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Cytology

Doctor 2019 | Medicine | JU

◉ Sheet ○ Slides

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Contributed in the Scientific Correction

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Doctor

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To Get Started :-

There are two major types of cells, prokaryotic-structurally and functionally simpler- and eukaryotic-more complex structurally and functionally-, distinguished by their size and the types of internal structures, or organelles , they contain.

The difference in nuclear structure is the basis for the terms prokaryotic (pro = before, karyon = nucleus) and eukaryotic (eu = true, karyon = nucleus).

-Example on prokaryotic cells:-Bacteria

-Examples on eukaryotic cells:- Protists, fungi, plants, and animals.

1.3 Characteristics That Distinguish Prokaryotic and Eukaryotic Cells

*First Appearance For Each Type :-

(IMPORTANT NOTE : THIS SUBJECT HAS NOT BEEN DISCUSSED DURING LECTURE , BUT INCLUDED IN THE TEXT BOOK)

FIRST APPEARANCE

EUKARYOTIC:-

-Complex multicellular animals appear in the fossil record 600 million years ago, but there is evidence that simpler **eukaryotic** organisms were present more than one billion years earlier.

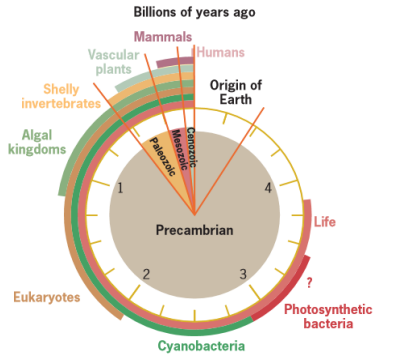


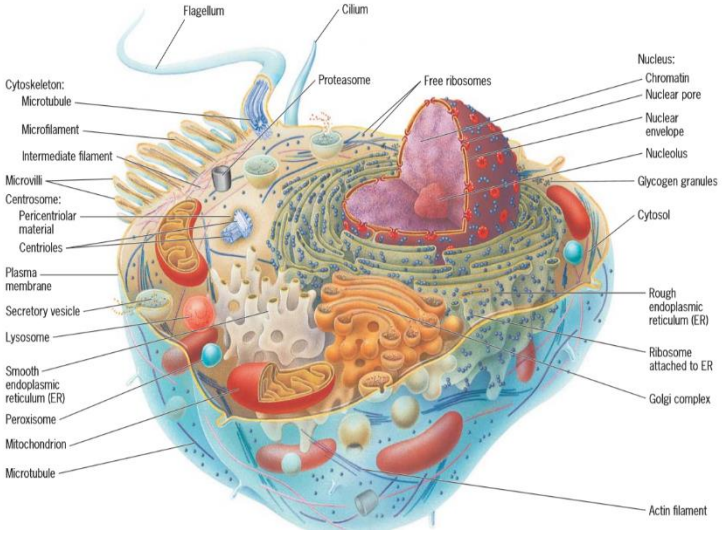
FIGURE 1.9 Earth's biogeologic clock. A portrait of the past five billion years of Earth's history showing a proposed time of appearance of major groups of organisms. Complex animals (shelly invertebrates) and vascular plants are relatively recent arrivals. The time indicated for the origin of life is speculative. In addition, photosynthetic bacteria may have arisen much earlier, hence the question mark. The geologic eras are indicated in the center of the illustration.

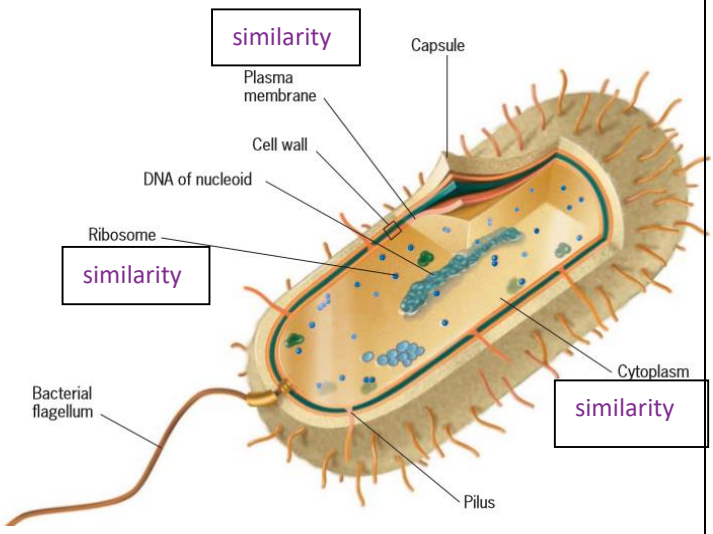
PROKARYOTIC:-

-Evidence of **prokaryotic** life has been obtain **2.7 billion** years of age, from rocks these rocks contains, fossilized microbes and organic molecules that are characteristic of particular types of prokaryotic organisms, such as cyanobacteria.

-Cyanobacteria appeared by **2.4 billion**, when the atmosphere became infused with oxygen **(O 2)**, which is a by-product of the photosynthetic activity of prokaryotes

*Main Features For Each Cell :-





Eukaryotic cells: -

- Genetic material DNA located inside the nucleus, a region bounded by a complex membranous structure called the nuclear envelope -separates the nuclear components from the rest cytoplasm, it is represented by a number of chromosomes in each cell for human -46 chromoseme-, each chromosome actually a nucleoprotein which is a condensed chromatin during division, when the cell is not dividing the chromatin is very thin single linear molecule of DNA with histones proteins.

-Some organelles are membranous such as, nucleus, Golgi apparatus , lysosomes mitochondria and a variety of simple membrane-bound vesicles of varying dimension, others are not membranous such as, Cytoskeletal elements, myosin microtubules, intermediate filament , and ribosomes 'workbenches' because it functions directly in the cytoplasm (structure and related function)

Specific features for plant cells: -

-Cell wall function as supporter and protector from osmotic pressure.

- autotrophic-photosynthetic- cells have chloroplasts which are the sites of photosynthesis because they produce their own organic substances.

-Plants often have a single large vacuole that can occupy most of the volume of the cell.

Prokaryotic cells: -

-Genetic material DNA is located in the DNA nucleoid, a poorly demarcated region of the cell that lacks a boundary membrane to separate it from the surrounding cytoplasm. ; it represents one circular chromosome.

-The cytoplasm of prokaryotic cells is essentially devoid of membranous structures

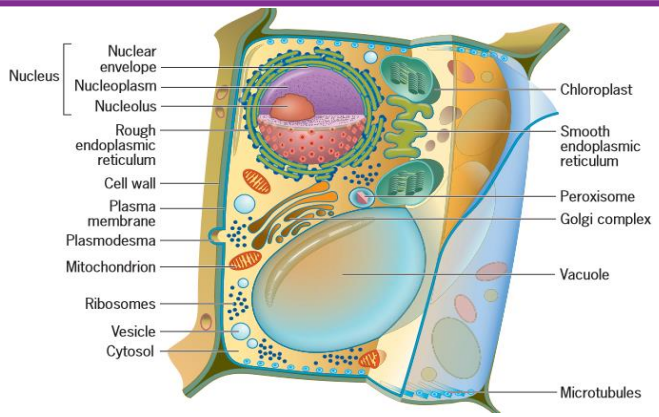
-Cell wall functions is : supporting and protection , composed of different chemicals.

Cell walls also found in bacteria, archaea, fungi, plants, and algae

-Pilus is an extension from the plasma membrane.

-No organelles, only one compartment ,all in the cytoplasm-not compartmentalized-.

-smaller in size, so directed intracytoplasmic communication is less important.

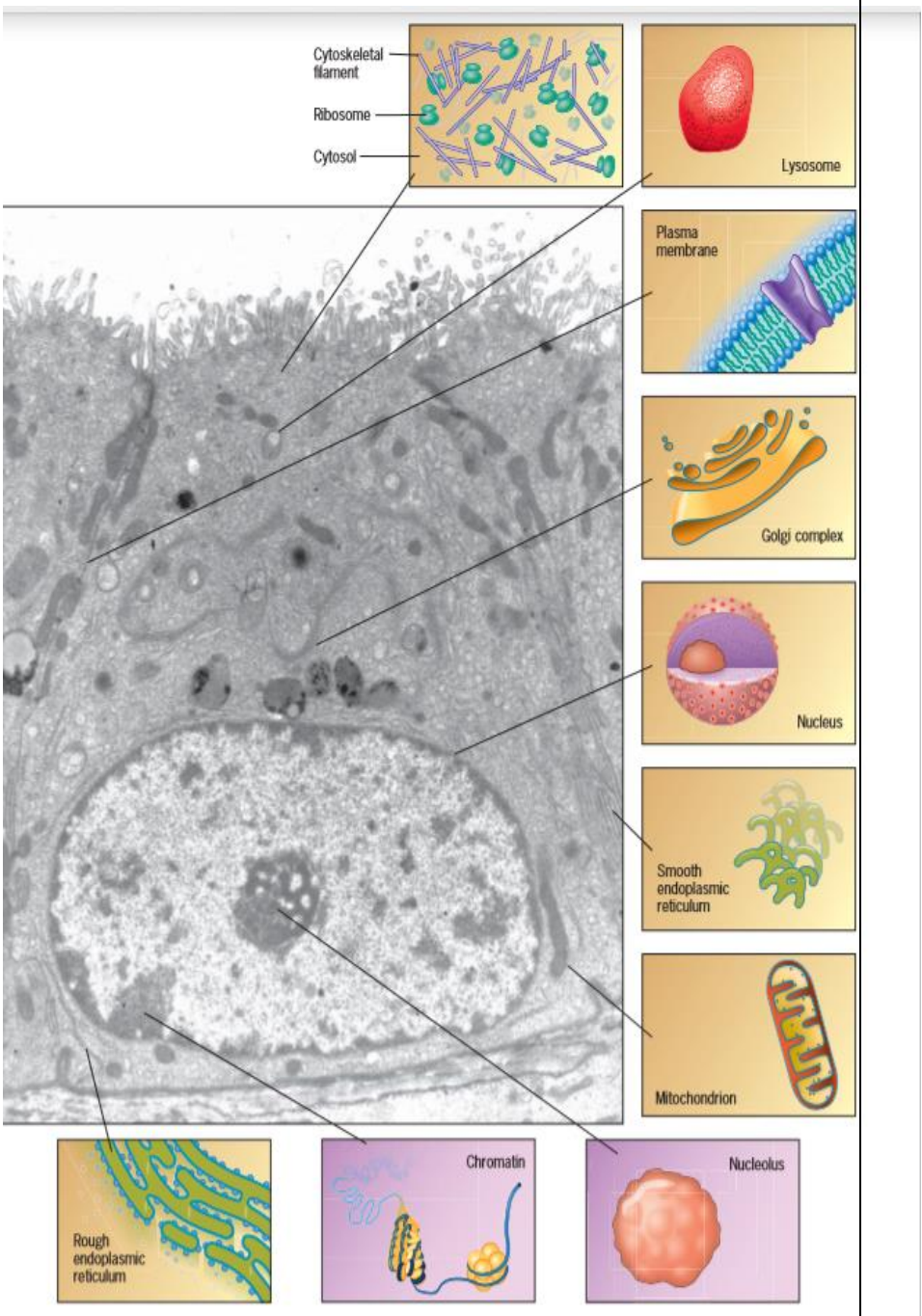


*This epithelial cell lines the male reproductive tract in the rat. A number of different organelles are indicated and depicted in schematic diagrams around the border of the figure

- The cytoplasmic membranes of eukaryotic cells form a system of interconnecting channels and vesicles that function in the transport of substances from one part of a cell to another, as well as between the inside of the cell and its environment-cell walls for eukaryotic differs in component from cell wall for prokaryotic cells

- It was thought for many years that prokaryotic cells lacked any trace of a cytoskeleton, but primitive cytoskeletal filaments have been found in bacteria. It is still fair to say that the prokaryotic cytoskeleton is much simpler, both structurally and functionally, than that of eukaryotes.

-microvilli increases the surface area for diffusion and minimize any increase in volume.



* Features held in common by the two types of cells: -

1)Both types of cells are bounded by plasma membranes of similar construction.

FUNCTION: selectively permeable barrier between the living and non-living worlds.

2) Genetic information encoded in DNA using identical genetic code.

3) Similar mechanisms for transcription and translation of genetic information, **similar ribosomes.**

4) Shared metabolic pathways (e.g., glycolysis and tricarboxylic acid cycle- TCA cycle/Kreps cycle

5) Similar apparatus for conservation of chemical energy as ATP (located in the plasma membrane of prokaryotes and the mitochondrial membrane of eukaryotes)

The shared properties reflect the fact that eukaryotic cells almost certainly evolved from prokaryotic ancestors. Because of their common ancestry, both types of cells share an identical genetic language, a common set of metabolic pathways, one benefit for this is the production of vaccines and protein therapies ,such as insulin, via bacterial cells , also both have common structural features

-Ribosomes present in nucleus as subunits.

The functional ribosomes present in the cytosol when the m RNA is ready for translating.

Ribosomal units in nucleus are small similar to prokaryotes' ribosomes

-Genes are located in:-

Nucleus, mitochondria, chloroplast

6) Similar mechanism of photosynthesis (between cyanobacteria and green plants)

7) Similar mechanism for synthesizing and inserting membrane proteins.

8) Proteasomes (protein digesting structures, responsible for breaking down misfolded proteins) of similar construction (between archaebacteria and eukaryotes)

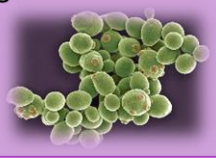
9) Cytoskeletal filaments built of proteins similar to actin and tubulin.

Notes :-

- eukaryotic ribosomes are larger than prokaryotic ribosomes, and contain more components.

- During electron transport chain in bacreria , protons are pumped to the space between plasma membrane and cell wall, in eukaryotic cells it is pumped to the intermembrane space.

-Prokaryotic cells contain relatively small amounts of DNA; the DNA content of bacteria ranges from about 600,000 base pairs to nearly 8 million base pairs and encodes between about 500 and several thousand proteins. 2 Although a “simple” baker’ s yeast cell has only slightly more DNA (12 million base pairs encoding about 6200 proteins) than the most complex prokaryotes, most eukaryotic cells contain considerably more genetic information, even yeast the simplest eukaryote, is much more complex structurally than an average bacterium, even though these two organisms have a similar number of genes.



*There is a classification for organisms on the basis of **nutrition** :-

Autotrophs : Those organisms which are not dependent on others for food & capable of preparing their own food are known as autotrophs or producers. For example- green plants.

Heterotrophs: Those organisms which are dependent on others for food as they cannot make their food on their own are known as heterotrophs. For example- animals & humans are dependent on plants for their food

*Features In Eukaryotic Cells Not Found In Prokaryotic: -

1)Division of cells into nucleus and cytoplasm, separated by a nuclear envelope containing complex pore structures.

2) Complex chromosomes composed of DNA and associated proteins that are capable of compacting into mitotic structures

3) Complex membranous cytoplasmic organelles (includes endoplasmic reticulum, Golgi complex, lysosomes, endosomes, peroxisomes, and glyoxisomes)

4) Specialized cytoplasmic organelles for aerobic respiration (mitochondria) and photosynthesis (chloroplasts)

5) Complex cytoskeletal system (including actin filaments, intermediate filaments, and microtubules) and associated motor proteins

6) Complex flagella and cilia

7) Ability to ingest particulate material by enclosure within plasma membrane vesicles (phagocytosis).(such as white blood cells perform phagocytosis on bacteria)

8) Cellulose-containing cell walls (in plants and algae),in fungi there is cellulose and chitin-has amino group-.

Some functions: -

- Mitochondria: chemical energy is made available to fuel cellular activities.(membranous)

-Endoplasmic reticulum: where many of a cell ' s proteins and lipids are manufactured(membranous)

- Golgi complexes: where materials are sorted, modified, and transported to specific cellular destinations.(membranous)

- Elongated tubules and filaments of the cytoskeleton, which participate in cell contractility, movement , support.(not membranous)

-Ribosomes: on which the proteins of the cell are manufactured.(not membranous)

-Nuclear pores: Exchange materials between cytoplasm and nucleoplasm, such as nucleotides and enzymes from the cytoplasm to the nucleus to build new RNAs, also ribosomal subunit-ribosomal RNA and proteins-exits through pores to the cytoplasm.

NOTES:-

-Animal cells are more dynamic than plant cells.

- cytosol : is the fluid between organelles (little space for the soluble phase of the cytoplasm), cytoplasm: is the fluid in the distance between plasma membrane and the nucleus(extremely crowded)(organelles + cytosol).

-the importance of compartmentalization -specialized activities can take place-in eukaryotic cells :-

*Increases the surface relative to the volume

*Each enzyme can function well in it's related organelle as an appropriate environment is provided.(such as lysosome has enzymes that function in acidic environment)

*cellulose and chitin are structural proteins ,made from beta glucose

9) Cell division using a microtubule-containing mitotic spindle that separates chromosomes. Eukaryotic cells divide by a complex process of mitosis in which duplicated chromosomes condense into compact structures that are segregated by an elaborate microtubule-containing apparatus This apparatus, which is called a mitotic spindle , allows each daughter cell to receive an equivalent array of genetic

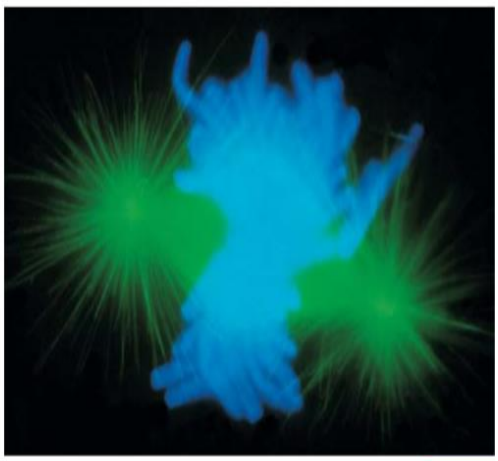


FIGURE 1.12 Cell division in eukaryotes requires the assembly of an elaborate chromosome-separating apparatus called the mitotic spindle, which is constructed primarily of microtubules. The microtubules in this micrograph appear green because they are bound by an antibody that is linked to a green fluorescent dye. The chromosomes, which were about to be separated into two daughter cells when this cell was fixed, are stained blue.

10) Presence of two copies of genes per cell (diploidy), one from each parent

* Diploidy is the condition of having two complete sets of chromosomes in the same cell nucleus.

11) Presence of three different RNA synthesizing enzymes (RNA polymerases)

12) Sexual reproduction requiring meiosis and fertilization.

Note :-

- The complex photosynthetic membranes of the cyanobacteria are a major exception between prokaryotes

Bacterial flagella are helically shaped structures containing the protein flagellin, it's motion is rotation.

TO SUM UP!

PROKARYOTIC CELLS:

- **Complexity** : structurally and functionally simpler.

-Cellular reproduction : divide by simple fission-may take half an hour ,so fast- , no mitosis because no cytoskeleton elements

-Cytoplasm: no membrane bound-organelles, no complex cytoskeleton proteins, smaller ribosomes

-Locomotion: have flagella but they differ in both mechanism and form.

-Genetic material:

***Packaging:** have nucleoid region-one third of the cytoplasmic region-

***Amount :** have less amount of genetic material

***Form:** single , circular DNA

EUKARYOTIC CELLS:

- **Complexity** : structurally and functionally more complex.

-Cellular reproduction : divide by mitosis -needs more time-

--Cytoplasm: no membrane-bound organelles, and complex cytoskeleton proteins, larger ribosomes

-Locomotion: use both cytoplasmic movement and cilia and flagella , but they-flagella- differ in both mechanism and form.

-Genetic material:

***Packaging**: have membrane bound nucleus.

***Amount** : have more amount of genetic material

***Form**: have many chromosomes made of both DNA and proteins

*** This is a colorized electron micrograph of a portion of the cytoplasm near the thin edge of a single-celled eukaryotic organism. This is a region of the cell where membrane-bound organelles tend to be absent. The micrograph shows individual filaments of the cytoskeleton (orange) and other large macromolecular complexes of the cytoplasm (turquoise). Most of these complexes are ribosomes. It is evident from this type of image that the cytoplasm of a eukaryotic cell is extremely crowded, leaving very little space for the soluble phase of the cytoplasm, which is called the cytosol .**

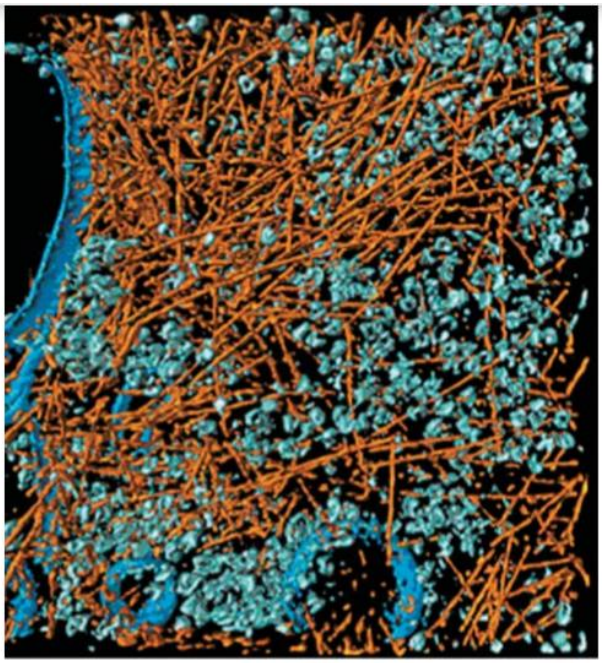


FIGURE 1.11 The cytoplasm of a eukaryotic cell is a crowded compartment. This colorized electron micrographic image shows a small region near the edge of a single-celled eukaryotic organism that had been quickly frozen prior to microscopic examination. The three-dimensional appearance is made possible by capturing two-dimensional digital images of the specimen at different angles and merging the individual frames using a computer. Cytoskeletal filaments are shown in orange, macromolecular complexes (primarily ribosomes) are turquoise, and portions of cell membranes are blue.

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* Bacterial conjugation:

Imaging showed that the DNA separates faster than the cell grows, and the precise mechanism by which prokaryotes segregate their genomes(sperm-so small- for men and ovum-10-100 micrometers for women) remains an open question. Some current models are based on regulated compaction or folding of the DNA so that the two copies would fold into two separate masses, thus separating them.

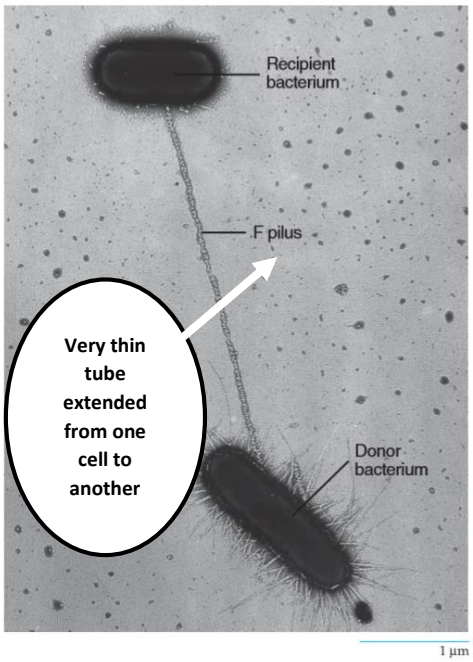


FIGURE 1.13 Bacterial conjugation. Electron micrograph showing a conjugating pair of bacteria joined by a structure of the donor cell, termed the F pilus, through which DNA is thought to be passed.
SOURCE: Courtesy of Charles C. Brinton, Jr., and Judith Carnahan.

prokaryotes are nonsexual organisms. They contain only one copy of their single chromosome and have no processes comparable to meiosis, gamete formation, or true fertilization.

Conjugation: a piece of DNA is passed from one cell to another ,must be from the same species.

*How do bacteria separates it's genome?

1) In prokaryotes, there is no mitotic spindle to separate the genome copies after replication. It was once thought that the two copies are separated by attaching the DNA to the cell surface allowing the growth of the cell membrane to pull them apart.

2) A piece of DNA is passed from one cell to another -**Conjugation** - However, the recipient almost never receives a whole chromosome from the donor, and the condition in which the recipient cell contains both its own and its partner' s DNA is fleeting. The cell soon reverts back to possession of a single chromosome.

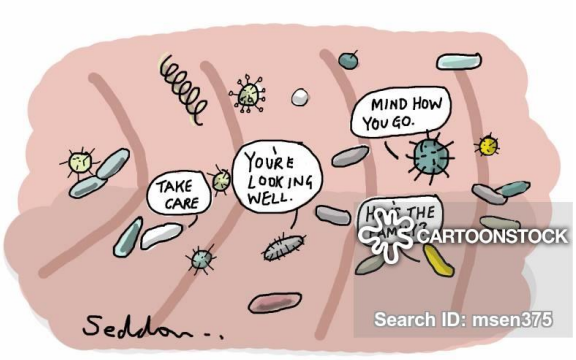
-Although prokaryotes may not be as efficient as eukaryotes in exchanging DNA with other members of their own species, they are more adept than eukaryotes at picking up and incorporating foreign DNA from their environment, which has had considerable impact on microbial evolution.

-Eukaryotic cells possess a variety of complex locomotor mechanisms, whereas those of prokaryotes are relatively simple. The movement of a prokaryotic cell may be accomplished by a thin protein filament, called a flagellum, which protrudes from the cell and rotates .

-The rotations of the flagellum, which can exceed 1000 times per second, exert pressure against the surrounding fluid, propelling the cell through the medium. Certain eukaryotic cells, including many protists and sperm cells, also possess flagella,

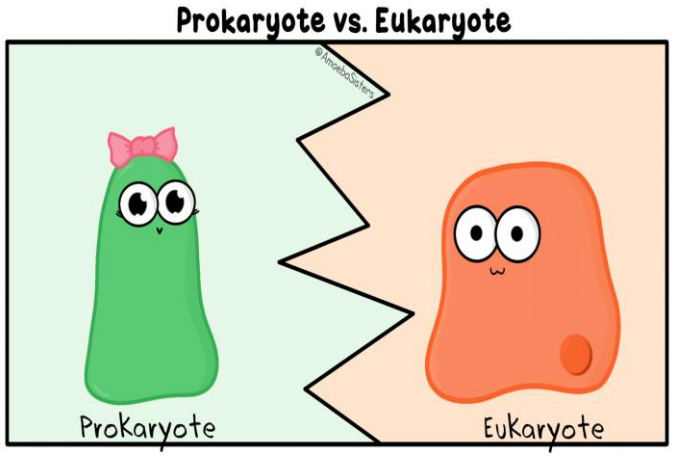
*DON'T WORRY YOU ARE NOT ALONE ;)

Trillions of prokaryotes are clinging to the outer surface of your body and feasting on the nutrients within your digestive tract. We think of these organisms as individual, solitary creatures, but recent insights have shown that they live in complex, multispecies communities called biofilms,(The layer of plaque that grows on our teeth is an example of a biofilm.)

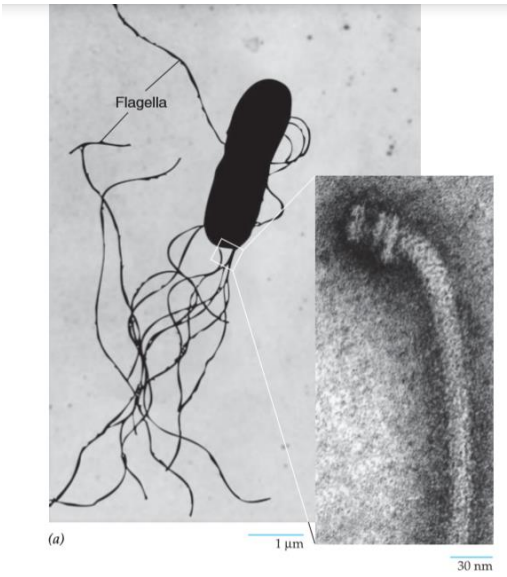


Friendly bacteria of the human gut.

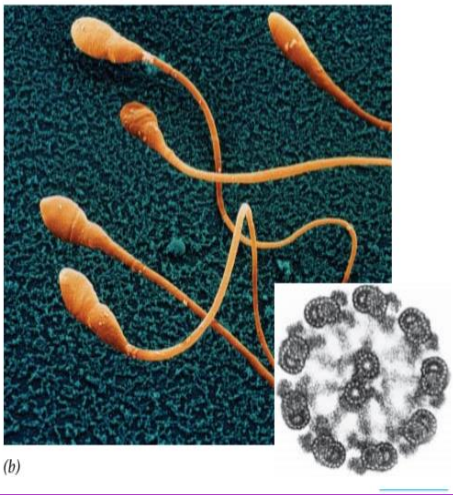
Consider also that, metabolically, prokaryotes are very sophisticated, highly evolved organisms. For example, a bacterium, such as Escherichia coli, a common inhabitant of both the human digestive tract and the laboratory culture dish, has the ability to live and prosper in a medium containing one or two low-molecular-weight organic compounds and a few inorganic ions. Other bacteria are able to live on a diet consisting solely of inorganic substances. One species of bacteria has been found in wells more than a thousand meters below the Earth ' s surface living on basalt rock and molecular hydrogen (H 2) produced by inorganic reactions. In contrast, even the most metabolically talented cells in your body require a variety of organic compounds, including a number of vitamins and other essential substances they cannot make on their own. In fact, many of these essential dietary ingredients are produced by the bacteria that normally live in the large intestine.



* The difference between prokaryotic and eukaryotic flagella.



The bacterium Salmonella with its numerous flagella. Inset shows a high-magnification view of a portion of a single bacterial flagellum, which consists largely of a single protein called flagellin



Each of these human sperm cells is powered by the **undulatory** movements of a single flagellum. The inset shows a cross section of the central core of a mammalian sperm flagellum. The flagella of eukaryotic cells are so similar that this cross section could just as well have been taken of a flagellum from a protist or green alga

BEST WISHES ;)