

# Bacterial structure

## Cytoplasm

The **cytoplasm** of prokaryotes has a similar composition to eukaryotic cells. However, there are no membrane structures in it. Bacteria lack the classic cytoskeleton.

## Ribosomes

Bacterial ribosomes have a different structure than eukaryotic ones. Prokaryotic ribosomes are smaller than eukaryotic ones and their subunits have different compositions. The small subunit consists of **30 S** (1 RNA, 21 protein molecules) and large **50 S** (2 RNA, 34 protein molecules). Together they have **70 S**.

Different ribosome structures can be used in antibiotic treatment. Such antibiotics include, for example, streptomycin, tetracycline, chloramphenicol, erythromycin, etc.

The number of ribosomes is proportional to the cell growth rate (constant translation rate of about 13 amino acids per second). At present, 1 mRNA of its kind (1000 in total) is present in the cell. They have a short lifespan (several minutes), but at the same time they have a quick adaptive response. **Transcription and translation can take place simultaneously..**

## Plasmids

One or more small circular chromosomes that are not essential for the survival and division of the bacterium are called **plasmids**. They are genetic endosymbionts. The plasmid has the ability to integrate into the chromosome. There may be 1-100 plasmids (plasmid number) in the cell. They may contain genes that alter the properties of the bacteria.

- **Tox** plasmids – genes for toxin production.
- **R** plasmids – resistance factor, genes for enzymes that degrade or modify ATB.
  - Often part of a transposon - a bacterial strain can quickly become a carrier of multiple resistance plasmids.
  - They are often conjugative - propagation.
- **Col** plasmids – the formation of bacteriocins (eg. colicins) that kill other bacteria.
- **F-factor** – genes for sex-pili production, attachment of b. F+ to b. F–, E. coli, salmonella.
- **Virulence** plasmids – endotoxin production, colonization factors.
- **Metabolic** plasmids.

The cell itself is not able to create a plasmid - it can obtain it:

- By **conjugation** through fimbriae from another bacterial cell - spread of antibiotic resistance, horizontal transmission of genetic information.
- By **transduction - through the bacteriophage.**
- By **transformation - the transfer of free DNA from the environment to the cell (Griffith's experiments, evidence of DNA as a carrier of genetic information).**

## Additional features and uses

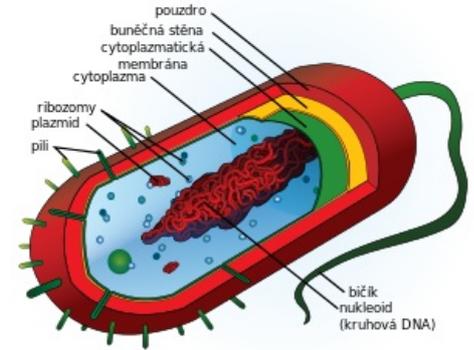
Degradation and oxidation of toxic substances, antibiotic resistance, heavy metals, production of antibiotics, toxins, formation of restriction and modification enzymes. They are used for their great replication capacity as **vectors** in genetic engineering.

## Inclusion bodies, granules

- Glycogen,
- polybetahydroxybutyric acid droplets - a specific storage substance for bacteria,
- polyphosphates,
- lipids,
- vacuoles – buoyancy of aquatic bacteria.

## Spores

Spores can be found in some bacteria (*Bacillus*, *Clostridium*).



Bacterial cell.

## Major circular chromosome (nucleoid)

Bacterial DNA is found freely in the cytoplasm, it is not enveloped by a membrane, so we are not talking about the nucleus. It consists of one circular chromosome. It is in the so-called *nucleolar region* and is attached in one place to the cytoplasmic membrane (**OriC**). This place is called **mesosome**.

The DNA of the double helix is enclosed in superhelicity - physiological is negative, ie more loose, negative superhelicity is maintained by enzymes topoisomerázami (I - releases, II - produces with ATP consumption). The double helix consists of about 3 Mbp with a length of about 1-2 mm (the degree of spiralization depends on the transcriptional activity of the genes that lie in the section). The size of the bacterial genome is species-specific, ranging from six to eight thousand genes.

The amount of protein around the chromosome is non-constant and depends on the intensity of proteosynthesis (these are mainly DNA and RNA polymerases). The proportion of RNA around the chromosome depends on the number of genes currently transcribed. The rate of cell division depends on the frequency of replication initiations (a new one can start during another ongoing one).

During division, DNA attaches to the mesosome. DNA duplication is subject to negative regulation - dilution of the replication inhibitor in a growing cell volume. When DNA is damaged, the SOS regulatory system is activated. There is only one haploid chromosome in the resting non-growing cell, mRNA unmodified - high transcription rate.

## Bacterial wall

**The bacterial wall** is made up of several layers. Because the cytoplasmic membrane is an essential component of all bacteria, other components of the bacterial wall may or may not be present. Their presence may **increase the pathogenicity** of the microbe.

### Cytoplasmic membrane

It consists of a phospholipid bilayer permeated by transmembrane proteins and glycoproteins. It does not contain cholesterol and at lower temperatures there is a higher proportion of unsaturated fatty acids. It has the function of transmembrane transport, the respiratory function (it represents the mitochondria), it anchors the rotor of bacterial flagella.

### Cell wall

The main components of the bacterial wall are **peptidoglycan polymers (mureins)**, composed of long disaccharide and shorter peptide chains, which together form a kind of *lattice*. The wall ensures the **shape** of the bacteria and allows them to survive in a **hypotonic environment**.

Its composition depends on whether the bacteria appear to be **G+** nebo **G-**.

- Bacteria with lipopolysaccharides and part of proteoglycans are **gram-negative**.
- Bacteria with only peptidoglycan walls are **gram-positive**.

It is present in most bacteria, it does not occur in mycoplasmas and **L-forms of bacteria**.

Information on the structure of the bacterial wall is essential for the choice of **antibiotics** in the treatment of bacterial infections.

## Movement and adhesion organelles

They occur only in some bacteria. Their structure and function differ from eukaryotic locomotor organelles.

### Function of adhesion molecules (adhesins)

- **Adherence** - interactions between structures on the surface of bacteria.
  - Tissue tropism of bacteria, **specific binding** to certain structures on the cell surface.
  - The need for proper orientation (negative charges of adhesins and receptors).
  - Adherence is not unique to pathogenic microbes.
- **Biofilm formation**.
- Knowledge of the chemical structure of receptors → the possibility of blockade for bacteria.

### Extracellular polymers (glycocalyx)

Extracellular polymers only occur in some bacteria (eg. *E. coli*). The presence may be a **determining factor in the pathogenicity** of the microbe (*Haemophilus influenzae*). Formation is influenced by the environment. Glycocalyx has a **polysaccharide** character (pneumococci, klebsielly, hemophilia...). *Bacillus anthracis* is made up of polypeptides. It is shown by negative coloring (**ink**). Colonies have a mucous appearance.

### Function

- **Adherence** (function of adhesins) - host colonization, bacterial coaggregation.
- **Biofilm formation**.

- **Resistance** to phagocytosis.
- **Antibiotic resistance.**

## Types

1. **Capsule**
  - Clearly separated from the environment, it clings firmly to the cell wall.
  - Structural integrity (well condensed polymer).
  - Antigenic properties, virulence and invasiveness factor.
2. **Slime** - loose amorphous mass.
3. **S-layer** - a squamous glycoprotein on the cell wall surface.

## Capsule

Only in some bacteria. It consists of polysaccharides. It has a protective function.

## Fimbria (pili)

- They allow the adhesion of bacteria to the host cells and to other bacteria (sex pili).
- Short rigid hollow fibers, made of **pilin** protein, brittle.
- **Only in G-**, tens to hundreds.
- **Adhesion** function - ability to colonize the host.
- Binding to membrane glycoproteins and glycolipids.
- Very **numerous**, mostly evenly on the surface.
- The formation of fimbriae is often coordinated with the formation of other tools of pathogenicity (toxins).
- High specificity, typical for each type of bacterium.
- Very fragile - constant formation of new fimbriae - virulence factor - **change in antigenic composition of pilin**, escape from IgA antibodies (anti-adherent).
- Mannose-sensitive and manno-resistant adherence (if possible inhibition by D-mannose).
- *E. coli* (P-fimbria - pyelonephritis), *N. gonorrhoeae*, *Pseudomonas aeruginosa*, *Bacteroides*, *Vibrio*.

1. **Sex fimbria**
  - Wider and longer than ordinary fimbriae.
  - Coded by a so-called fertile plasmid.
  - DNA transfer between bacteria (**conjugation**).
2. **Curli**
  - Clusters of slender and wrinkled fibers.
  - On the surface of some **escherichia and salmonella**.
  - Serum proteins binding (**sepsis**).

## Non-fimbrial adhesins

- **Protein F** (binds fibronectin, *Str. pyogenes*).
- They can also act as hemagglutinins (yersinie, bordetely, mykoplasmata).

## Flagellum

- They are made of the protein **flagellin**, they have a simpler structure than eukaryotes. The movement of bacteria is caused by their rotation, which is caused by a ring of proteins in the plasma membrane around the flagellum → the ring responds by changing the conformation to a change in the gradient of H<sup>+</sup> ions.
- Longer than the whole cell - up to 20 μm, thickness 20-30 nm.
- 3 parts - filament, hook and basal body:
  1. Flagellin **filament** (hollow, globular protein, species specific).
  2. (**Hook**) - strengthening and connection to the basal body, by 90°.
  3. **Basal body** - anchored by rings into the wall (stator) and cytoplasmic membranes (rotor), differ in G+ a G- (different cell wall structure).

## Distribution of bacteria according to flagella

1. Monotricha - one on pole - *Vibrium*.
  2. Lophotricha - bundle at one pole - *Pseudomonas fluorescens*.
  3. Amfitricha - bundles at both poles - *Spirillum minus*.
  4. Peritricha - flagella all over the surface - majority (*Proteus*, *Escherichia*).
- Representation by **silvering**, indirect identification by motion detection.
  - **Axial fibers** - a structure analogous to a whip, but placed below the surface of the cells - the movement of **spirochetes**.
  - Spirochetes move by changing their shape. Myxobacteria move by the produced secretion.

## Links

## Related articles

- Bacteria
- Prokaryotes
- Bacteria reproduction
- Conjugation, Transformation and Transduction.
- Regulation of gene expression in prokaryotes

## Sources

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- JANSKÝ, Petr. *Zpracované otázky z mikrobiologie* [online]. [cit. 2012-01-31]. <[https://www.yammer.com/wikiskripta.eu/uploaded\\_files/3804405](https://www.yammer.com/wikiskripta.eu/uploaded_files/3804405)>.

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