Components external to the cell wall

Capsules: Well organized and not easily washed off.
Not reqd for growth, reproduction. Help resist phagocytosis,
Thus retain pathogenicity. Prevent desiccation.

Slime layers: Diffused and easily washed off

Glycocalyx: Net work of polysaccharides extending from the surface of bacteria. Help in attachment.

S-layers: Common to Archae. Composed of proteins or glycoproteins.
In G - ve cells these adhere to the O.M.
Where as in G + ve, these are associated with the PG.

Pili and Fimbriae: Many G -ve bacteria have short, fine, hair like appendages, thinner than flagella and not involved in motility. Help in attaching bacteria to rocks, host tissue etc.

Sex pili: Larger than fimbriae, determined by sex factor or conjugative plasmids. Required for bacterial mating / conjugation

Flagella and motility: Make bacteria motile.

Distribution of flagella (fig 3.31):
Monotrichous (polar); Amphitricous (both ends);
Lophotrichous (bunch); Peritrichous (all around)

Flagellar ultrastructure (fig 3.33)
Filament (flagellin, a protein);
basal body (4 rings in G -ve, 2 rings in G +ve)
hook

Flagellar synthesis/growth (fig 3.34)
Synthesis involves 20-30 genes. Self-assembly at external end.

Mechanism of flagellar movement (fig 3.35, 3.36)
Proton gradient provides the energy. Filament is a rigid helix.
Bacteria move when the helix rotates. Forward: CCW; Tumbles: CW

Chemotaxis: (Biased random walks) figs 3.37, 3.38, 3.39
Mechanism (fig. 12.33) will be discussed later in the semester
Bacteria are attracted to chemicals like sugars and amino acids and repelled by harmful waste products. Chemoreceptors detect attractants at very low levels (10^{-8} M). Bacterium travels in line, “RUN”, for a few seconds, stops, “TUMBLES/TWIDDLES”, followed by another “RUN”, in a different direction.

Bacterial endospores: Certain Gram +ve bacteria (e.g. Bacillus, Clostridium-pathogens) form a special dormant structure called endospores (with in the vegetative cell), in response to nutrient deprivation.

Endospores are highly resistant to stress: heat, UV, chemicals, desiccation.
Endospores can be very dangerous, surviving 500-7500 years!
In order to sterilize food (packaged food), it is important to autoclave in order to destroy the endospores of pathogenic organisms.

Endospores can be looked under the light microscope by staining these by Schaeffer-Fulton spore stain (a differential staining technique using malachite green and saffranin).

Electron microscopy lets one see the detailed structure of the endospore.

Location: (fig 3.40)
Varies within the sporangium: central, subterminal, terminal with swollen sporangium

Structure: (fig 3.41)
Exosporium (delicate)
Spore coat (resistance): protein, thick, impermeable
Cortex: less cross linked peptidoglycan
Spore wall: surrounds the spore
Core: contains the protoplast with the nucleoid and the ribosomes

What makes the endospore so resistant?
Dipicolinic acid and calcium
Small acid-soluble DNA-binding proteins
Dehydration: greater stability of cell proteins adapted to growth at high temp.

Spore formation (fig 3.43)
Sporogenesis/sporulation/spore formation starts when growth ceases due to lack of nutrients. It is a complex process. It has been studied well for *Bacillus megaterium*. The process can be divided into 7 steps lasting approximately 8-10 hours.

Endospore germination (fig 3.44)
Transformation of dormant spores into active vegetative cells is a complex process too. It involves 3 stages:
a) Activation: by heat
b) Germination: breaking of spore's dormant state: spore swelling, rupturing, increase in metabolic activity
c) Outgrowth: Grows out of spore coat, new components are made

Properties of vegetative cells and endospores (Hand out from Brock)