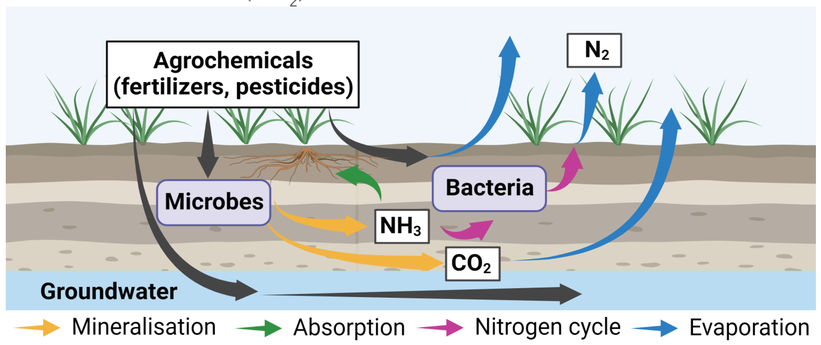
Soil microbes and their contribution to agriculture

By Young C. Song

Soil bacteria and fungi play important roles in maintaining soil health and promoting plant growth. Examples of their contributions include breaking down complex molecules present in soil into nutrients that can be absorbed by plants, as well as facilitating biogenochemical cycles (e.g,. carbon and nitrogen cycles). Investigating various metabolic properties of soil microbes therefore is important in multiple disciplines, including agriculture.

Microbes in bioremediation

Some bacterial and fungal species are able to degrade pesticides and fertilizers into less harmful molecules such as ammonia (NH_3) and carbon dioxide (CO_2).



Examples of microorganisms capable of degrading multiple pesticides

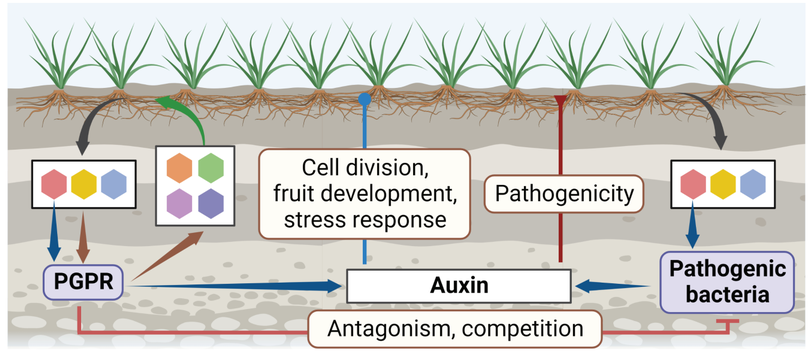
Bacteria ● Insecticide ● Herbicide
Fungi ● Fungicide

Phylum	Genus	Chlorpyrifos	Cypermethrin	DDT	Phorate	Acetochlor	Glyphosate	Penoxsulam	Epoxiconazole	Tebuconazole
Actinobacteriota	*Brevibacterium*	○	○	○	●	○	○	○	○	○
Firmicutes	*Bacillus*	○	●	○	●	○	○	○	○	○
Proteobacteria	*Acinetobacter*	○	○	○	○	○	○	○	●	○
	Azospirillum	○	○	○	○	○	○	○	●	○
	Comamonas	○	○	○	○	○	○	○	●	○
	Hydrogenophaga	○	○	○	○	○	○	○	●	○
	Methylobacillus	○	○	○	○	○	○	○	●	○
	Ochrobacterum	●	○	○	○	○	●	●	○	○
	Pseudomonas	○	○	○	●	○	○	○	○	○
	Ralstonia	○	○	●	○	○	○	○	○	○
	Serratia	○	○	○	○	○	○	○	○	●
Fungi	*Aspargillus*	○	○	○	○	○	○	●	○	○
	Cordyceps	○	○	○	○	●	○	○	○	○
	Formitopsis	○	○	●	○	○	○	○	○	○
	Fusarium	○	○	○	○	○	●	○	○	○
	Ochrobactrum	○	○	○	○	○	○	○	○	○
	Tolyptocladium	○	○	○	○	●	○	○	○	○

Data from [1, 2]

Plant growth promoting bacteria

Plant growth promoting bacteria (PGPR) produce hormone (auxin) that enhance various physiological traits of plants. In addition, they suppress pathogens using multiple mechanisms. Some bacterial species also degrade compounds in root exudates into elemental nutrients that can be taken up by plants.

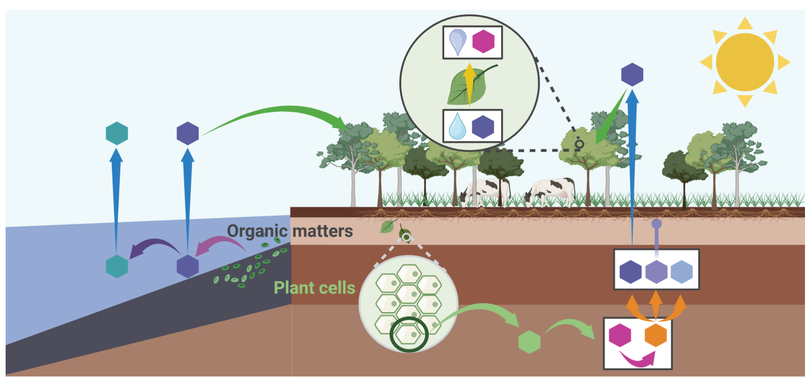


Biogeochemical cycles

Soil bacteria are capable of converting elemental nutrients or complex organic compounds into forms that can be absorbed by plants and back into the elemental form that are evaporated back into the atmosphere

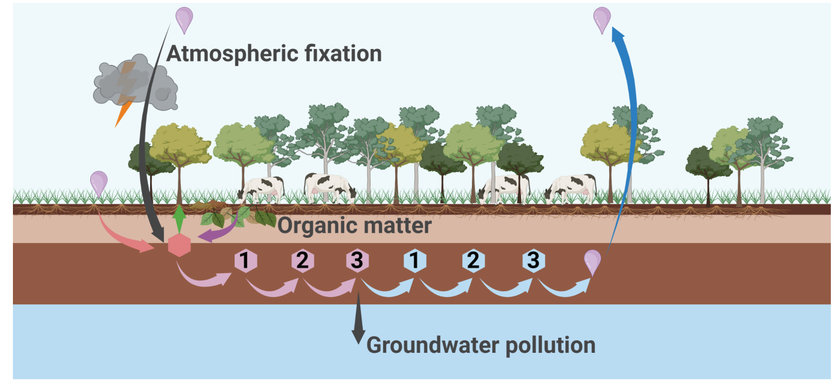
Carbon cycle

Some species of soil microbes are able to convert organic matters in the soil and in the marine sediment to carbon dioxide and/or methane. Carbon dioxide can also become a starting compound for photosynthesis, generating sugars used by plants for their growth.



Nitrogen cycle

Nitrogen makes up about 78% of Earth's atmosphere. In its gaseous form, its availabity for biological use is limited. Soil bacteria and fungi are capable of converting the atmospheric nitrogen into ammonia that can be used by plants and other organisms. An intermediate generated from these microbial reactions, nitrate could potentially seep into ground water, causing pollution. Microbial denitrification converts nitrate to nitrogen, helping to mitigate the groundwater pollution. The nitrogen produced from this mechanism could be released back into the atmosphere, renewing the cycle.



Biogeochemical cycle reactions present in selected groups of soil bacteria

● Carbon cycle ● Nitrogen cycle

Phylum	Genus	Cellulose degr.	Fermentation	Glycolysis	Photosynthesis	N_2 fixation	Nitrification	Denitrification
Actinobacteriota	*Mycobacterium*	○	○	●	○	○	○	○
	Streptomyces	○	○	●	○	○	○	○
Bacteroidota	*Flavobacterium*	●	○	●	○	○	○	○
Cyanobacteria	*Nostoc*	○	○	●	●	○	○	○
Firmicutes	*Bacillus*	○	●	●	○	○	○	○
	Clostridium	○	●	●	○	○	○	○
Proteobacteria	*Agrobacterium*	○	○	●	○	○	○	●
	Azospirillum	○	○	●	○	●	○	●
	Bradyrhizobium	○	○	○	○	●	○	●
	Mesorhizobium	○	○	●	○	●	○	○
	Methylocella	○	○	●	○	●	○	○
	Methylocystis	○	○	●	○	●	●	○
	Rhizobium	○	○	○	○	●	○	●
	Burkholderia	○	○	●	○	○	○	○
	Xanthomonas	●	○	●	○	○	○	○

Data from [2, 3]

References

1. Raffa C and F Chiampo. *Bioeng.* 8 (92). 2021.
2. Parks D *et al. Nat. Biotech.* 38, 1079-1086. 2020.
3. Kanehisa M *et al. Nucleic Acids Res.* 51, D587-D592. 2023.