The Cell

Diversity and complexity

***Cellulae* (Small room)**

The Organism's Basic Unit of Structure and Function

Types of cells

Prokaryotic

Micro-organisms

Eukaryotic

All other forms of life

Cell Theory

- All organisms are composed of one or more of cells.

- Cell is the basic unit of life.

- The new cell arises only from pre-existing cell.

Prokaryotic and eukaryotic cells: difference in size and complexity

SIMILARITIES

- All cells are surrounded by a *plasma membrane*.
- The semi-fluid substance within the cell is called "cytosol", containing the cell organelles.
- All cells contain chromosomes which have genes in the form of DNA.
- All cells have tiny organelles called "*Ribosomes*" that make proteins.

Prokaryotic and eukaryotic cells: difference in size and complexity

DIFFERENCES

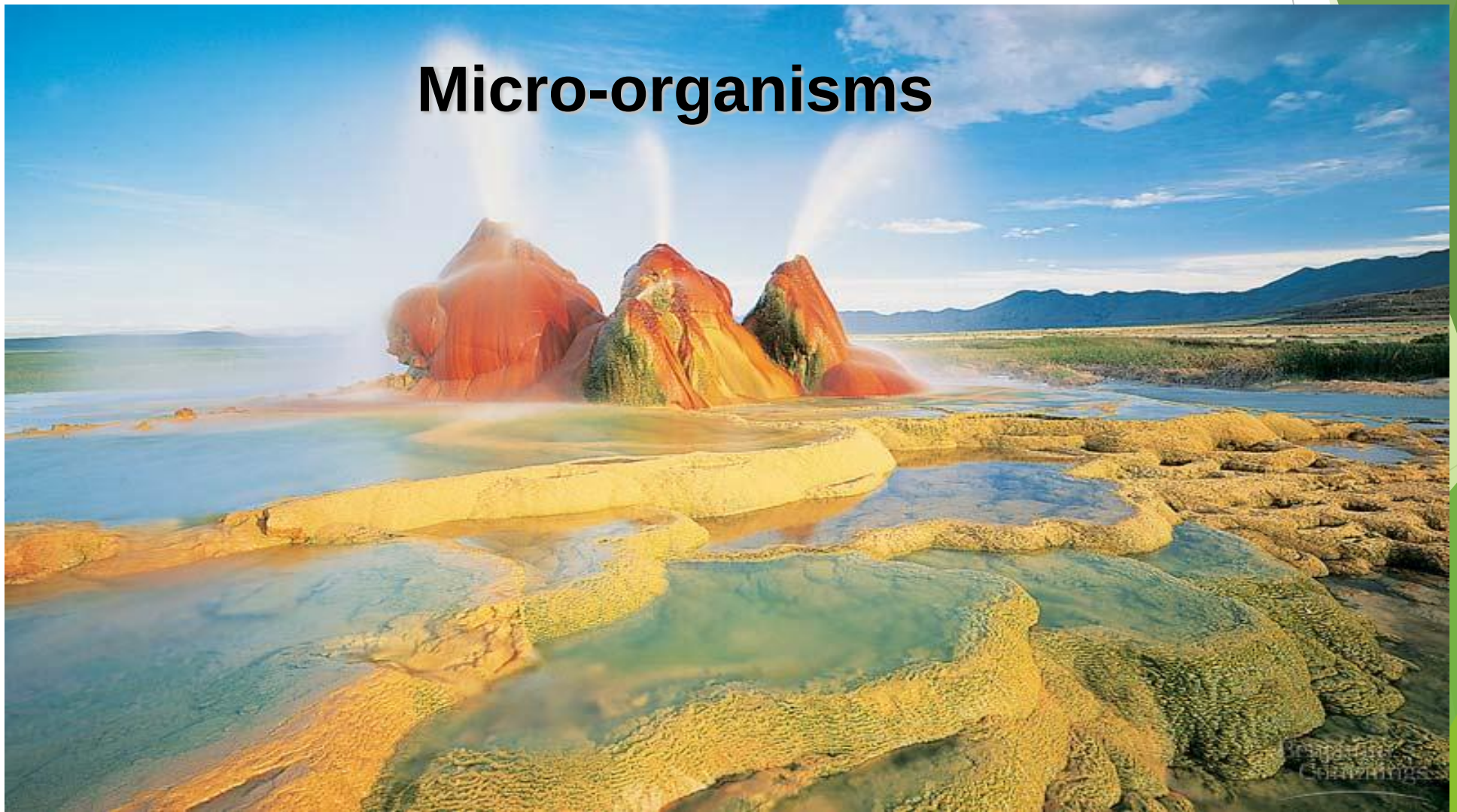
- **A major difference between prokaryotic and eukaryotic cells is the location of chromosomes.**

  - **In an eukaryotic cell, chromosomes are contained in a true *nucleus*).**
  - **In a prokaryotic cell, the DNA is concentrated in the nucleoid) without a membrane separating it from the rest of the cell.**
  - **In prokaryotic cell, DNA is a single strand or double strand DNA. But in eukaryotic cell, DNA is double strand.**

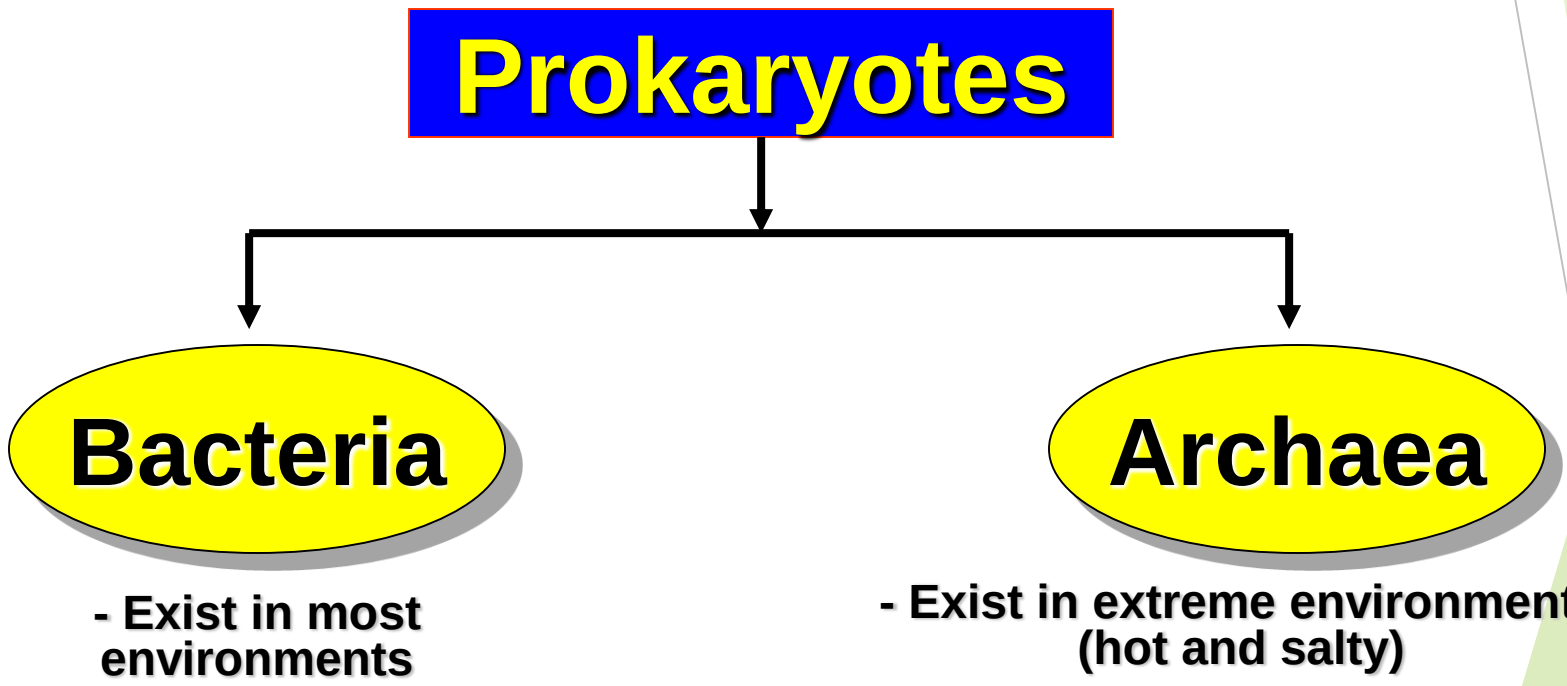
Prokaryotic and eukaryotic cells: difference in size and complexity

- **All cells are surrounded by a *plasma membrane*.**
- **The semifluid substance within the membrane is the cytosol, containing the organelles.**
- **All cells contain chromosomes which have genes in the form of DNA.**
- **All cells also have *ribosomes,* tiny organelles that make proteins using the instructions contained in genes.**

Prokaryotes



Types of Prokaryotes



They are differing in some other structural, biochemical and physiological characteristics

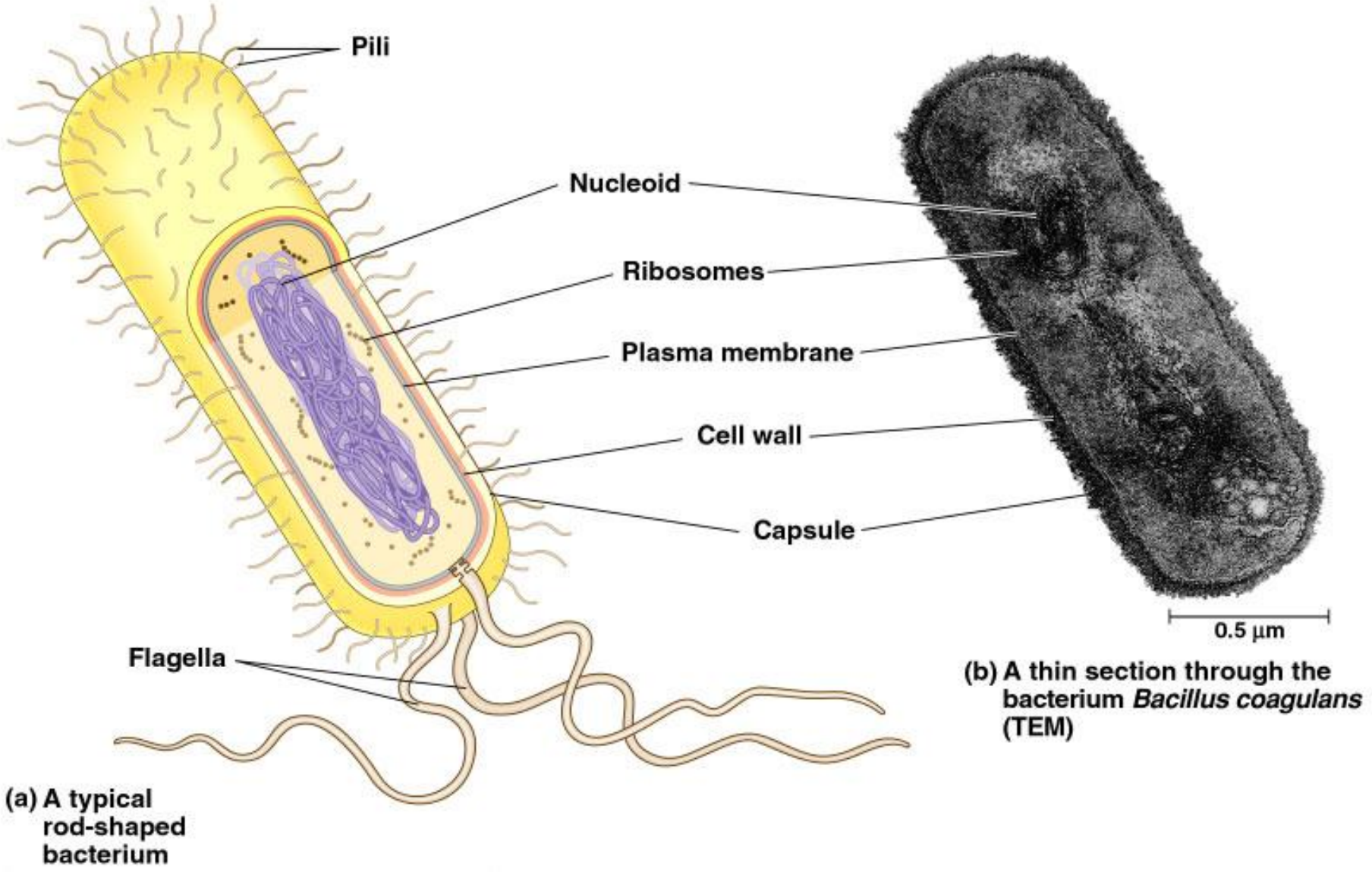


Fig. The prokaryotic cell is much simpler in structure, lacking a nucleus and the other membrane-enclosed organelles of the eukaryotic cell.

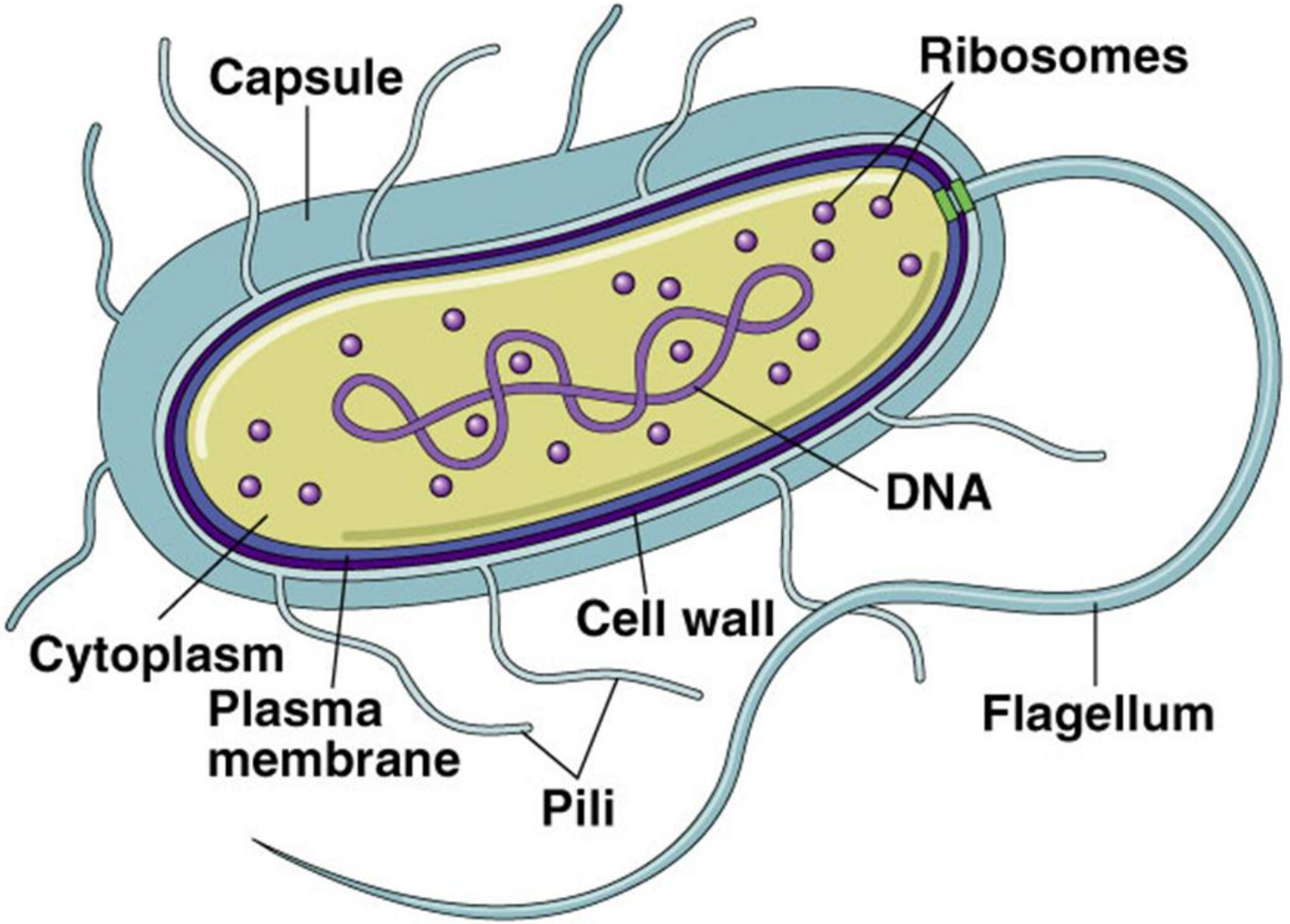
- In eukaryote cells, the chromosomes are contained within a membranous nuclear envelope.
- The region between the nucleus and the plasma membrane is the **cytoplasm**.
  - All the material within the plasma membrane of a prokaryotic cell is cytoplasm.
- Within the cytoplasm of a eukaryotic cell is a variety of membrane-bounded organelles of specialized form and function.
  - These membrane-bounded organelles are absent in prokaryotes.

Prevalence of Prokaryotes

- In almost every place or environment microbiologists (scientists who study small organisms) look, prokaryotes have been found.
  - Hot springs, hypersaline environments, highly toxic gaseous environment, within clean rooms of hospitals
- In the 1980's a new method of classification was used
- Divided prokaryotes into 2 groups:
  - Archaebacteria (Archae) and bacteria

Prevalence of Prokaryotes

- Prokaryotes are the oldest, structurally simplest, and most abundant forms of life on earth.
  - abundant for over 2 billion years before the appearance of eukaryotes
  - Prokaryotic synthesis (from cyanobacteria) is thought to have been the source for much of the earth's oxygen in atmosphere
  - 5,000 different kinds currently recognized


Capsule
Ribosomes
DNA
Cell wall
Cytoplasm
Plasma membrane
Pili
Flagellum

Structure of a Prokaryotic Cell

- Most prokaryotic cells are small and lack interior organization.
- The plasma membrane is enclosed within a rigid cell wall
- DNA not contained within a membrane-bounded nucleus.
- Prokaryotes exteriorly may have a flagellum and other outgrowths called pili.
- Pili aid in attachment to other cells

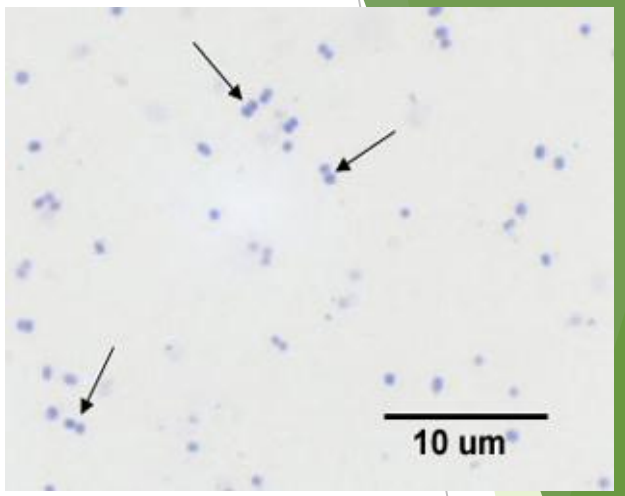
Prevalence of Prokaryotes

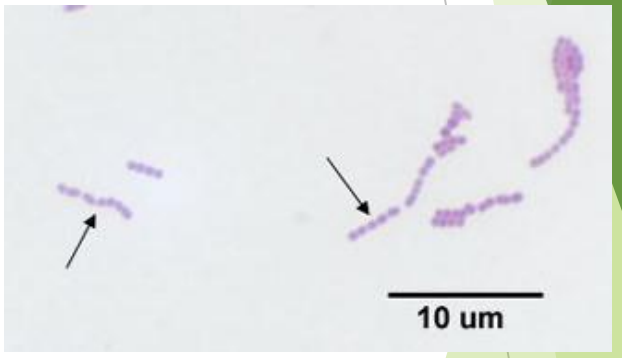
- Prokaryotic form
  - bacillus (bacilli) straight and rod-shaped
  - coccus (cocci) spherical shaped
  - spirillum (spirilla) long and helical shaped
- Some bacillus and coccus bacteria form colonies
- Spirilla generally do not form colonies and are often free swimming
- Some bacterial colonies form spore producing structures.

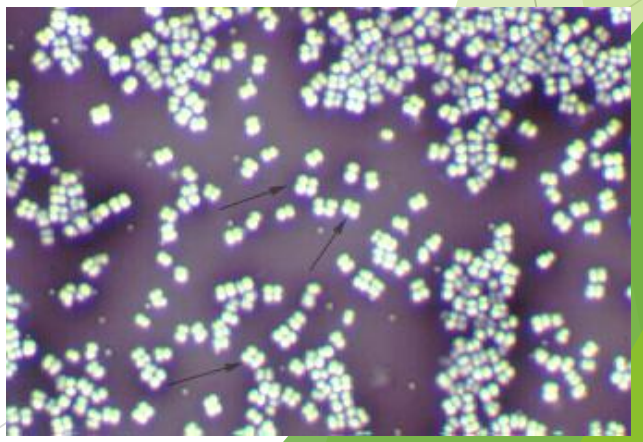
- Prokaryotic form :

Coccus

- Diplococcus
  - pairs
- *Streptococcus*
  - chains
- Tetrad
  - quads



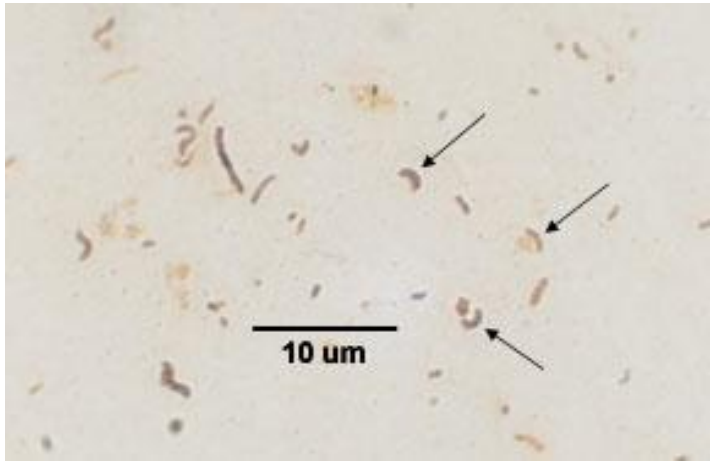




Spiral Types

Vibrio

Comma shaped

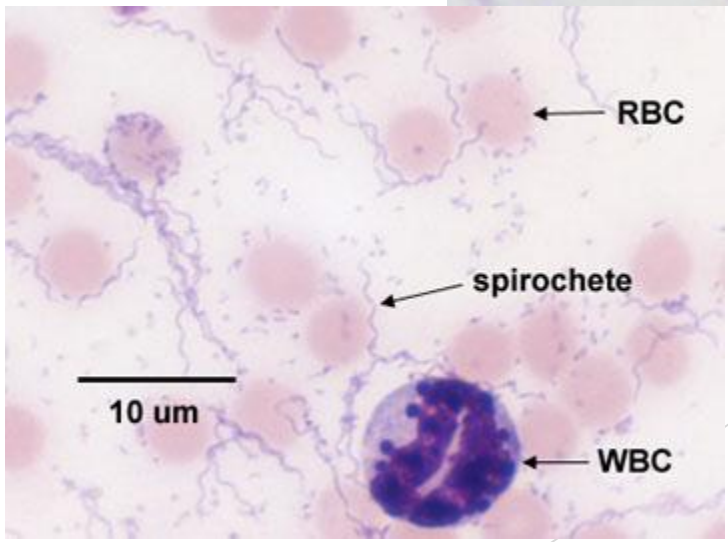


Sprillium

Thick rigid spiral

Spirochete

Thin flexible



- Prokaryotes versus Eukaryotes
  - Unicellularity
    - some may form filamentous matrices
  - cell size :1 μm or less in diameter
    - May vary by 5 orders of magnitude
  - chromosomes
    - “naked” (no protein) circular DNA located in nucleoid
  - cell division and recombination : binary fission (asexual)
  - internal compartmentalization : No internal compartments (mitochondria or chloroplasts)
    - only organelle is the ribosome
  - Flagella : Single protein flagella of flagellin
    - Spin like propellers instead of whiplike
  - metabolic diversity
    - Several kinds of anaerobic and aerobic photosynthesis
    - Chemoautotrophs

Prokaryotic Diversity

- Original key classification characteristics
  - photosynthetic or non photosynthetic
  - motile or no motile
  - unicellular or colony-forming or filamentous
  - spore formation by division or transverse binary fission

Prokaryotic Diversity

- Now prokaryotic classification completed with genetic and molecular approaches
  - Analysis of amino acids sequence of key proteins
  - Nucleic acid analysis by establishing % guanine (G) and cytosine (C)
  - nucleic acid hybridization
  - ribosomal RNA sequencing
  - whole genome sequencing

Kinds of Prokaryotes

- Very early, prokaryotes split into two lines
  - Archaea and bacteria are as different in structure and metabolism from each other as either is from eukarya. Archae (archebacteria) not actually as old as Bacteria

Prokaryotic Diversity

- Comparing archaebacteria and bacteria
  - plasma membranes
    - composed of different lipids
  - cell wall
    - archaebacteria lack peptidoglycan
  - gene translation machinery
    - Bacteria ribosomal proteins and RNA polymerases different from eukaryotes
    - archaebacteria similar to eukaryotes
  - gene architecture
    - bacteria genome not interrupted by introns
    - some archaebacteria posses introns

Prokaryotic Complexity

- Prokaryotic cell surface – identifying features
  - Cell wall maintains shape and protects the cell from swelling and rupturing
    - usually consist of peptidoglycan
    - Gram-positive - thicker peptidoglycan
    - (purple color after stain)
    - Gram-negative - thinner peptidoglycan
    - (red color after stain)
  - flagella – slender protein - locomotion
  - pili - hairlike structures – attachment (7.5 – 10 nm)
  - endospores - resistant to environment

- Eukaryotic cells are generally much bigger than prokaryotic cells.
- The logistics of carrying out metabolism set limits on cell size.
  - At the lower limit, the smallest bacteria, mycoplasmas, are between 0.1 to 1.0 micron.
  - Most bacteria are 1-10 microns in diameter.
  - Eukaryotic cells are typically 10-100 microns in diameter.