Department of biology

2025-2026

((Microbial Physiology))

Stage (-3-)

LEC- ((1))

Introduction of microbial physiology

By

Asst.Lec. Dhuha .S Al-khafaji

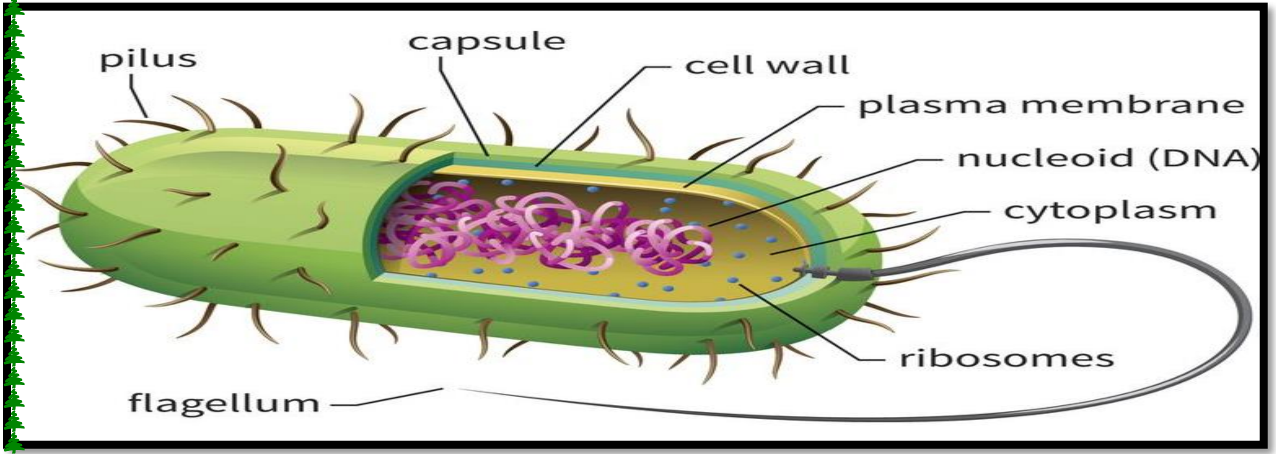
Introduction of microbial physiology :

Microbial physiology is defined as the study of how microbial cell structures, growth and metabolism function in living organisms. It covers the study of viruses, bacteria and fungi. It is also conveyed as the study of microbial cell functions which includes the study of microbial growth , microbial metabolism and microbial cell structure. Microbial physiology is important in the field of metabolic engineering and also functional genomics.

To understand the general principles of microbial metabolism; to obtain an overview of the principles governing energy generation during cellular metabolism and the integration and control of metabolic processes; the metabolic pathways involved in the assimilation (anabolism) and dissimilation (catabolism) of organic carbon-based compounds by microbial enzymes , Clearly microbial physiology is an important research field, not only in fundamental research on microbial species, but also in all applied aspects of microbiology, i. e. industrial microbiology, environmental microbiology, and medical microbiology.

Structure and Composition of microbial cells

Microorganisms are grouped into either prokaryotes or eukaryotes according to their cellular structure. With only a few exceptions, prokaryotic cells do not have subcellular organelles separated from the cytoplasm by phospholipid membranes such as the nuclear and mitochondrial membranes. Organelles like the nucleus, mitochondria and endoplasmic reticulum are only found in eukaryotic cells .The detailed structure of prokaryotic cells is described below.



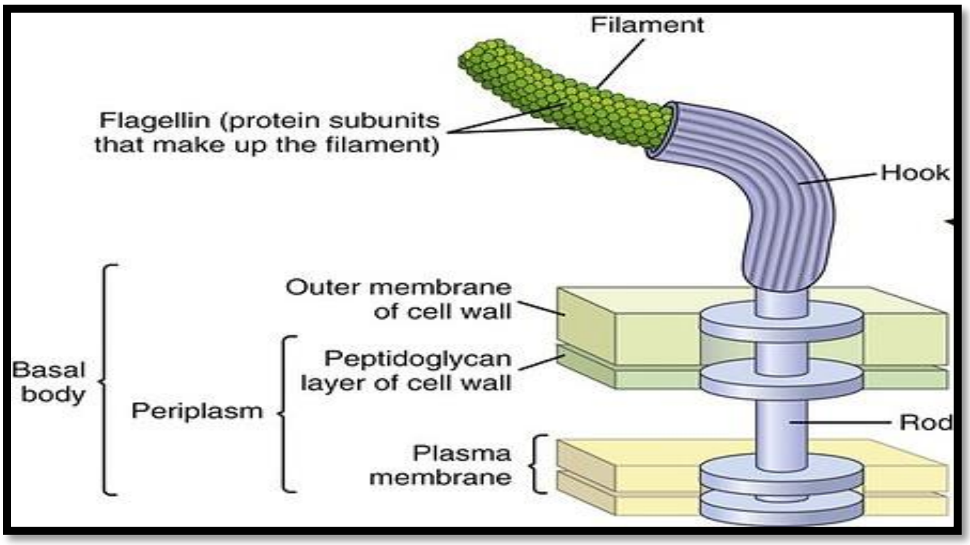
Bacteria cell structure

1 . Flagella and pili

Motile prokaryotic cells have an appendage called a flagellum (plural, flagella) involved in motility, and a similar but smaller structure, the fimbria (plural, fimbriae). Fimbriae are not involved in motility and are composed of proteins.

The bacterial flagellum consists of three parts . These are a basal body, a hook and a filament . The basal body is embedded in the cytoplasmic membrane and cell surface structure and connected to the filament through the hook. In Gram-negative bacteria the basal body consists of a cytoplasmic membrane ring, a periplasmic ring and an outer-membrane ring through which the central rod passes. The diameter of the rings can be 20–50nm depending on the species. **The cytoplasmic ring of the basal body is associated with additional proteins known as the Mot complex. The Mot complex rotates the basal body with the entire flagellum consuming a proton motive force (or sodium motive force) .** The cytoplasmic membrane ring is therefore believed to function as a motor with the Mot complex. In addition to the Mot complex , the basal body is associated with an export apparatus through which the building blocks of the filament are transported.

The hook connects the central rod of the basal body to the filament and is composed of a single protein called the hook protein. The filament, with a diameter of 10–20 nm, can be dissolved at pH 3–4 with surfactants to a single protein solution of flagellin. The molecular weight of flagellin varies from 20 to 65 kD depending on the bacterial species. In Gram-negative bacteria the basal body consists of a cytoplasmic membrane ring, a periplasmic ring and an outer-membrane ring through which the central rod passes. The diameter of the rings can be 20–50nm depending on the species. The cytoplasmic ring of the basal body is associated with additional proteins known as the Mot complex . The Mot complex rotates the basal body with the entire flagellum consuming a proton motive force (or sodium motive force) . The cytoplasmic membrane ring is therefore believed to function as a motor with the Mot complex. The number and location of flagella vary depending on the bacterial species.



The bacterial flagellum

The fimbria, also known as the pilus (plural, pili), is observed in many Gram-negative bacteria but rarely in Gram-positive bacteria. Fimbriae have been proposed as the fibrils that mediate attachment

to surfaces. For this reason, the term pilus should be used only to describe the F-pilus, the structure that mediates conjugation. Fimbriae are generally smaller in length (0.2–20 mm) and width (3–14 nm) than flagella. Fimbriae help the organism to stick to surfaces of other bacteria, to host cells of animals and plants, and to solid surfaces.

Different kinds of fimbriae are known which depend on the species as well as the growth conditions for a given organism. Fimbriae consist of a major protein with minor proteins called adhesions that facilitate bacterial attachment to surfaces by recognizing the appropriate receptor molecules. They are classified as type I through to type IV according to such receptor recognition properties. Adhesive properties are inhibited by sugars such as mannose, galactose and their oligomers, suggesting that the receptors are carbohydrate in nature. **A fibril bigger in size than fimbriae occurs in many Gram-negative bacteria that harbour the conjugative F-plasmid . This is called the F-pilus or sex pilus and mediates attachment between mating cells for the purpose of transmitting DNA from the donor cell by means of the F-pilus to a recipient cell. The F-pilus recognizes a receptor molecule on the surface of the recipient cell and after attachment, the F-pilus is depolymerized so that there is direct contact between the cells for DNA transmission.**

2. Capsules and slime layers

Many prokaryotic cells are covered with polysaccharides. In some cases the polymers are tightly integrated with the cell while in others

they are loosely associated. The former is called a capsule, and the latter a slime layer.

Slime layer materials can diffuse into the medium with their structure and composition being dependent on growth conditions. An important role for these structures is adhesion to host cells for invasion or to a solid surface to initiate and stabilize biofilm formation. These structures are also responsible for resistance to phagocytosis, thereby increasing virulence. In some bacteria the capsule functions as a receptor for phage. Since the polysaccharides are hydrophilic, they can also protect cells from desiccation.

3. S-layer, outer membrane and cell wall

Unicellular prokaryotes have elaborate surface structures. These include the S-layer, outer membrane and cell wall. The cell wall determines the physical shape of prokaryotic cells in most cases. Prokaryotes can be classified into four groups according to their cell wall structure. These are mycoplasmas, Gram-negative bacteria, Gram-positive bacteria and archaea. Cell walls are not found in mycoplasmas which are obligate intracellular pathogens. Murein is the sole building block of the cell wall in Gram-negative bacteria which also have an outer membrane. Murein and teichoic acid constitute the cell wall in Gram-positive bacteria which do not possess an outer membrane. Some archaea have cell walls that do not contain murein, while others are devoid of cell walls.

S-layer : A protein or glycoprotein layer is found on the surface of all prokaryotic cells except mycoplasmas. This is called an S-layer . All prokaryotic cells studied are surrounded by this layer, but this

property can be lost in some laboratory strains. This suggests that this layer is indispensable in natural environments.

The proposed functions of the S-layer are (1) protection from toxic compounds, (2) adhesion to solid surfaces, (3) a phage receptor, (4) a physical structure to maintain cell morphology, and (5) a binding site for certain extracellular enzymes.

Strains devoid of an S-layer are less resistant to murein- and protein-hydrolyzing enzymes, and more prone to release from biofilms with environmental changes such as pH. The S-layer serves as a cell wall in some archaea. Amylase is bound to the S-layer in Bacillus stearothermophilus. The protein forming the S-layer is one of the most abundant proteins in bacterial cells, comprising 5–10% of total cellular protein. In a fast-growing organism, this protein needs to be synthesized and exported very efficiently. The promoter and signal sequence of this protein has therefore been studied for use in foreign protein production using bacteria.

]