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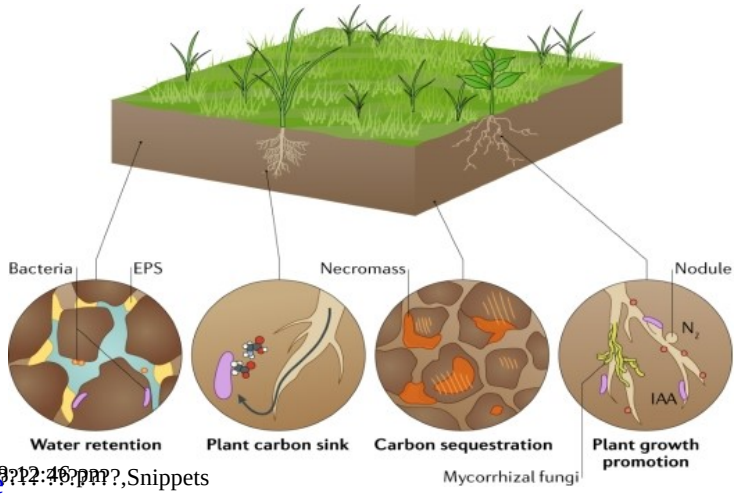
Climate Change Threatens Soil Microbiomes, Posing Risks to Global Carbon Balance



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Soil microbiomes—complex communities of bacteria, fungi, and microorganisms—are vital to Earth's carbon cycle and global climate regulation. These invisible soil dwellers help capture and store atmospheric carbon, playing a crucial role in reducing greenhouse gases, enhancing soil fertility, and supporting agricultural productivity.
Microbial processes in soil can sequester 3 to 5 gigatons of carbon globally each year. In agricultural lands, they capture up to 1.5 metric tons of CO? per hectare annually, depending on farming practices. Regenerative agriculture, organic amendments, cover cropping, and minimal tillage are among the methods that boost microbial health and improve soil carbon retention.
Certain microbes also support crop resilience by improving nutrient uptake, reducing the need for synthetic fertilizers, and enhancing soil structure. This microbial activity not only benefits the environment but also strengthens long-term food security—particularly in climate-vulnerable regions.
However, climate change is threatening the stability of these underground ecosystems. Rising temperatures, unpredictable rainfall, prolonged droughts, and thawing permafrost are disrupting soil conditions globally. These shifts increase carbon and methane emissions by accelerating microbial decomposition or favoring greenhouse gas-producing organisms.
A 2019 study shows that for every 1°C rise in temperature, soil respiration—and thus carbon release—increases by 0.1%. Drought reduces microbial diversity and activity, while excess moisture supports methane-producing microbes in wet soils. In Arctic regions, thawing permafrost is releasing ancient carbon, rapidly broken down by microbes, creating a dangerous feedback loop.
According to the Intergovernmental Panel on Climate Change (IPCC), up to 30% of organic carbon in topsoil could be lost by 2100 under high-emission scenarios. This would severely weaken soils' ability to function as carbon sinks, while also affecting crop yields, water retention, and ecosystem health.
Despite these risks, soil microbiomes offer powerful opportunities for climate mitigation. Strategies like biochar application, microbial inoculants, and climate-smart farming are gaining global attention. Experts urge that

protecting microbial biodiversity must be a priority in climate and agricultural policies.
Soils are not lifeless matter—they are living ecosystems. Preserving their microbial life is crucial for a stable climate, healthy crops, and a food-secure future.