General biology 2

2^{nd} stage

The Bacteria

By

M.SC Jaafar Hamid Jaafar

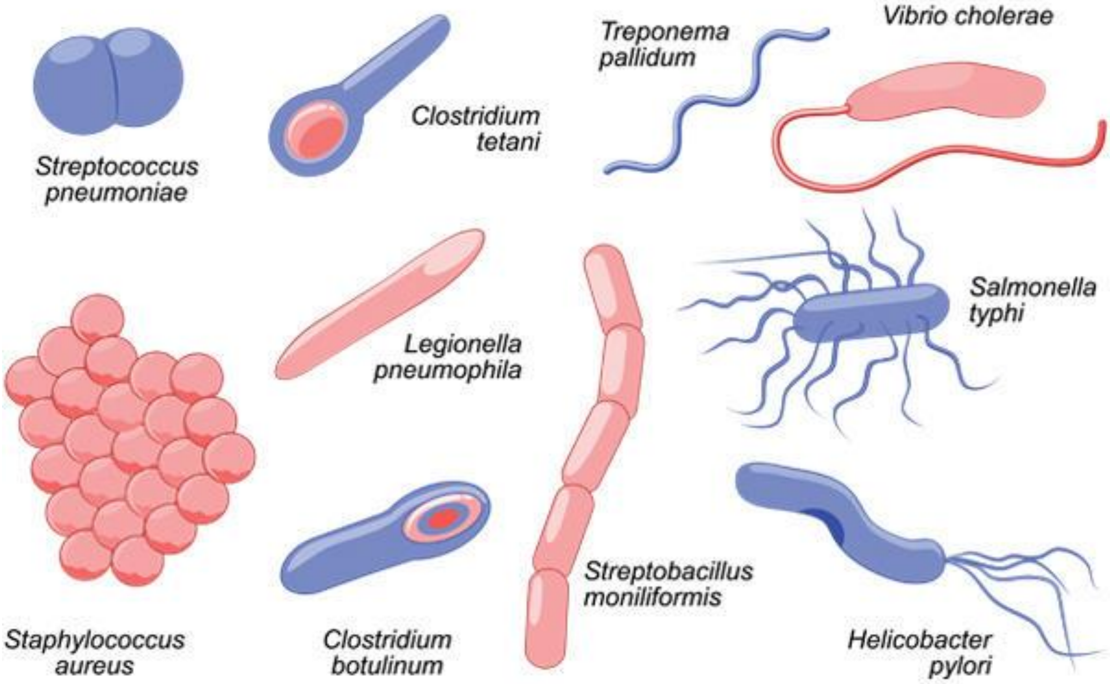
M.SC Sura Mohamme

Bacteria : 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.

containing the genetic information, is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid rather than a nucleus. The plasmid often contains genes that give the bacterium some advantage over other bacteria. For example it may contain a gene that makes the bacterium resistant to a certain antibiotic.

Bacteria are classified into five groups according to their basic shapes: spherical (cocci), rod (bacilli), spiral (spirilla), comma (vibrios) or corkscrew (spirochaetes). They can exist as single cells, in pairs, chains or clusters.

Bacteria are found in every habitat on Earth: soil, rock, oceans and even arctic snow. Some live in or on other organisms including plants and animals including humans. There are approximately 10 times as many bacterial cells as human cells in the human body. A lot of these bacterial cells are found lining the digestive system. Some bacteria live in the soil or on dead plant matter where they play an important role in the cycling of nutrients. Some types cause food spoilage and crop damage but others are incredibly useful in the production of fermented foods such as yoghurt and soy sauce. Relatively few bacteria are parasites or pathogens that cause disease in animals and plants.



1- Bacteria are found in three basic shapes which are:

A- rod (bacillus, pl., bacilli)

B- round or spherical (coccus, pl., cocci)

C- spiral or helical-shaped (spirillum, pl., spirilla).

2-These three basic shapes may occur in particular arrangements

A- cocci may form clusters (staphylococci, diplococci) or chains (streptococci).

B- Rod-shaped bacteria may appear as very short rods (coccobacilli) or as very long filaments.

a. Bacilli in pairs b. Cocci in chains c. A spirillum with flagella

3- Most bacterial cells are protected by a cell wall that contains the unique molecule peptidoglycan.

4- Traditionally, bacteria are classified according to whether their cell wall is Gram-positive or Gram-negative.

5- Gram-positive bacteria retain a dye-iodine complex and appear purple under the light microscope, while Gram-negative bacteria do not retain the complex and appear pink.

6- Gram-positive bacteria have a thick layer of peptidoglycan on their cell wall, whereas Gram-negative bacteria have only a thin layer.

7- There are many characteristics have been used to classify bacteria which are:

a- presence of endospores.

b- metabolism

c- growth

e- nutritional

8- A new way of classifying bacteria on the basis of rRNA (ribosomal RNA) sequences was introduced in the 1980s.

Bacteria that share the same sequence of rRNA bases are put into the same group.

Cellular structure

Bacterial cell structure

Prokaryote cell with structure and parts

Structure and contents of a typical Gram-positive bacterial cell (seen by the fact that only one cell membrane is present.

Intracellular structures

The bacterial cell is surrounded by a cell membrane, which is made primarily of phospholipids. This membrane encloses the contents of the cell and acts as a barrier to hold nutrients, proteins and other essential components of the cytoplasm within the cell. Unlike eukaryotic cells, bacteria usually lack large membrane-bound structures in their cytoplasm such as a nucleus, mitochondria, chloroplasts and the other organelles present in eukaryotic cells. However, some bacteria have protein-bound organelles in the cytoplasm which compartmentalize aspects of bacterial metabolism, such as the carboxysome. Additionally, bacteria have a multi-component cytoskeleton to control the localisation of proteins and nucleic acids within the cell, and to manage the process of cell division.

Q/ Bacteria form endospore? why

When faced with unfavorable environmental conditions, some bacteria, such as anthrax bacteria form endospores.

Q/ Talking about endospore formation in bacteria?

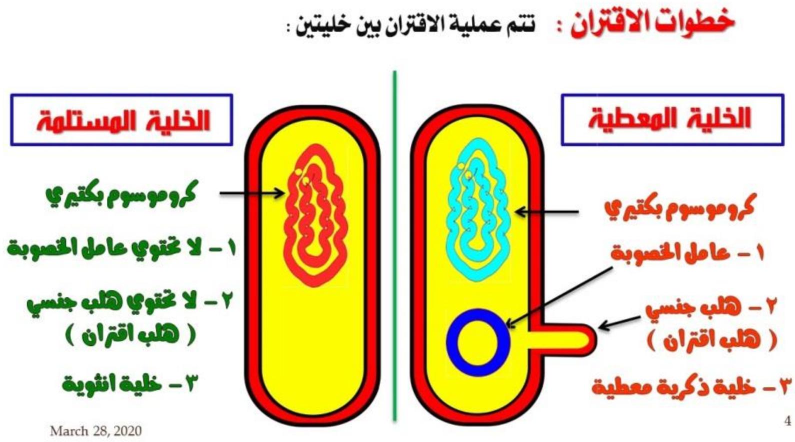
1- A portion of the cytoplasm and a copy of the chromosome dehydrate and are then encased by three heavy, protective spore coats.

2- The rest of the bacterial cell deteriorates, and the endospore is released.

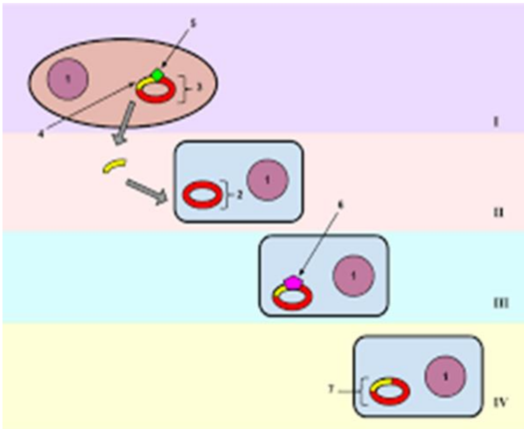
3- When environmental conditions are again suitable for growth, the endospore absorbs water and grows out of the spore coats.

genetic recombination in bacteria:

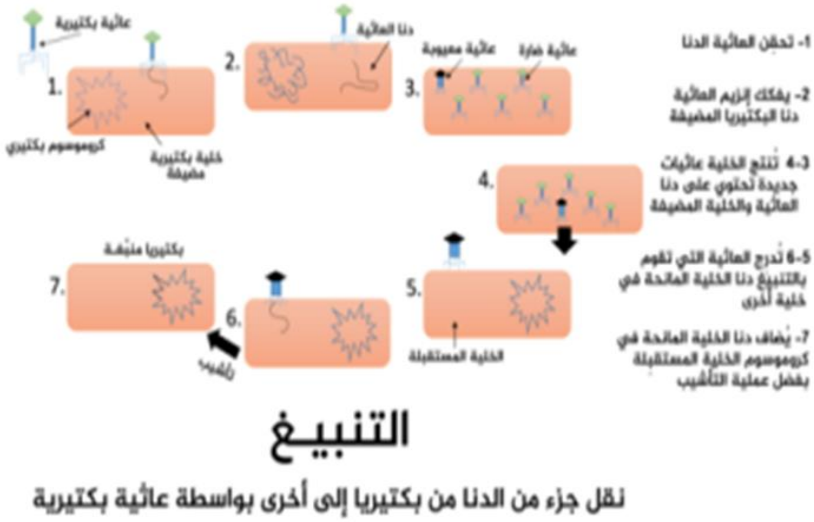
a- ***Conjugation****:* takes place when the so-called male cell passes DNA to the female cell by way of a sex pilus.



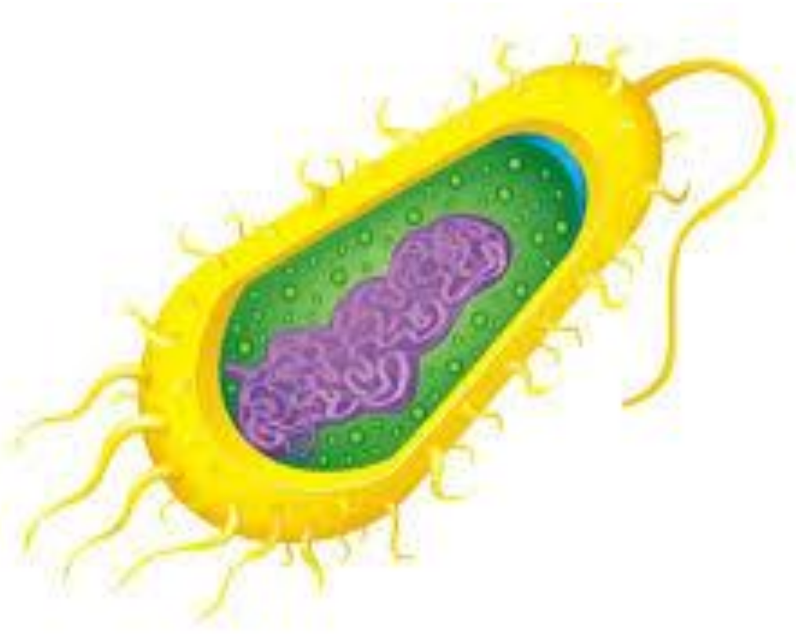
b- ***Transformation****:* occurs when a bacterium binds to and then takes up DNA released into the medium by dead bacteria.



c- ***transduction****:* bacteriophages carry portions of DNA from one bacterium to another.



Bacterial motility



Transmission electron micrograph of Desulfovibrio vulgaris showing a single flagellum at one end of the cell. Scale bar is 0.5 micrometers long.

Many bacteria are motile (able to move themselves) and do so using a variety of mechanisms. The best studied of these are flagella, long filaments that are turned by a motor at the base to generate propeller-like movement. The bacterial flagellum is made of about 20 proteins, with approximately another 30 proteins required for its regulation and assembly. The flagellum is a rotating structure driven by a reversible motor at the base that uses the electrochemical gradient across the membrane for power.

The different arrangements of bacterial flagella: A-Monotrichous; B-Lophotrichous; C-Amphitrichous; D-Peritrichous

Bacteria can use flagella in different ways to generate different kinds of movement. Many bacteria (such as E. coli) have two distinct modes of movement: forward movement (swimming) and tumbling. The tumbling allows them to reorient and makes their movement a three-dimensional random walk. Bacterial species differ in the number and arrangement of flagella on their surface; some have a single flagellum (monotrichous), a flagellum at each end (amphitrichous), clusters of flagella at the poles of the cell (lophotrichous), while others have flagella distributed over the entire surface of the cell (peritrichous). The flagella of a unique group of bacteria, the spirochaetes, are found between two membranes in the periplasmic space. They have a distinctive helical body that twists about as it moves.

Two other types of bacterial motion are called twitching motility that relies on a structure called the type IV pilus, and gliding motility, that uses other mechanisms. In twitching motility, the rod-like pilus extends out from the cell, binds some substrate, and then retracts, pulling the cell forward.

Motile bacteria are attracted or repelled by certain stimuli in behaviours called taxes: these include chemotaxis, phototaxis, energy taxis, and magnetotaxis. In one peculiar group, the myxobacteria, individual bacteria move together to form waves of cells that then differentiate to form fruiting bodies containing spores.The myxobacteria move only when on solid surfaces, unlike E. coli, which is motile in liquid or solid media.

Several Listeria and Shigella species move inside host cells by usurping the cytoskeleton, which is normally used to move organelles inside the cell. By promoting actin polymerisation at one pole of their cells, they can form a kind of tail that pushes them through the host cell's cytoplasm.

Communication

A few bacteria have chemical systems that generate light. This bioluminescence often occurs in bacteria that live in association with fish, and the light probably serves to attract fish or other large animals.

Bacteria often function as multicellular aggregates known as biofilms, exchanging a variety of molecular signals for intercell communication and engaging in coordinated multicellular behaviour.

The communal benefits of multicellular cooperation include a cellular division of labour, accessing resources that cannot effectively be used by single cells, collectively defending against antagonists, and optimising population survival by differentiating into distinct cell types. For example, bacteria in biofilms can have more than five hundred times increased resistance to antibacterial agents than individual "planktonic" bacteria of the same species.

One type of intercellular communication by a molecular signal is called quorum sensing, which serves the purpose of determining whether the local population density is sufficient to support investment in processes that are only successful if large numbers of similar organisms behave similarly, such as excreting digestive enzymes or emitting light. Quorum sensing enables bacteria to coordinate gene expression and to produce, release, and detect autoinducers or pheromones that accumulate with the growth in cell population.

Bacterial taxonomy

Classification seeks to describe the diversity of bacterial species by naming and grouping organisms based on similarities. Bacteria can be classified on the basis of cell structure, cellular metabolism or on differences in cell components, such as DNA, fatty acids, pigments, antigens and quinones. While these schemes allowed the identification and classification of bacterial strains, it was unclear whether these differences represented variation between distinct species or between strains of the same species. This uncertainty was due to the lack of distinctive structures in most bacteria, as well as lateral gene transfer between unrelated species.Due to lateral gene transfer, some closely related bacteria can have very different morphologies and metabolisms. To overcome this uncertainty, modern bacterial classification emphasises molecular systematics, using genetic techniques such as guanine cytosine ratio determination, genome-genome hybridisation, as well as sequencing genes that have not undergone extensive lateral gene transfer, such as the rRNA gene. Classification of bacteria is determined by publication in the International Journal of Systematic Bacteriology, and Bergey's Manual of Systematic Bacteriology. The International Committee on Systematic Bacteriology (ICSB) maintains international rules for the naming of bacteria and taxonomic categories and for the ranking of them in the International Code of Nomenclature of Bacteria.

Historically, bacteria were considered a part of the Plantae, the Plant kingdom, and were called "Schizomycetes" (fission-fungi). For this reason, collective bacteria and other microorganisms in a host are often called "flora".The term "bacteria" was traditionally applied to all microscopic, single-cell prokaryotes. However, molecular systematics showed prokaryotic life to consist of two separate domains, originally called Eubacteria and Archaebacteria, but now called Bacteria and Archaea that evolved independently from an ancient common ancestor. The archaea and eukaryotes are more closely related to each other than either is to the bacteria. These two domains, along with Eukarya, are the basis of the three-domain system, which is currently the most widely used classification system in microbiology. However, due to the relatively recent introduction of molecular systematics and a rapid increase in the number of genome sequences that are available, bacterial classification remains a changing and expanding field. For example, Cavalier-Smith argued that the Archaea and Eukaryotes evolved from Gram-positive bacteria.