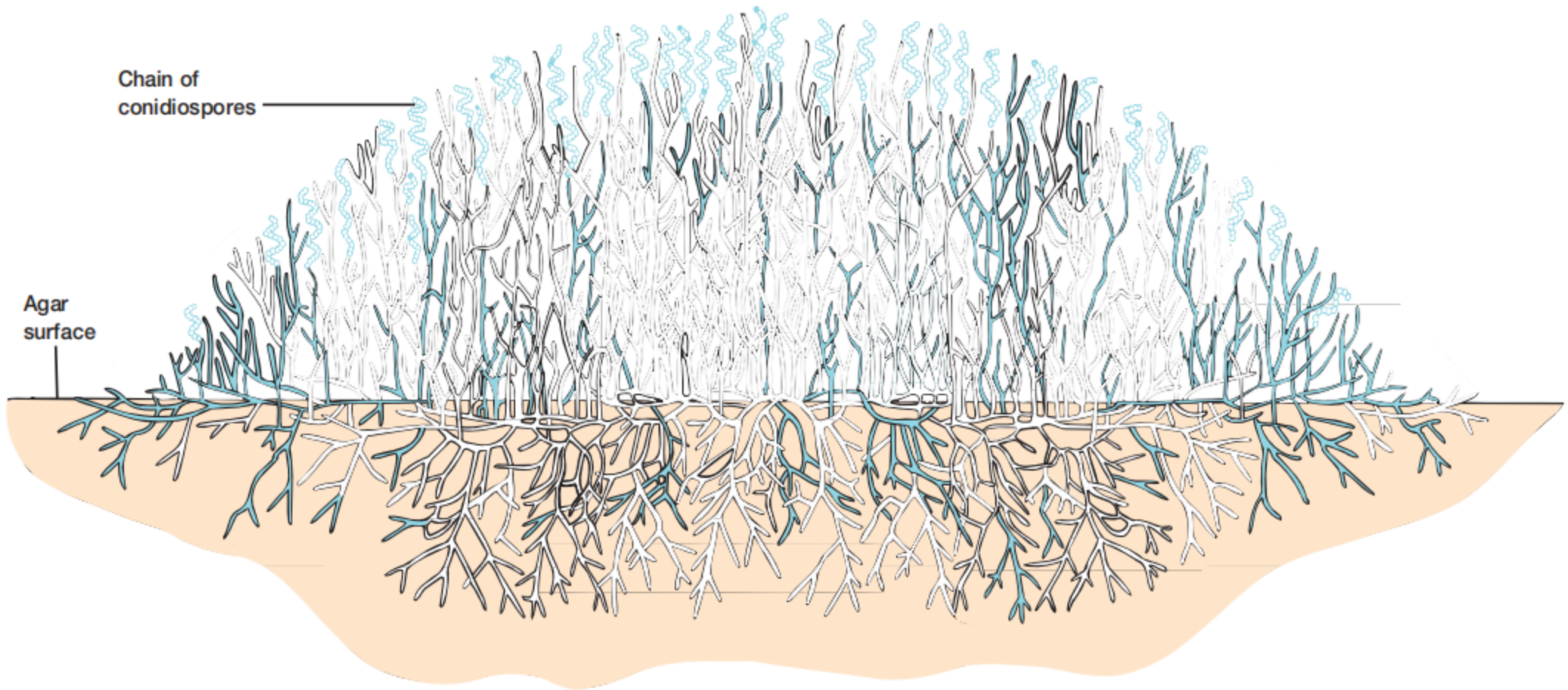
High G+C (Actinobacteria)

By- Dr. Ekta Khare

Actinomycetes

- The **actinomycetes** [s., actinomycete] are aerobic, gram-positive bacteria that form branching filaments or hyphae and asexual spores.
- Although they are a diverse group, the actinomycetes do share many properties.
- When growing on a solid substratum such as agar, the branching network of hyphae developed by actinomycetes grows both on the surface of the substratum and into it to form a substrate mycelium.
- Septa usually divide the hyphae into long cells (20 µm and longer) containing several nucleoids. Sometimes a tissuelike mass results and may be called a **thallus.**
- Many actinomycetes also have an aerial mycelium that extends above the substratum and forms asexual, thin-walled spores called **conidia** [s., conidium] or **conidiospores** on the ends of filaments.
- If the spores are located in a sporangium, they are called **sporangiospores.**
- The spores can vary greatly in shape.
- Actinomycete spores develop by septal formation at filament tips, usually in response to nutrient deprivation.


Chain of
conidiospores
Agar
surface

- Most are not particularly heat resistant but do withstand desiccation well and thus have considerable adaptive value.
- Most actinomycetes are not motile. When motility is present, it is confined to flagellated spores.
- Bergey’s manual uses 16S rRNA sequences to classify the high G+C gram positives, gram-positive bacteria with a DNA base composition above approximately 50 mol% G+C.

Suborder Corynebacterineae

- This suborder contains seven families with several well-known genera.
- Three of the most important genera are *Corynebacterium, Mycobacterium*, and *Nocardia.*
- The family Corynebacteriaceae contains one genus, *Corynebacterium,* which contains aerobic and facultative, catalase positive, straight to slightly curved rods, often with tapered ends.
- Club-shaped forms are also seen.
- The bacteria often remain partially attached after snapping division, resulting in angular arrangements of the cells, somewhat like Chinese letters, or a palisade arrangement in which rows of cells are lined up side by side (pleomorphic).
- Corynebacteria form metachromatic granules, and their walls have meso-diaminopimelic acid.
- Although some species are harmless oil and water saprophytes, many corynebacteria are plant or animal pathogens.
- For example, *C. diphtheriae* is the causative agent of diphtheria in humans.

Family Mycobacteriaceae

- The family *Mycobacteriaceae contains the genus Mycobacterium,* which is composed of slightly curved or straight rods that sometimes branch or form filaments**.**
- **Mycobacterial** filaments differ from those of actinomycetes in readily fragmenting into rods and coccoid bodies when distributed.
- They are aerobic and catalase positive.
- Mycobacteria grow very slowly and must be incubated for 2 to 40 days after inoculation of a solidified complex medium to form a visible colony.
- Their cell walls have a very high lipid content and contain waxes with 60 to 90 carbon **mycolic acids.**
- **These are complex fatty acids with** a hydroxyl group on the β-carbon and an aliphatic chain attached to the α-carbon.
- The presence of mycolic acids and other lipids outside the peptidoglycan layer makes mycobacteria **acid-fast** (basic fuchsin dye cannot be removed from the cell by acid alcohol treatment).

… Family Mycobacteriaceae

- Extraction of wall lipid with alkaline ethanol destroys acid-fastness.
- Although some mycobacteria are free-living saprophytes, they are best known as animal pathogens. *M. bovis* causes tuberculosis in cattle, other ruminants, and primates.
- Because this bacterium can produce tuberculosis in humans, dairy cattle are tested for the disease yearly; milk pasteurization kills the pathogen and affords further protection against disease transmission.
- Thus *M. tuberculosis* is the chief source of tuberculosis in humans.
- The other major mycobacterial human disease is leprosy, caused by *M. leprae.*

Family *Nocardiaceae*

- The family Nocardiaceae is composed of two genera, *Nocardia* and *Rhodococcus.*
- Because these and related genera resemble members of the genus *Nocardia (named after Edmond* Nocard [1850–1903], French bacteriologist and veterinary pathologist), they are collectively called **nocardioforms.**
- **These** bacteria develop a substrate mycelium that readily breaks into rods and coccoid elements**.**
- **Several genera also** form an aerial mycelium that rises above the substratum and may produce conidia.
- All genera have a high G + C content like other actinomycetes, and almost all are strict aerobes.
- Most species have peptidoclycan with meso-diaminopimelic acid and no peptide interbridge.
- The wall usually contains a carbohydrate composed of arabinose and galactose; mycolic acids are present in *Nocardia and Rhodococcus.*
- *Nocardia* is distributed worldwide in soil and also is found in aquatic habitats.
- Nocardiae are involved in the degradation of hydrocarbons and waxes and can contribute to the biodeterioration of rubber joints in water and sewage pipes.
- Although most are free-living saprophytes, some species, particularly *N. asteroides,* are opportunistic pathogens that cause nocardiosis in humans and other animals.

Suborder Propionibacterineae

- This suborder contains two families and 10 genera.
- The genus *Propionibacterium* will be placed in the family Propionibacteriaceae.
- The genus contains pleomorphic, nonmotile, nonsporing rods that are often club-shaped with one end tapered and the other end rounded.
- Cells also may be coccoid or even branched.
- They can be single, in short chains, or in clumps.
- The genus is facultatively anaerobic or aerotolerant; lactate and sugars are fermented to produce large quantities of propionic and acetic acids, and often carbon dioxide.
- *Propionibacterium* is usually catalase positive.
- The genus is found growing on the skin and in the digestive tract of animals, and in dairy products such as cheese.
- *Propionibacterium* contributes substantially to the production of Swiss cheese.
- *P. acnes* is involved with the development of body odor and acne vulgaris.

Suborder Streptomycineae

- The suborder Streptomycineae has only one family, Streptomycetaceae, and three genera, the most important of which is *Streptomyces.*
- *Streptomyces* is an enormous genus; there are around 500 species.
- Members of the genus are strict aerobes, are wall type I (L,L-diaminopimelic acid, Glycine interbridge), and form chains of nonmotile spores within a thin, fibrous sheath (figure 24.14).
- The 03 to many conidia in each chain are often pigmented and can be smooth, hairy, or spiny in texture.
- *Streptomyces* species are determined by means of a mixture of morphological and physiological characteristics, including the following:
  - the color of the aerial and substrate mycelia,
  - spore arrangement,
  - surface features of individual spores,
  - carbohydrate use,
  - Antibiotic production,
  - melanin synthesis,
  - nitrate reduction, and
  - the hydrolysis of urea and hippuric acid.

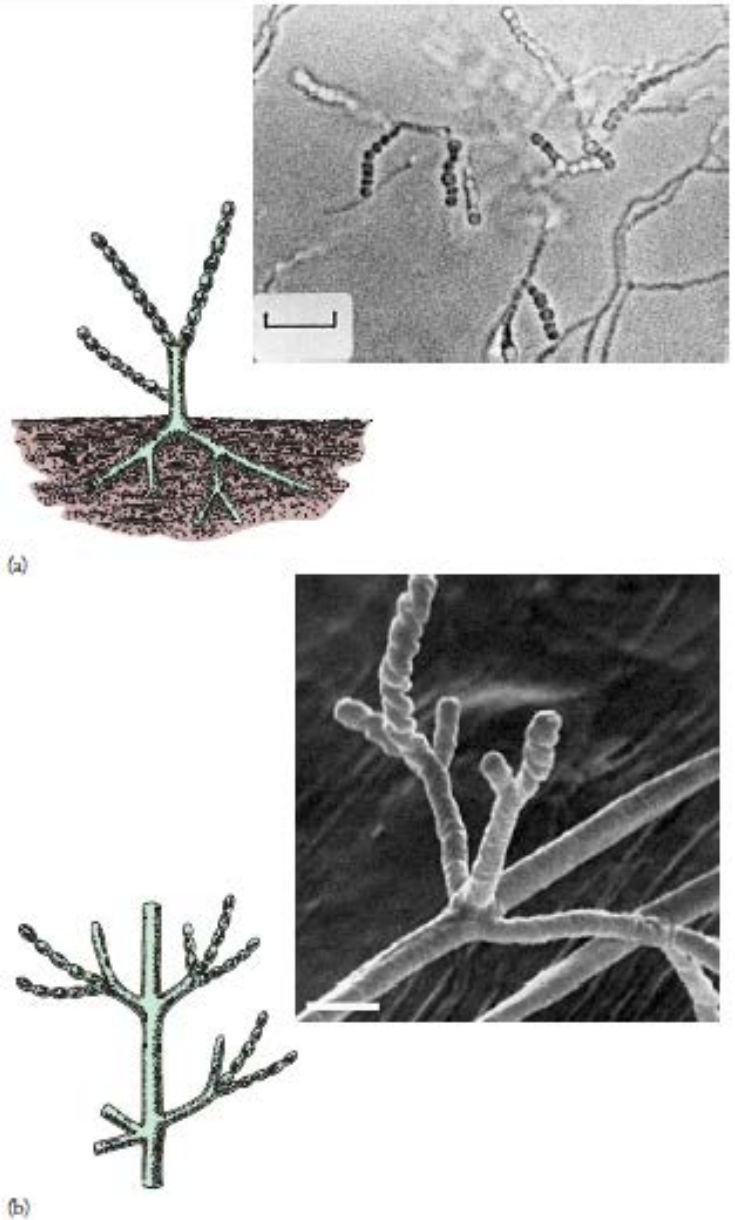


Figure 24.13 ***Streptomyces*** **and Related Genera.** Streptomycete conidia arrangement. (**a**) An illustration of typical *Streptomyces* morphology; a light micrograph of *S. carpinesis* spore chains. Bar = 5 μm. (**b**) *Streptoverticillium* (*Streptomyces*) morphology; a scanning electron micrograph of *Sv. salmonis* with developing spore chains. Bar = 2 μm.

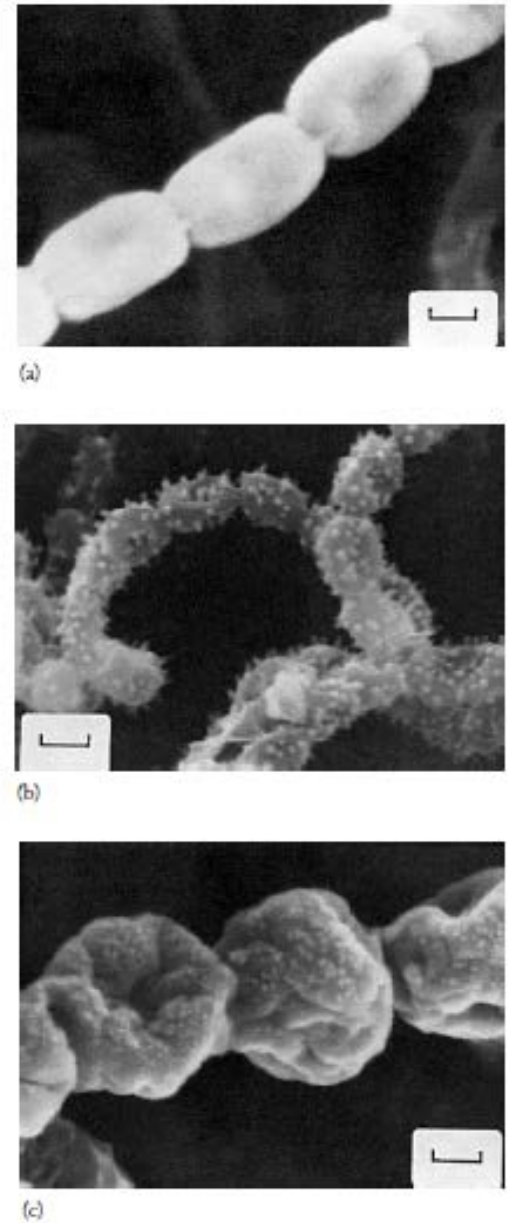
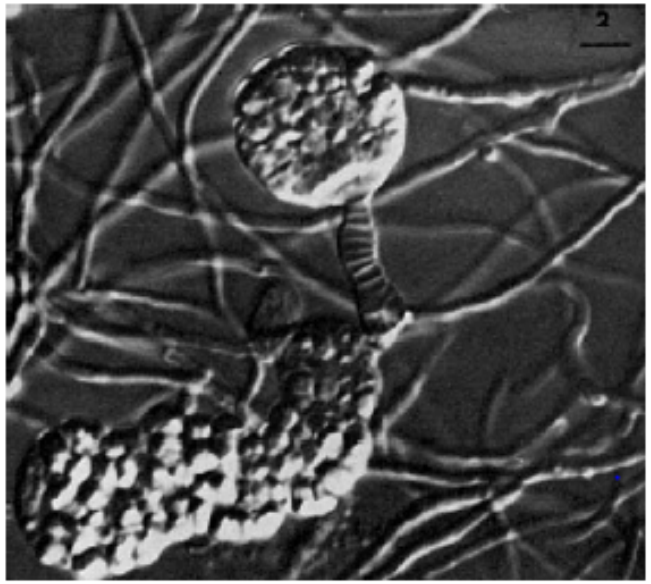


Figure 24.14 **Streptomycete Spores.** (**a**) Smooth spores of *S. niveus;* scanning electron micrograph. Bar = 0.25 μm. (**b**) Spiney spores of *S. viridochromogenes.* Bar = 0.5 μm. (**c**) Warty spores of *S. pulcher.* Bar = 0.25 μm.

- The natural habitat of most streptomycetes is the soil, where they may constitute from 1 to 20% of the culturable population.
- In fact, the odor of moist earth is largely the result of streptomycete production of volatile substances such as **geosmin.**
- Streptomycetes play a major role in mineralization.
- They are flexible nutritionally and can aerobically degrade resistant substances such as pectin, lignin, chitin, keratin, latex, and aromatic compounds.
- Streptomycetes are best known for their synthesis of a vast array of antibiotics, some of which are useful in medicine and biological research.
- Examples include amphotericin B, chloramphenicol, erythromycin, neomycin, nystatin, streptomycin.

Suborder *Frankineae*

- Frankia form clusters of spores when a hypha divides both transversely and longitudinally.
- They have type III cell walls (Meso-Diaminopimelic acid, with no glycine interbridge) sugar patterns differ.
- The G+C content varies from 57 to 75 mol%.
- *Frankia* forms nonmotile sporangiospores in a sporogenous body.
- It grows in symbiotic association with the roots of at least eight families of higher nonleguminous plants (e.g., alder trees) and is a microaerophile able to fix atmospheric nitrogen.
- The roots of infected plants develop nodules that fix nitrogen so efficiently that a plant such as an alder can grow in the absence of combined nitrogen when nodulated.
- Within the nodule cells, *Frankia* forms branching hyphae with globular vesicles at their ends.
- These vesicles may be the sites of nitrogen fixation.



An interference contrast micrograph showing hyphae, multilocular sporangia, and spores.

Order Bifidobacteriales

- The order Bifidobacteriales has one true family, Bifidobacteriaceae, and eight genera.
- *Bifidobacterium* probably is the best-studied genus.
- *Bifidobacteria* are nonmotile, nonsporing, gram-positive rods of varied shapes that are slightly curved and clubbed; often they are branched**.**
- **The rods can be single or in clusters and V-shaped** pairs.
- *Bifidobacterium* is anaerobic and actively ferments carbohydrates to produce acetic and lactic acids, but no carbon dioxide.
- It is found in the mouth and intestinal tract of warm-blooded vertebrates, in sewage, and in insects.
- *B. bifidus* is a pioneer colonizer of the human intestinal tract, particularly when babies are breast fed.
- A few *Bifidobacterium* infections have been reported in humans, but the genus does not appear to be a major cause of disease.