# **Aerobic Actinomycetes (Nocardia and Relatives)**

This group includes **filamentous branching Gram-positive rods** that are aerobic.

Key genera: **Nocardia**, **Rhodococcus**, **Gordonia**, **Tsukamurella**, **Streptomyces**, **Actinomadura**, **Trophyerma** etc.

They are soil-associated organisms that can cause chronic infections (e.g. nocardiosis, mycetoma) especially in immunocompromised patients. They somewhat resemble fungi (forming branching filaments), but are bacteria.

**Nocardia** species:

* 100 species
* **Strict aerobes**
* **catalase positive**.
* Filamentous, branching rods that often fragment into bacillary or coccoid forms. On Gram stain they appear as branching Gram-positive filaments. May be irregularly stained
* many species are **partially acid-fast** (weakly positive on a modified Kinyoun acid-fast stain with 1% sulfuric acid decolorizer)
* Aerial hyphae are **almost always produced**
* Colonies are slow-growing, often chalky, matte, or velvety, with white to orange pigmentation;
* Modified Thayer-Martin medium or buffered charcoal-yeast extract agar may enhance recovery
* some Nocardia colonies have a distinct **earthy odor**.
* *Nocardia* in sputum may be coloniser or contamination
* *Nocardia asteroides* complex causes pulmonary nocardiosis, (also separated into N. farcinica and N. nova)
* *Nocardia brasiliensis* causes cutaneous mycetomas.
* Traditional identification includes substrate hydrolysis tests: e.g., casein, xanthine, and tyrosine hydrolysis – *N. brasiliensis* hydrolyzes casein and tyrosine but not xanthine, whereas *N. asteroides* generally does not hydrolyze these. However these tests find it difficult to distingtui N. asteroides from non pathogenic Nocardia, or related genera like Mycobacterium and Rhodococcus.

**Streptomyces**:

* 600 species
* Also catalase-positive branching filamentous rods, but **non-acid-fast** (lacks mycolic acid but contains L-DAP)
* Colonies often have a **“fresh soil” odor** and may produce aerial hyphae and conidiaspores (giving a fuzzy appearance).
* They can produce various pigmentations.
* *Streptomyces* rarely cause human disease, but some species can cause actinomycetoma (e.g. *S. somaliensis*). Differentiation from Nocardia: *Streptomyces* are typically **acid-fast negative** and often **non-pathogenic**;
* they may be catalase positive or negative depending on species.
* They hydrolyze casein, xanthine, tyrosine in various patterns that differ from Nocardia.
* *S. somaliensis* and *S. sudanensis* are associated with infections such as mycetoma.

**Rhodococcus (e.g. R. equi):**

* 50 species
* Cocci to short rods that may show a diphtheroid arrangement and can be misidentified as *Corynebacterium* on first glance.
* Pale pink/coral/yellow and may be slimy or non slimy on BHI agar
* Does not form aerial hyphae
* *Rhodococcus equi* is known to cause pneumonia and cutaneous disease in AIDS patients (and foals, in veterinary context).
* Colonies are often **salmon-pink** after a few days.
* They are **weakly acid-fast** (especially in younger cultures)
* **catalase positive**.
* *Rhodococcus* is urease positive and can be identified by biochemical panels or MALDI. The transition from coccoid to rod forms in culture is a clue (hence “diptheroid-like”).
* Inability to ferment carbohydratedistinguishes from *Corynebacteria*

**Gordonia and Tsukamurella:** These are other **aerobic actinomycetes** that are **partially acid-fast** and resemble *Rhodococcus/Corynebacterium*. They are rarely encountered, often as contaminants or in immunocompromised hosts. catalase positive. Differentiation between them is beyond the scope of most exams, but just know they exist as Nocardia relatives.

**Actinomadura madurae** and **Actinomadura pelletieria:**

**Dietzia** is another genus (acid-fast positive rods) occasionally seen.

**Identification Approach:**

* **Acid-Fast Stain (Modified Kinyoun):** Take a filamentous Gram-positive isolate and perform a modified acid-fast stain. **Positive (red filaments)** suggests *Nocardia* or related (Rhodococcus, Gordonia, Tsukamurella are often partially acid-fast as well); **negative** suggests *Streptomyces* or other actinomycete.
* **Colony Morphology & Growth:** Nocardia grows on routine media in 2–7 days, often producing chalky, pigmented colonies. *Streptomyces* often take longer and may form aerial hyphae. *Rhodococcus* forms smooth or mucoid colonies that turn salmon-pink.
* **Lysozyme Resistance:** *Nocardia* can grow in broth with lysozyme (thus “lysozyme resistant”), whereas

*Streptomyces* is usually inhibited (lysozyme sensitive). This classic test can differentiate Nocardia vs Streptomyces.

* **Urease:** Many Nocardia (including *N. asteroides* complex) are **urease positive**. *Rhodococcus equi* is also urease positive.
* **Sugar utilization and decomposition tests:** Historically used but not commonly needed in a general exam context. For example, *Nocardia cyriacigeorgica* vs *N. farcinica* differences, etc., are too detailed unless specifically asked.
* **Modern methods:** In the lab, once partial acid-fast filamentous bacteria are seen, they often presumptively call it Nocardia and send for confirmation or MALDI. MALDI-TOF can usually speciate Nocardia and others reliably.

**Key Points for Exams:**

* Nocardia = aerobic, filamentous, partially acid-fast, causes chronic lung infections and brain abscesses in immunosuppressed (treatable with sulfonamides).
* Streptomyces = looks similar but not acid-fast, usually non-pathogenic except mycetoma.
* Rhodococcus = salmon-pink colonies, acid-fast coccobacilli, associated with AIDS patients (causes pneumonia similar to TB).
* If given a case of a patient with cavitary pneumonia and brain lesions and a lab finding of branching Grampositive rods that are weakly acid-fast, *Nocardia* is the answer.

# **Actinomyces Species (Anaerobic Branching Gram-Positive Rods)**

**Characteristics:** *Actinomyces* are **anaerobic (or microaerophilic) Gram-positive rods** that can form branching filaments, though generally shorter and less filamentous than Nocardia.

* The primary pathogen is *Actinomyces israelii*, which causes **actinomycosis >** classically, cervicofacial “lumpy jaw” infections with draining sinus tracts and **sulfur granules** in the exudate
* **non-sporeforming** and **non-acid-fast**.
* Other species include *A. gerencseriae, A. odontolyticus, A. turicensis*, etc., often part of normal oral/GI flora.

**Identification Highlights:**

* **Colony Morphology:** After 1–2 weeks anaerobic incubation, *A. israelii* forms characteristic **molar tooth colonies** on blood agar – small, heaped, and opaque white/yellow with a “tooth-like” surface. The colonies are very dense/hard.
* **Gram Stain:** Shows tangled masses of filamentous rods
* In pus, *Actinomyces* forms **sulfur granules** (clumps of organisms that appear as yellowish granules). Crushing a sulfur granule and Gram-staining it reveals a radiating network of Grampositive filaments (often with clubs at the end due to protein-polysaccharide coating).
* **Biochemical**
  + **Catalase:** Actinomyces are **catalase negative** (helps differentiate from Nocardia which is catalase positive).
  + **Indole** and **Urease:** Variable by species (not a primary ID method).
  + **Nitrate reduction:** *Actinomyces israelii* reduces nitrates (nitrite positive).

**Other anaerobic rods in the differential:** *Propionibacterium* (now *Cutibacterium*) species are anaerobic diphtheroid-like rods that can also form branches. *Cutibacterium acnes* (formerly *Propionibacterium acnes*) is catalase positive and indole positive, distinguishing it from Actinomyces (catalase neg). Also, *Cutibacterium propionicum* can cause an actinomycetoma-like infection; it’s catalase positive and has different sugar fermentations.

**Confirmatory ID:**

* Actinomyces often require prolonged incubation.
* Definitive identification to species may rely on biochemical panels or 16S rRNA sequencing, especially because multiple Actinomyces species can cause similar infections.
* In exam settings, recognizing the **sulfur granule** and **molar tooth colony** clues is usually enough to identify *Actinomyces*.

**Summary:** If you have an **anaerobic, branching Gram-positive rod that is not acid-fast**, think *Actinomyces*. The clinical picture of chronic jaw/facial abscess with sinus tracts yielding yellow granules is classic. Treatment is prolonged penicillin, so lab identification is important for proper management.