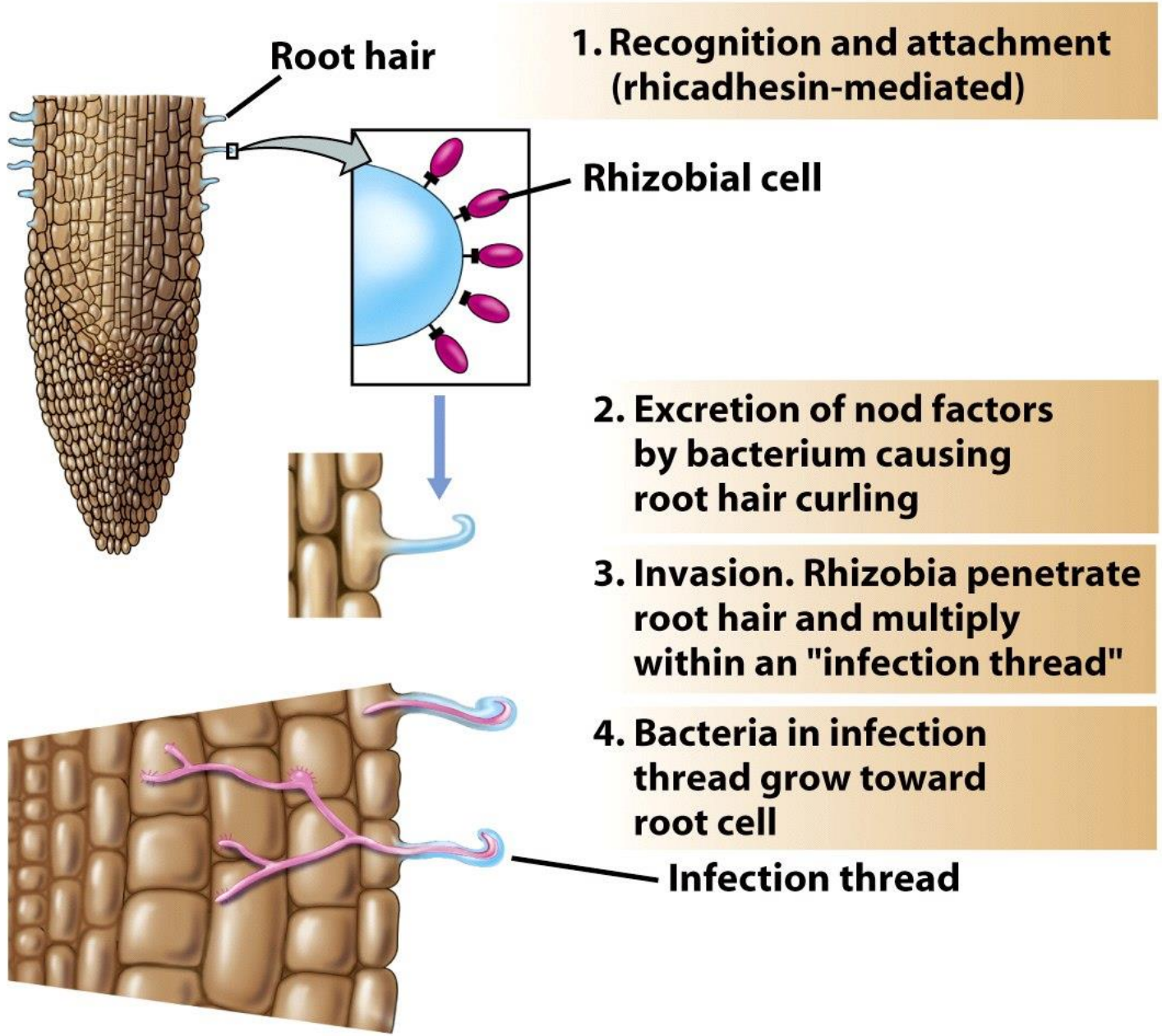
Table 17.10 **Some nitrogen-fixing organisms[a]**

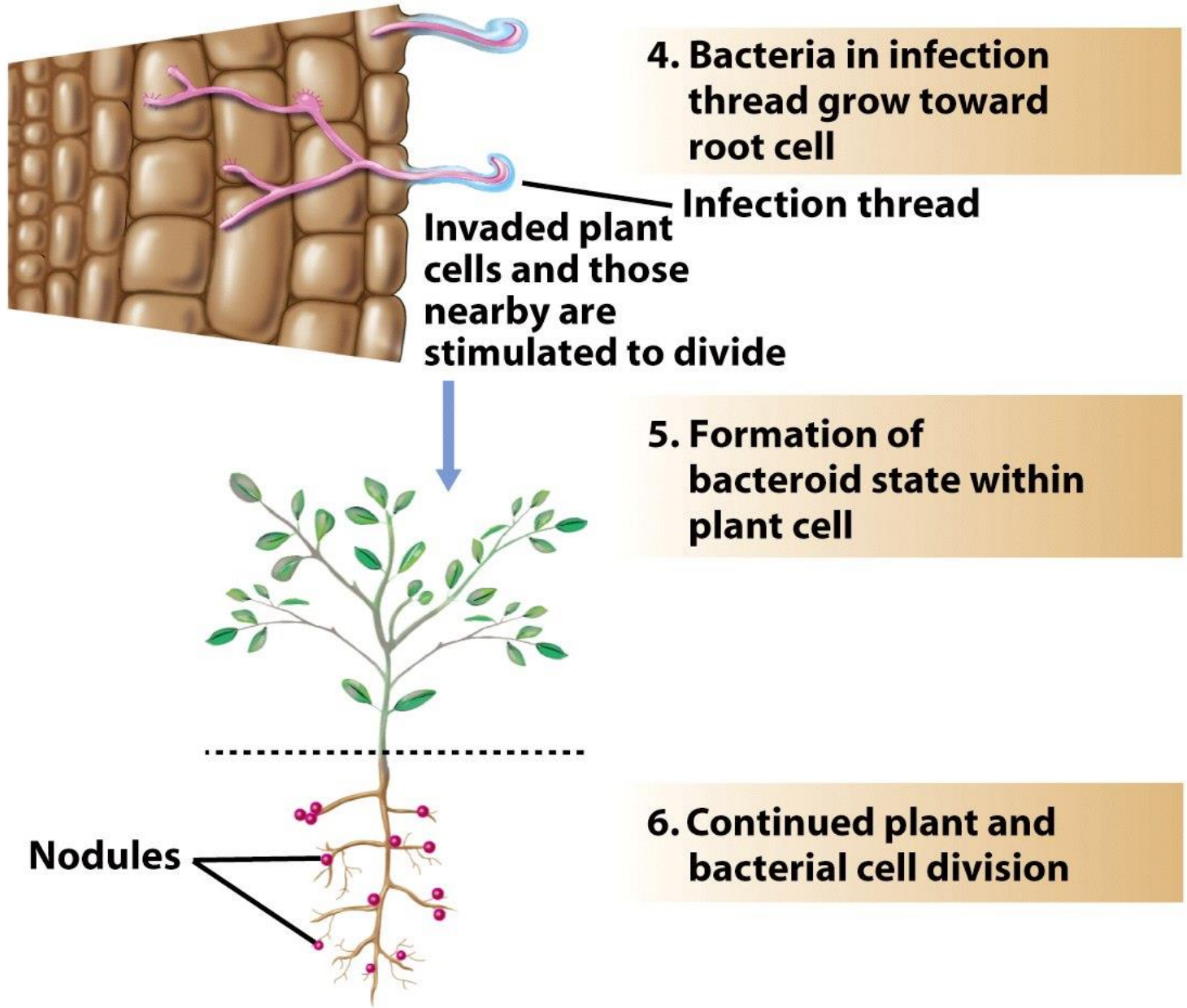
Free-living aerobes

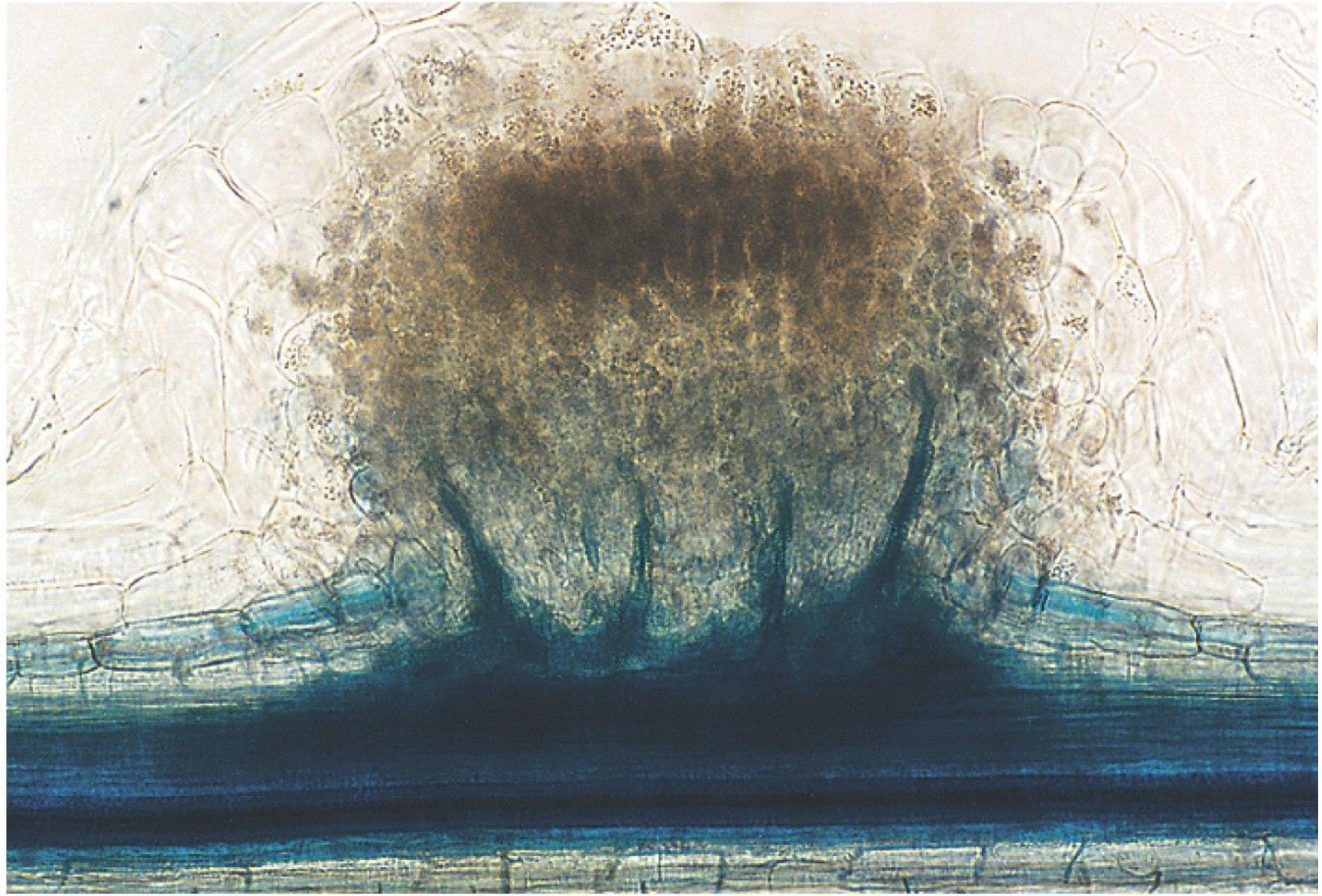
Chemo-organotrophs	Phototrophs	Chemo-lithotrophs
Bacteria:	Cyanobacteria	*Alcaligenes*
Azotobacter		*Thiobacillus*
Azomonas		*Acidithiobacillus*
Agrobacterium		*Streptomyces thermoautotrophicus*
Klebsiella[b]		
Beijerinckia		
Bacillus polymyxa		
Mycobacterium flavum		
Azospirillum lipoferum		
Citrobacter freundii		
Acetobacter diazotrophicus		
Methylomonas		
Methylococcus		
Methylosinus		
Pseudomonas		

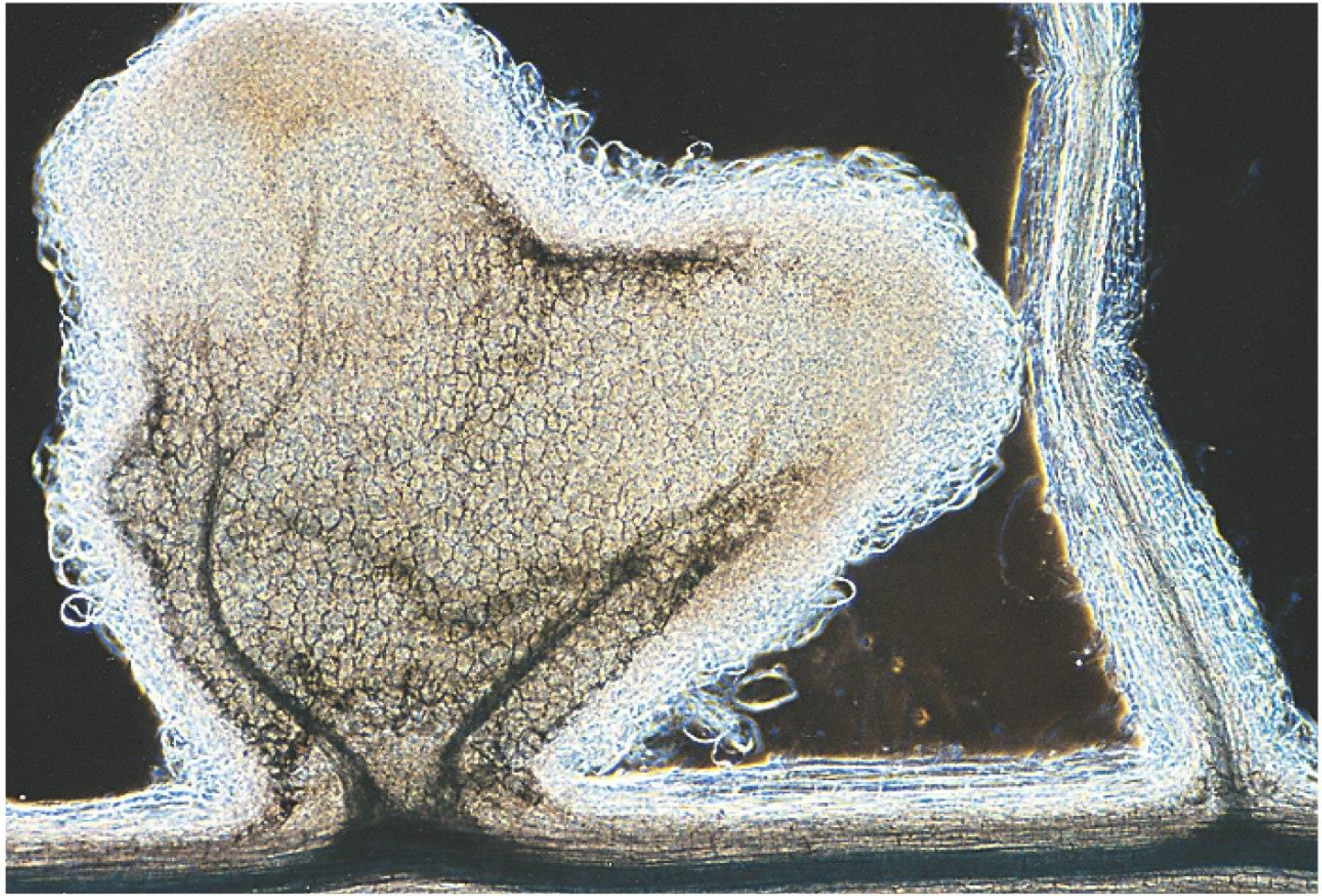
Table 17.10 Some nitrogen-fixing organisms[a]

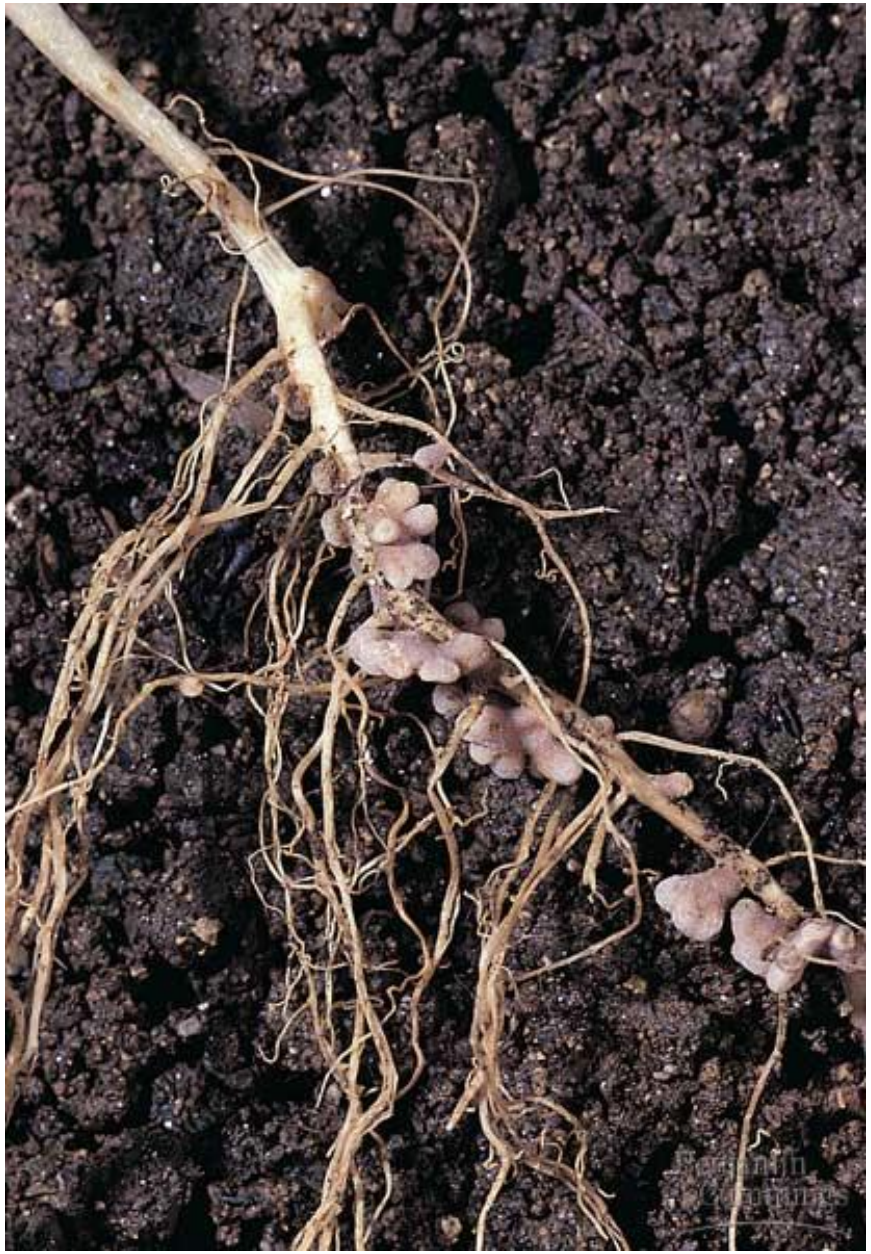
Symbiotic	
Leguminous plants	**Nonleguminous plants**
Soybeans, peas, clover, locust, and so on, in association with a bacterium of the genus *Rhizobium*, *Bradyrhizobium*, *Sinorhizobium*, or *Azorhizobium*	*Alnus*, *Myrica*, *Ceanothus*, *Comptonia*, *Casuarina*; in association with actinomycetes of the genus *Frankia*


Root hair
1. Recognition and attachment (rhicadhesin-mediated)
Rhizobial cell
2. Excretion of nod factors by bacterium causing root hair curling
3. Invasion. Rhizobia penetrate root hair and multiply within an "infection thread"
4. Bacteria in infection thread grow toward root cell
Infection thread


4. Bacteria in infection thread grow toward root cell
Infection thread
Invaded plant cells and those nearby are stimulated to divide
5. Formation of bacteroid state within plant cell
Nodules
6. Continued plant and bacterial cell division







Algae (Cyanobacteria), a large and diverse group of photosynthetic eukaryotic organisms.

Hormidium

Scenedesmus

Protosiphon

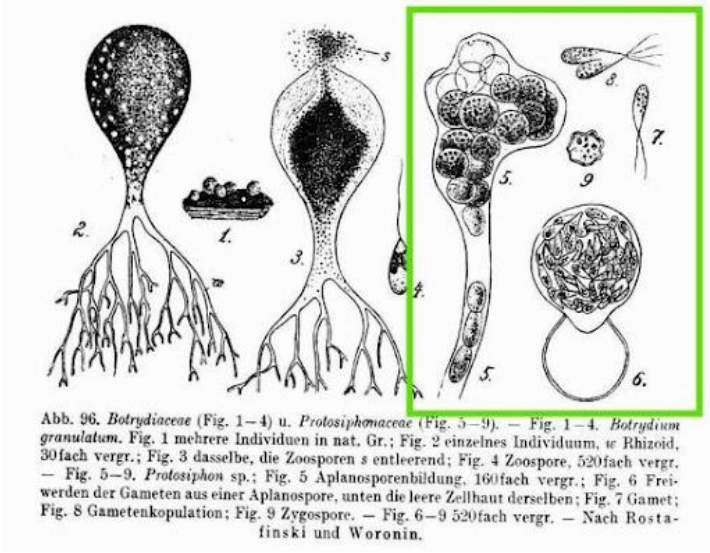


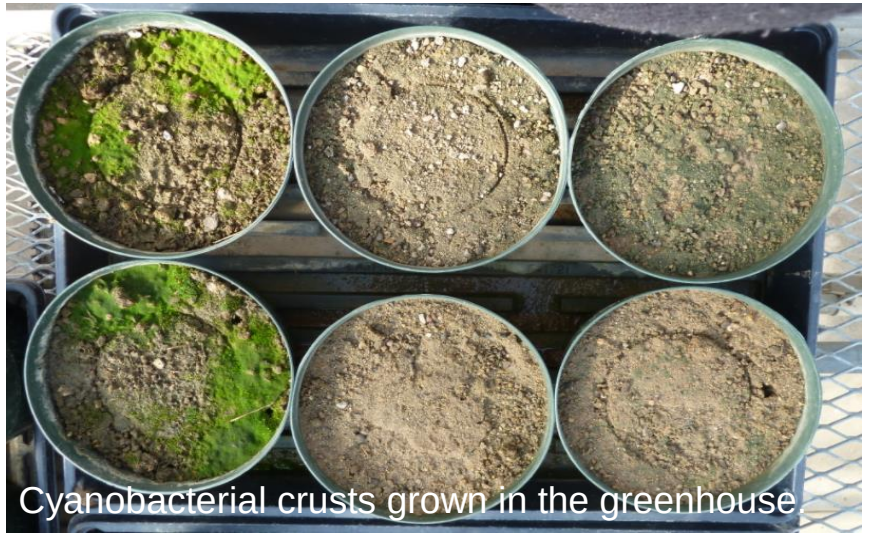
Abb. 96. *Botrydiaceae* (Fig. 1–4) u. *Protosiphonaceae* (Fig. 5–9). — Fig. 1–4. *Botrydium granulatum*. Fig. 1 mehrere Individuen in nat. Gr.; Fig. 2 einzelnes Individuum, *w* Rhizoid, 30fach vergr.; Fig. 3 dasselbe, die Zoosporen *s* entleerend; Fig. 4 Zoospore, 520fach vergr. — Fig. 5–9. *Protosiphon* sp.; Fig. 5 Aplanosporenbildung, 160fach vergr.; Fig. 6 Freiwerden der Gameten aus einer Aplanospore, unten die leere Zellhaut derselben; Fig. 7 Gamet; Fig. 8 Gametenkopulation; Fig. 9 Zygospore. — Fig. 6–9 520fach vergr. — Nach Rostafinski und Woronin.

Soil algae

- play an important role in organic matter formation by excreting polysaccharides
- increase soil aggregation.

two major types of soil algae are **green algae and diatoms**.

Soil algae are broadly divided into four major classes, i.e., Cyanophyta (blue–green algae), Chlorophyta (grass-green algae), Xanthophyta (yellow–green algae), and Bacillariophyta (diatoms).


Cyanobacterial crusts grown in the greenhouse.

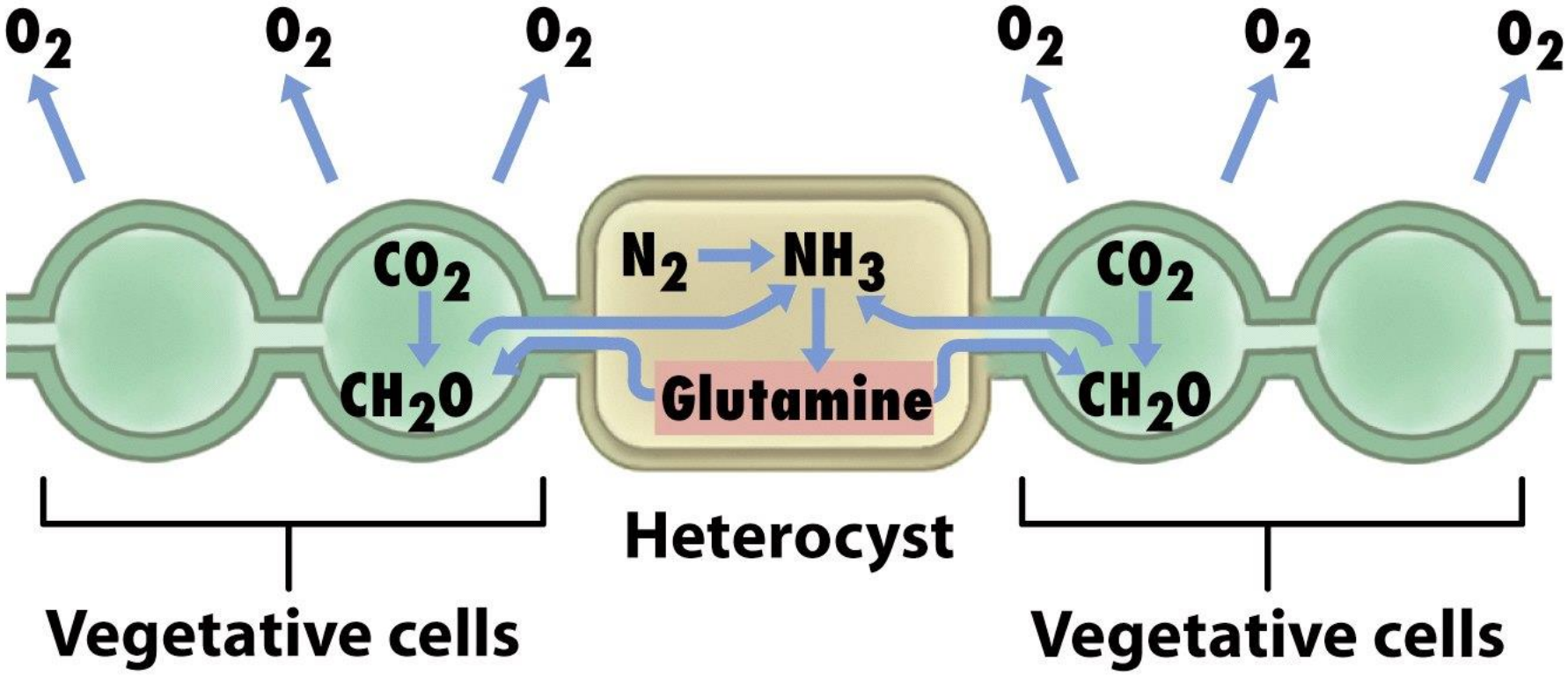

https://sites.psu.edu/soilmicrobiology/files/2017/02/GreenSoilFilm-2nchu7x.jpg

Cyanobacterial soil film.

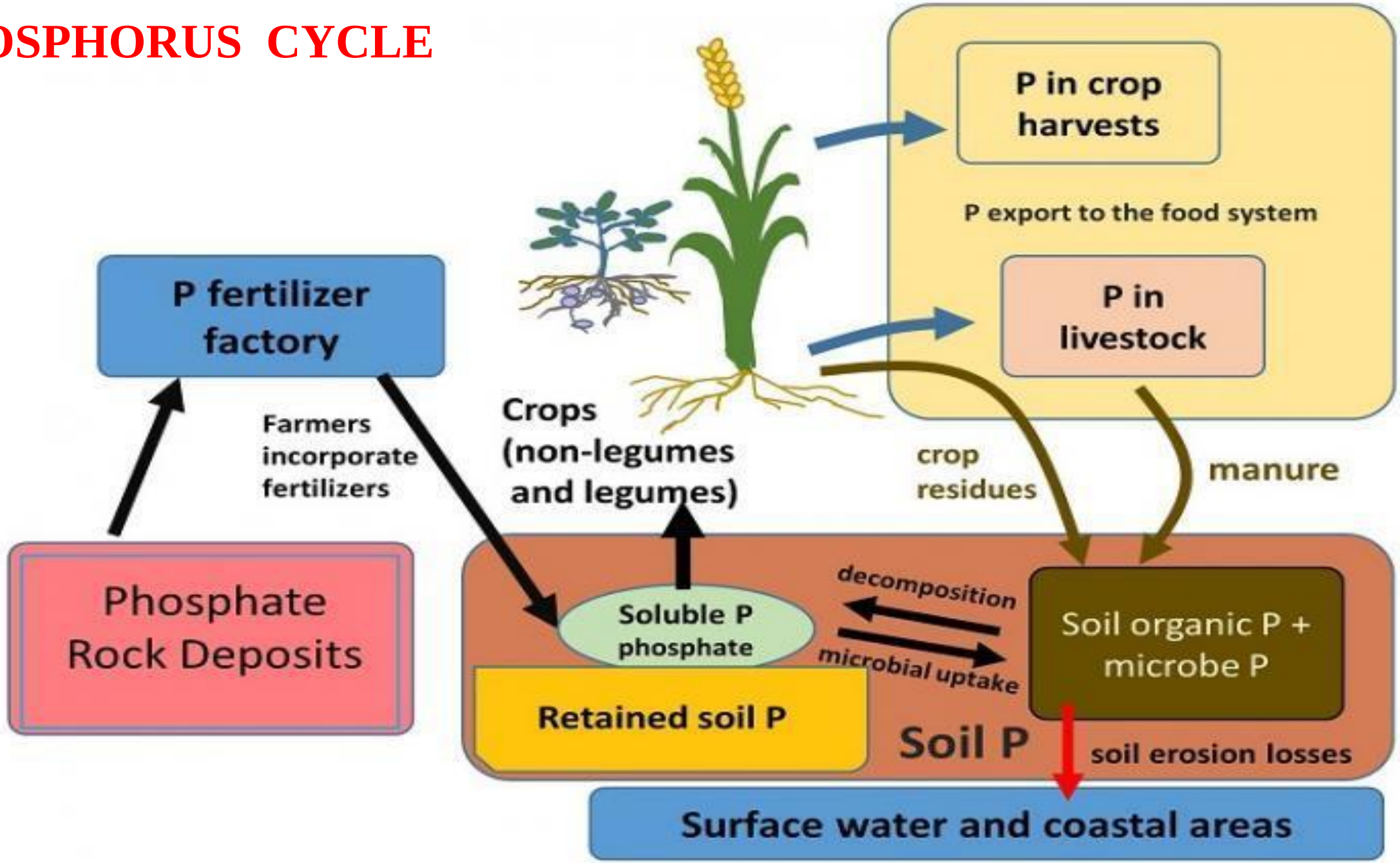

Biological soil crust is made up of cyanobacteria (algae)

Heterocyst

Nitrogene fixation by Cyanobacteria (algae) in heterocyst



PHOSPHORUS CYCLE



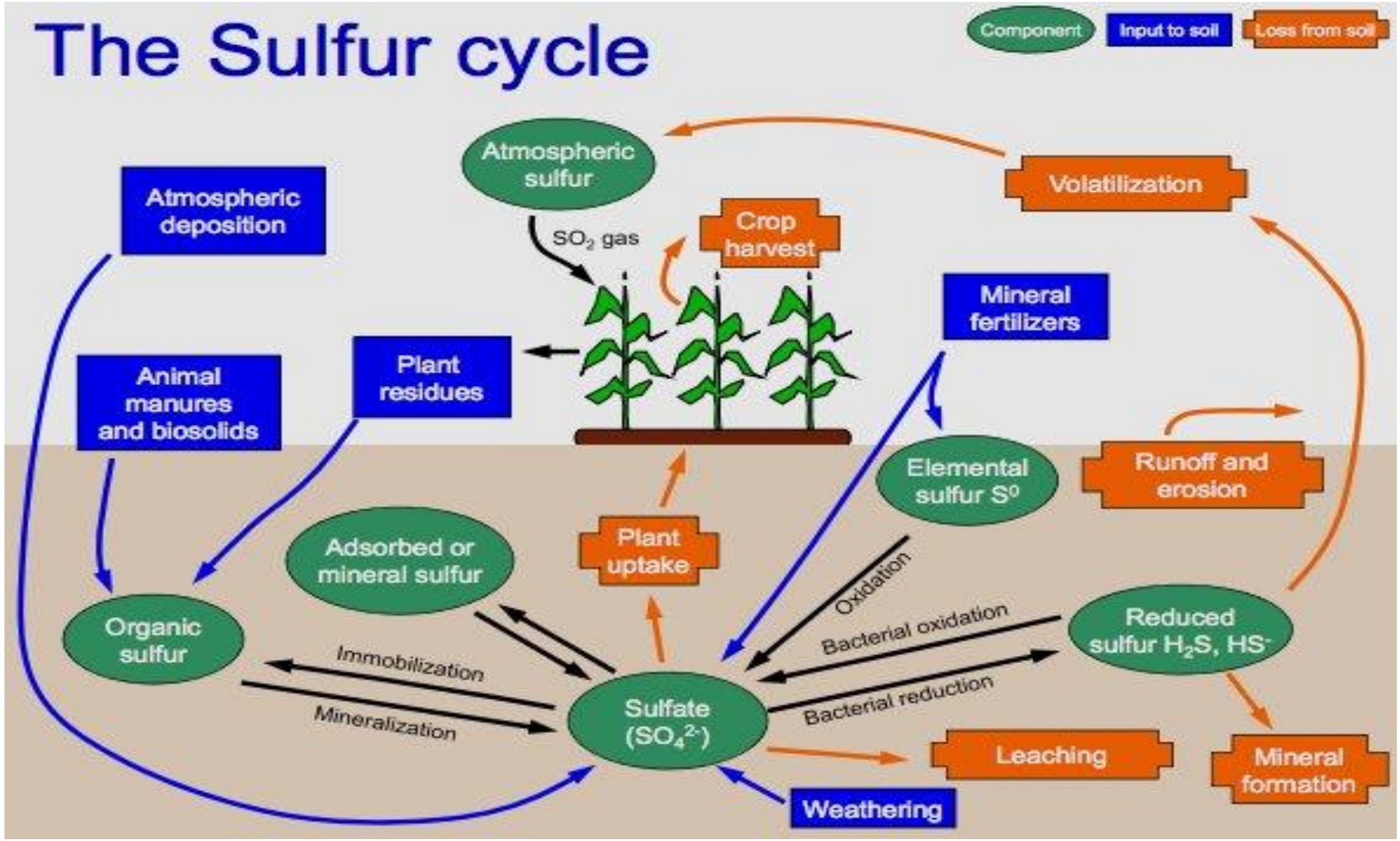
Mycorhiza

Symbiotic soil fungi that live in the root zone of 90% of plants in the world.

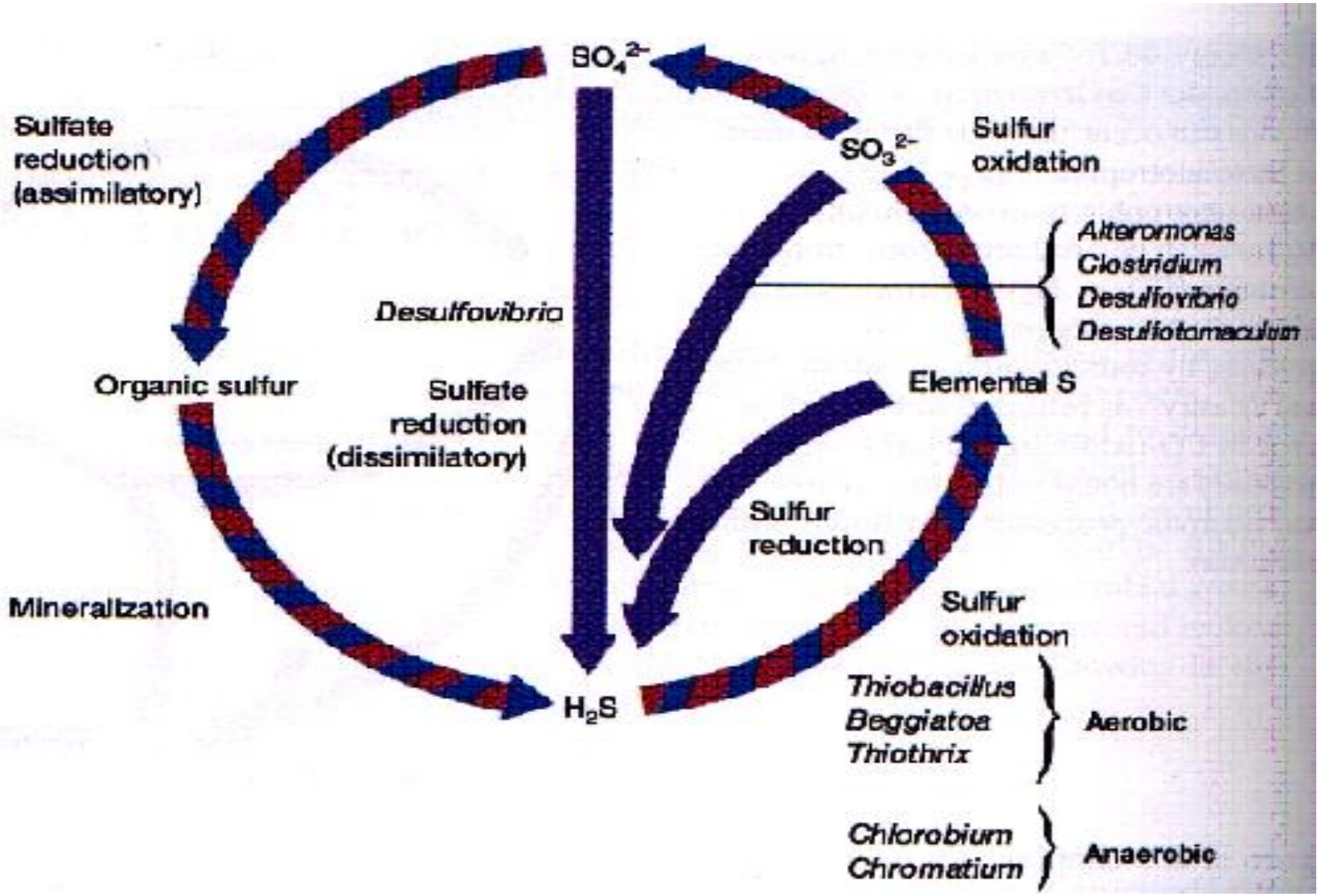
In this relationship, mycorrhiza provides plants necessary nutrients (N, P, K, Mg) for the biomass production, while receiving carbohydrates from the plant necessary for its own life.

Ectomycorrhizal fungi (Basidiomycetes sp) develops on the root cortical layer (formation of Hartig network).

Arbuscular mycorrhizal fungi forms a highly branched hypha network called arbuscule within the plant. This network extends through the plant into the soil space and performs nutrient transfer **(mainly P)**


The Sulfur cycle
Component
Input to soil
Loss from soil
Atmospheric sulfur
Volatilization
Atmospheric deposition
SO_2 gas
Crop harvest
Mineral fertilizers
Plant residues
Animal manures and biosolids
Elemental sulfur S^0
Runoff and erosion
Adsorbed or mineral sulfur
Plant uptake
Oxidation
Organic sulfur
Bacterial oxidation
Reduced sulfur H_2S, HS^-
Immobilization
Mineralization
Sulfate (SO_4^{2-})
Bacterial reduction
Leaching
Mineral formation
Weathering

Sulphure Cycle



Sülfür döngüsünde anahtar prosesler ve m.o.'lar

Proses	Organizma
Sulphur oxidation ($H_2S \rightarrow S^0 \rightarrow SO_4^{2-}$)	
Aerobic	Sulfur chemolithotrophs (*Thiobacillus*, *Beggiatoa*, many others)
Anaerobic	Purple and green phototrophic bacteria, some chemolithotrophs
Sulphur reduction (anaerobic) ($SO_4^{2-} \rightarrow H_2S$)	*Desulfovibrio, Desulfobacter*
Sulphur reduction (anaerobic) ($S^0 \rightarrow H_2S$)	*Desulfuromonas*, many hyperthermophilic Archaea
Sulphur reaction ($S_2O_3^{2-} \rightarrow H_2S + SO_4^{2-}$)	*Desulfovibrio* and others
Organic sulphur oxidation and reduction	($CH_3SH \rightarrow CO_2 + H_2S$) (DMSO→DMS)
Desulphurisation (organic-S → H_2S)	birçok m.o. bu işi yapabilir