

Actinomycetes:

(Streptomycetes, ray fungi), a group of microorganisms combining the traits of bacteria and fungi. The actinomycetes are characterized by a filamentous or rod-and-coccus structure and the presence of lateral protuberances. They are all gram-positive.

The actinomycetes include Actinomyces itself, which forms spores on sporophores. The spores form in long chains by segmentation or fragmentation of the sporophores. There are also the Proactinomyces, with a well-developed mycelium which breaks up into rods and cocci; the Mycobacterium, with a typical branching of the mycelium in the form of rod-like cells which multiply by division (by segmentation); the Mycococcus, in the form of round, irregular cells (often with lateral protuberances, or buds), which multiply by segmentation and gemmation; and the Micromonospora, a group consisting of four genera (Micromonospora, Microbispora, Micropolyspora, and Actinobifida). There are also forms with complex fruit-bearing organs, called sporangia,

with spores inside (Streptosporangium, Actinosporangium, and others), and forms which generate spores with cilia (Actino-planes, Dermatophilus, and others).

Actinomycetes are widely found in soil, in the silt of bodies of water, in the air, and in plant remains. Among the actinomycetes there are also pathogenic forms which cause actinomycosis, tuberculosis (Mycobacterium tuberculosis), and diphtheria (Corynebacterium diphtheriae). Certain types of mycobacteria are injurious to plants, while the Proactinomyces forms nodules on the roots of alder trees and other plants, contributing to their growth.

A majority of the actinomycetes feed on protein or nonprotein organic matter. Among the actinomycetes there are also autotrophs, as well as forms for which waxes, resins, paraffins, and petroleum can be used as the source of carbon. For them, nitrates, ammonium salts, urea, amino acids, and other substances can be used as the source of nitrogen. Actinomycetes live under the most diverse conditions, aerobic and anaerobic, at

temperatures of 5–7°C and 45–70°C. Actinomycetes participate in diverse soil processes (ammonium fixation, decomposition of cellular tissue, and the synthesis and decomposition of humus). Many actinomycetes are used to produce antibiotics, vitamins, pigments, amino acids, and other biologically active substances.

- Form of fungi like bacteria.
- Sometimes called thread bacteria.
- In composting they give off a earthy smell .
- Primary decomposers of woody stems, newspapers and bark.
- Are very common in the soil at a rate of 1/4 pound per cubic foot in healthy soil especially higher Ph soil(alkaline) and drier soils.
- Comprise of 5% of soil's total bacteria population.
- Streptomyces is the most numerous of all actinomycetes.

- Different species of actinomycetes work in the compost cycle at different phases of composting or decomposition.
- Help in the decomposition of organic matter into humus and release of nitrogen.
- Primary source of antibiotics used in topical antibiotic creams.
- In high fertile soil they will not develop that well.
- In the decomposing cycle actinomycetes release carbon, ammonia and nitrogen which in turn make the nutrients of minerals available for our plants.

Actinomycetes functions and characteristics are:

Actinomycetes are from the class actinobacteria. They are gram positive filamentous bacteria that generally live in soil and break down organic matter such as dead trees and leaves. They produce spores. They produce secondary metabolites that are highly useful pharmaceutical products. In 1980 70% of naturally occurring

antibiotics were derived from actinomycetes.

Antibiotic Actinomycetes – *Streptomyces* and Discovery of Streptomycin:

Scientists have long known that actinomycetes somehow kept soil bacteria populations in balance. This fact led scientists Selman Waksman and Albert Shatz to think that some of these actinobacteria might be useful as antibiotics against human disease. Shatz was particularly driven by his experience as a lab assistant at a Miami Hospital during the 2nd World War. Here he witnessed the death of many young soldiers at the hand of penicillin immune infections, especially Tuberculosis.

Actinomycetes

Remarkable Antibiotics, Nitrogen Fixing Bacteria, Decomposer

- Actinomycetes are a remarkable type of bacteria. So far we know they function in at least three

important ways.

- The Streptomyces family, provides us with many of the important antibiotics we use in medicine today.
- The Frankia family, works in a symbiotic relationship with many non legume plants as nitrogen fixing

bacteria.

- Other actinomycetes are decomposers digesting tough plant tissues like the cellulose and lignin in bark.
- Paper and stems and the chitin or hard exoskeletons of insects.

Actinomycetes are a fungi-like bacteria forming long filaments that stretch through the soil. They have

sometimes been classed as fungi because they both look like, and decompose similar material as fungi.

However, they have no defined nucleus. As well antibacterial agents work against them but antifungal agents

do not. So now we can call them actinobacteria.

Shatz, when released from the Miami Hospital returned to Dr Selman's lab at Rutgers University. On October

19th, 1943, after three months of work, he managed to isolate two strands of actinobacteria that could effectively stop the growth of penicillin resistant bacteria. Streptomycin, the first antibiotic to cure tuberculosis, was the result of this work. Streptomycin is still used, but in combination with other drugs, in the battle against TB.

The Streptomyces produce over two-thirds of the clinically useful antibiotics that are natural in origin including Erythromycin, Neomycin, Tetracycline and Cefoxitin. Kind of puts mud baths and masks along with the age old childhood habit of eating dirt in a different light, doesn't it.

The Nitrogen Fixing Bacteria – *Frankia*:

Nitrogen is a critical nutrient for virtually all life forms. We get our nitrogen either directly or indirectly from plants. While nitrogen makes up about 79% of our atmosphere, plants can no



t use nitrogen in its gaseous state. It first must be fixed or combined into either ammonia, NH_3 or Nitrate, NO_3 .

The natural nitrogen cycle relies on nitrogen fixing bacteria like those found in the Frankia family of actinobacteria, to supply the fixed nitrogen. Fixed nitrogen is often the limiting factor for growth, both in your garden and in the general environment.

About 15% of the world's nitrogen fixed naturally is from symbiotic relationships between various species of the Frankia family of actinobacteria and their host plants.

The plants that form symbiotic relationships with Frankia are called actinorhizal plants. Scientists have found over 160 plants that host these actinomycetes including alders, Russian olive, bayberry, sweet fern, bitterbrush and cliffrose. The Frankia is able to provide most or all of the host plant's nitrogen needs. Here is a photo of the very cool looking nitrogen fixing nodules on an alder root.

These nitrogen fixing bacteria and their host plants are often pioneer species on young nitrogen deficient and disturbed soils such as moraines, volcanic flows and sand dunes. They help create a reservoir of nitrogen rich

soil that the next wave of plants can benefit from.

Scientists believe that much of the new nitrogen in temperate forests, dry chaparral, sand dunes, moraines, and mine waste tailings is thanks to the mutualism of Frankia and host plants. They are the main nitrogen fixing relationships in large parts of the world and will only become more important as we adjust to climate change.

The Decomposer Actinomycete:

As a decomposer the actinomycetes specialize in breaking down tough cellulose and lignin found in wood and paper and the chitin found in the exoskeletons of insects. The breakdown of these materials makes nutrients once again available to plants.



The "earthy" smell of freshly turned soil is caused by actinomycetes at work.

While some species of actinobacteria are thermophiles, loving the heat of an active hot compost, in my own

compost pile I find them in the outer two to six inches of the heap. During the long cool curing stage of compost they extend their hyphae like threads throughout the compost. They are those whitish grey cobweb like threads like you can see in this picture.

To help both the actinobacteria and fungi to develop in your compost stop turning your pile during the curing phase. You'll have a nice rich batch of soil life to inoculate your garden beds with. If lazy like me - you can tell people you never turn your pile so that these amazing critters can flourish.

References:

1. **Kashima Y, Udaka S. High-level production of hyperthermophilic cellulase in the *Bacillus brevis* expression and secretion system. *Biosci Biotechnol Biochem.* 2004;68:235–237.**
2. **Udaka S, Yamagata HY. Protein secretion in *Bacillus brevis*. *Antonie Van Leeuwenhoek.* 1993;64:137–143.**
3. **Lam KHE, Chow KC, Wong WKR. Construction of an efficient *Bacillus subtilis* system for extracellular production of heterologous proteins. *J Biotechnol.* 1998;63:167–177.**
4. **Loir YL, Azevedo V, Oliveira SC, Freitas DA, Miyoshi A, Bermúdez-Humarán LG, Nouaille S,**

Ribeiro LA, Leclercq S, Gabriel JE, Guimaraes VD, Oliveira MN, Charlier C, Gautier M,

Langella P. Protein secretion in *Lactococcus lactis* : an efficient way to increase the overall

heterologous protein production. *Microb Cell Fact.* 2005;4:2.

5. Kuipers OP, de Ruyter PG, Kleerebezem M, de Vos WM. Controlled overproduction of proteins

by lactic acid bacteria. *Trends Biotechnol.* 1997;15:135–140.

6. Billman-Jacobe H. Expression in bacteria other than *Escherichia coli*. *Curr Opin Biotechnol.*

1996;7:500–504

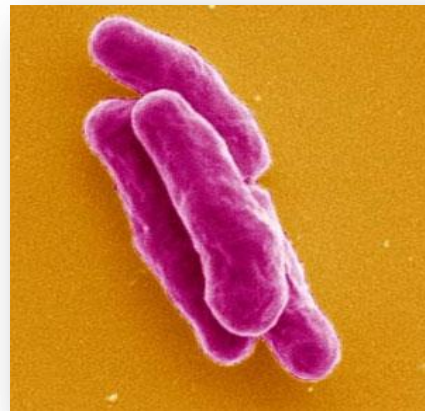
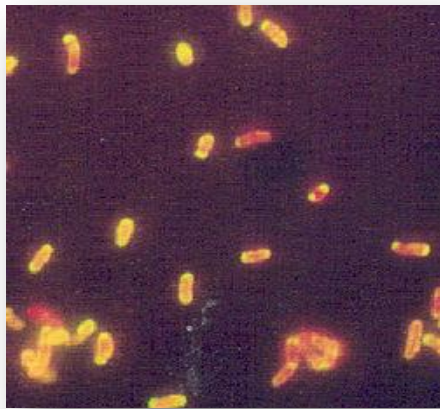
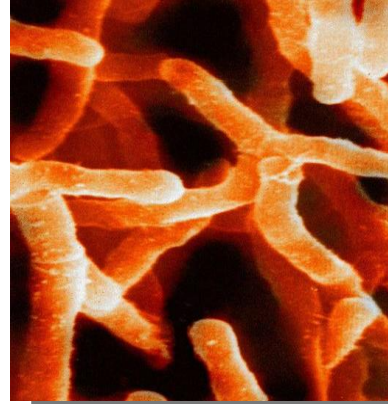
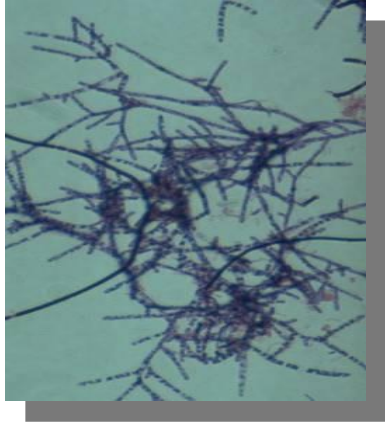
7. Brooks SA. Appropriate glycosylation of recombinant proteins for human use: implications of

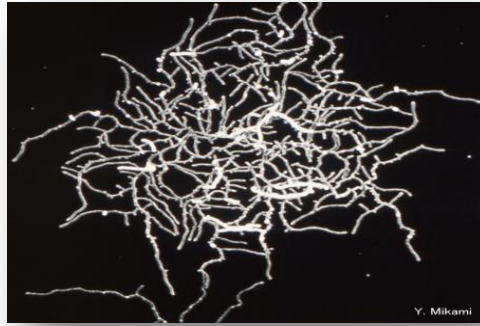
choice of expression system. *Mol Biotechnol.* 2004;28:241–256.

8. **Connell ND. Expression systems for use in actinomycetes and related . Flores FJ, Rincón J, Martin JF. Characterization of the iron-regulated *desA* organisms. *Curr Opin Biotechnol.* 2001;12:446–449**
9. **promoter of *Streptomyces pilosus* as a system for controlled gene expression in actinomycetes. *Microb Cell Fact.* 2003;2:5**
10. **Heraï S, Hashimoto Y, Higashibata H, Maseda H, Ikeda H, Omura S, Kobayashi M. Hyper-inducible expression system for streptomycetes. *Proc Natl Acad Sci USA.* 2004;101:14031–14035.**
11. **Nakashima N, Tamura T. A novel system for expressing recombinant proteins over a wide temperature range from 4 to 35 degrees C. *Biotechnol Bioeng.* 2004;86:136–148.**

12. Nakashima N, Tamura T. Isolation and characterization of a rolling-circle-type plasmid

from *Rhodococcus erythropolis* and application of the plasmid to multiple-recombinant protein expression. *Appl Environ Microbiol.* 2004;70:5557–5568.





Photos of forms of Actinomycetes