National Pharmaceutical University
Department of Microbiology, Virology and Immunology

Lecture on Microbiology with immunology fundamentals specialty 226 Pharmacy

Morphology of bacteria

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LECTURE PLAN

1. **Definition of bacteria**
2. **Cell organization of bacteria**
3. **Differences between procaryotic and eucaryotic cells**
4. **Plasma membrane structure**
5. **Structure of Internal Systems**
6. **Differences between Gram-positive and Gram-negative types of cell wall**
7. **Bacterial Endospore**

Questions for self-examination:

Classification of microorganisms.
Microscopy. Types of Microscopes.
Basic form of bacterial cells

Recommended literature

General microbiology: synopsis of lectures to laboratory classes /N. I Filimonova, M.M. Velika, N. Yu. Shevelyova. – Kharkiv : NUPh : Golden Pages, 2011. – 128 p.

Special microbiology in tables / N. I Filimonova, A. Bocharov. – Kharkiv : NUPh : Golden Pages, 2012. – 28 p.

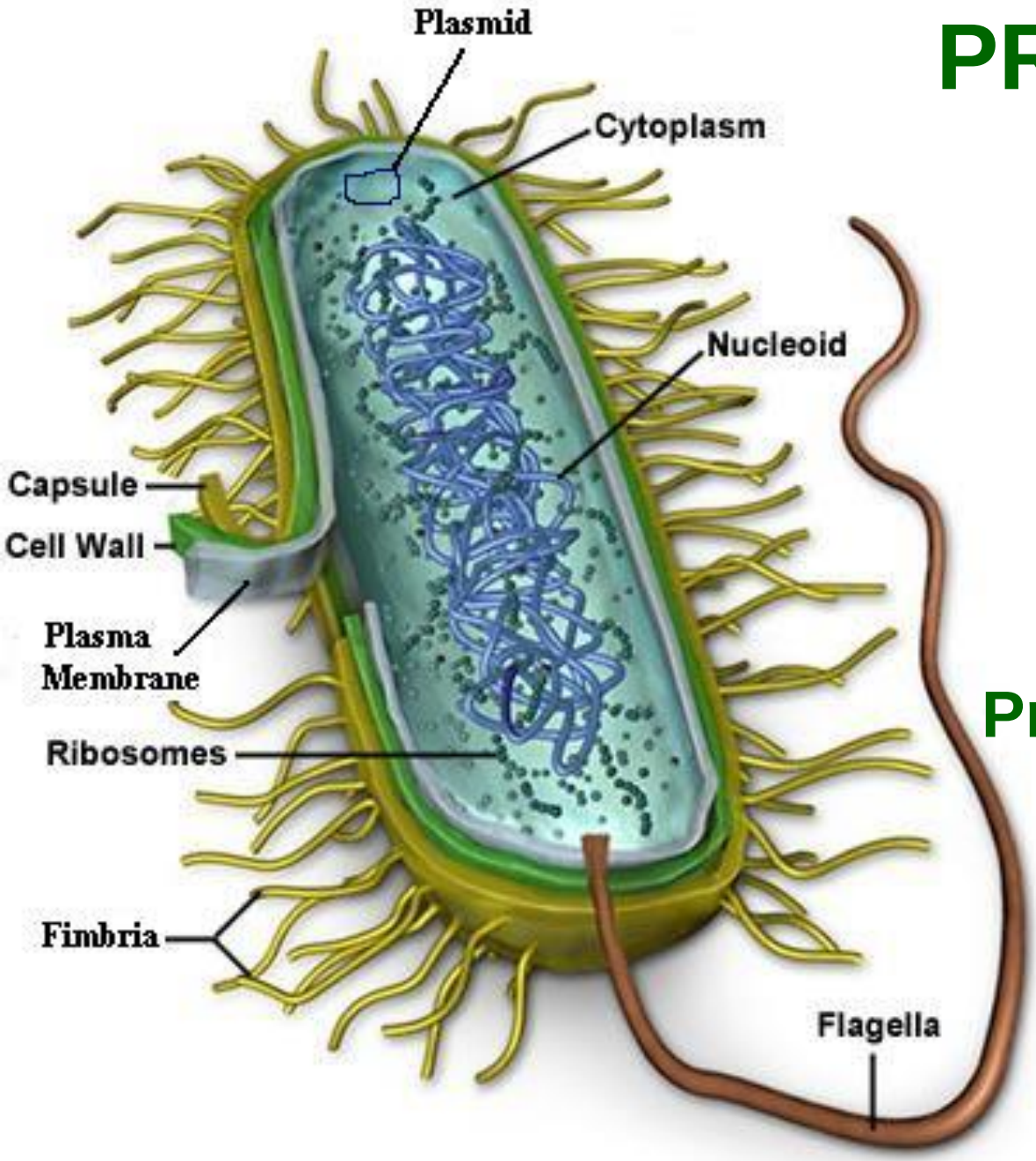
Microbiology: Sub. for stud/ I. L. Dyky, I. Yu.Holupyak, N.Yu. Shevelev, and others. 2nd form. - X .: Professional, 2006. - 433 pp.

Microbiology: A Guide to Laboratory Lessons. Study a manual for students of higher educational institutions / IL Wild, I.I. Sidorchuk, I.Yu. Kholupiak, N.E. Shevelev, MM Great, N.A. Volkova, L.F. Silayeva, O.P. Strilec, O.G. Heyderich, V.E. Litarov - Kh.: Publishing house of NfaU; Golden Pages, 2002. 444 p.

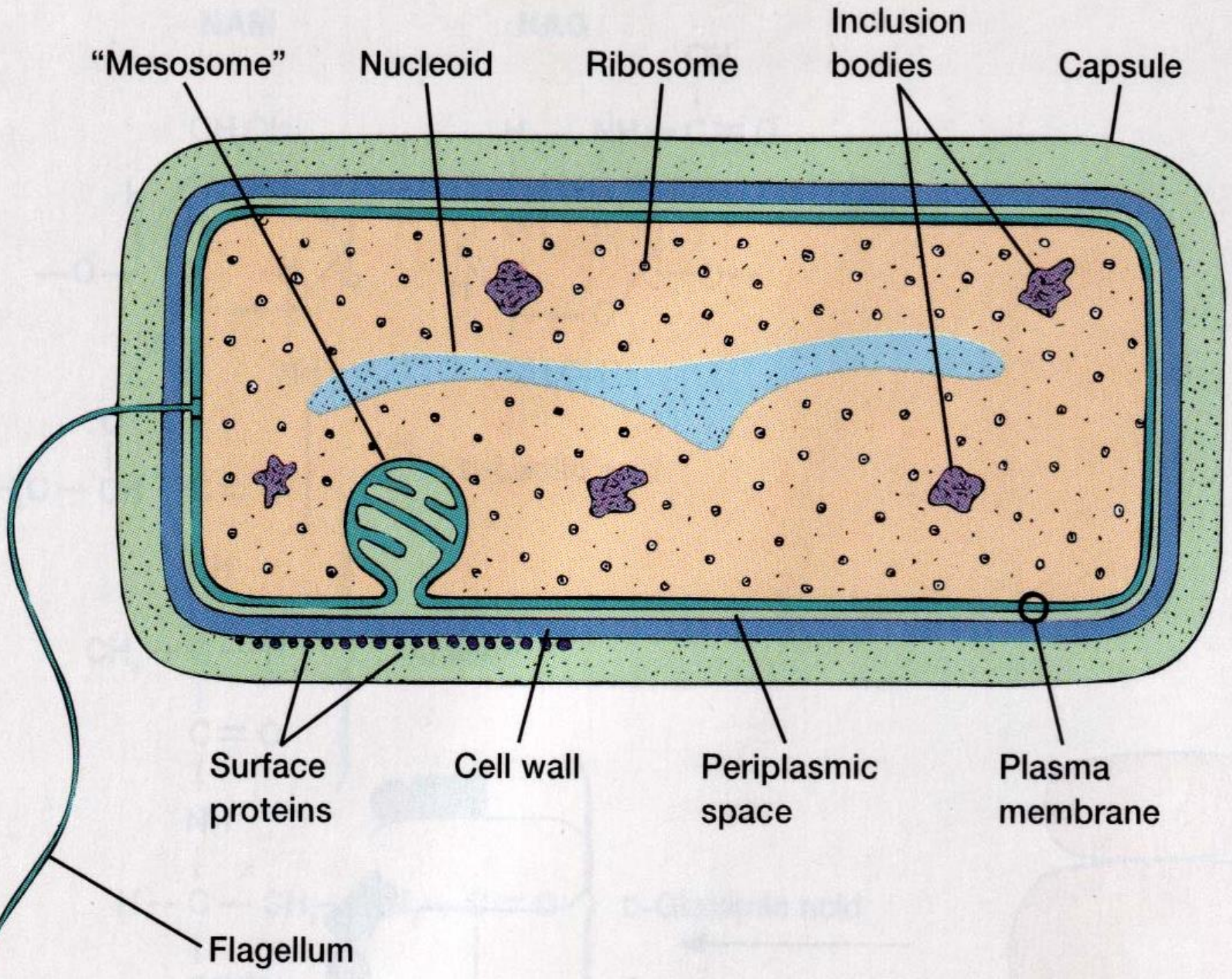
Microbiology Methodical recommendations for students of pharmaceutical higher educational institutions / IL Wild, I.Yu. Kholupiak, MM Great, NE Shevelev and others - X., 2004. - 144 p.

PROCARIOTIC CELL ORGANIZATION

PROCARYOTIC CELL STRUCTURE



Procaryotic cells are morphologically much simpler than eucaryotic cells


"Mesosome"
Nucleoid
Ribosome
Inclusion bodies
Capsule
Surface proteins
Cell wall
Periplasmic space
Plasma membrane
Flagellum

Differences between procaryotic and eucaryotic cells

Procaryotic cell

Nucleus

- **ABSENT:**
  - Nuclear membrane
  - Nucleolus
  - Mitotic division
- **CHROMOSOME:**
  - One
- **DNA:**
  - Circular

Eucaryotic cell

Nucleus

- **PRESENT:**
  - Nuclear membrane
  - Nucleolus
  - Mitotic division
- **CHROMOSOME:**
  - More
- **DNA:**
  - Linear

Differences between procaryotic and eucaryotic cells

Procaryotic cell

Cytoplasm

- **ABSENT:**
  - Cytoplasmic streaming
  - Mitochondria
  - Lysosomes
  - Golgi apparatus
  - Endoplasmic reticulum
- **CYTOPLASMIC RIBOSOME:**
  - 70s

Eucaryotic cell

Cytoplasm

- **PRESENT:**
  - Cytoplasmic streaming
  - Mitochondria
  - Lysosomes
  - Golgi apparatus
  - Endoplasmic reticulum
- **CYTOPLASMIC RIBOSOME:**
  - 80s

Differences between procaryotic and eucaryotic cells

Procaryotic cell

Miscellaneous

- **DIAMETER:**
  1 µm
- **OXIDATIVE PHOSPHORYLATION SITE:**
  periplasmic space of cell membrane
- **CILIA:**
  Absent
- **PILI:**
  Present

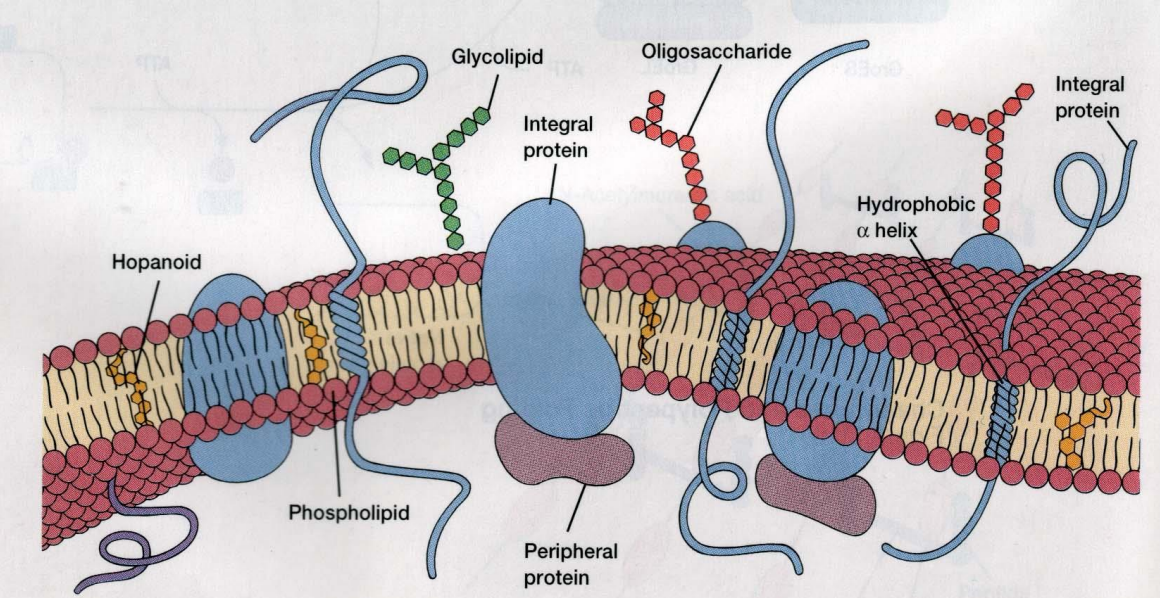
Eucaryotic cell

Miscellaneous

- **DIAMETER:**
  10 µm
- **OXIDATIVE PHOSPHORYLATION SITE:**
  Mitochondria Chloroplast
- **CILIA:**
  Present
- **PILI:**
  Absent

Procaryotic Cell Membranes

The **plasma membrane** encompasses the cytoplasm of cell. Membranes contain both proteins and lipids. Lipids are with polar (**hydrophilic**) and nonpolar (**hydrophobic**) ends and are called amphipathic. This property of lipids enables them to form a bilayer in membranes. Cell membranes are very thin structures, about 5 to 10 nm thick.



Plasma Membrane Structure
Figure 3.7

Roles of the Plasma Membrane

- Selectively permeable barrier
- Mechanical boundary of cell
- Nutrient and waste transport
- Location of many metabolic processes (respiration, photosynthesis)
- Detection of environmental cues for chemotaxis.

Internal Membrane Systems

Mesosomes - are invaginations of the plasma membrane in the shape of vesicles, tubules, or lamellae.

Mesosomes may be involved in cell wall formation during division or play a role in chromosome replication and distribution to daughter cells.

Mesosomes also may be involved in secretory processes and respiration processes.

The Cytoplasmic Matrix

Inclusion Bodies:

- **Organic –**

  Glycogen, PHB (Poly-β-hydroxybutyrate) – are carbon storage reservoirs providing material for energy and biosynthesis.

  Carboxysomes - serve as a reserve of this enzyme and may be a site of CO2 fixation.

  Gas vacuole - give bacteria buoyancy.

- **Inorganic –**

  Volutin – storage reservoirs for phosphate.

  Sulfur granules - storage reservoirs for sulfur.

  Metachromatic granules - energy reserve.

Ribosomes

The cytoplasmic matrix often is packed with **ribosomes;** they also are loosely attached to the plasma membrane. Ribosomes are actually very complex objects made of both protein and ribonucleic acid (RNA). They are the sites of protein synthesis.

Nucleoid

The procaryotic chromosome, almost always a single circle of double-stranded **deoxyribonucleic acid** (DNA), is located in an irregularly shaped region called the **nucleoid** (other names are also used: the nuclear body, chromatin body, nuclear region).

Plasmids

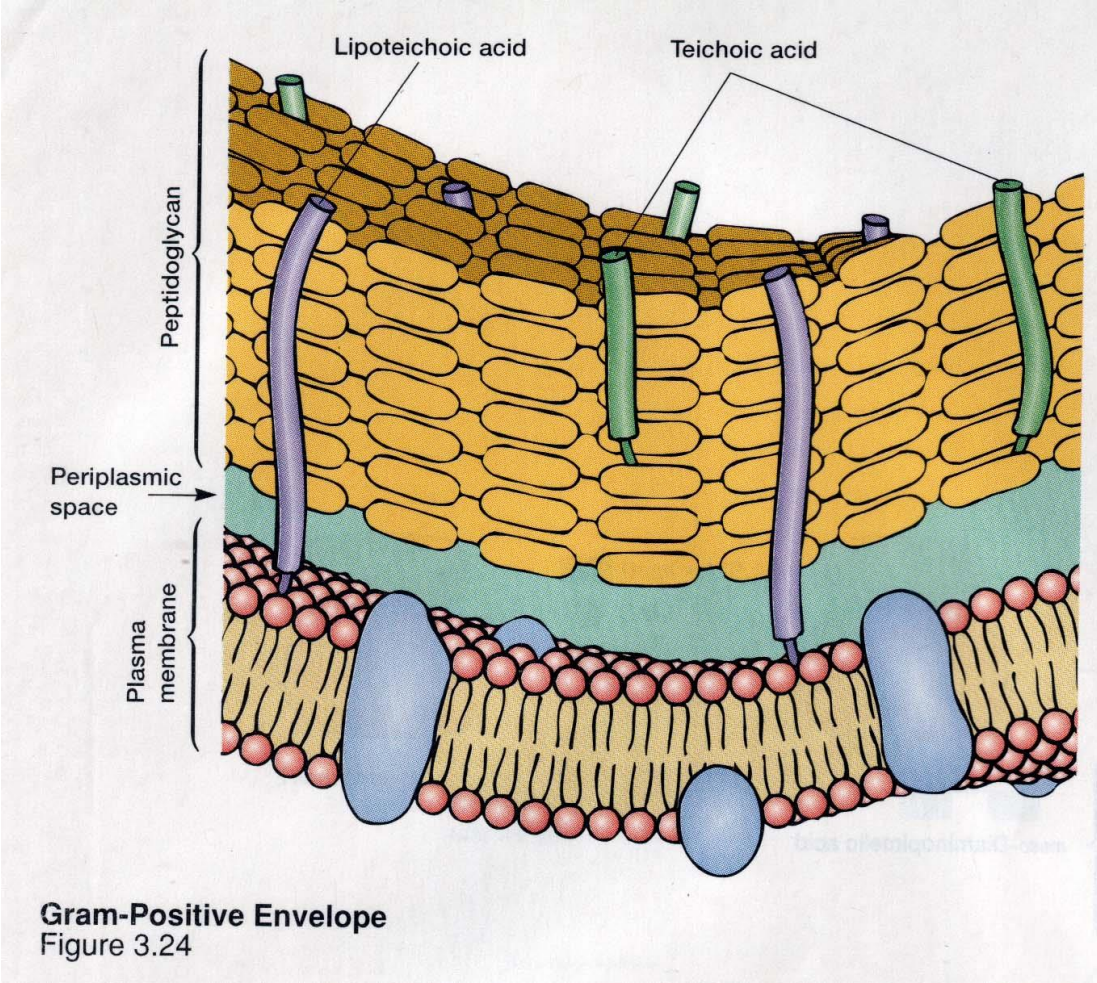
Many bacteria possess **plasmids** in addition to their chromosome. These are circular, double-stranded DNA molecules that can exist and replicate independently of the chromosome or may be integrated with it. Plasmid genes can render bacteria drug-resistant, give them new metabolic abilities, make them pathogenic, or endow them with a number of other properties.

Procaryotic Cell Wall

Most bacteria have strong **walls** that give them shape and protect them from osmotic lysis.
The **cell walls** of many pathogens have components that contribute to their pathogenicity. The wall can protect a cell from toxic substances and is the site of action of several antibiotics. After Christian Gram developed the Gram stain in 1884, it soon became evident that bacteria could be divided into two major groups based on their response to the Gram-stain procedure.

Gram-positive cell wall

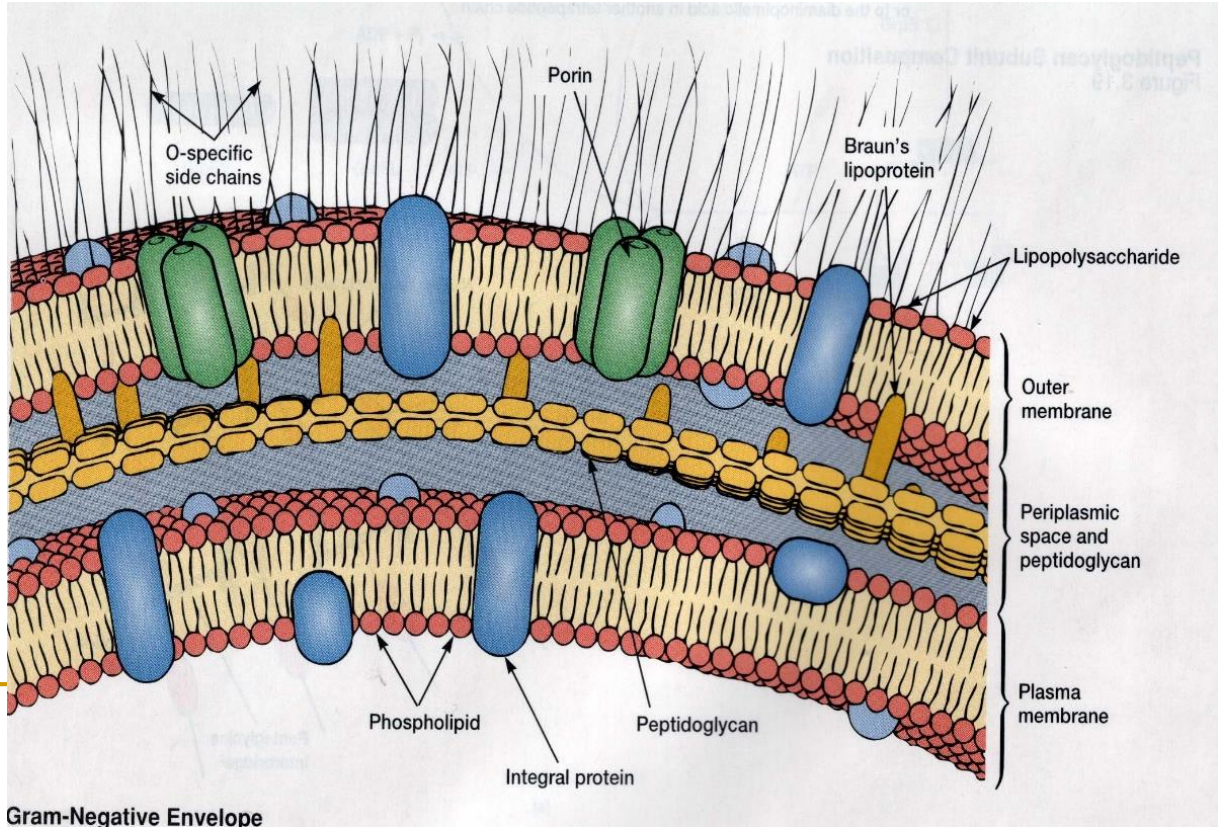
The gram-positive cell wall consists of a single 20 to 80 nm thick homogeneous **peptidoglycan or murein** layer lying outside the plasma membrane.



Gram-Positive Envelope
Figure 3.24

Gram-negative cell wall

The gram-negative cell wall is quite complex. It has a 1-to 3nm peptidoglycan layer next to the plasma membrane. The **outer membrane** lies outside the thin peptidoglycan layer. A space between the plasma membrane and the outer membrane is called the **periplasmic space.**It contains many proteins, hydrolytic enzymes



Gram-Negative Envelope

the Cell Wall External Components

Some bacteria have a layer of material lying outside the cell wall. When the layer is well organized and not easily washed off, it is called a **capsule.** Capsule help bacteria resist phagocytosis by host phagocytic cells. Capsules contain a great deal of water and can protect bacteria against desiccation. They exclude bacterial viruses and most hydrophobic toxic materials such as detergents.

Pili and Fimbriae

Many gram-negative bacteria have short, fine, hairlike appendages that are thinner than flagella and not involved in motility. These are usually called **fimbriae** (s., **fimbria).** Some types of fimbriae attach bacteria to solid surfaces such as rocks in streams and host tissues.
Sex **pili** (s., **pilus)** are similar appendages,
Pili often are larger than fimbriae. They are genetically determined by sex factors or conjugative plasmids and are required for bacterial mating.

Flagella

Most motile bacteria move by use of **flagella**. Bacterial species often differ distinctively in their patterns of flagella distribution.

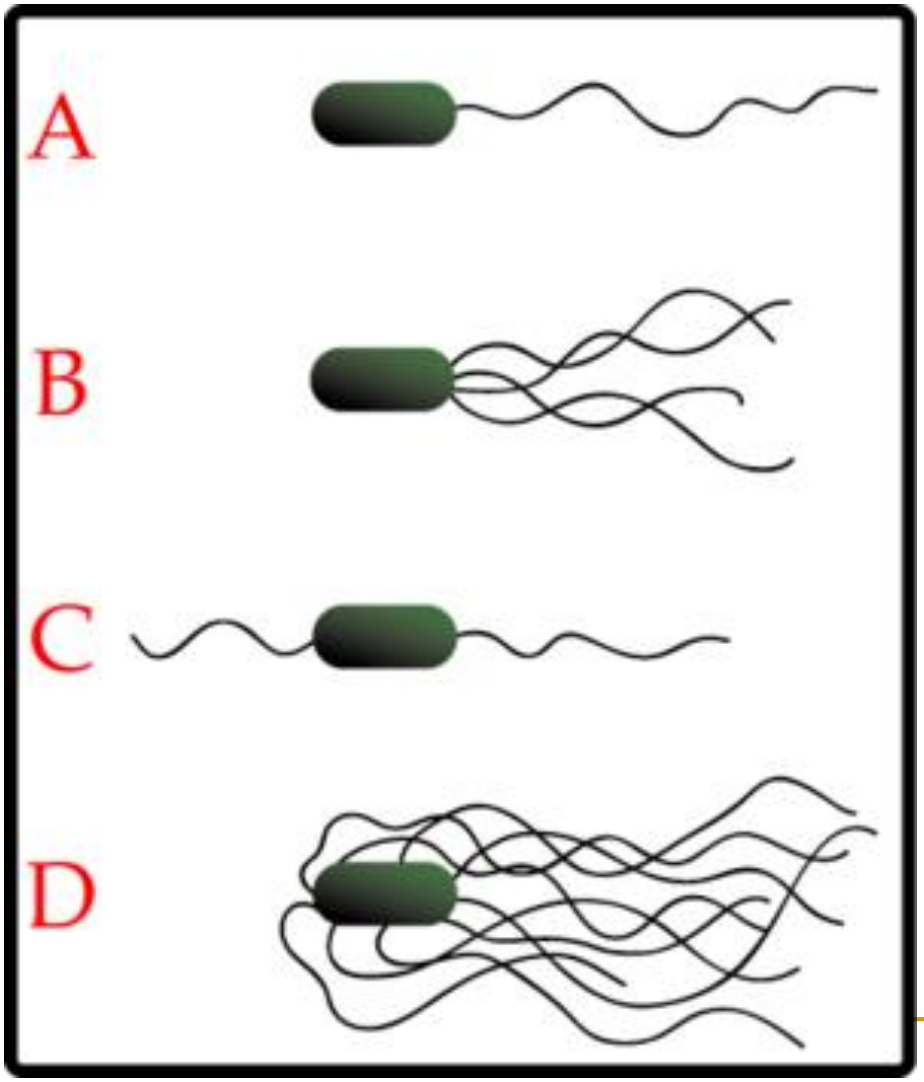
Monotrichous bacteria *(trichous* means hair) have one flagellum.

Amphitrichous bacteria *(amphi* means "on both sides") have a single flagellum at each pole.

Lophotrichous bacteria *(lopho* means tuft) have a cluster of flagella at one or both ends.

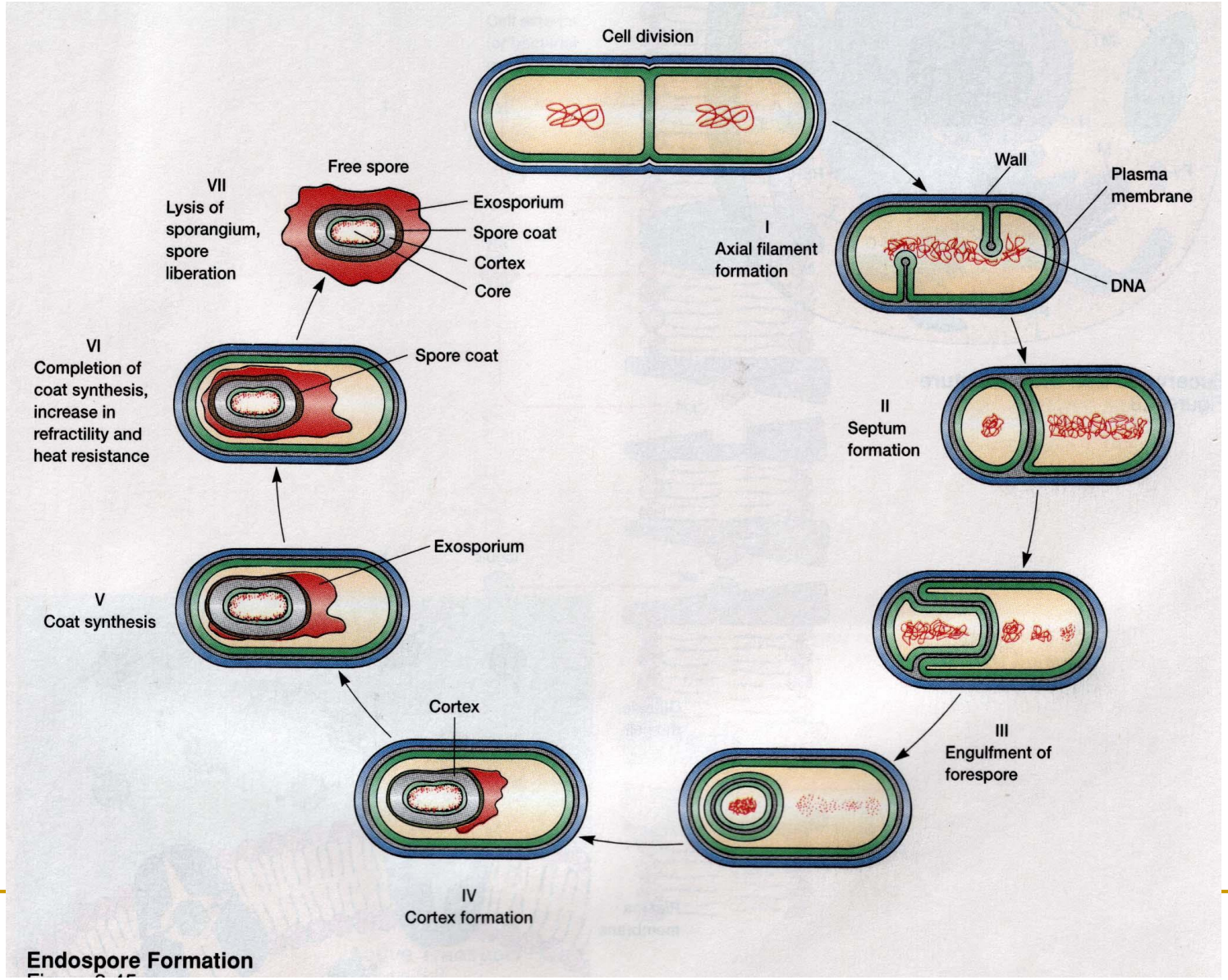
Flagella are spread fairly evenly over the whole surface of **peritrichous** *(peri* means "around") bacteria.

Flagella



- A - **Monotrichous**
- B –**Lophotrichous**
- C - **Amphitrichous**
- D - **Peritrichous**

The Bacterial Endospore

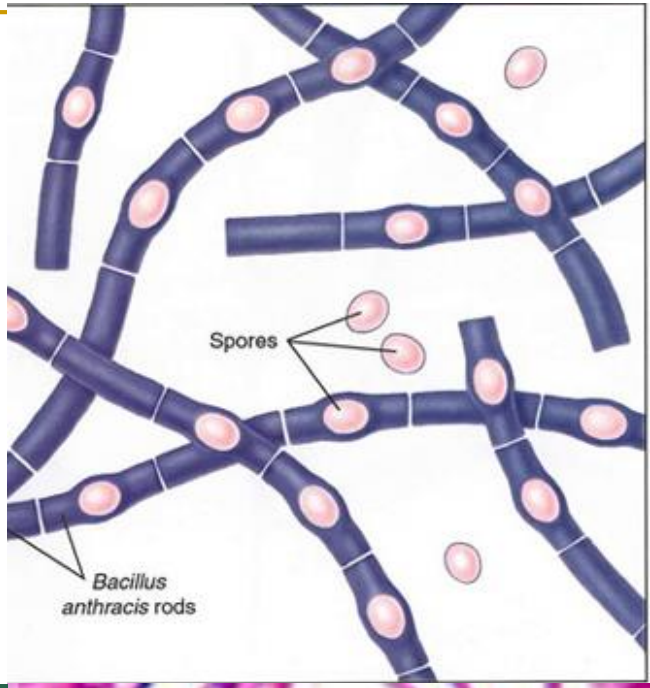


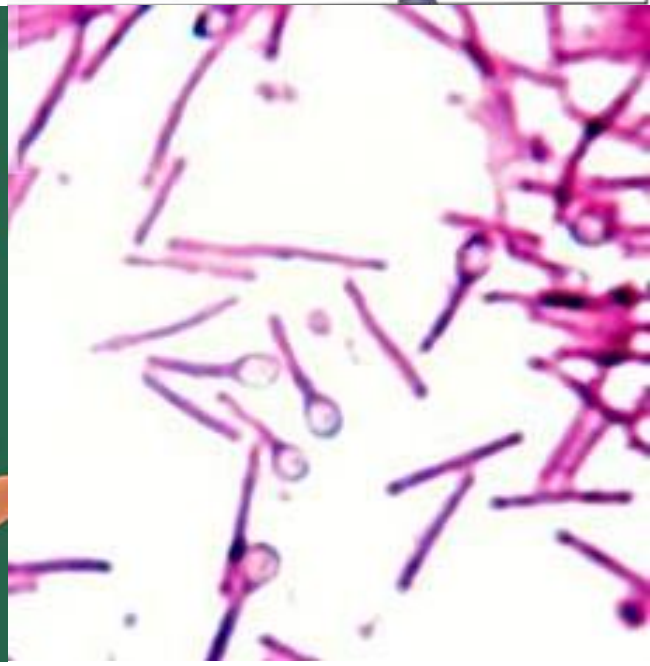
Spore Formation, sporogenesis or sporulation

It is complex process and may be divided into seven stages. An axial filament of nuclear material forms (stage I), followed by an inward folding of the cell membrane to enclose part of the DNA and produce the forespore septum (stage II). The membrane continues to grow and engulfs the immature spore in a second membrane (stage III). Next, cortex is laid down in the space between the two membranes, and both calcium and dipicolinic acid are accumulated (stage IV). Protein coats then are formed around the cortex (stage V), and maturation of the spore occurs (stage VI). Finally, lytic enzymes destroy the sporangium releasing the spore (stage VII). Sporulation requires only about 10 hours.

The transformation of dormant spores into active vegetative cells seems almost as complex a process as sporogenesis. It occurs in three stages: (1) activation, (2) germination, and (3) outgrowth.

A number of gram-positive bacteria can form a special resistant, dormant structure called an **endospore.**
These structures are resistant to environmental stresses such as heat, ultraviolet radiation, chemical disinfectants, and desiccation.
Spore position in cell differs among species, making it of considerable value in identification.
Spores may be **centrally** located, close to one end (**subterminal**), or definitely **terminal**. Sometimes a spore is so large that it swells the sporangium.





Conclusions:

- Procaryotic cells are morphologically much simpler than eucaryotic cells
- The cell envelope of gram-positive cells is relatively simple, consisting of two to three layers: the cytoplasmic membrane, a thick peptidoglycan layer, and in some bacteria an outer layer called the capsule. The structure and function of these layers are described below.
- This is a highly complex, multilayered structure. The cytoplasmic membrane (called the inner membrane in gram-negative bacteria) is surrounded by a single planar sheet of peptidoglycan to which is anchored a complex layer called the outer membrane. An outermost capsule may also be present. The space between the inner and outer membrane is called the periplasmic space.

Thank you for attention