

Microbial Diversity: Chapt. 27 – Prokaryotes and the Origins of Metabolic Diversity

What are microbes?

Single-celled organisms and some non-cellular parasites

Kinds of microbes: Non-cellular, parasitic molecules

Viruses – Single- or double-stranded RNA or DNA with a protein coat
Common cold, Ebola, HIV

Viroids – Short, single strand of RNA w/o protein coat
Primarily infect plants

Prions – Protein particles w/o genetic material
Kuru, mad cow, chronic wasting disease

Kinds of microbes: Prokaryotes Domain Bacteria & Domain Archaea

Kinds of microbes: Eukaryotes Several Kingdoms in Domain Eukarya

Carl Woese's 3 Domains of Life: Bacteria, Archaea, Eukarya [See Fig. 27.12]
Based primarily on genetic sequence data; *e.g.*, **small subunit ribosomal RNA** – present in all organisms

NOTE: “**Microbes**” and “**Prokaryotes**” are not taxonomic categories

NOTE: **Eukarya & Archaea** are more closely related than either is to **Bacteria**

Even so, **Archaea & Bacteria** share more structural & functional properties than either does with **Eukarya**

Microbes are microscopic, but very diverse & extremely abundant

Prokaryotes

Domains Bacteria & Archaea

Simple cells – with no nucleus or membrane-bound organelles

First organisms on Earth – at least 3 billion years ago

Distributed globally – including many **extremophiles**

Nutrition – **autotrophs** & **heterotrophs**

All organisms require a source of energy & carbon [See Table 27.1]

Autotrophs can obtain all their C from CO₂

Heterotrophs require at least one organic nutrient, *e.g.*, glucose

Phototrophs obtain their energy from the sun

Chemotrophs obtain their energy from chemical compounds

Bacteria

STRUCTURE

Systematic / phylogenetic relationships among bacteria are based on genetic data, but structural properties are indispensable for identifying them

Cell wall – unique, **peptidoglycan**

Peptidoglycan – structural polysaccharides (sugars) cross-linked by peptides (chains of amino acids)

Two biochemical groups of bacteria

Gram positive bacteria (outer peptidoglycan layer will stain)

Gram negative bacteria (inner peptidoglycan layer will not stain)

3 common bacterial shapes

Cocci – spheres

Bacilli – rods

Spirilli – spirals

Capsules or **slime layer**

E.g., **slime layer** allows bacteria to cling to tooth enamel or other substrates

Pili (singular: **pilus**) & **flagella**

Pili = protein filaments that attach bacteria to other cells & substrates

Some prokaryotes have **flagella** (singular: **flagellum**)

Used for locomotion

The base of a bacterial flagellum is the only known wheel in nature [See Fig. 27.6]

What is “**taxis**”?

Motility allows some bacteria to move towards or away from stimuli

Phototaxis

Chemotaxis

Magnetotaxis

Circular DNA molecule & plasmids

REPRODUCTION

Asexual, through **binary fission**

Binary fission – Daughter cells are identical copies

Neither **mitosis** nor **meiosis** occurs in prokaryotes

No true **sexual reproduction**, since neither **mitosis** nor **meiosis** exist in prokaryotes

Horizontal transfer of genetic material

Transformation – Uptake of genetic material from the environment

Transduction – Transfer of genetic material between prokaryotes by viruses

Conjugation – Direct transfer of genetic material from one prokaryote to another; sex pilus connects cells and draws them together; conjugation tube forms

Surviving harsh conditions

Endospore – forms inside a bacterium and then persists through inhospitable conditions

Bacteria – Impacts on other organisms, including human society

Decomposition – Note Louis Pasteur’s experiments

Photosynthesis – Especially common in cyanobacteria

N-fixation – *E.g.*, root nodules of beans

Symbiosis

Mutualism, commensalism, parasitism

Agents of disease [see next page for **Koch’s Postulates**]

Bioremediation – Breaking down toxic waste

Koch's Postulates

Robert Koch (late 1800s) was the first person to link diseases to specific species of bacteria

The “**Germ Theory**” revolutionized medicine in the early 20th century

Koch's Postulates guide the identification of disease agents:

1. Find the same pathogen in each victim
2. Isolate the pathogen & grow it in pure culture
3. Induce the disease in a healthy individual from culture
4. Isolate the same pathogen after disease occurs

Archaea

STRUCTURE

Several basic biochemical differences distinguish them from Bacteria

E.g., No **peptidoglycan** in their **cell walls**

No known **pathogens!**

Many are **extremophiles**...

Even so, archaea are not restricted to extreme habitats

Archaea account for 20-30% of marine microbial cells