Pharmaceutical Microbiology

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Of

Immunology And Microbiology

Course outlines of pharmaceutical microbiology and parasitology .

- Dr. Mohammad Hussein Taleb
- Marks distribution:
  - Quizez 30%. ..... Midterm exams 30%..... , Final exam ..... 40 %
  - Textbook : Essentials of Medical Microbiology .. Fourth Edition Rajesh Bhatia
  - Email.....

- Week 1 Chapter1. Introduction to microbiology (General Bacteriology)
- Week2. Chapter2. Pathogenesis of Bacterial Infection
- Week3 Chapter 3.Classification of bacteria
- Week4 and Week5 Chapter4 and Chapter 5. G-positive cocci bacteria (staphyllococci and Streptococci
- Week 6 Chapter 6. G-negative cocci bacteria

- Week7 Chapter 7. Gram-Positive Bacilli: Aerobic Non–Spore-Forming
- Week 8 Chapter 7. Gram-Positive Bacilli: Aerobic Non–Spore-Forming
- Week 9Chapter 8. Gram-negative Bacilli
- Week 10 Chapter 9. General Mycology (Fungi as Human Pathogens)
- Week 11 & week 12 Chapter 10 . Major subjects in Parasitology
- Week 13 Chapter 11 General Virology (Viruses as Human Pathogens)
- Week 14. Chapter 12 . General Aspects in Immunology

Instructions for 95%

أهم عوامل التفوق الدراسي

1. التفوق في الدراسات السابقة في المراحل السابقة .
2. التفرغ للدراسة .
3. الإلتحاق بالتخصص عن رغبة أكيدة .
4. المذاكرة من بداية العام الدراسي .
5. زيادة عدد ساعات المذاكرة اليومية .
6. تشجيع الأسرة على الدراسة وعلى وجه خاص تشجيع الوالدين .
7. تشجيع الأساتذة على الدراسة والمذاكرة والتفوق .
8. تشجيع المدارس والكليات على التفوق .
9. التشجيع على المنافسة في التفوق بين الطلاب على مستوى المدارس والجامعات.
10. توجيه الميول إلى الدراسات المناسبة .
11. إستخدام القيم الموجهة لإثارة الهمم العالية وتحفيزها .
12. إتخاذ الأهداف العليا من التعلم مثل خدمة الدين والأمة .
13. تخصيص أماكن خاصة ومناسبة للدراسة والسكن سواء في نطاق الأسرة أو المدرسة والجامعة .

Chapter 1

Week 1

Fundamentals

Of

Microbiology

Introduction

- **Microbiology** is the study of microorganisms, **a large and diverse group of microscopic organisms** that exist as **single cells** or **cell clusters**; it also **includes viruses**, which **are microscopic but not cellular.**
- They are **responsible for cycling the chemical elements essential for life**, including **carbon, oxygen, nitrogen, sulfur, and hydrogen**; **more photosynthesis is carried out by microorganisms than by green plants.**

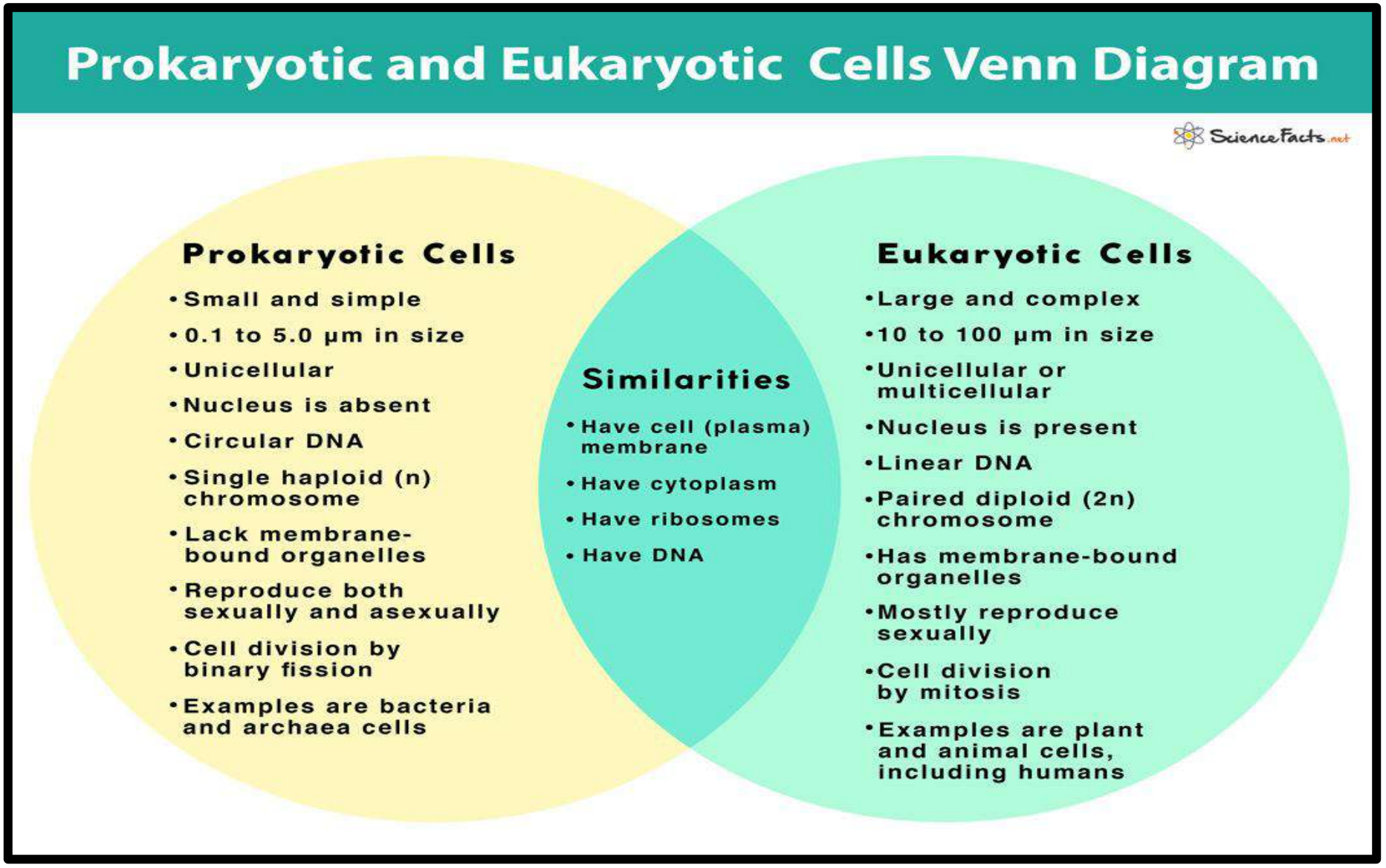
- In fact, **Robert Koch** bagged the most prestigious **Nobel prize in the year 1905** for his spectacular and wonderful discovery for the isolation and characterization of the *bacteria* that cause **anthrax***** and **tuberculosis.******

Scope of microbiology

Microbial world

- **Scope of medical microbiology:**
  - Bacteriology → Bacteria
  - Mycology → Fungi
  - Parasitology → Parasites (protozoons and helminths)
  - Virology → Viruses
  - Immunology → Immune system

Comparison between Prokaryotic and Eukaryotic cells



General information

About

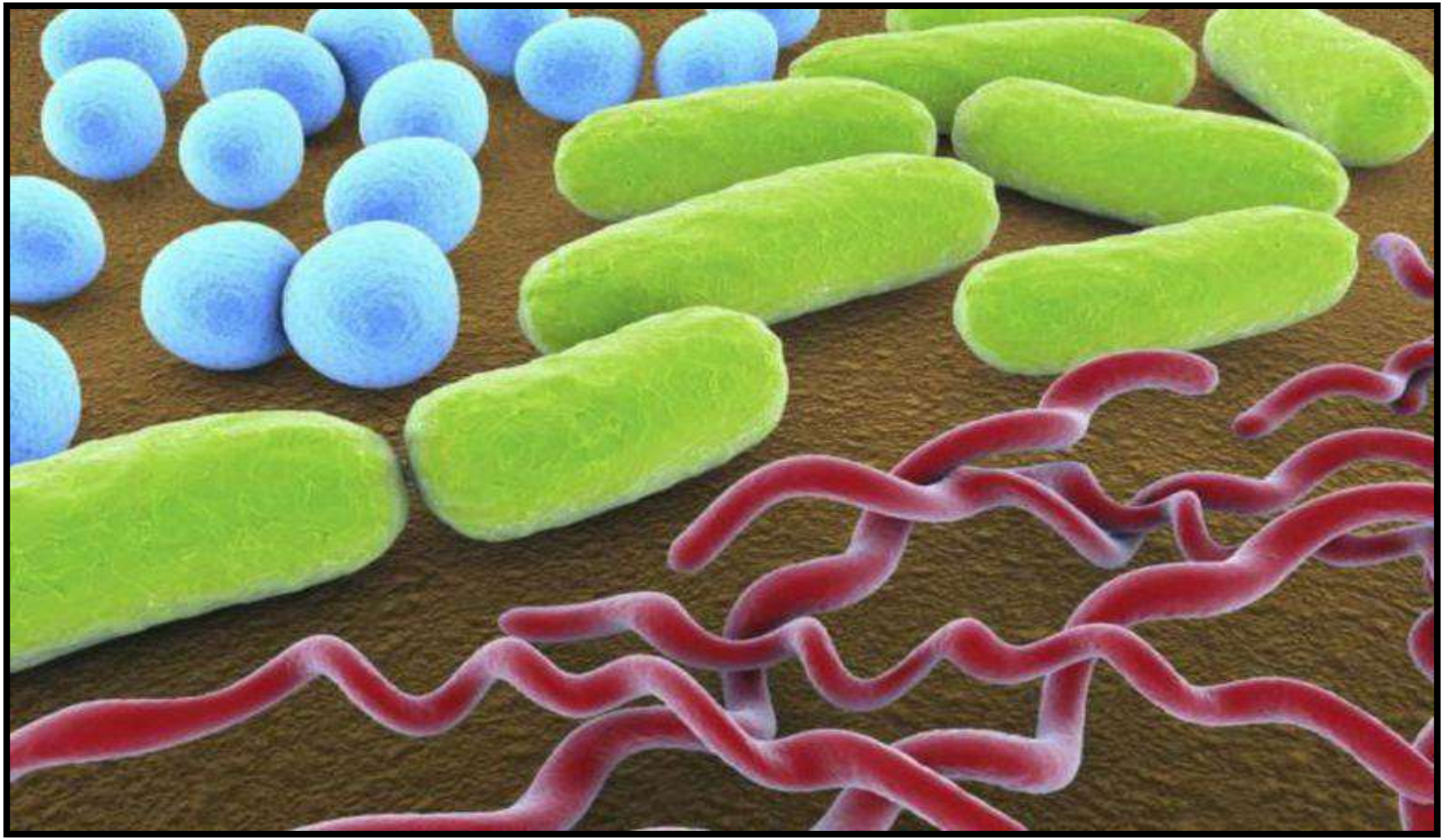
bacteria

Bacteria infection types

Bacteria

- Bacteria; common noun bacteria, singular bacterium) are ubiquitous, **mostly free-living organisms often consisting of one biological cell.**
- They constitute a **large domain of prokaryotic microorganisms.**
- **Typically a few micrometres in length, bacteria were among the first life forms to appear on Earth, and are present in most of its habitats.**

Bacterial forms



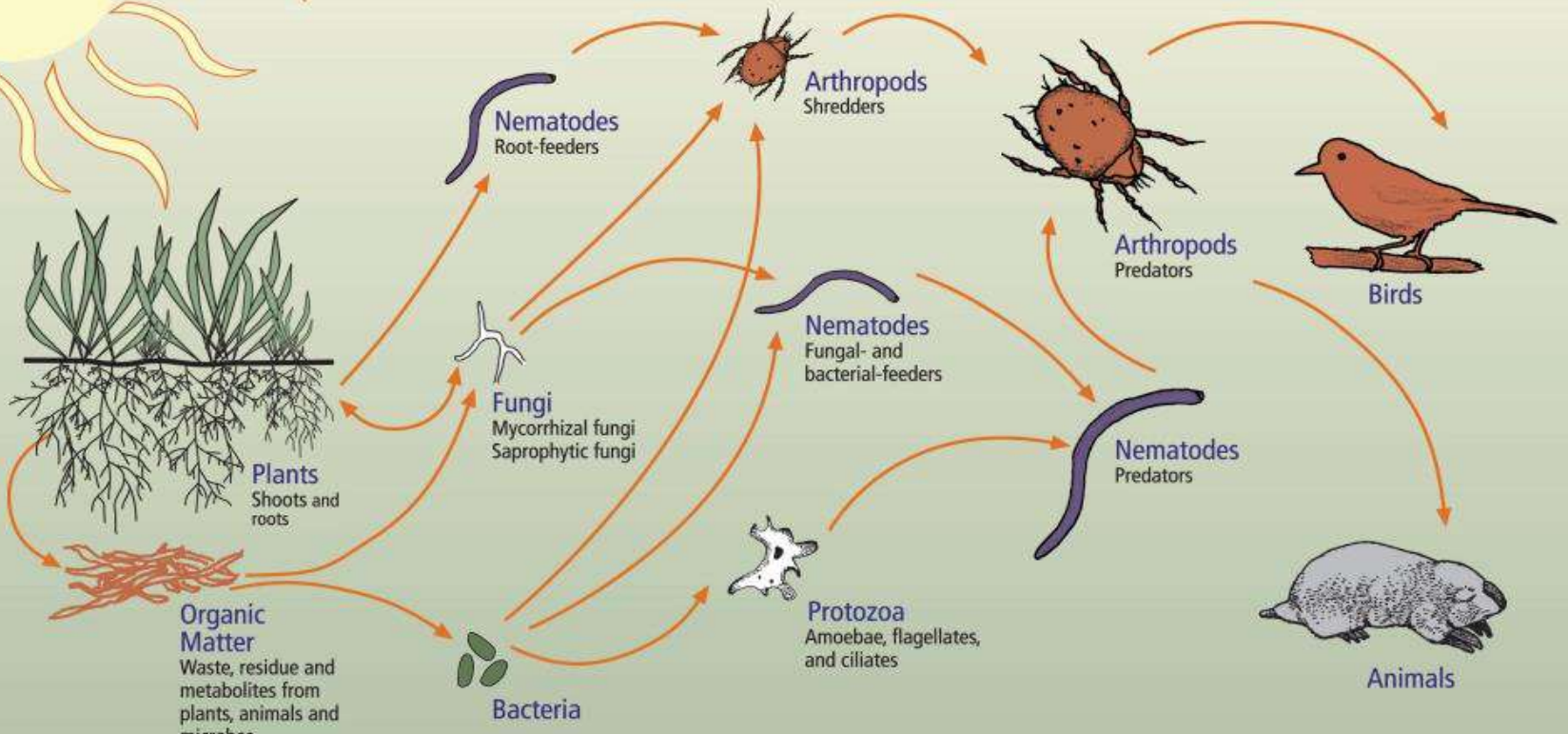
Bacteria

- Bacteria inhabit soil, water, acidic hot springs, radioactive waste, and the deep biosphere of Earth's crust.
- Bacteria are vital in many stages of the nutrient cycle by recycling nutrients such as the fixation of nitrogen from the atmosphere.
- The **nutrient cycle includes the decomposition of dead bodies**; **bacteria are responsible for the putrefaction stage in this process.**

- **There are typically 40 million bacterial** cells in a gram of soil and a million bacterial cells in a milliliter of fresh water.
- There are approximately 5×10^{30} bacteria on Earth, forming a **biomass which exceeds that of all plants and animals.**

- There are **approximately 39 trillion bacterial cells in the human microbiota as personified by a "reference" 70 kg male 170 cm tall.**
- The largest number exist in the gut flora, and a large number on the skin.
- The **vast majority of the bacteria in the body are rendered harmless** by the protective effects of the immune system, though many are beneficial, **particularly in the gut flora**.

The Soil Food Web



First trophic level:
Photosynthesizers

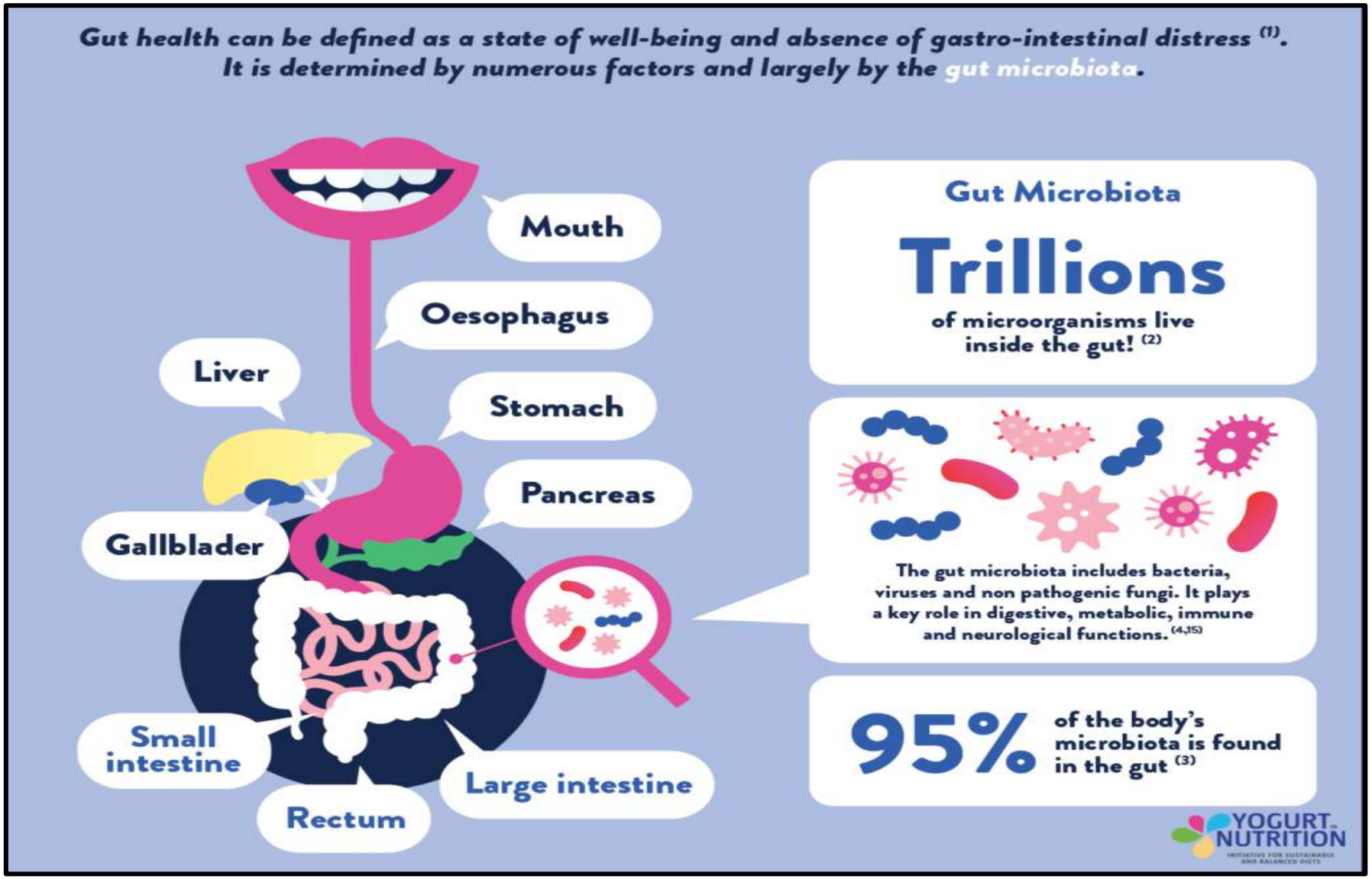
Second trophic level:
Decomposers
Mutualists
Pathogens, Parasites
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Higher level predators

Fifth and higher trophic levels:
Higher level predators

Gut microbiota



- However, **several species of bacteria are pathogenic and cause infectious diseases, including cholera, syphilis, anthrax, leprosy, and bubonic plague. The most common fatal bacterial diseases are respiratory infections, with tuberculosis alone killing about 2 million people per year, mostly in sub-Saharan Africa.**

- In developed countries, antibiotics are used to treat bacterial infections and are also used in farming, making antibiotic resistance a growing problem.
- In industry, bacteria are important in sewage treatment and the breakdown of oil spills, the production of cheese and yogurt through fermentation, the recovery of gold, palladium, copper and other metals in the mining sector, as well as in biotechnology, and the manufacture of antibiotics and other chemicals.

Taxonomy of bacteria

- **Taxonomic ranks** form the basis for the organization of bacteria. **Linnaean taxonomy** is the system most familiar to biologists. It uses the formal taxonomic ranks of **kingdom, phylum, class, order, family, genus, and species.**

Taxonomic ranks Formal rank example

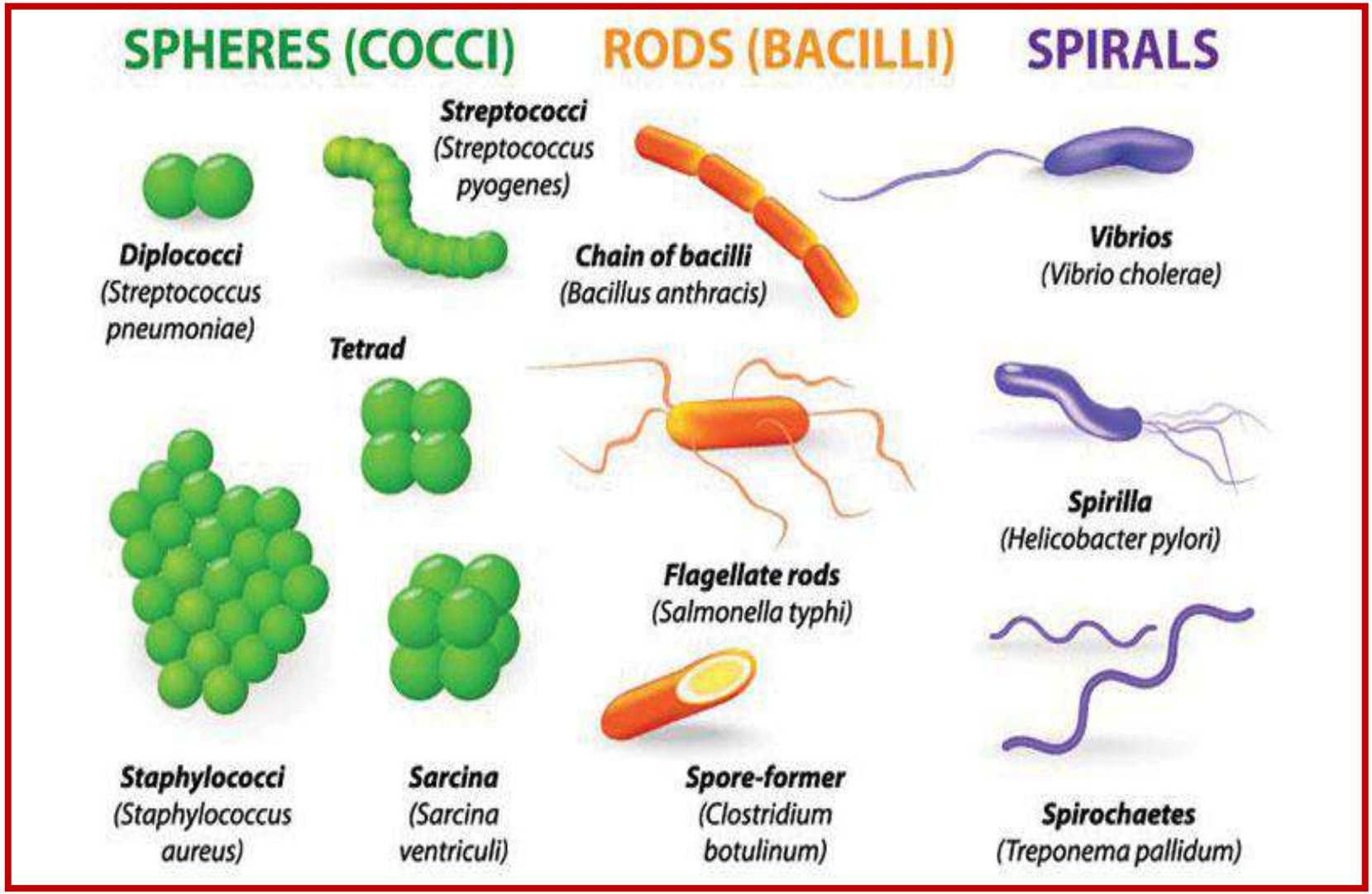
- **Kingdom**: Prokaryotae
- **Division**: Gracilicutes
- **Class:** Scotobacteria
- **Order:** Eubacteriales
- **Family:** Enterobacteriaceae
- **Genus:***Escherichia*
- **Species:** *coli*
- **Subtype:** *Escherichia coli* O157: H7

Classification of bacteria

- Classification of bacteria depends on

1. Shape
2. Oxygen demand
3. Resistance of temprature
4. Gram staining
5. Growth on different media
6. Biochemical tests
7. Immunological tests

1-Shapes of bacteria



2-Based on Oxygen demand

Classification of bacteria based on Oxygen requirement:

Based on Oxygen requirement, bacteria may be classified as:

- **Obligate aerobes:** they require O_2 for growth. They use O_2 as a final electron acceptor in aerobic respiration.

- **Obligate anaerobes** : they do not need or use O_2 . In fact, O_2 is a toxic substance for them, which either kills or inhibits their growth.

- **Facultative anaerobes** : these are bacteria that can switch between aerobic and anaerobic types of metabolism.
  - Under anaerobic conditions, they generate energy mainly by fermentation .
  - In the presence of O_2 they switch to aerobic respiration.

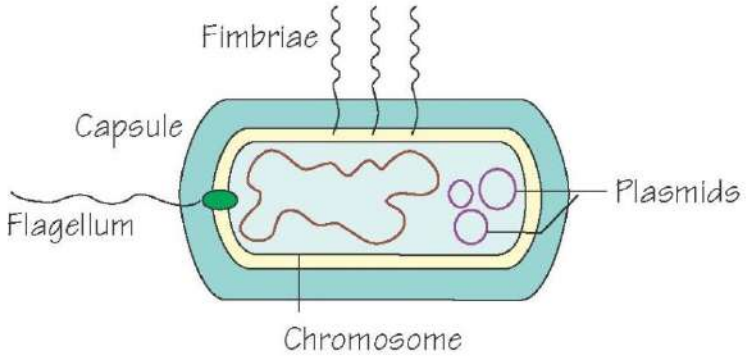
- **Aerotolerant anaerobes:** these are bacteria that are exclusively anaerobic (fermentative). However, they are insensitive (not killed) to the presence of O_2. They live by fermentation alone whether or not O_2 is present in their environment

- **Microaerophilic**: these bacteria need O2 in low concentration

3-On the bases of temprature

ON THE BASIS OF TEMPERATURE

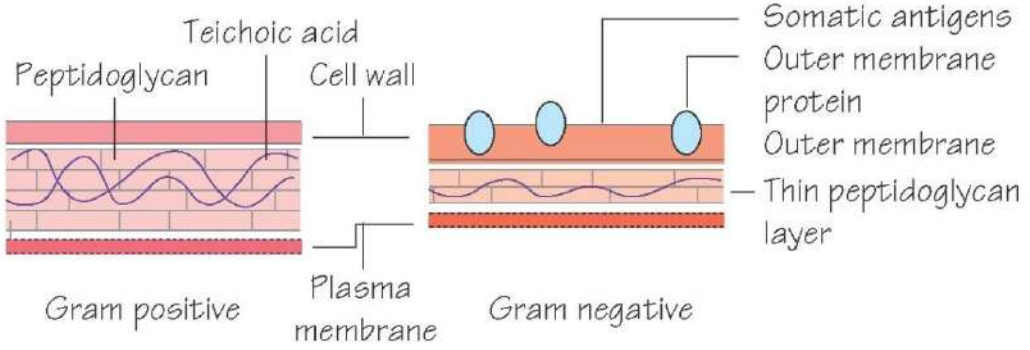
- **Psychrophiles** e.g Bacillus psychrophilus
- **Psychrotrophs** e.g Listeria monocytogenes
- **Mesophiles** e.g E.coli
- **Thermophiles** e.g Bacillus stearothermophiles
- **Hyperthermophiles** e.g Sulpholobus



Bacterial classification

Shape
- Cocci
- Spiral
- Bacilli

Cocci are spherical; bacilli are long and thin, with coccobacilli in between; and there are also curved and spiral bacilli with different wavelengths



Gram reaction

Growth

Atmosphere
- Obligate aerobes → Require oxygen
- Microaerophiles → Require reduced oxygen
- Obligate anaerobes → Require no oxygen
- Facultative anaerobes → Anaerobic or aerobic
- Capnophiles → Require increased CO_2

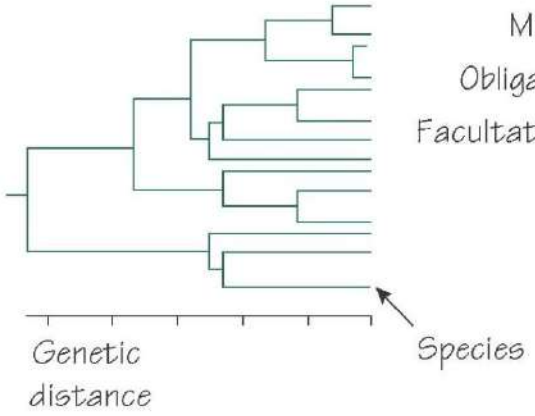
Spores → Endospore

Present on *Clostridium* and *Bacillus* spp.

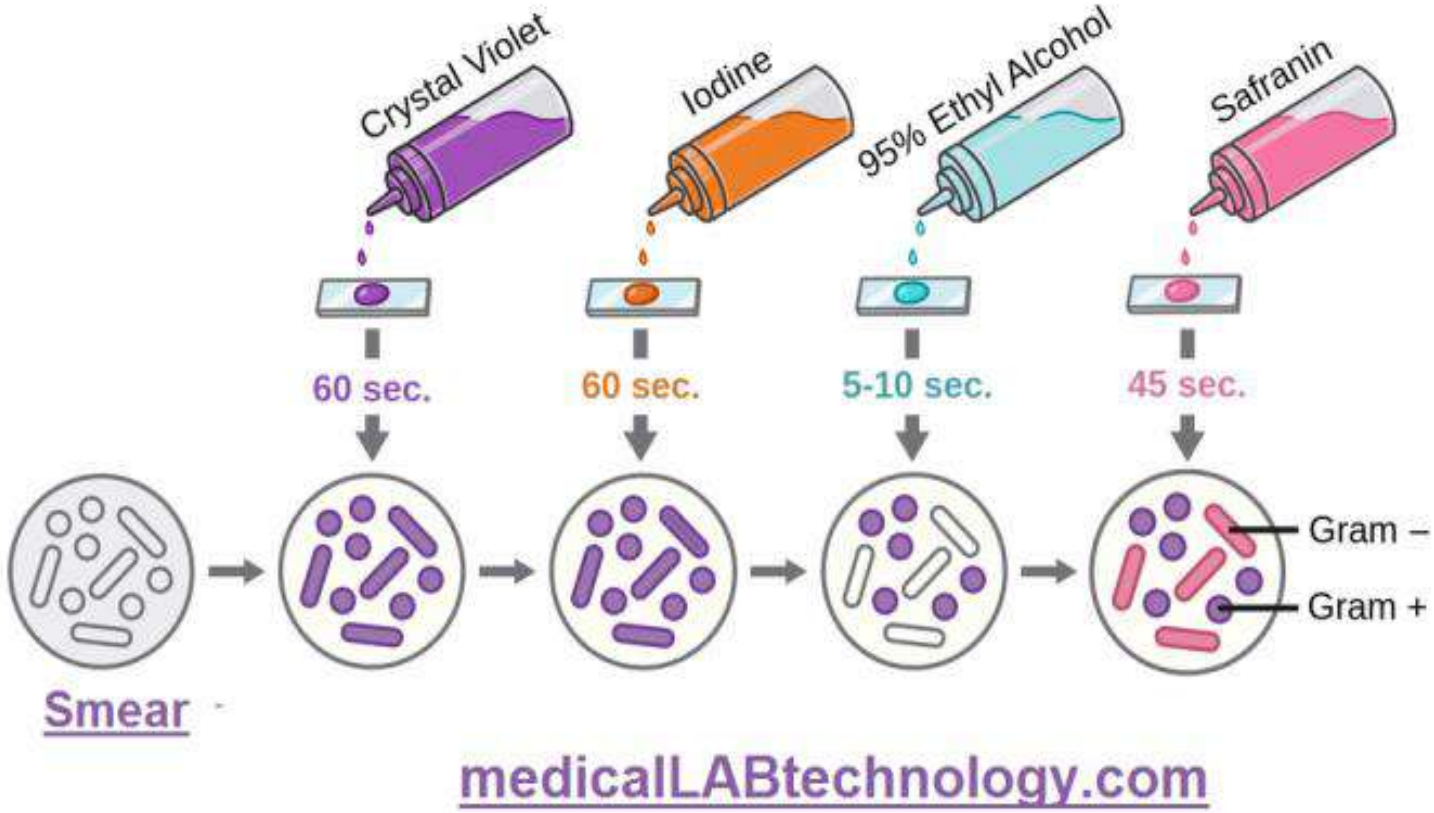
Biochemistry, Genetic classification → Batteries of reactions are needed for species identification

Serology typing

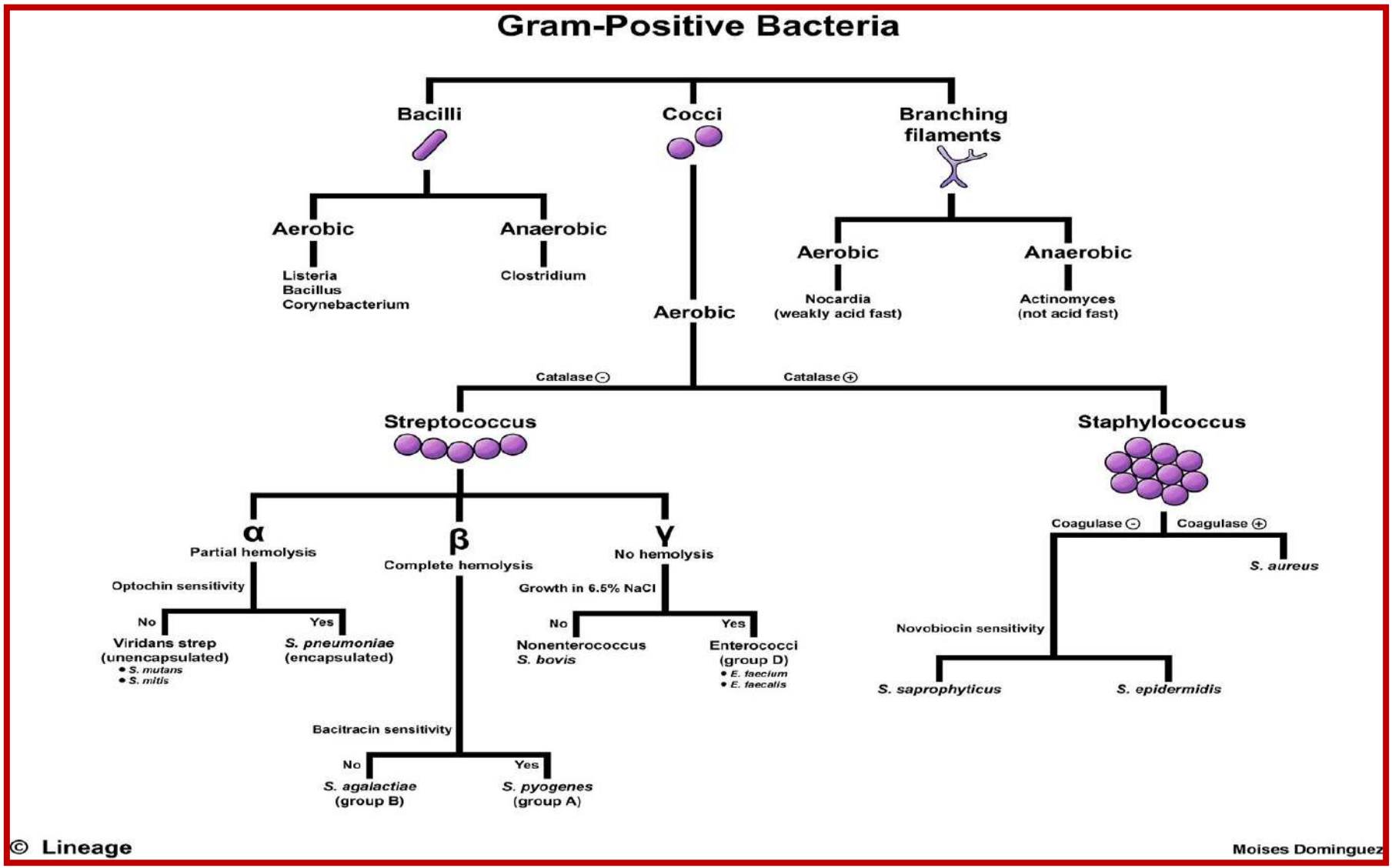
Genetic classification

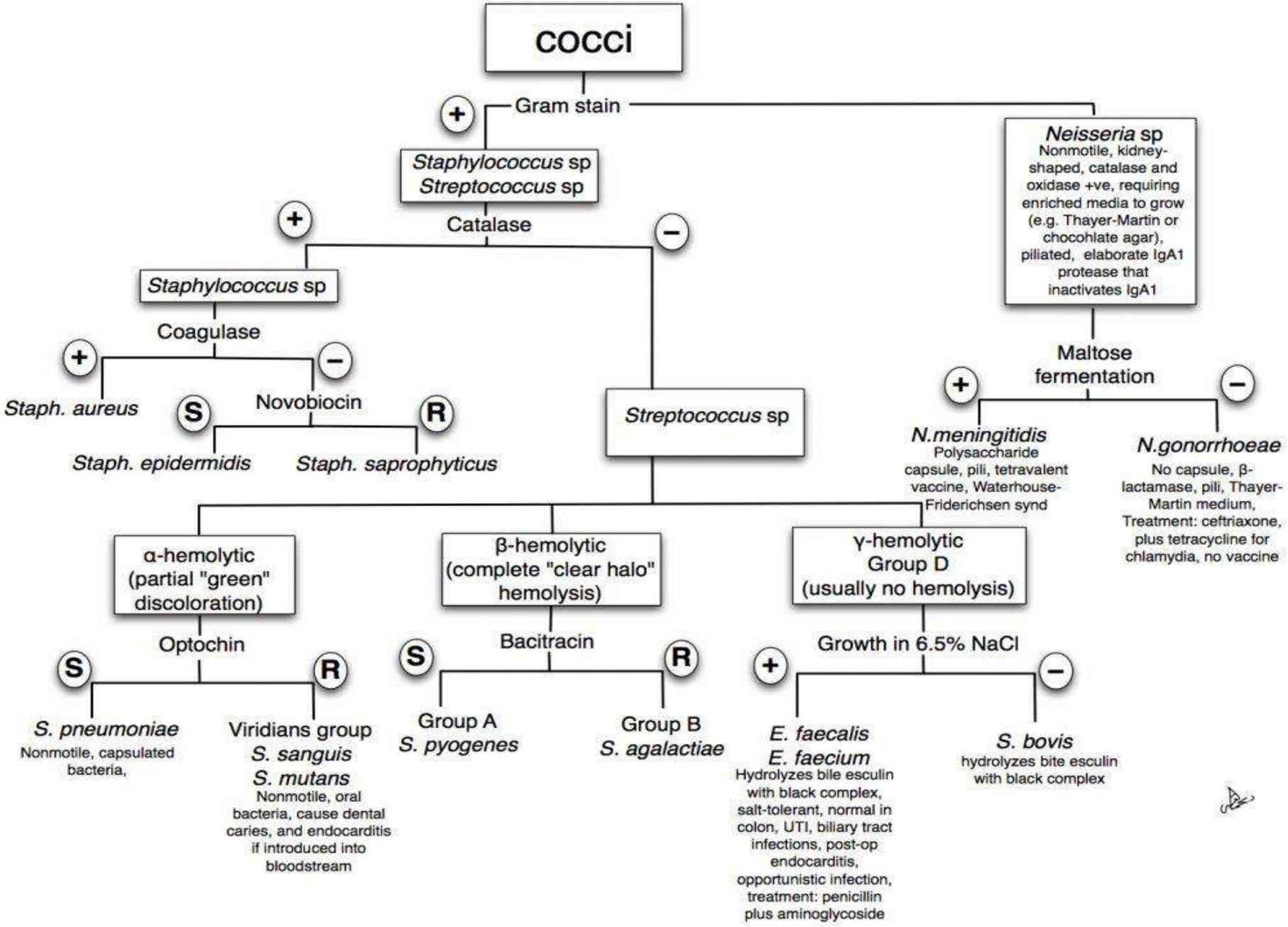


4-On the bases of Gram staining

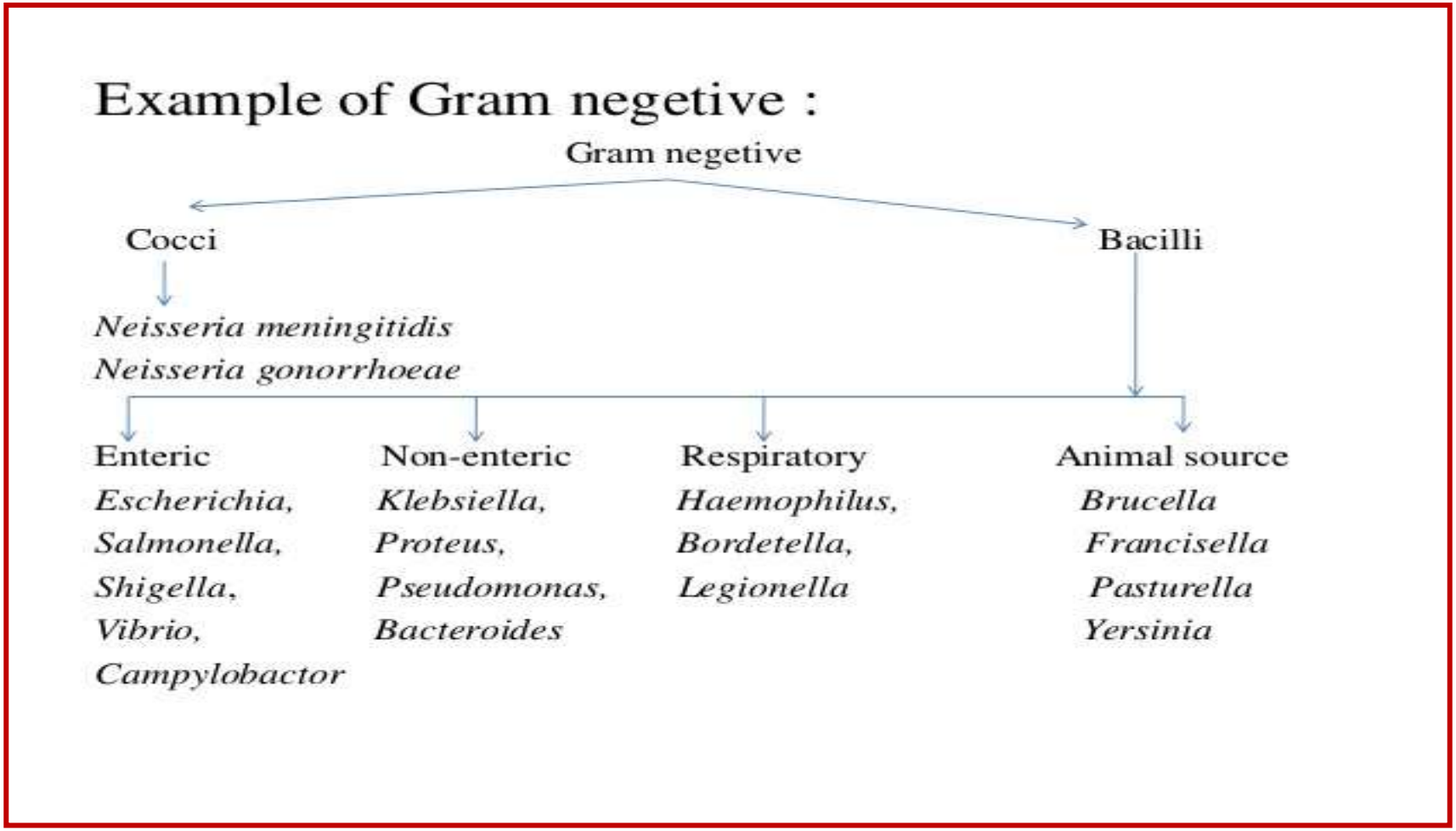


4-Gram staining




cocci
Gram stain
+
Staphylococcus sp
Streptococcus sp
Catalase
+
−
Staphylococcus sp
Coagulase
+
−
Staph. aureus
S
Novobiocin
R
Staph. epidermidis
Staph. saprophyticus
Streptococcus sp
Neisseria sp
Nonmotile, kidney-shaped, catalase and oxidase +ve, requiring enriched media to grow (e.g. Thayer-Martin or chocohlate agar), piliated, elaborate IgA1 protease that inactivates IgA1
Maltose fermentation
+
−
N.meningitidis
Polysaccharide capsule, pili, tetravalent vaccine, Waterhouse-Friderichsen synd
N.gonorrhoeae
No capsule, β-lactamase, pili, Thayer-Martin medium, Treatment: ceftriaxone, plus tetracycline for chlamydia, no vaccine
α-hemolytic (partial "green" discoloration)
β-hemolytic (complete "clear halo" hemolysis)
γ-hemolytic Group D (usually no hemolysis)
Optochin
S
R
S. pneumoniae
Nonmotile, capsulated bacteria,
Viridians group
S. sanguis
S. mutans
Nonmotile, oral bacteria, cause dental caries, and endocarditis if introduced into bloodstream
Bacitracin
S
R
Group A
S. pyogenes
Group B
S. agalactiae
Growth in 6.5% NaCl
+
−
E. faecalis
E. faecium
Hydrolyzes bile esculin with black complex, salt-tolerant, normal in colon, UTI, biliary tract infections, post-op endocarditis, opportunistic infection, treatment: penicillin plus aminoglycoside
S. bovis
hydrolyzes bite esculin with black complex

Gram negative bacteria



- **Clinical samples** from normally **nonsterile sites** (eg, the throat or the colon) contain multiple species of organisms, including **potential pathogens and resident microbial flora**.

- Media can be **nonselective** or **selective**; the latter are used **to distinguish among the various bacteria in a clinical sample containing many different organisms.**

5- Depends on growth on Media

- In contrast to viruses and most parasites, many bacterial pathogens can be isolated on solid agar-containing media. The general **cultivation of most bacteria requires media rich in metabolic nutrients.**
- These media generally include **agar, a carbon source, and an acid hydrolysate or enzymatically degraded source of biologic material (eg, casein).** Because of the undefined composition of the latter, these types of media are referred to as **complex media**.

A. Nonselective Media

- **Blood agar** and **chocolate agar** are examples of complex, **nonselective media**, which support the growth of many different bacteria.
- These media are **intended to cultivate as many species as possible, thus giving rise to numerous types of bacterial colonies.**

B. Selective Media

- **Because of the diversity of microorganisms** that typically reside at some sampling sites (e.g, **the skin, respiratory tract, intestines, vagina**), **selective media are used to eliminate (or reduce) the large numbers of irrelevant bacteria in these specimens**.

- The **basis for selective media is the incorporation of an inhibitory agent that specifically selects against the growth of irrelevant bacteria.**
- .

- **Examples of such agents are:**

- **Sodium azide**—selects for gram-positive bacteria over gram-negative bacteria

- **Bile salts** (sodium deoxycholate)—select for gram-negative enteric bacteria and inhibit gram-negative mucosal and most gram-positive bacteria

Colistin and nalidixic acid—inhibit the growth of many gram-negative bacteria

- Examples of selective media are **MacConkey agar** (**contains bile**) that selects for the Enterobacteriaceae and **CNA blood agar** (contains colistin and nalidixic acid) that selects **for Staphylococci and Streptococci**.

C. Differential Media

- **Upon culture**, some bacteria produce characteristic pigments, and others can be differentiated on the basis of their complement of extracellular enzymes; the activity of these enzymes often can be detected as zones of clearing surrounding colonies grown in the presence of insoluble substrates (e g, **zones of hemolysis in agar medium containing red blood cells).**

- Many of the members of the **Enterobacteriaceae** can be differentiated on the **basis of their ability to metabolize lactose**. For example, whereas pathogenic salmonellae and shigellae **do not ferment lactose on a MacConkey plate form white colonies**, **lactose-fermenting members of the Enterobacteriaceae (eg, *E coli*)** form red or pink colonies.
- However, it should be noted **that biochemical identification is an important means to classify microbial pathogens**.

6-Biochemical Tests

- Tests such as the **oxidase test**, which uses an **artificial electron acceptor**, can be used to distinguish organisms on the **basis of the presence or absence of a respiratory enzyme**, **cytochrome C**, the lack of which differentiates **the Enterobacteriaceae from other gram-negative rods.**

- Similarly, **catalase** activity can be used, for example, to differentiate between the gram-positive cocci; the **species staphylococci are catalase positive** whereas the **species streptococci are catalase negative**. If the organism is demonstrated to be catalase positive (*Staphylococcus* spp.), the species can be **subdivided by a coagulase test into *Staphylococcus aureus* (coagulase positive) or *Staphylococcus epidermitidis* (coagulase negative)**

7-Immunologic Tests—Serotypes, Serogroups, and Serovars

- The designation **"sero"** simply indicates the use of antibodies (**polyclonal or monoclonal**) that **react with specific bacterial cell surface structures such as lipopolysaccharide (LPS), flagella, or capsular antigens**.

- The terms "**serotype,**" "**serogroups,**" **and** "**serovars**" are, for all practical purposes, identical—they all use the specificity of **these antibodies to subdivide strains of a particular bacterial species**.
- This has been described earlier in this chapter as it relates to the relationship ***E coli* O157:H7** and HUS.

End of part 1 of Chapter 1