BASIC BACTERIOLOGY

Microbes causing infectious Diseases

- Bacteria
- Fungi
- Protozoa
- Helminths
- Viruses

TABLE 1-1 Biologic Relationships of Pathogenic Microorganisms

Kingdom	Pathogenic Microorganisms	Type of Cells
Animal	Helminths (worms)	Eukaryotic
Protists	Protozoa	Eukaryotic
Fungi	Fungi (yeasts and molds)	Eukaryotic
Prokaryote	Bacteria	Prokaryotic
	Viruses	Noncellular

METHOD OF REPLICATION:

Replication of cells:

- Division into two progeny cell by…
- Binary fission or
- Mitosis,
- Bacteria can replicate extracellularly except Rickettsiae & chlamydiae

Replication of Viruses:

- Disassemble,
- Reassemble – multiple progeny viruses,
- Replication within host cell,

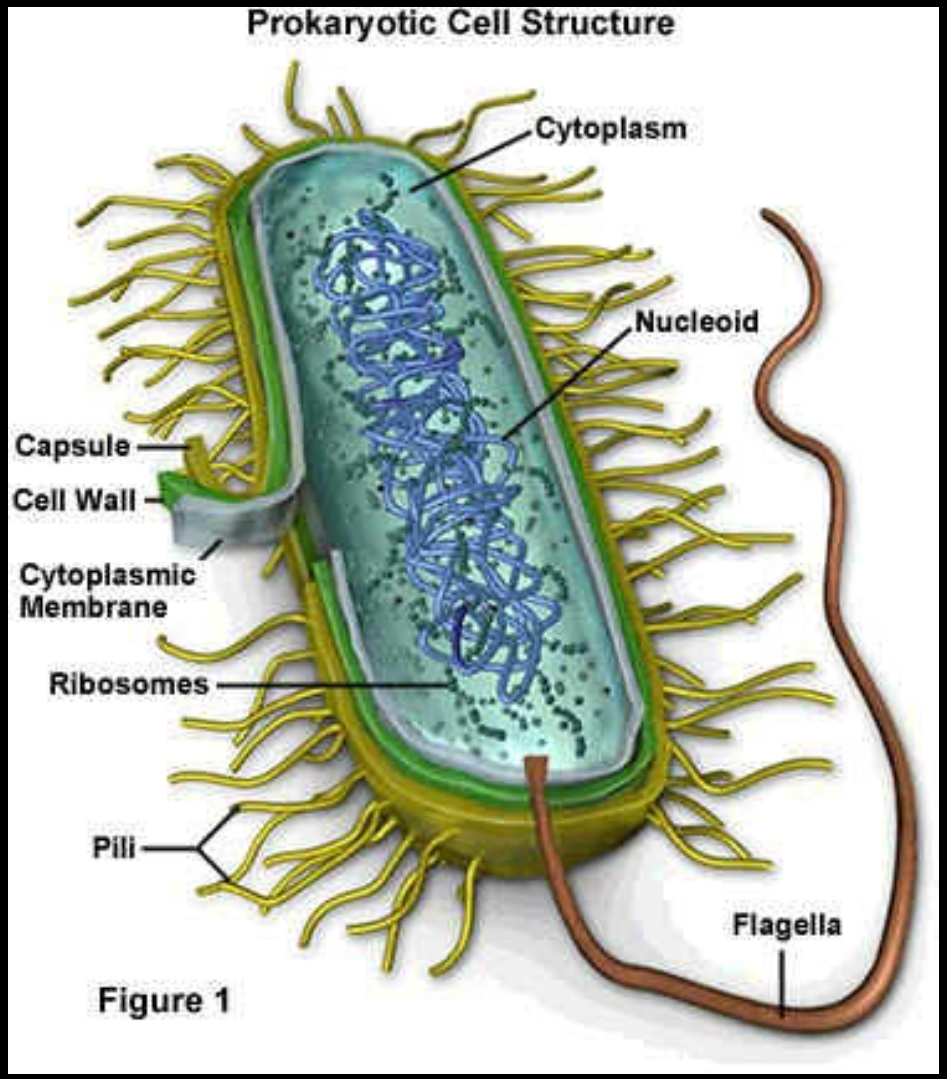
Structure of bacterial cells

Prokaryotic Vs. Eukaryotic Cells

- Prokaryotes
  - Pro: “first” or “primitive”
  - Simple cell organization
- Eukaryotes
  - Higher organisms: animals, plants, fungi, protozoa
  - Cellular complexity **with** ***nuclear membrane***

Bacterial Structure & Cell Components

- Cytoplasm
  - DNA
  - Plasmids
  - Ribosome
- Envelope
  - Cytoplasmic membrane
  - Cell wall
- Capsule/ Slime layer
- Flagella
- Pili
- Spores



Cell wall

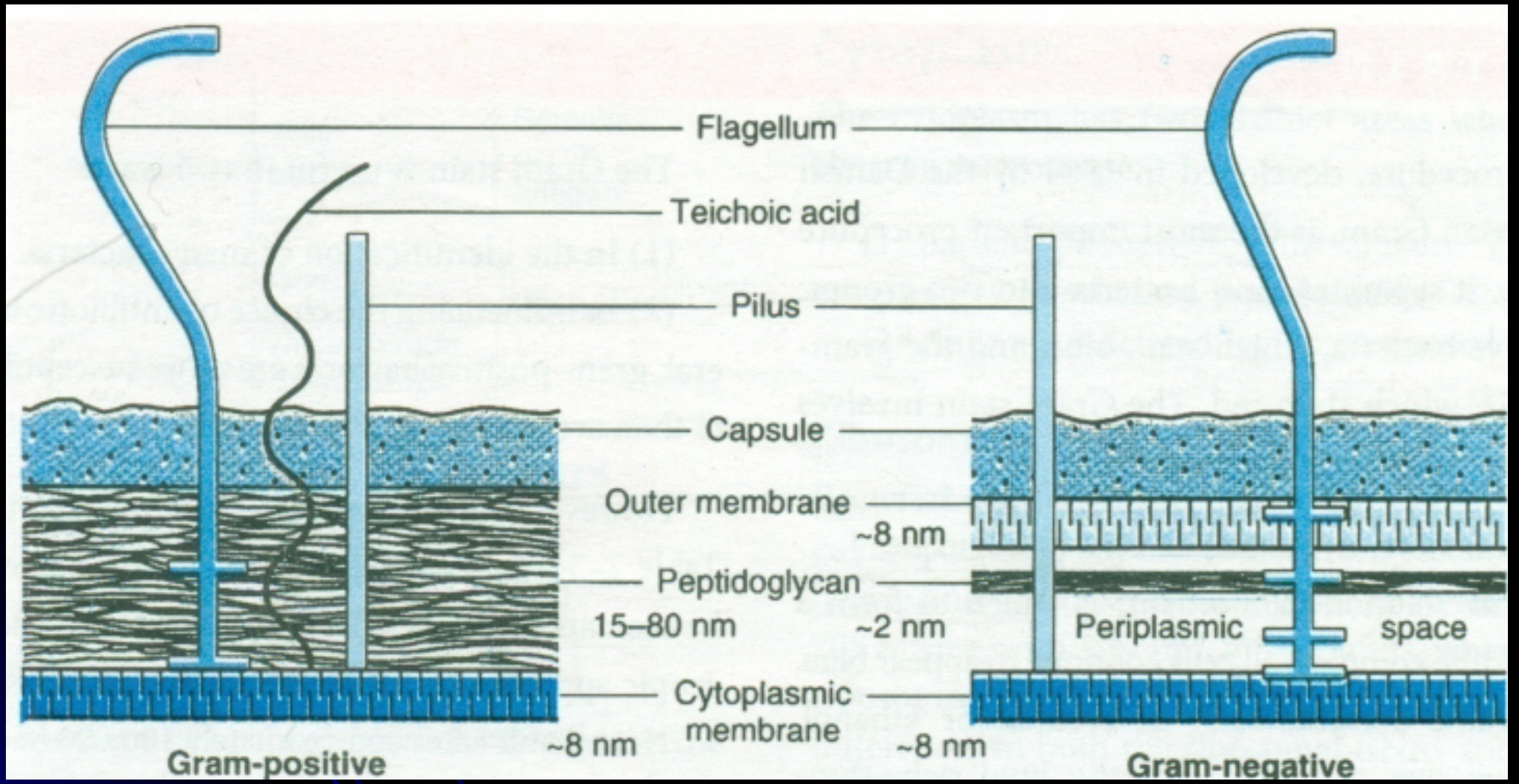
- Outer most component of bacteria
- Present outside cytoplasmic membrane
- Multilayered consists of peptidoglycan layer (both G +ve & G –ve bacteria)

  outer membrane (only G –ve bacteria)
- Important properties

  LPS/ endotoxin

  Antigens (proteins and polysaccharides)

  Porin proteins


Flagellum
Teichoic acid
Pilus
Capsule
Outer membrane
~8 nm
Peptidoglycan
15–80 nm
~2 nm
Periplasmic space
Cytoplasmic membrane
~8 nm
~8 nm
Gram-positive
Gram-negative

Importance

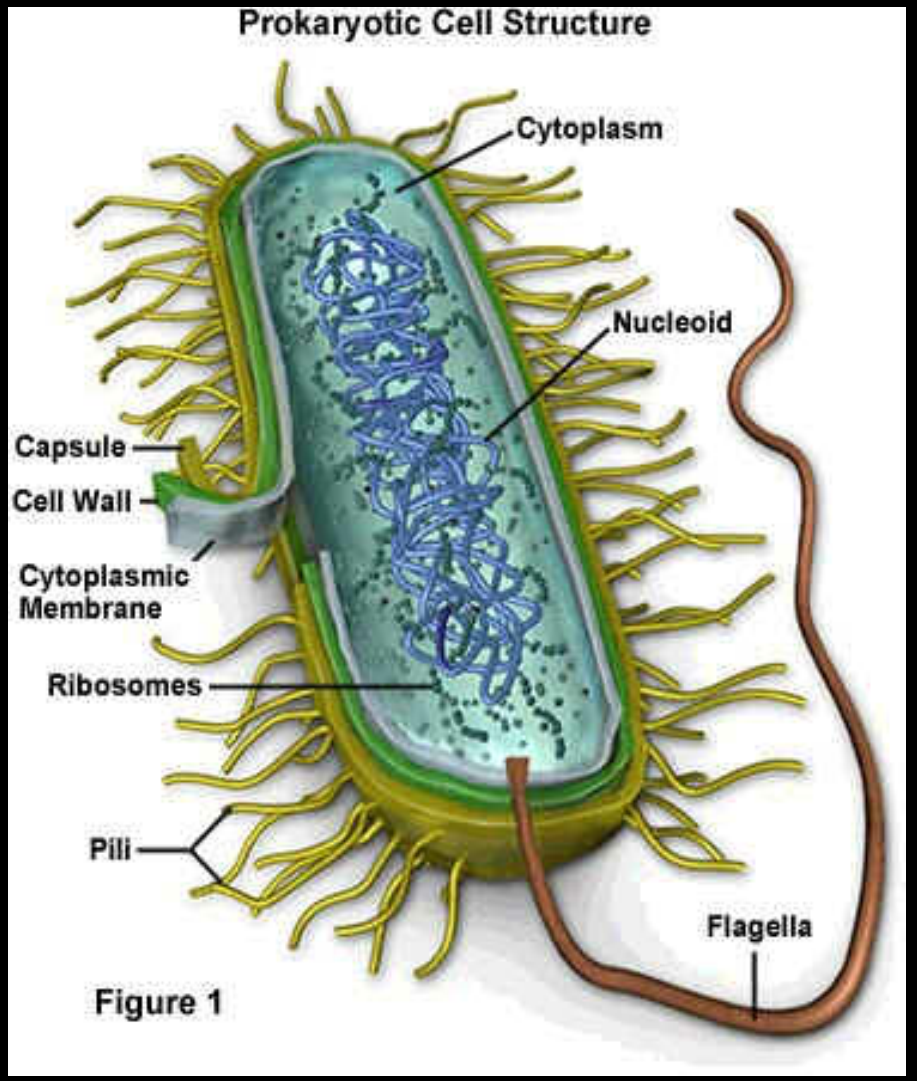
- Provides rigid support to cell
- Responsible for shape
- Allow the cells to withstand low osmotic pressure
- Target for penicillins and cephalosporins
- Lysozyme can cleave peptidoglycan (breaks glycosyl bonds)
- **Protoplast**

Cytoplasmic membrane

- The cytoplasmic membrane
- Present inside peptidoglycan layer
- Composed of phospholipid bilayer. Eukaryotic membranes and Mycoplasma contain sterols
- Functions
  - Active transport of molecules into the cell
  - Energy generation by oxidative phosphorylation
  - Synthesis of precursors of cell wall
  - Secretion of enzymes and toxins

Cytoplasm

- Has two distinct areas
- An amorphous matrix that contains:
  - Ribosome
  - Nutrient Granules
  - Metabolites
  - Plasmids
- An inner nucleoid region composed of DNA



Ribosomes

- Composed of
  - Ribosomal RNA/ rRNA (60%)
  - Protein (40%)
- Bacterial ribosome is 70S (50S+30S subunits)
- Function: the site of protein synthesis
- Selective action of antibiotics.

Plasmids

- Extra-chromosomal DNA
- Double stranded
- Circular DNA molecules
- Capable of replicating independently of bacterial chromosomes
- Can be integrated into the bacterial chromosome
- Occur in both G+ve and G-ve bacteria
- Several different types of plasmids can exist in the same cell.

TRANSMISSIBLE PLASMIDS

- Can be transferred from cell to cell by conjugation
- Contain genes responsible for synthesis of sex pilus & for the enzymes required for transfer.
- 1-3 copies per cell

NONTRANSMISSIBLE PLASMIDS

- Smaller in size,
- Do not contain the transfer genes
- 10-60 copies/cell

IMPORTANCE

Carry genes for following functions and structures of medical importance

- Antibiotic resistance – mediated by a variety of enzymes
- Resistance to heavy metals
- Resistance to uv light – mediated by DNA repair enzymes
- Pili – mediate adherence
- Exotoxins
- Code for bacteriocins

Transposons

- Pieces of DNA that move readily from one site to another (jumping genes).
- Code for – drug resistant enzymes, toxins or metabolic enzymes.
- Can cause mutations or alter the expression of nearby genes.
- Not capable of independent replication.

Capsule

- A gelatinous layer covering the entire bacterium.
- Made of Polysaccharide
- Also useful in the determination of serotype within a species.
- 84 different serotype of strep. pnumoniae

Importance

- Determinant of virulence – antiphagocytic action.
- Specific identification of an organism by using antiserum against the capsular polysaccharide (quellung reaction)
- Used as antigen in vaccines
- Help in adherence of bacteria to human tissues.

Flagella

- Medical importance
- Some species of motile bacteria e.g., E. Coli and proteus cause uti
- Flagella propel the bacteria from urethra into bladder
- Some species of bacteria e.g., Salmonella are identified by the use of specific antibodies against flagellar protiens.

PILI

- Also called fimbriae
- Hair like filaments
- Shorter and straighter than flagella
- Composed of pilin protien
- Found mainly on gram –ve organisms
- Functions :
- Mediate attachment of bacteria
- Transport of bacterial DNA during conjugation – sex pilus

Glycocalyx

- Polysaccharide coating secreted by many bacteria
- Covers surfaces like a film called biofilm
- Allows bacteria to adhere firmly with structures: teeth, heart valves and catheters.
- P. aeruginosa → RTI in cystic fibrosis pts

Spores

- Formed in response to adverse conditions e.g., depletion of nutrients.
- Produced by genus bacillus & clostridium
- Spore forms inside the cell & contain bacterial DNA, a small amount of cytoplasm, cell membrane, peptidoglycan, very little water & a thick keratin-like coat → resistance to heat, dehydration, radiation & chemicals.
- No detectable metabolic activity
- Able to survive for years

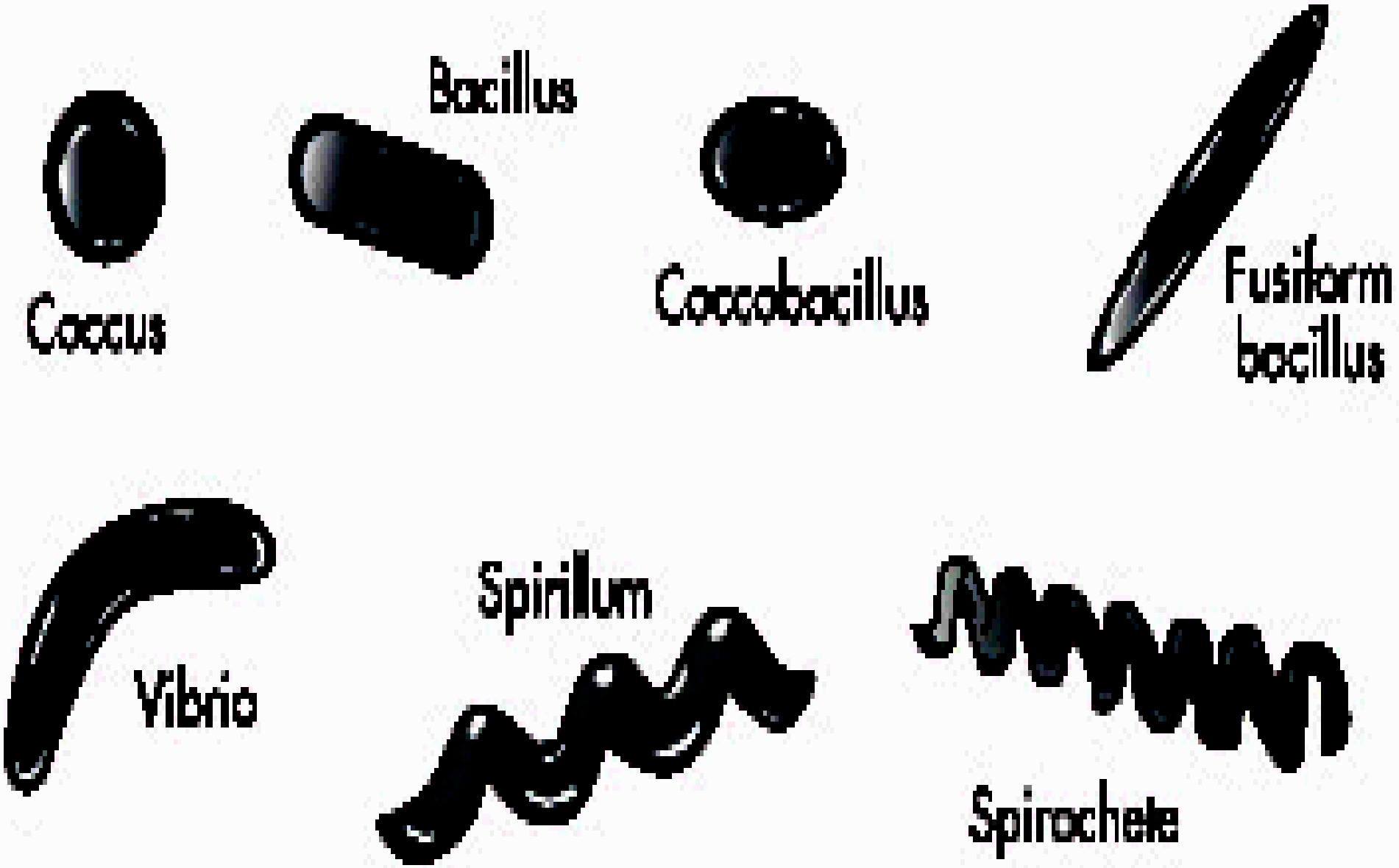
GERMINATION

- Occurs when they encounter suitable conditions
- Specific enzymes degrade the coat,
- Water and nutrients enter → germination into a potentially pathogenic bacterial cell.

Importance

- Extraordinary resistance to heat and chemicals,
- Sterilization cannot be achieved by boiling
- Steam heating under pressure at 121 C for thirty minutes (autoclaving)
- Spores are not recovered from clinical specimens as nutrients are adequate.

Bacterial Morphology Shapes



AEROBIC AND ANAEROBIC BACTERIA

- OBLIGATE AEROBES
- ANAEROBES
- FACULTATIVE ANAEROBES
- MICROAEROPHILIC
- STRICT OR OBLIGATE ANAEROBES

GENETICS

MUTATIONS

- Change in the base sequence of DNA → insertion of a different AA into a protein → altered phenotype.
- Mutations can be caused by chemicals, radiation or viruses.
- Mutations result from three types of molecular changes.
- BASE SUBSITUTION
- FRAMESHIFT
- TRANSPOSONS

TRANSFER OF DNA BETWEEN BACTERIAL CELL

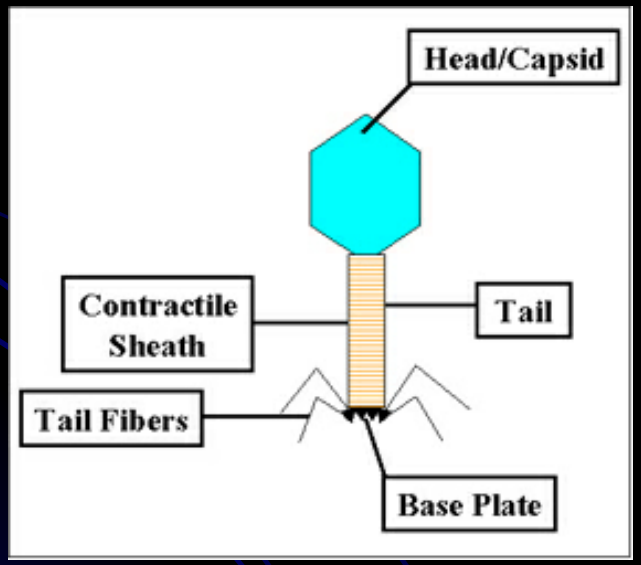
1. CONJUGATION
2. TRANSDUCTON
3. TRANSFORMATION

1. CONJUGATION:

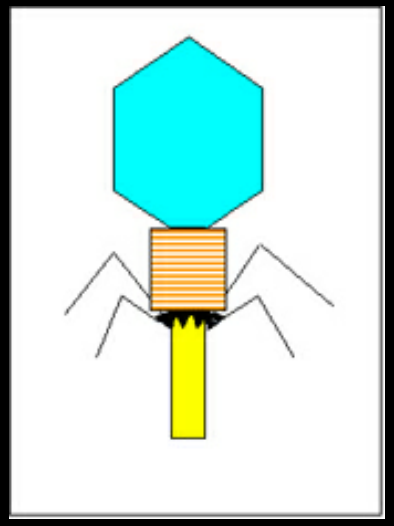
- Mating of two bacterial cells – DNA is transferred from the donor to recipient.
- Process is controlled by F (fertility) plasmid (F factor)

2. Transduction

- Genetic recombination in which a DNA fragment is transferred from one bacterium to another by a bacteriophage



Structure of T4 bacteriophage



Contraction of the tail sheath of T4

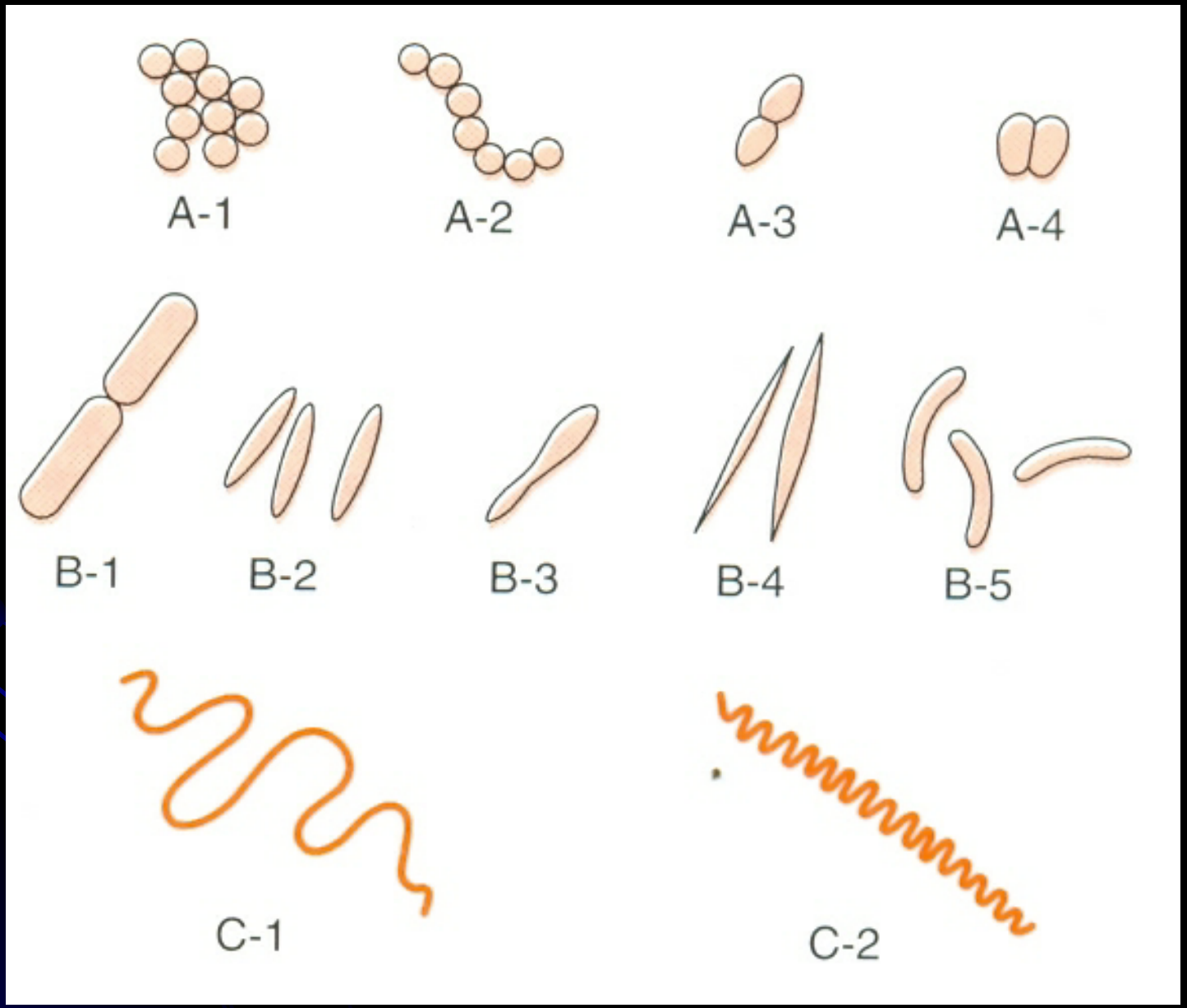
3. TRANSFORMATION:

- Transfer of DNA itself from one cell to another

1. Dying bacteria release their DNA which may be taken up by recipient bacteria.
2. Extraction of DNA from one type of bacteria and introduction into genetically different bacteria.

- Purified DNA injected into the nucleus of eukaryotic cell - TRANSFECTION

SHAPES OF BACTERIA



CLASSIFICATION OF MEDICALLY IMPORTANT BACTERIA

- Criteria for the classification of bacteria…
  - Nature of the cell wall,
  - Staining characteristics,
  - Morphology,
  - Ability to grow in the presence or absence of oxygen &
  - The ability to form spores.
- The current criterion is based upon the base sequence of the genome DNA.

Characteristics	Genus	Representative Diseases
I. Rigid, thick-walled cells		
A. Free-living (extracellular bacteria)		
1. Gram-positive		
a. Cocci	*Streptococcus*	Pneumonia, pharyngitis, cellulitis
	Staphylococcus	Abscess of skin and other organs
b. Spore-forming rods		
(1) Aerobic	*Bacillus*	Anthrax
(2) Anaerobic	*Clostridium*	Tetanus, gas gangrene, botulism
c. Non-spore-forming rods		
(1) Nonfilamentous	*Corynebacterium*	Diphtheria
	Listeria	Meningitis
(2) Filamentous	*Actinomyces*	Actinomycosis
	Nocardia	Nocardiosis
2. Gram-negative		
a. Cocci	*Neisseria*	Gonorrhea, meningitis
b. Rods		
(1) Facultative		
(a) Straight		
(i) Respiratory organisms	*Haemophilus*	Meningitis
	Bordetella	Whooping cough
	Legionella	Pneumonia
(ii) Zoonotic organisms	*Brucella*	Brucellosis
	Francisella	Tularemia
	Pasteurella	Cellulitis
	Yersinia	Plague
(iii) Enteric and related organisms	*Escherichia*	Urinary tract infection, diarrhea
	Enterobacter	Urinary tract infection
	Serratia	Pneumonia
	Klebsiella	Pneumonia, urinary tract infection
	Salmonella	Enterocolitis, typhoid fever
	Shigella	Enterocolitis
	Proteus	Urinary tract infection
(b) Curved	*Campylobacter*	Enterocolitis
	Helicobacter	Gastritis, peptic ulcer
	Vibrio	Cholera
(2) Aerobic	*Pseudomonas*	Pneumonia, urinary tract infection
(3) Anaerobic	*Bacteroides*	Peritonitis
3. Acid-fast	*Mycobacterium*	Tuberculosis, leprosy
B. Non-free-living (obligate intracellular parasites)	*Rickettsia*	Rocky Mountain spotted fever, typhus, Q fever
	Chlamydia	Urethritis, trachoma, psittacosis
II. Flexible, thin-walled cells (spirochetes)	*Treponema*	Syphilis
	Borrelia	Lyme disease
	Leptospira	Leptospirosis
III. Wall-less cells	*Mycoplasma*	Pneumonia

NORMAL FLORA

- Various bacteria and fungi which are permanent residents of certain body sites e. g. skin, oropharynx, colon & vagina.

Colonization

- Acquisition of a new organism that is not a member of normal flora.

1. It may cause an infectious disease,
2. It may be eliminated by the host defense,
3. It may be transmitted to others.

Clinical significance of normal flora:

- They can cause disease,
- They constitute a protective host defense mechanism by colonization resistance,
- Nutritional function – vitamin B & K.

PATHOGENESIS

Pathogen:

- An organism that is capable of causing disease.

Opportunistic pathogens:

- Usually causing infections in immunocompromised patients.

Virulence:

- A quantitative measure of pathogencity; measured by the number of organism required to cause disease.

LD50 (50% lethal dose):

- The number of organisms needed to kill half the hosts.

ID50 (50% infectious dose):

- The number of organisms needed to cause infection in half the hosts.
- Variation in the infective dose.

Virulence factors:

- Pili
- Exotoxins or endotoxins
- Capsule
- Survival despite nonspecific host factors