Biostimulants, Microbials, and Biological Nitrogen Fixation

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envita SC

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Types of Biological Products

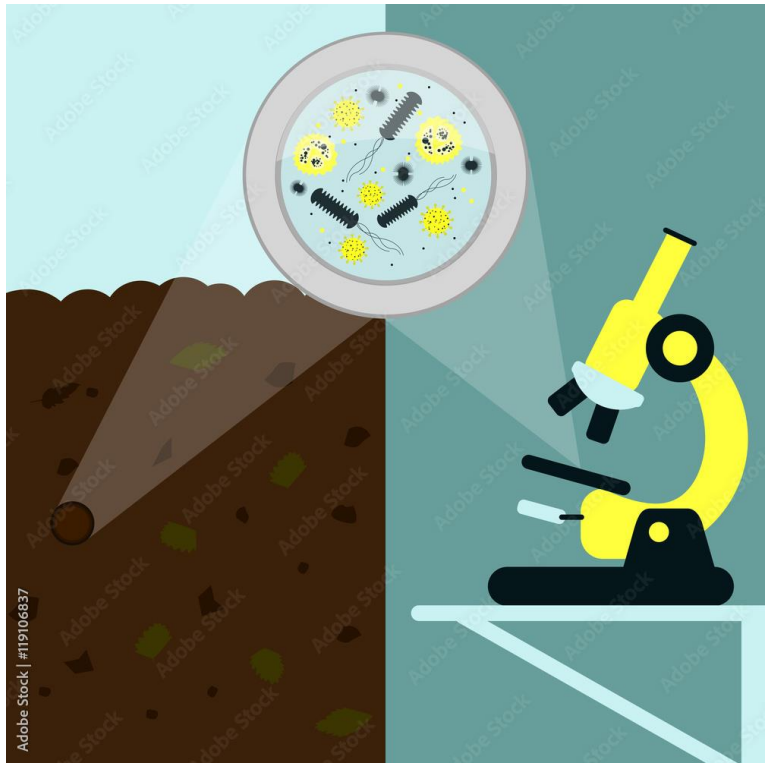
- **Biopesticides**
- **Biostimulants**
- **Biological organisms**

Definition of plant biostimulant:

“A plant biostimulant is a **substance**(s), **microorganism**(s), or mixtures thereof, that, when applied to seeds, plants, the rhizosphere, soil or other growth media, act to **support a plant's natural processes independently of the biostimulant's nutrient content, thereby improving nutrient availability, uptake or use efficiency, tolerance to abiotic stress, and consequent growth**, development, quality, or yield.”

Benefits of Biostimulants

- Improve soil health
- Enable plants to adapt to drought and extreme temperature
- Improve a plants ability to utilize nutrients
- Improve efficiencies of fertilizer applications(e.g. less nutrient loss to air and water)
- Increase crop yields



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Categories of Biostimulants

1) **Non-microbial Biostimulants** (organic compounds):

- Plant Extracts
- Humic/Fulvic Acids
- Protein hydrolysate
- Purified molecules

2) **Microbial Biostimulants** (generally bacteria/fungi):

- Nitrogen-Fixing Bacteria
- P-Solubilizing Bacteria
- Nutrient enhancement or Plant Growth Promoting
- Mycorrhizal Fungi

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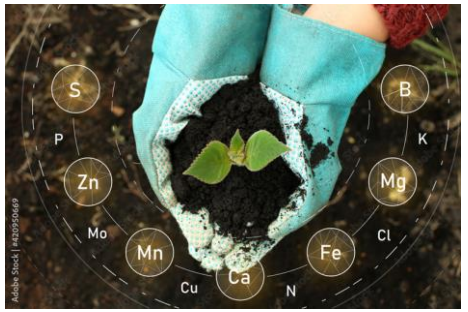
Categories of Biostimulants: Non-microbials

Plant extracts

- Seaweed extract – biofertilizer
- Contain macro and micro nutrients, humic acids and phytohormones

Organic Acids (eg: Humic Substances)

- Humic acids and organic compounds formed from decomposition of plant and animal materials.



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Categories of Biostimulants: Non-microbials

Protein Hydrolysate (eg: Amino Acids)

- Hydrolyzed protein: Breakdown of protein into their constituent parts such amino acids.

Purified Molecules (eg: Chitin)

- Chitin is a component of the exoskeletons of insects and shellfish.

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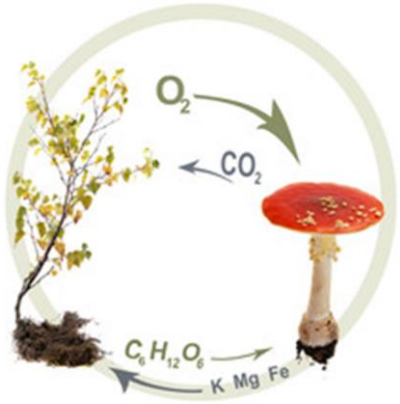
Categories of Biostimulants: Microbials - Fungi

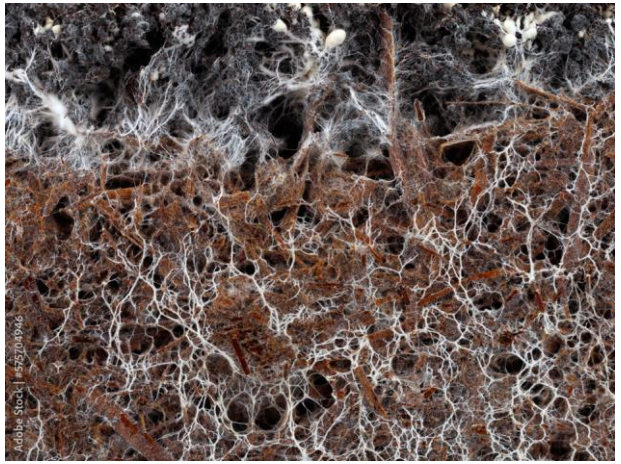


Asymbiotic

- live on decaying materials
- live independent of plants
- free up nutrients
- subject to environmental interactions

Symbiotic fungi (mycorrhizae)

- form a mutually beneficial relationship with living plants



Fungi are a group of spore producing organisms that feed on organic matter.

- Mycorrhizae: form a symbiotic relationship with plants where they exchange absorbed nutrients from the soil such as phosphorous in exchange for carbohydrates.

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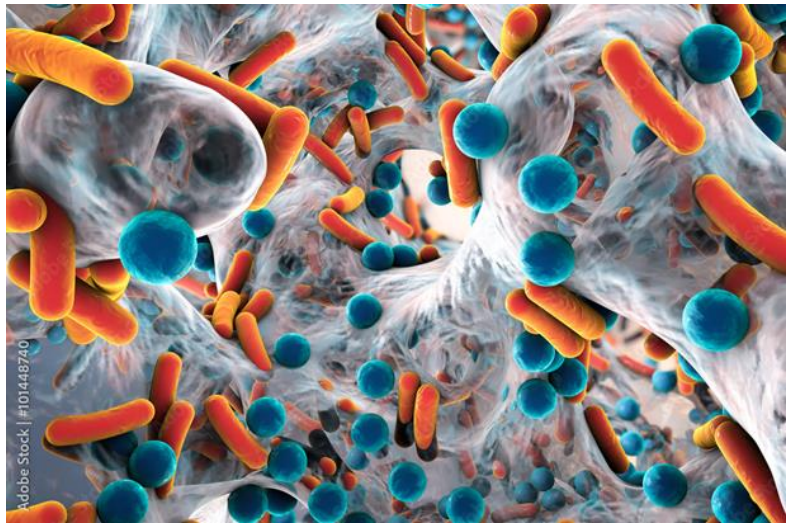
Categories of Biostimulants: Microbials - Bacteria

Asymbiotic

- live on decaying materials and other elements
- live independent of plants
- may free up nutrients
- are subject to environmental interactions both beneficial and competitive



Symbiotic bacteria

- form a mutually beneficial relationship with living plants
- often close in proximity to plant
- can even live within the plant (**endophytic**)
    - protected by plant when endophytic

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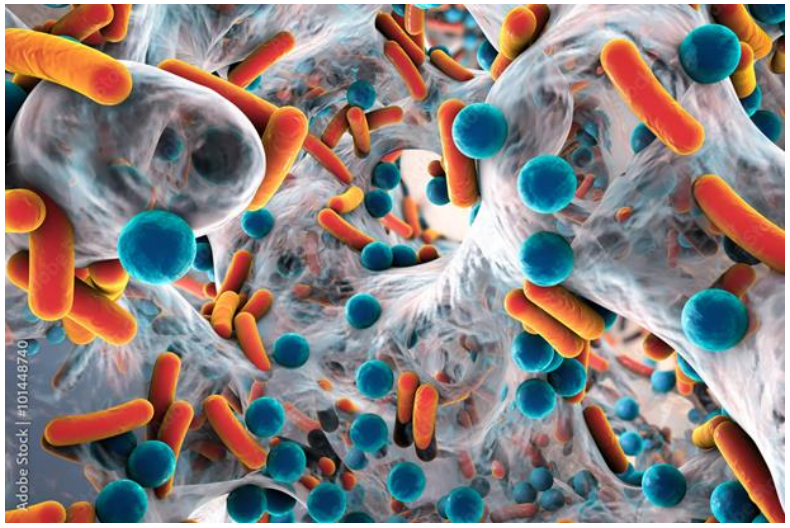
Function of Biostimulants: Microbials - Bacteria



General function

- Nutrient availability
    - mineralize/solubilize (make available)
    - help translocate to or within the plant
    - some fix nitrogen
- Elicit (trigger) plant response
    - enhance defense
        - abiotic stress tolerance
        - pathogen resistance
    - elicit offense
        - plant morphology (roots, leaves…)
        - yield
        - quality

Biological Nitrogen Fixation with Bacteria

Until about 6 years ago, biological N fixation (BNF) was with legumes

Now there are various options and conditions for BNF

Let’s dive deeper into BNF

- soil or free living
- symbiotic (mutually beneficial)
- categorized as diazotrophs

Biological Nitrogen Fixation - Soil

Factors affecting nitrogen fixation in **soil living bacteria**:

- All nitrogenases are inhibited by high [NH_4+], [NO_3-] and [O_2].

Diazotrophs fix nitrogen if:

Carbon is not limiting.

- Preferred source of C (sugar) must be abundantly available.

Nitrogen is limiting.

- Most diazotrophs have a nitrate reductase enzymes and will assimilate nitrogen instead of fixing N

Micronutrients are not limiting.

- Primarily molybdenum, iron, sulfur and magnesium

Oxygen is limiting

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Biological Nitrogen Fixation – Symbiotic

Conditions for N-fixation **inside plant** tissues and cells

Carbon is not limiting

- There is a constant supply of simple C compounds (sugars, organic acids) provided by the host plant.
- Competition for C by other microbes is limited.

Nitrogen is limiting

- Ammonium and/or nitrate is low

Micronutrients are not limited (Mo, P, Fe, S, Mg)

- Delivered by the plant so long as plant has access to them

Oxygen is limiting

- Adaptions in some cases

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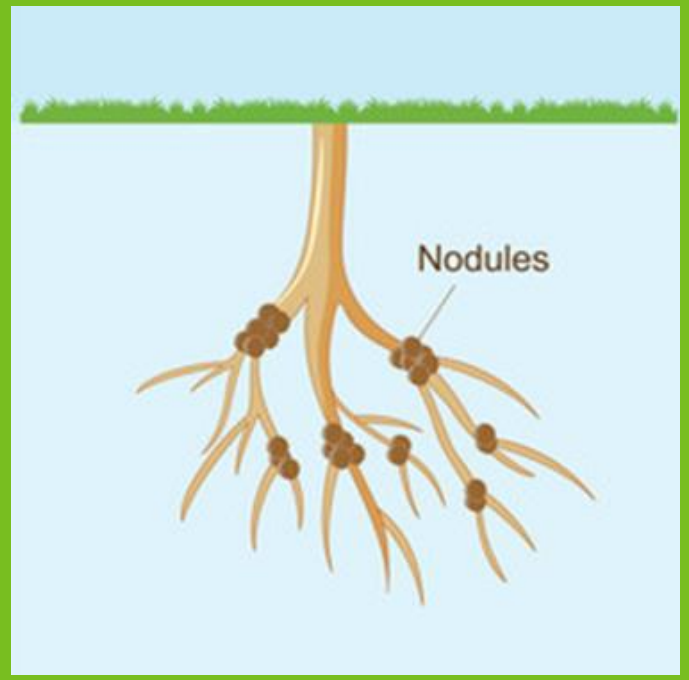
Nitrogen Fixing Bacteria

Example: Rhizobia



Commonly understood symbiotic bacteria

Bacteria that convert atmospheric nitrogen into ammonia

Bacteria are specific to a species

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Significance of Location of N Fixation

Soil	- Subject to competition by other micro-organisms - Subject to loss - Move to or intercepted by roots - Cross root membrane, is translocated
Rhizosphere	- Subject to fates in soil and competition by other microbes - Cross root membrane, is translocated
Nodular	- Protected by tissue or the nodule - Inside plant root membrane, but requires transportation
Inter cellular	- Inside plant - between cells: Translocation across cell wall
Intra cellular (inside)	- Most intimate - Less translocation cost - Not subject to loss or competition

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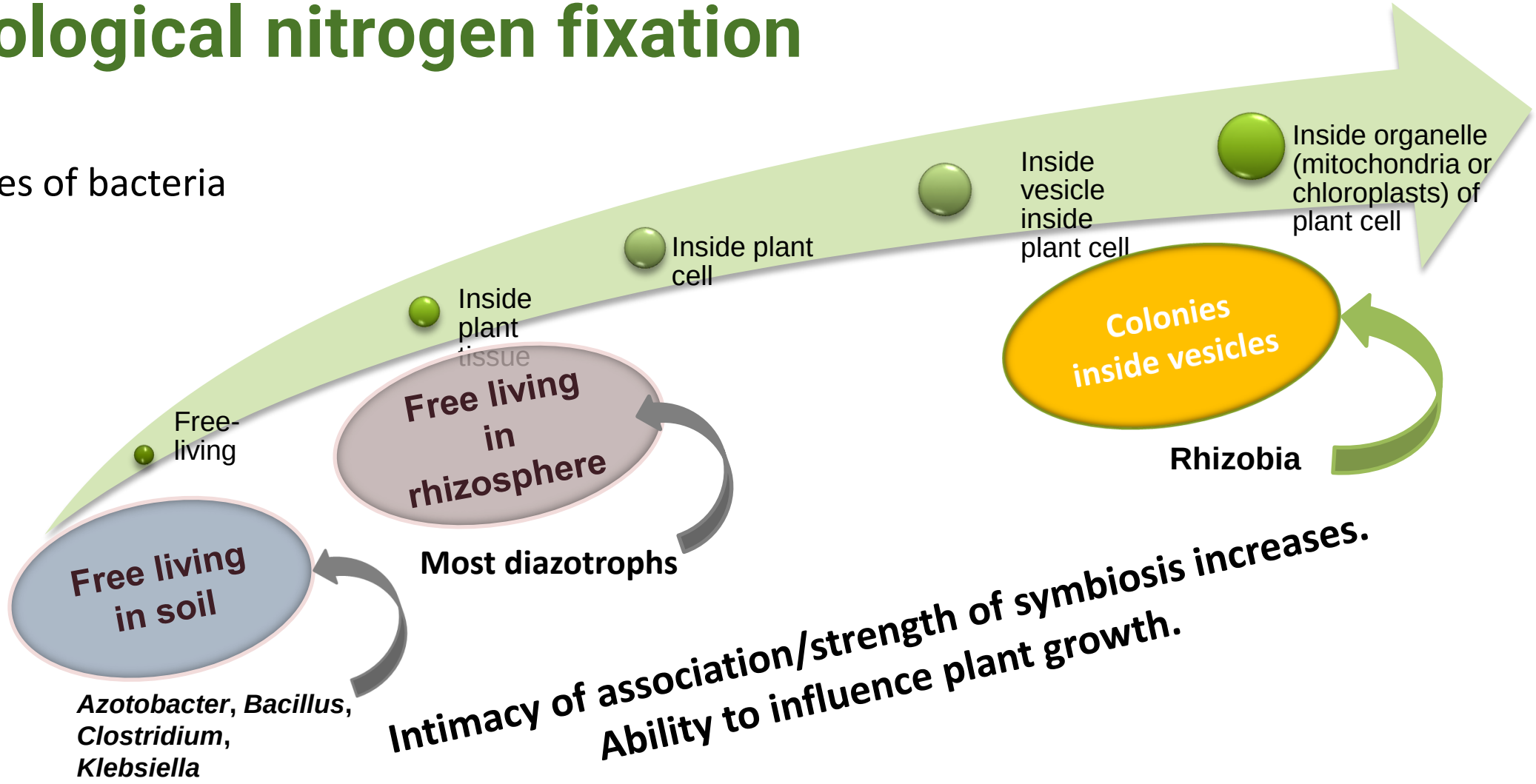
Biological nitrogen fixation

Types of bacteria



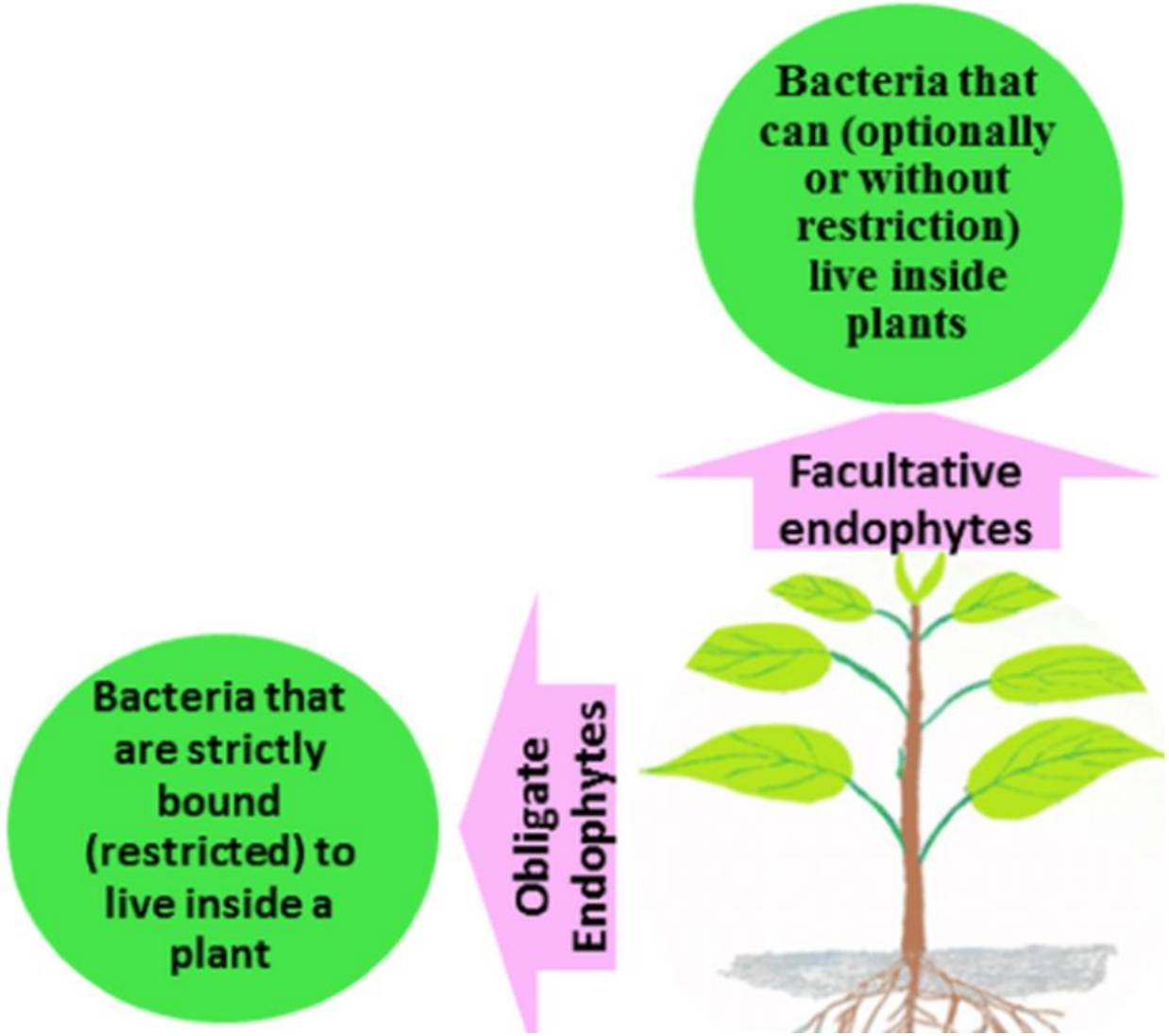
Bacteria

Obligate Endophyte:

- Dependent on host plant for their growth, survival and propagation.
- Consistently inside plant and exerting influence.

Facultative Endophyte:

- Reside inside and outside the plant.
- Only inside of the plant some of the time exerting influence.



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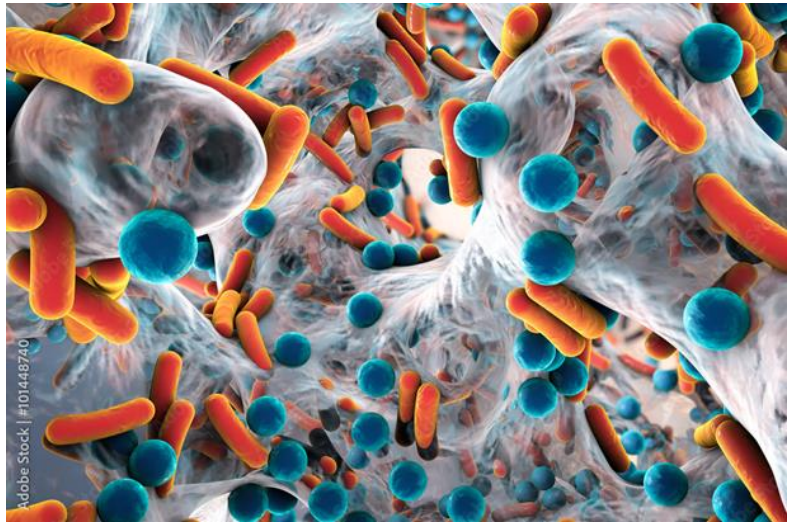
Commercially available non host specific nitrogen fixing bacteria

Azoarcus indigens	Soil
Azorhizobium caulinodans	Endophyte
Azosporillum brasiiense	Soil
Curtobacterium salicis	Endophyte
Gluconacetobacter diazotrophicus	Endophyte
Klebsiella variicola	Soil
Kosakonia sacchari	Endophyte
Methilobacterium symbioticum	Endophyte
Paenibacillus polymyxa	Endophyte



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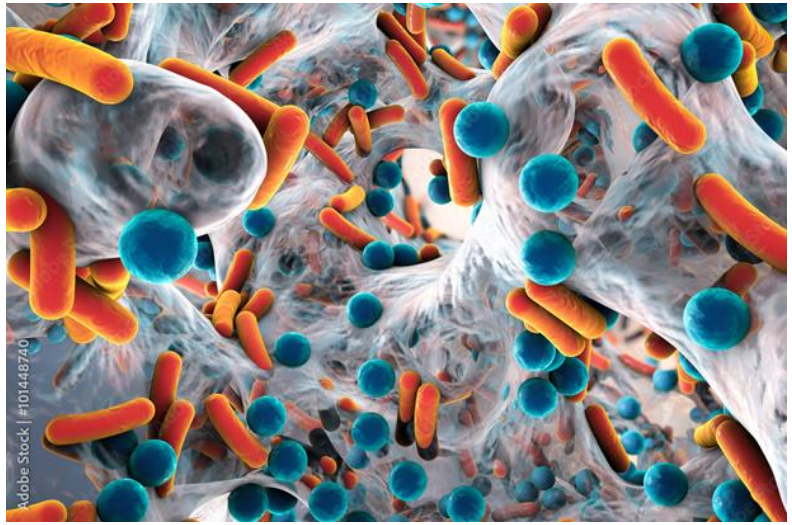

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	Rhizobia	*G. diazotrophicus*
Crops	Crop specific	Multiple crops
Establishment & Crop Response	Weeks	Days
Total Amount of Nitrogen Supplied	Significant and majority of need	Supporting, yet significant
Location of Nitrogen Fixation	Outside plant cells – in nodule (Intercellular)	Inside plant cells (Intracellular & intercellular)
Life in soil without a host	Able to survive for extended time as free living	Cannot exist extended time as free living (requires host)
Plant segment of Nitrogen Fixation	Roots: Nodules	Systemic (shoots & roots):
N Fixation in presence of extra Nitrogen	Nitrate Slows or stops fixation (plant becomes lazy)	Nitrate does not inhibit Nitrogen fixation

Observed Crop Responses to *G. diazotrophicus*

- Improved nitrogen use efficiency
  - Supplemental N
- Increased chlorophyl content
- Water use efficiency
- Yield increase
- Quality

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Potato Agronomist Quote:

Excerpt from an email communication in 2022:
“We’ve looked at Envita (*Gluconacetobacter diazotrophicus*) ... for 2 years in MI. [Gd] helps with drought stress (delayed each irrigation by 1/2 to 1 day on [Var]), and also helps plants use Nitrogen more efficiently …”

Observation from same agronomist: later in the season, potatoes didn’t wilt so much during the day when treated with Gd. This was noted at the later foliar fungicide timing. (paraphrase)

Gluconacetobacter diazotrophicus Offers

- Systemic, season-long nitrogen fixation
  - Endophytic (inside) and throughout the plant
  - Such N is plant available and protected
  - Fills in the gaps
- Crop flexibility from alfalfa to zucchini
- Flexibility in application method and timing
- Offers productivity and sustainability

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