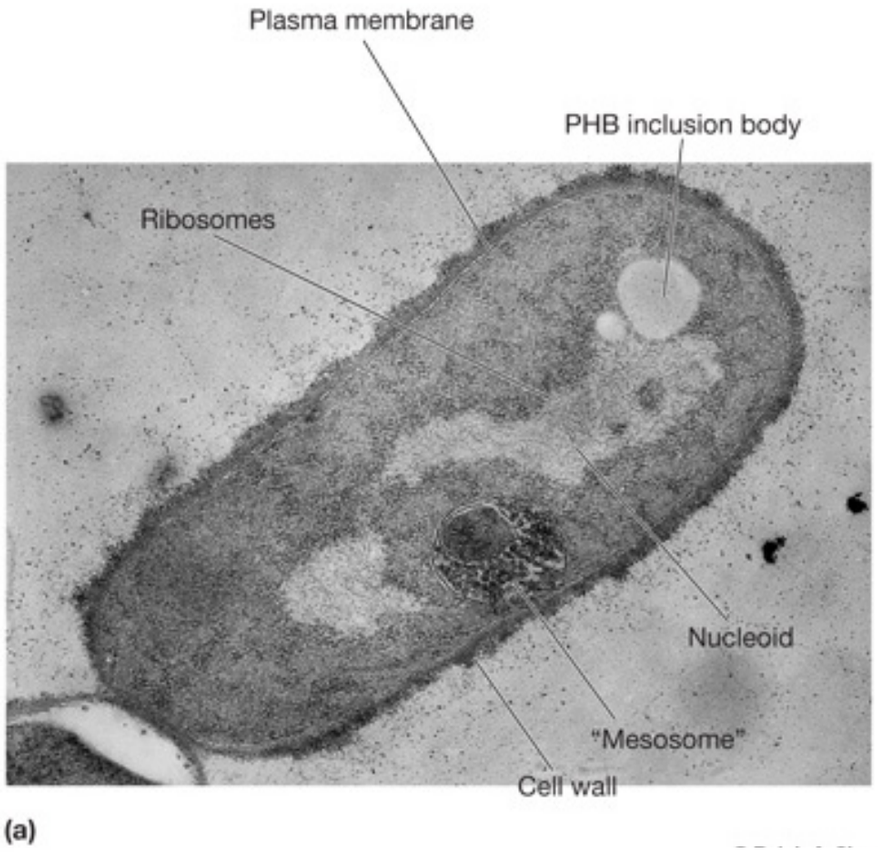
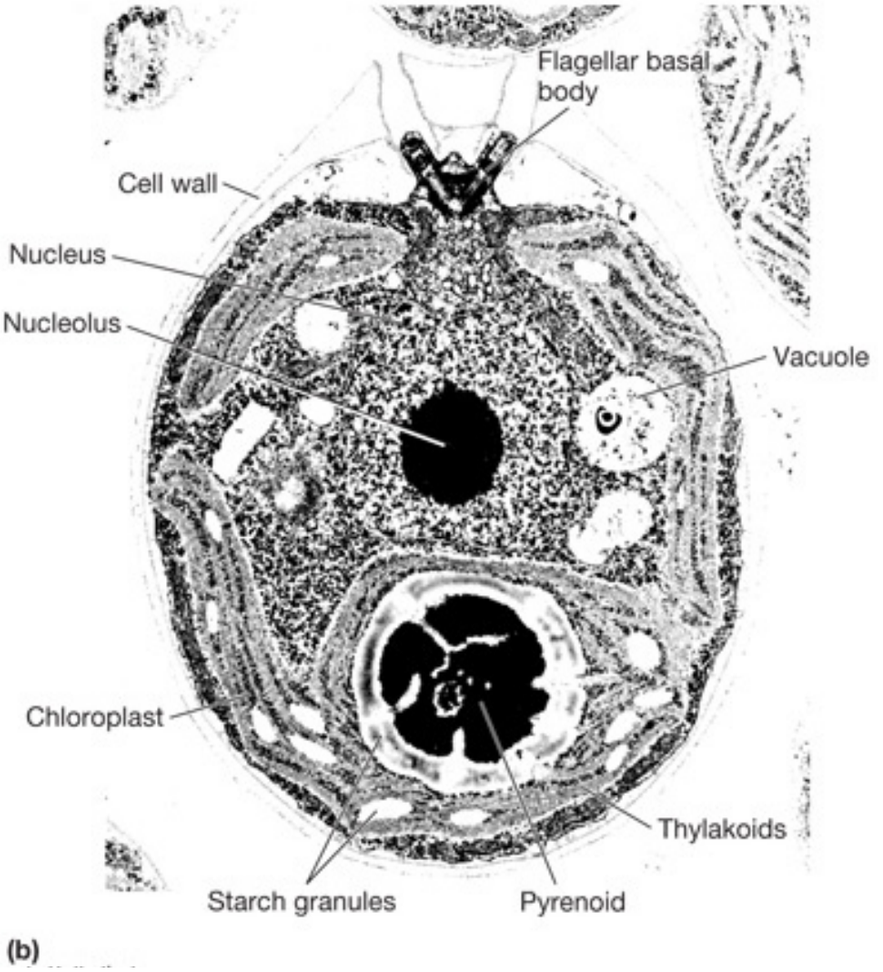
Procaryotes Eucaryotes

size, membranous organelles



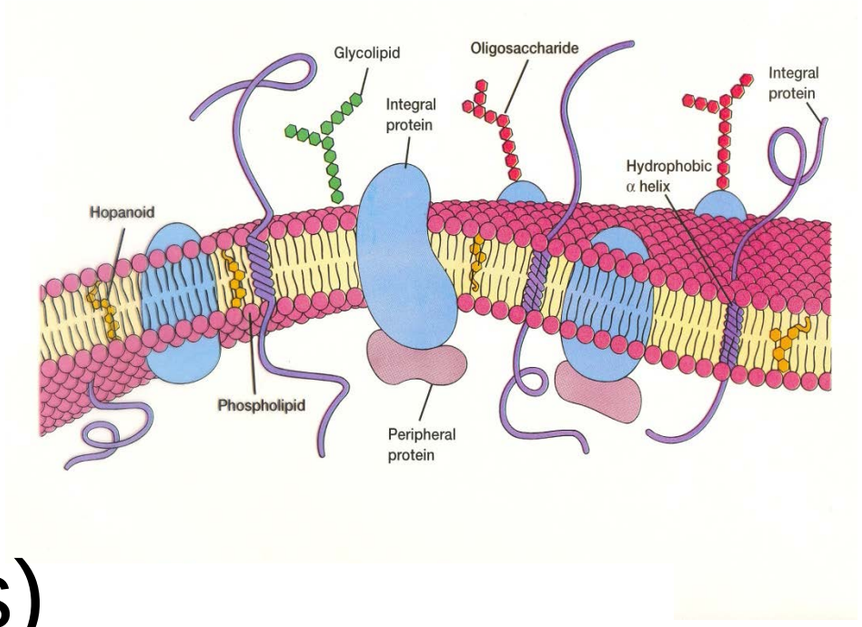


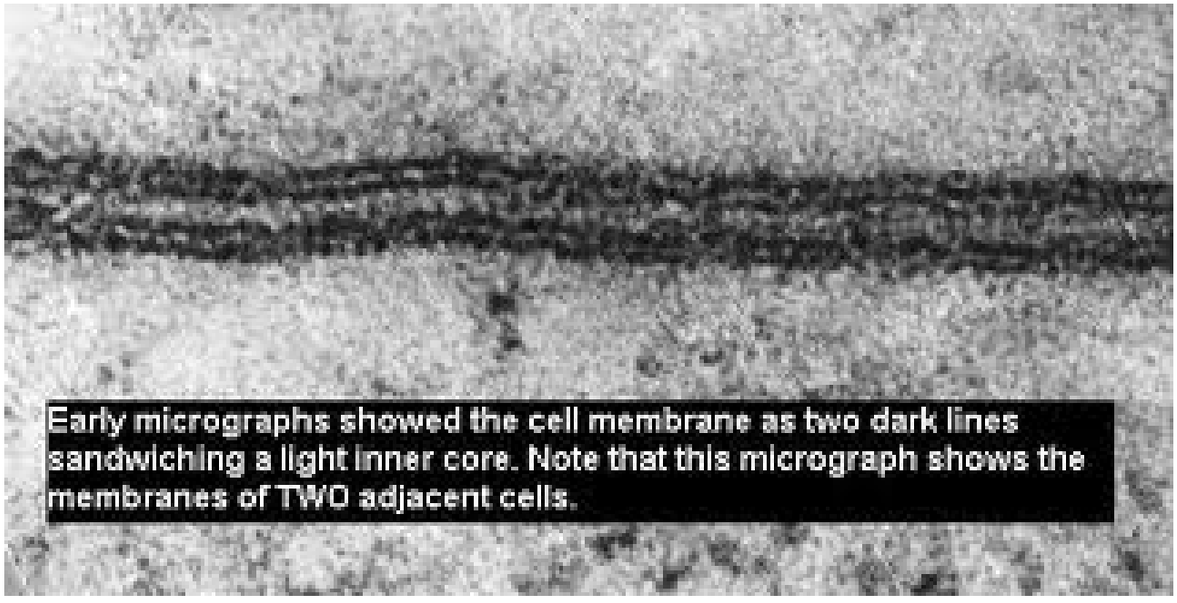
* same basic chemical composition
* same genetic code
* same basic metabolic processes

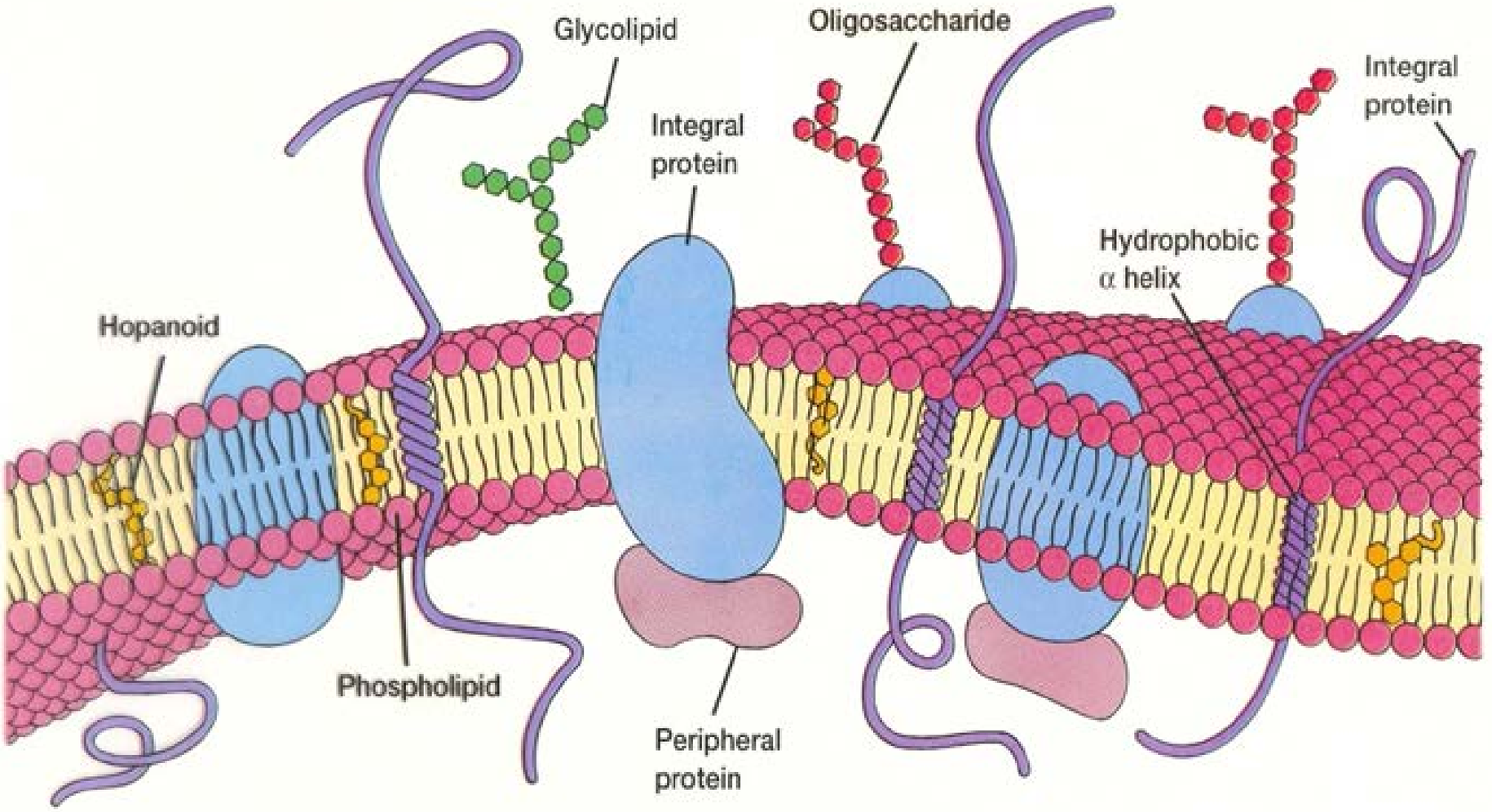
Plasma membrane
(cell membrane, cytoplasmic membrane)

Function

- Semi-permeable barrier
- Transport
- Proton gradient (energy processes)
- Receptors
- Cell division
- Biosynthesis



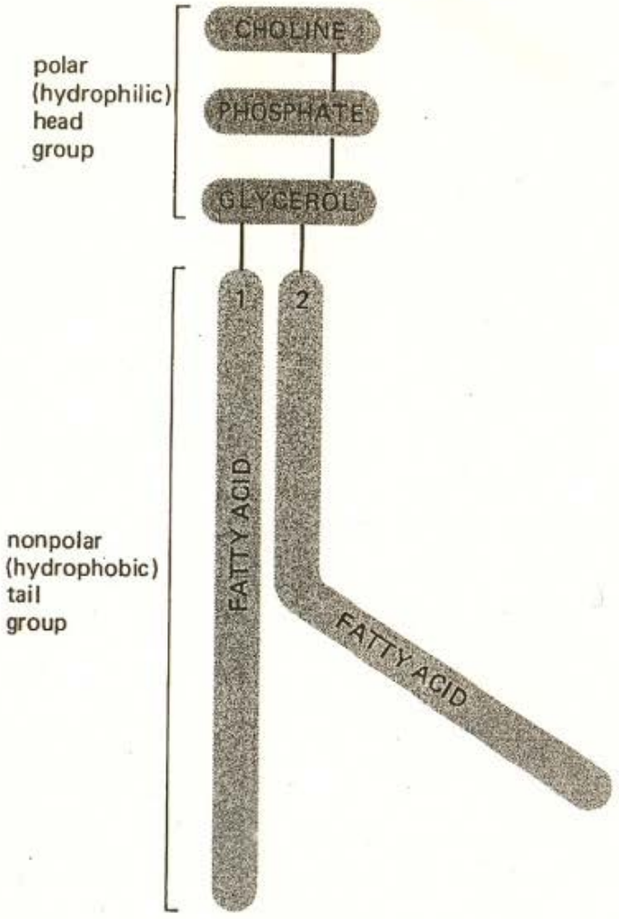

Early micrographs showed the cell membrane as two dark lines sandwiching a light inner core. Note that this micrograph shows the membranes of TWO adjacent cells.



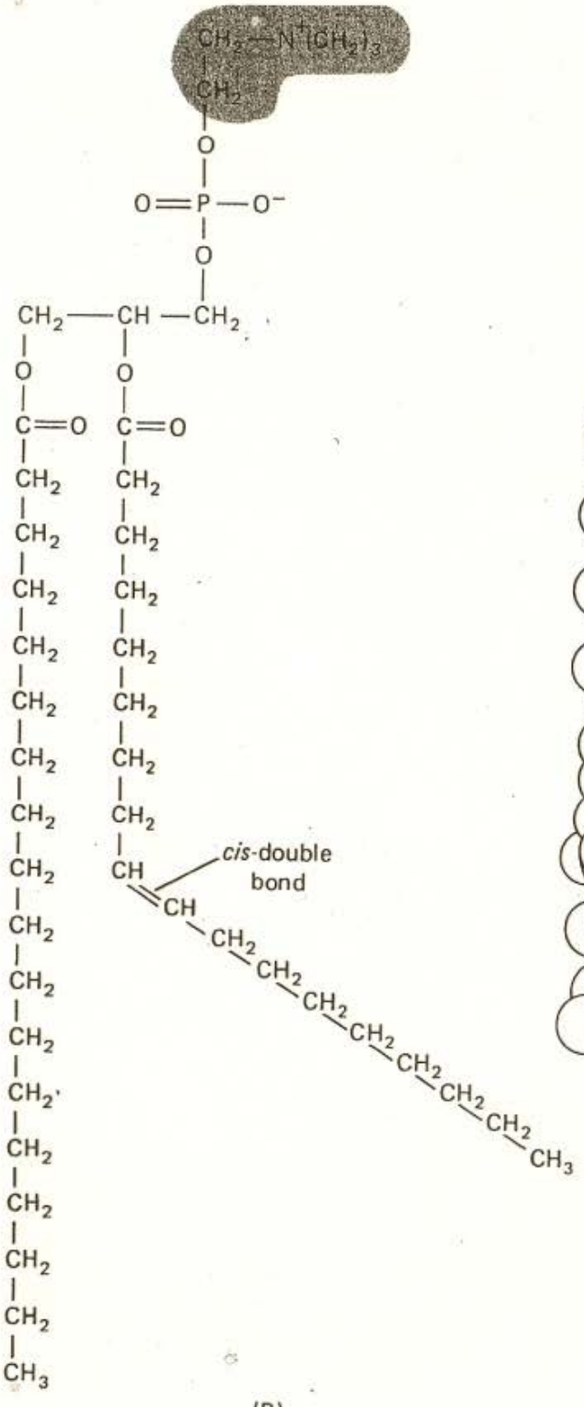
Constituents

- 25% lipids (phospholipids)
- 75% proteins (transport, receptors, energy processes, etc.
- 5-10 mm
- “Floating mosaic”
- Bacteria lack sterols but contain hopanoids

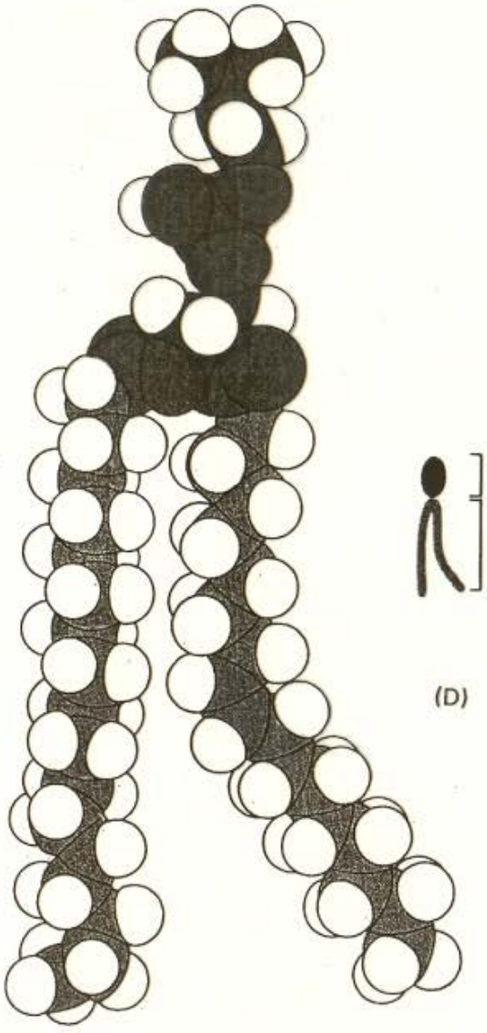
Phospholipids



(A)

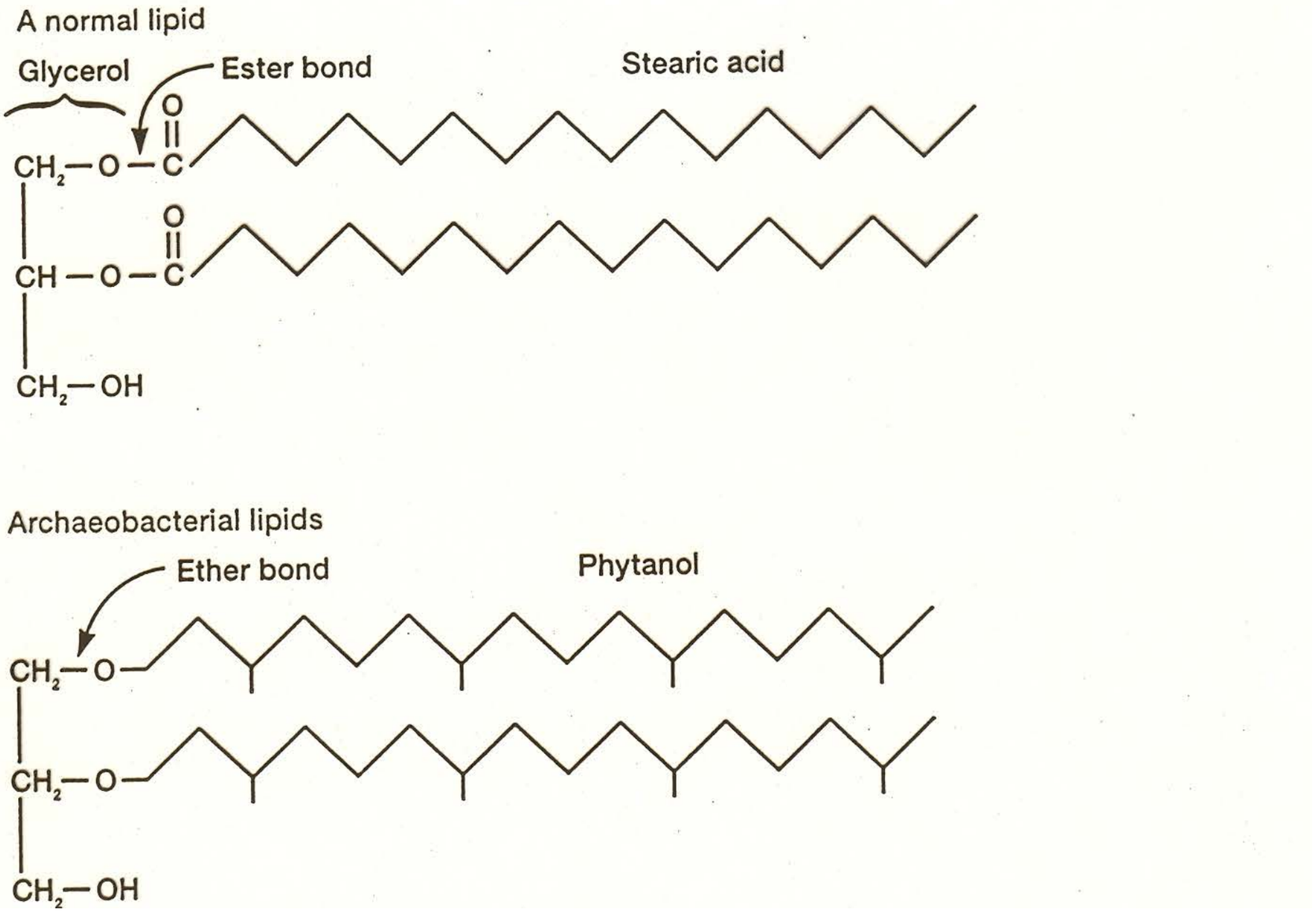


(B)



(C)

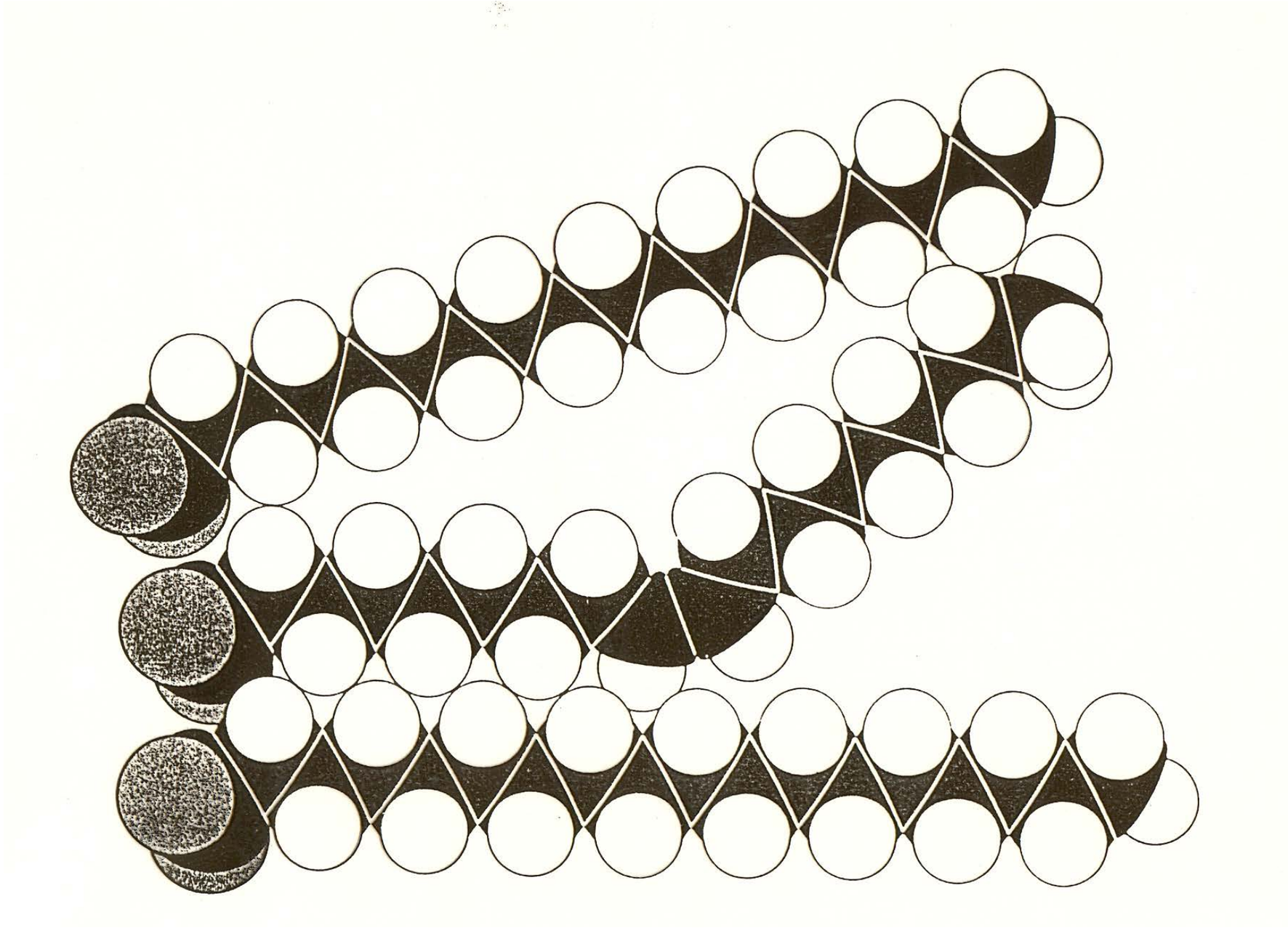
(D)



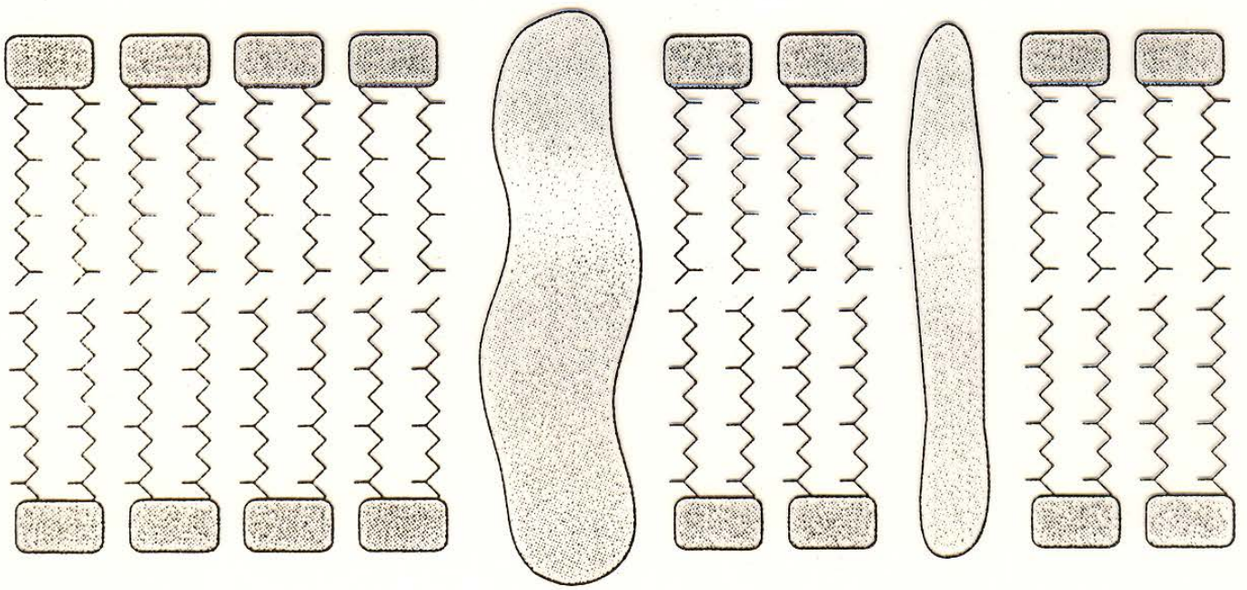
Ester bond = eukaryotes and eubacteria

Ether bond = archaebacteria

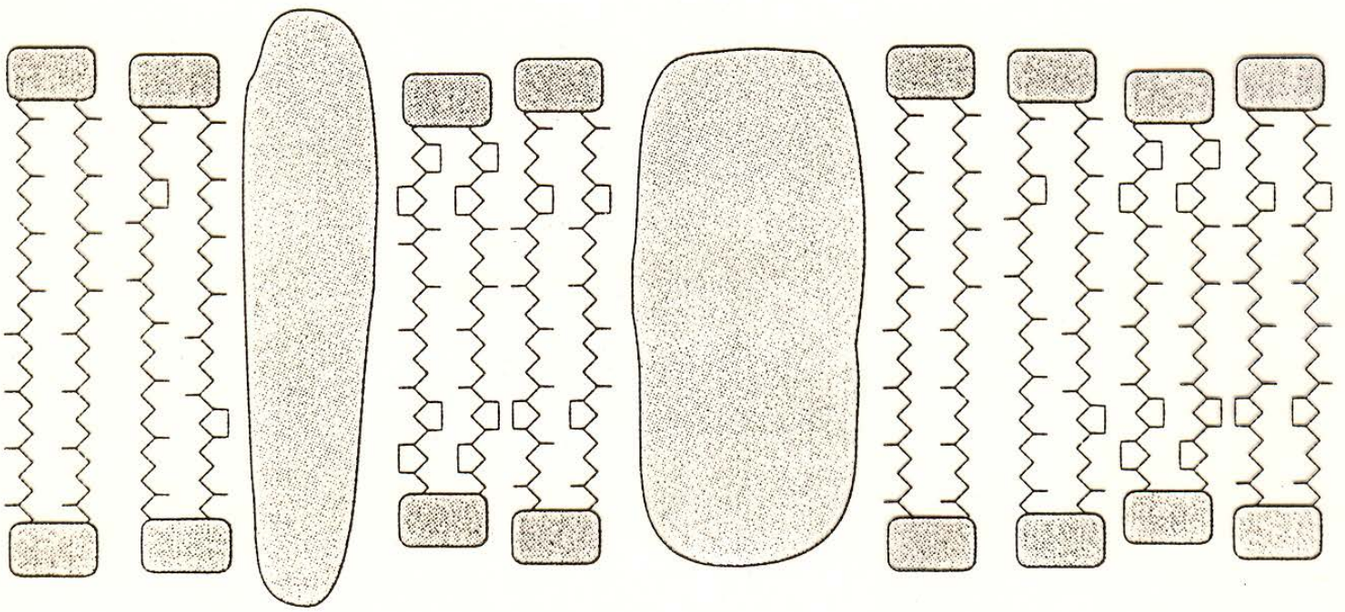
Phospholipids unsaturated fatty acids (Psychrophilic micro-organisms)



Plasma membrane of thermophilic micro-organisms



(a)



(b)

A Monstrous Microbe

Biologists often have distinguished between procaryotes and eucaryotes based in part on cell size. Generally, procaryotic cells are supposed to be smaller than eucaryotic cells. Procaryotes grow extremely rapidly compared to most eucaryotes and lack the complex vesicular transport systems of eucaryotic cells (*see chapter 4*). It has been assumed that they must be small because of the slowness of nutrient diffusion and the need for a large surface-to-volume ratio. Thus when Fishelson, Montgomery, and Myrberg discovered a large, cigar-shaped microorganism in the intestinal tract of the Red Sea brown surgeonfish, *Acanthurus nigrofuscus*, they suggested in their 1985 publication that it was a protist. The microorganism seemed too large to be anything else. In 1993 Esther Angert, Kendall Clemens, and Norman Pace used rRNA sequence comparisons (*p. 404*) to identify the microorganism, now called *Epulopiscium fishelsoni*, as a procaryote related to the gram-positive genus *Clostridium*.

Epulopiscium fishelsoni. This photograph, taken with pseudo dark-field illumination, shows *E. fishelsoni* at the top of the figure dwarfing the paramecia at the bottom (×200).

E. fishelsoni [Latin, *epulum*, a feast or banquet, and *piscium*, fish] can reach a size of 80 µm by 600 µm, and normally ranges from 200 to 500 µm in length (see Box figure). It is about a million times larger in volume than *Escherichia coli*. Despite its huge size the organism does have procaryotic cell structure. It is motile and swims at about two body lengths a second (approximately 2.4 cm/min) using the bacterial-type flagella that cover its surface. The cytoplasm contains large nucleoids and many ribosomes, as would be required for such a large cell. *Epulopiscium* appears to overcome the size limits set by diffusion by having an outer layer consisting of a highly convoluted plasma membrane. This increases the cell's surface area and aids in nutrient transport. The bacterium reproduces when between one and about seven daughter cells develo asexually within the parent and then escap through a centrally located slit in th parental cell envelope.

Epulopiscium also has been found i surgeonfish from the Great Barrier Reef i Australia. Presumably it is a symbiont of th surgeonfish, and its reproduction and behav ior are closely correlated with its host' feeding habits. During the day when the sur geonfish feeds, the bacteria are in the middl intestine with the partially digested food an grow larger. At night when the fish is rest ing, the bacteria move to the back of the in testine where they reside in a bolus of foo and divide repeatedly. Because there is littl growth between divisions, the bacteria be come smaller. In the morning *Epulopiscium* leaves the bolus of food and moves forwar again.

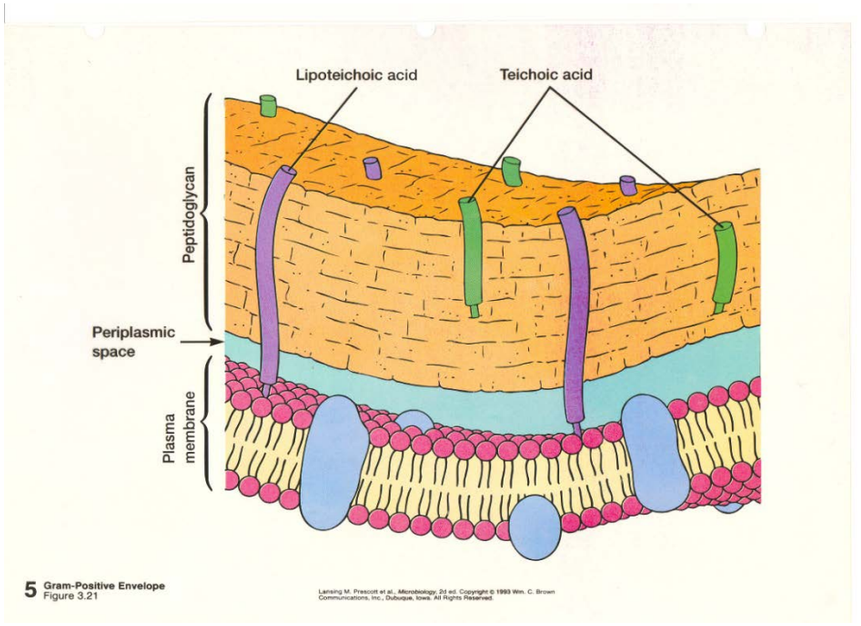
It appears that *Epulopiscium* is transmitted between hosts through fecal contamination of the fish's food. Th bacterium can be eliminated by starving the surgeonfish for a few days If juvenile fish that lack the bacterium are placed with infected hosts they are reinoculated. Interestingly this does not work with uninfected adult surgeonfish.

The discovery of this procaryote greatly weakens the distinction between procaryotes and eucaryotes based on cell size. *Epulopiscium* is certainly larger than a normal eucaryotic cell. In addition, some eucaryotic cells have been discovered that are smaller than previously thought possible. The best example is *Nanochlorum eukaryotum*. *Nanochlorum* is only about 1 to 2 µm in diameter, yet is truly eucaryotic and has a nucleus, a chloroplast, and a mitochondrion. Our understanding of the factors limiting procaryotic cell size must be reevaluated. It is no longer safe to assume that la ge cells are eucaryotic and small cells are procaryotic.

G^+ cell walls in eubacteria

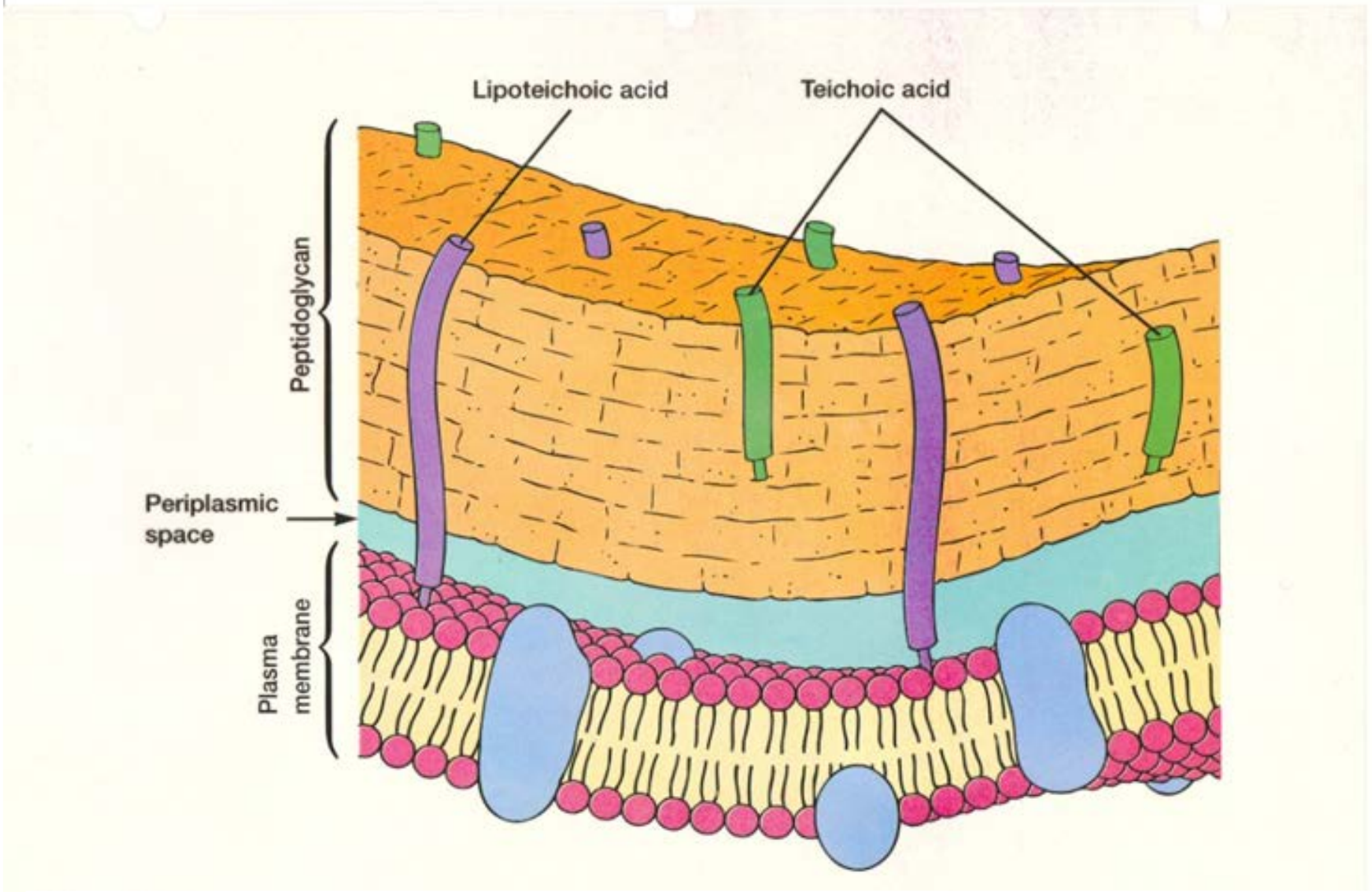
Function

- Mechanical, chemical and physical protection
- Protection against osmotic lysis



Examples of its importance

- Gram staining
- Turgor
- Lysozymes
- Food preservatives



Constituents

- Peptidoglycan (a polymer consisting of n-acetyl glucosamine, n-acetyl muraminic acid and peptides, 20-80 nm)
- Periplasmic space
- Teichoic acid
- S-layer
- Capsule

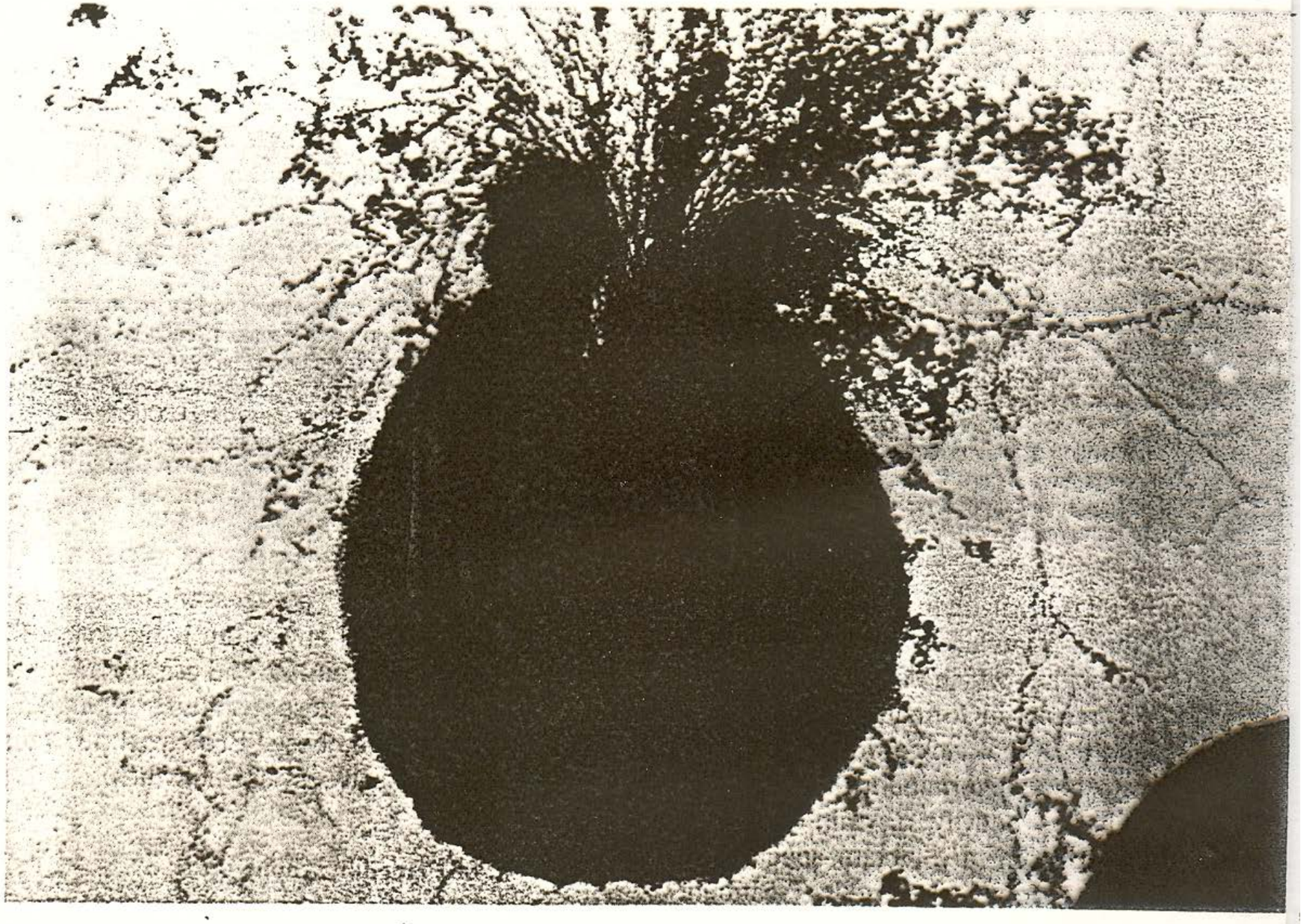
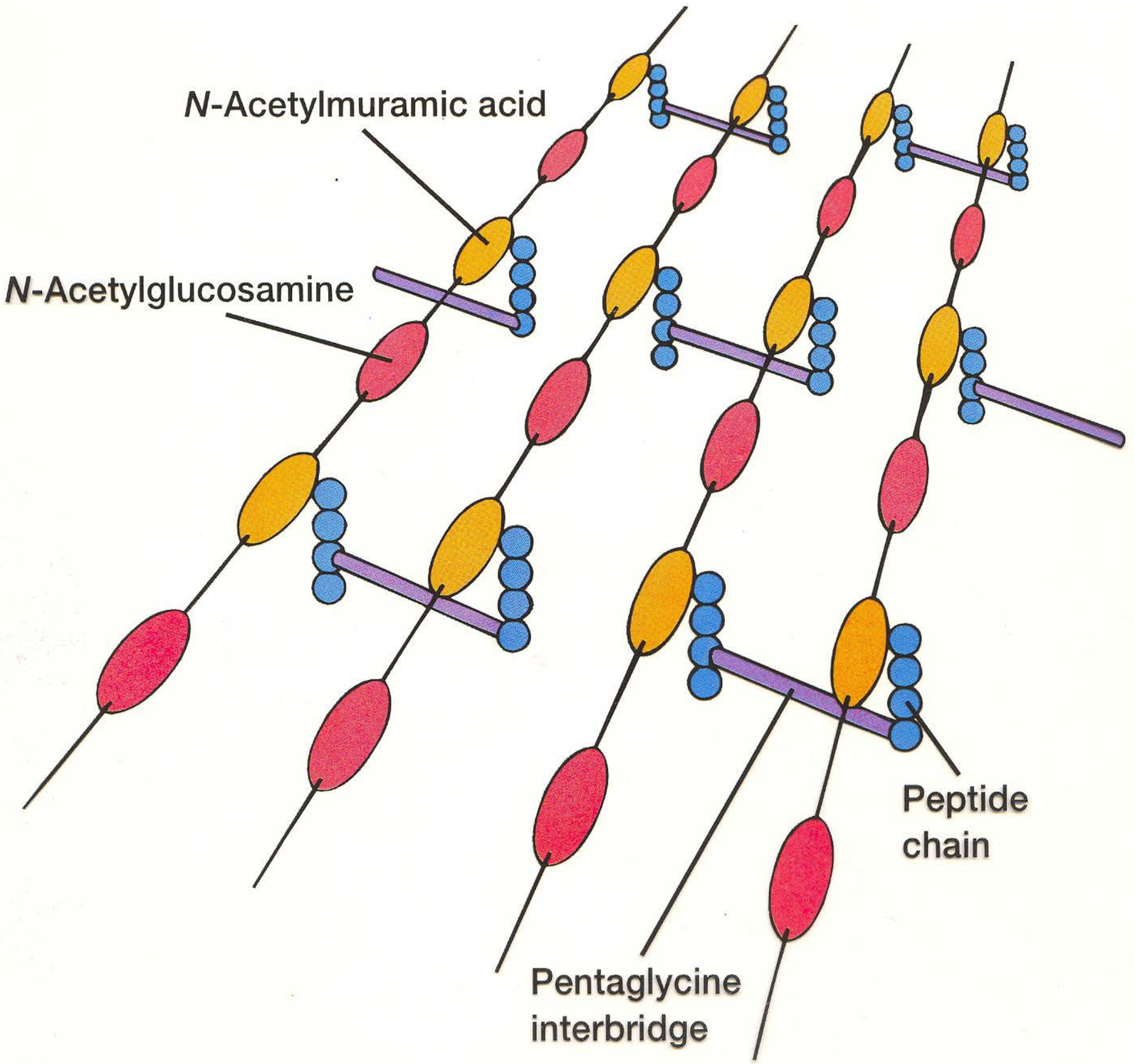
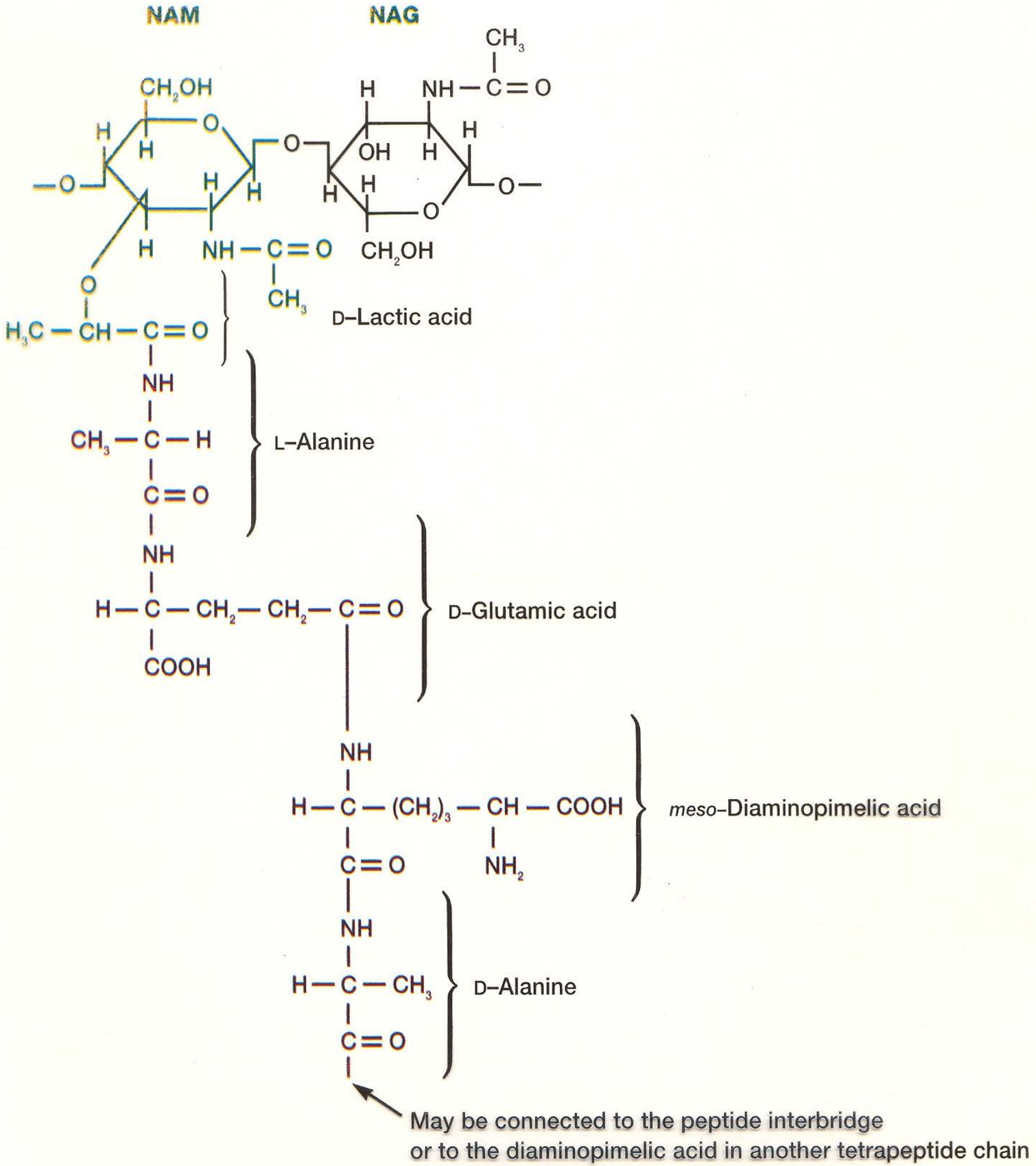


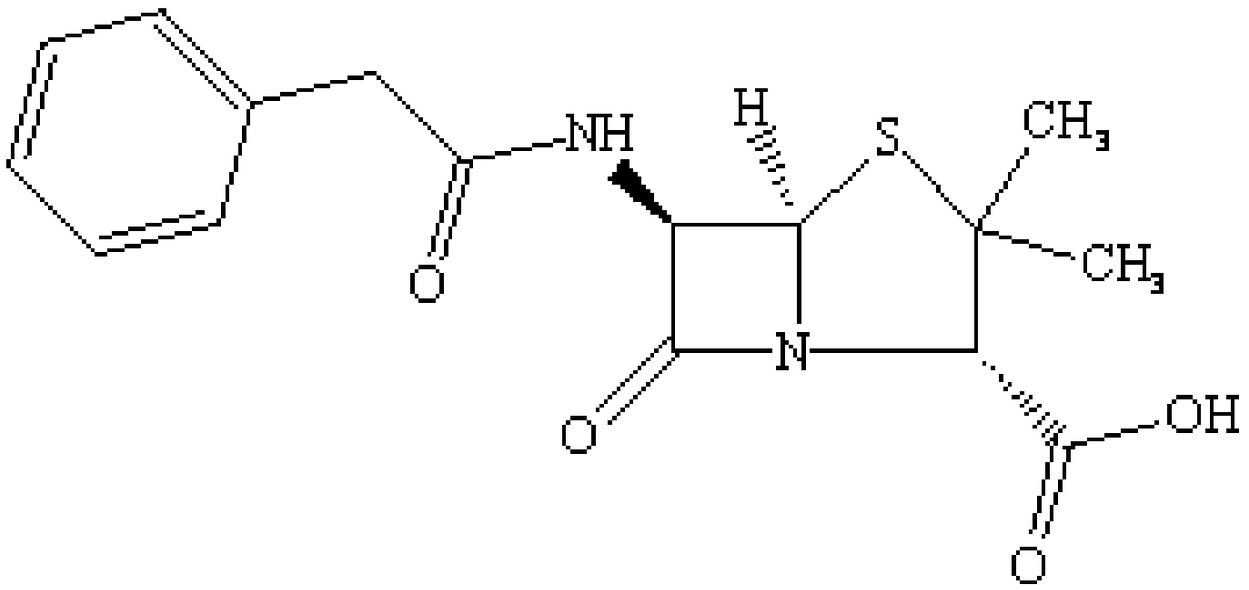
Figure 19–8. *Staphylococcus aureus* grown on medium containing fosfomycin. A similar lytic event occurs when cells are grown in the presence of any cell-wall inhibitor.

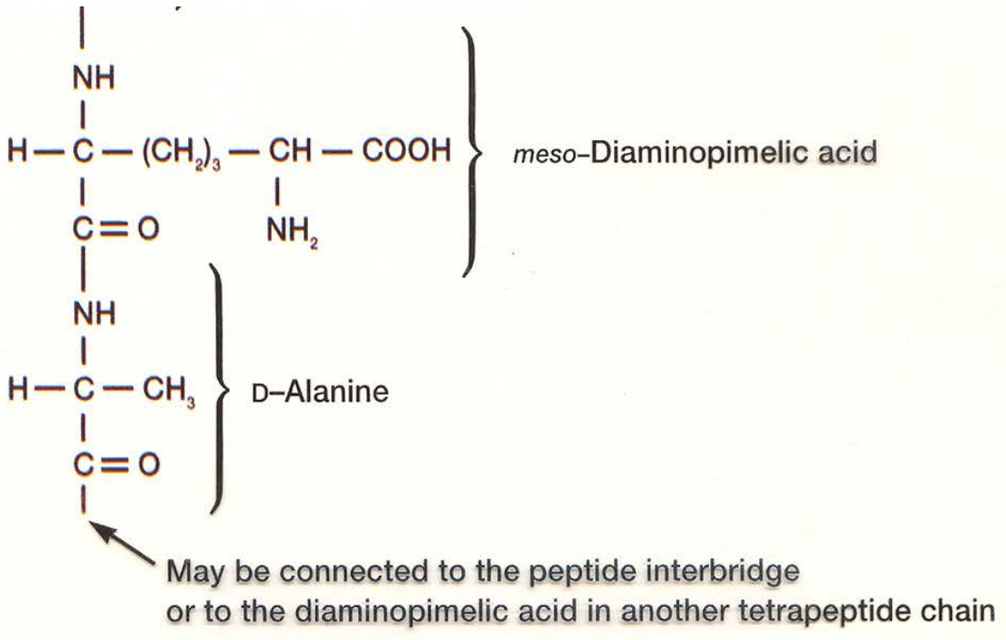

N-Acetylmuramic acid
N-Acetylglucosamine
Peptide chain
Pentaglycine interbridge

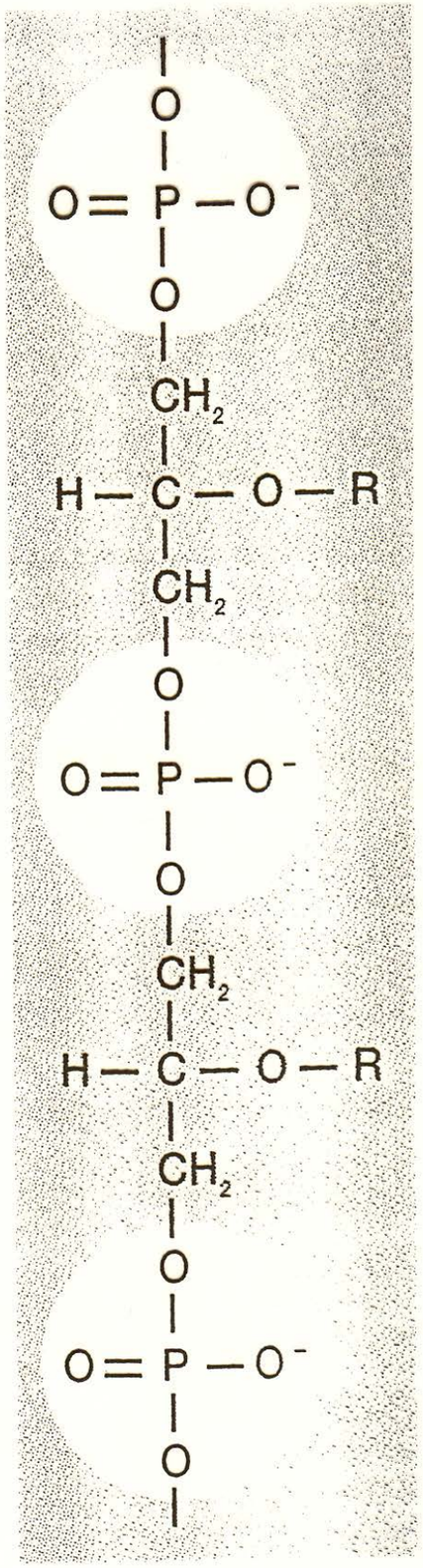
(a)


NAM
NAG
D–Lactic acid
L–Alanine
D–Glutamic acid
meso–Diaminopimelic acid
D–Alanine
May be connected to the peptide interbridge
or to the diaminopimelic acid in another tetrapeptide chain

Penicillin

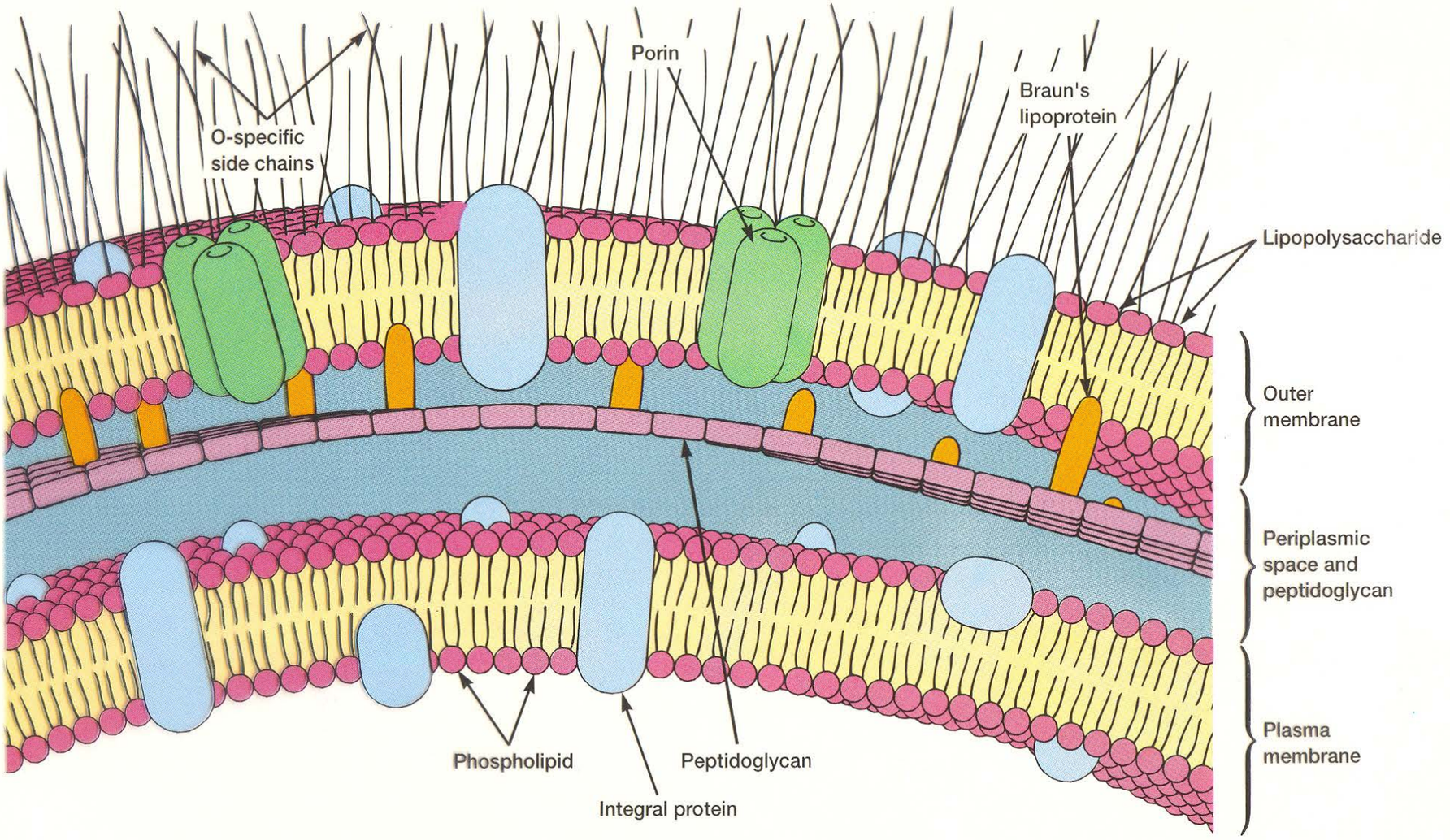

NH
H
S
CH3
CH3
O
N
O
OH
O


NH
H—C—(CH2)3—CH—COOH
C=O
NH2
meso-Diaminopimelic acid
NH
H—C—CH3
C=O
D-Alanine
May be connected to the peptide interbridge
or to the diaminopimelic acid in another tetrapeptide chain

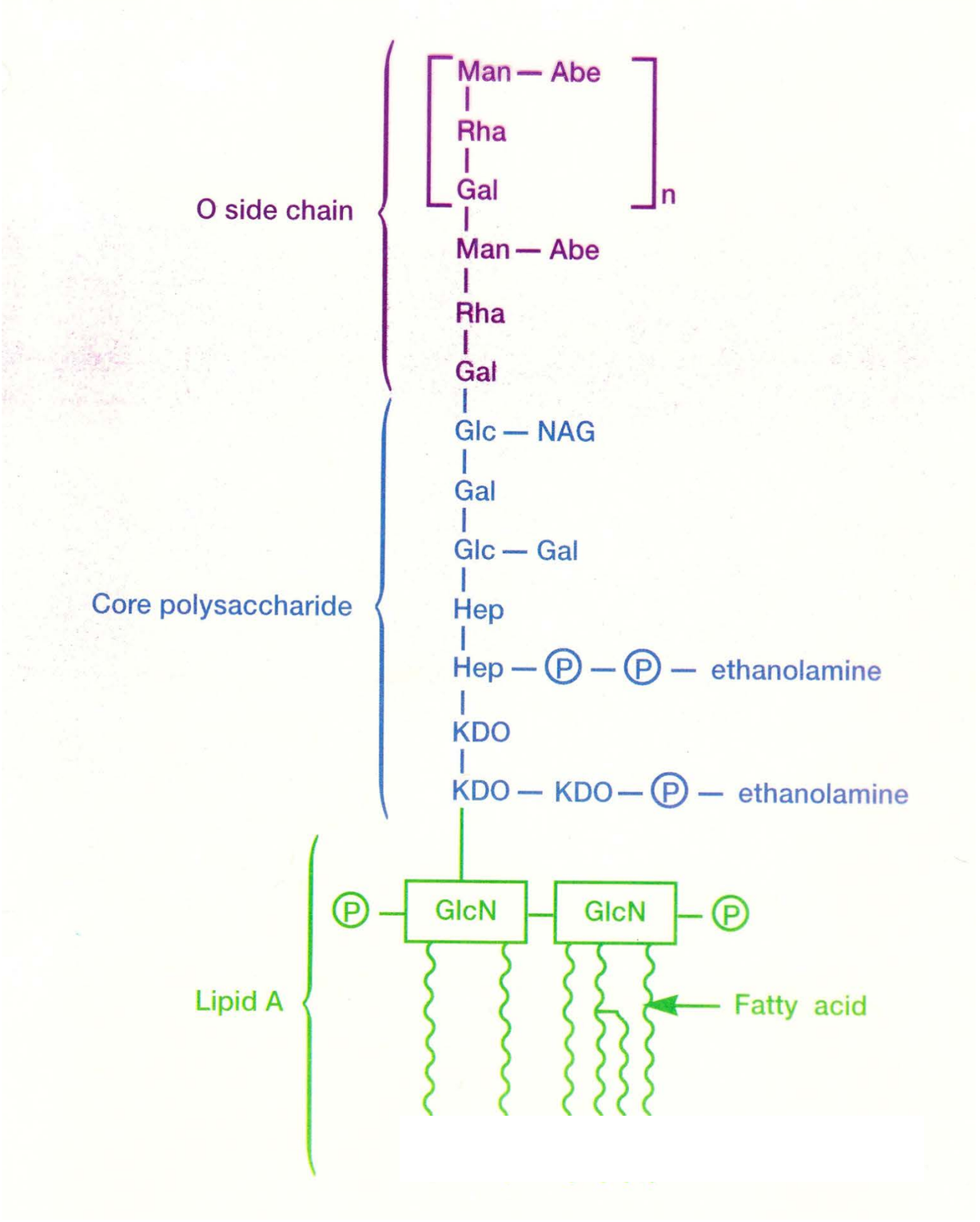


Teichoic Acid Structure.

G⁻ cell walls in eubacteria



Lipopolysaccharide (LPS)



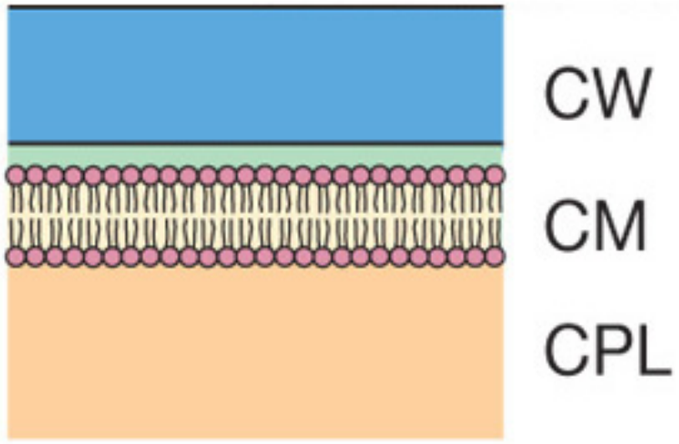
Rapid Microbiological Methods in the Pharmaceutical Industry

- An extract of the horseshoe crab's blood is used by the pharmaceutical and medical device industries to ensure that their products, e.g., intravenous drugs, vaccines, and medical devices, are free of bacterial contamination.

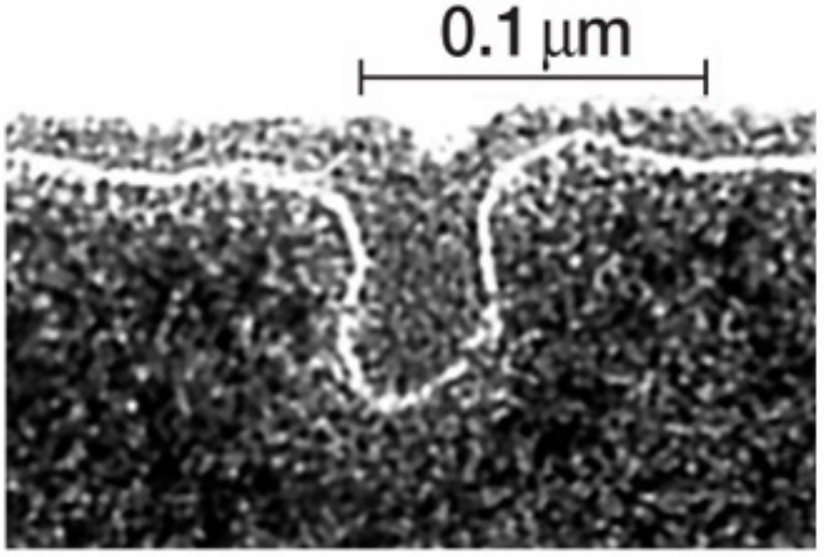
LIMULUS TEST

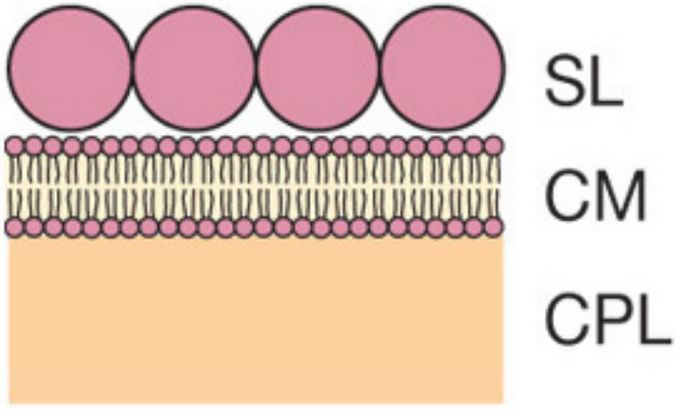
Blood from the horseshoe crab, *Limulus polyphemus* reacts with bacterial endotoxin

Cell envelopes of archaebacteria

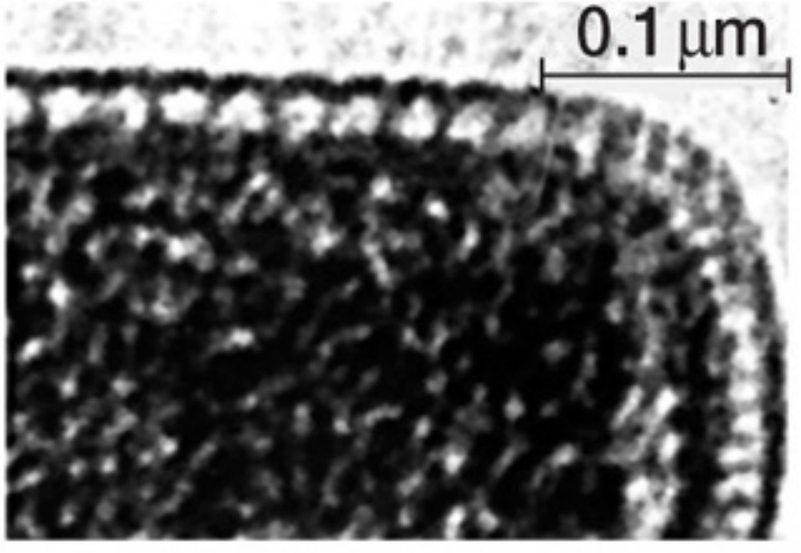


(a)

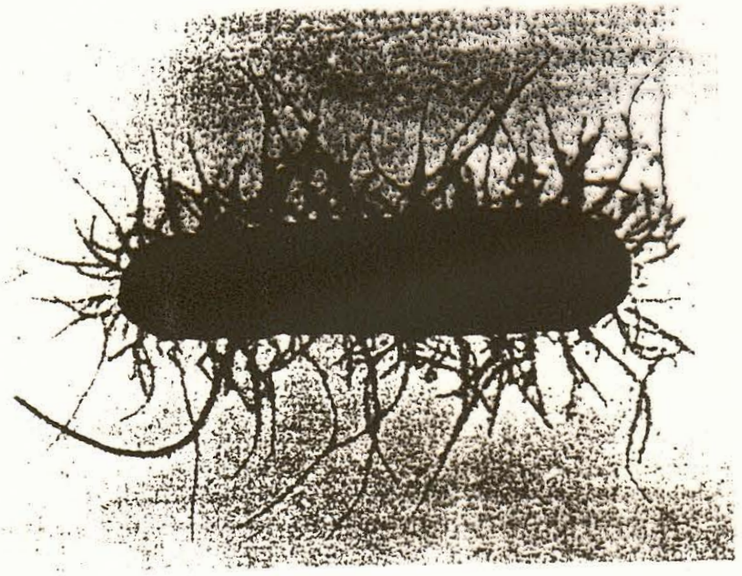




(b)



Fimbriae and flagella



sex pili (s., pilus) similar to fimbriae except longer, thicker, and less numerous (1-10/cell) required for mating

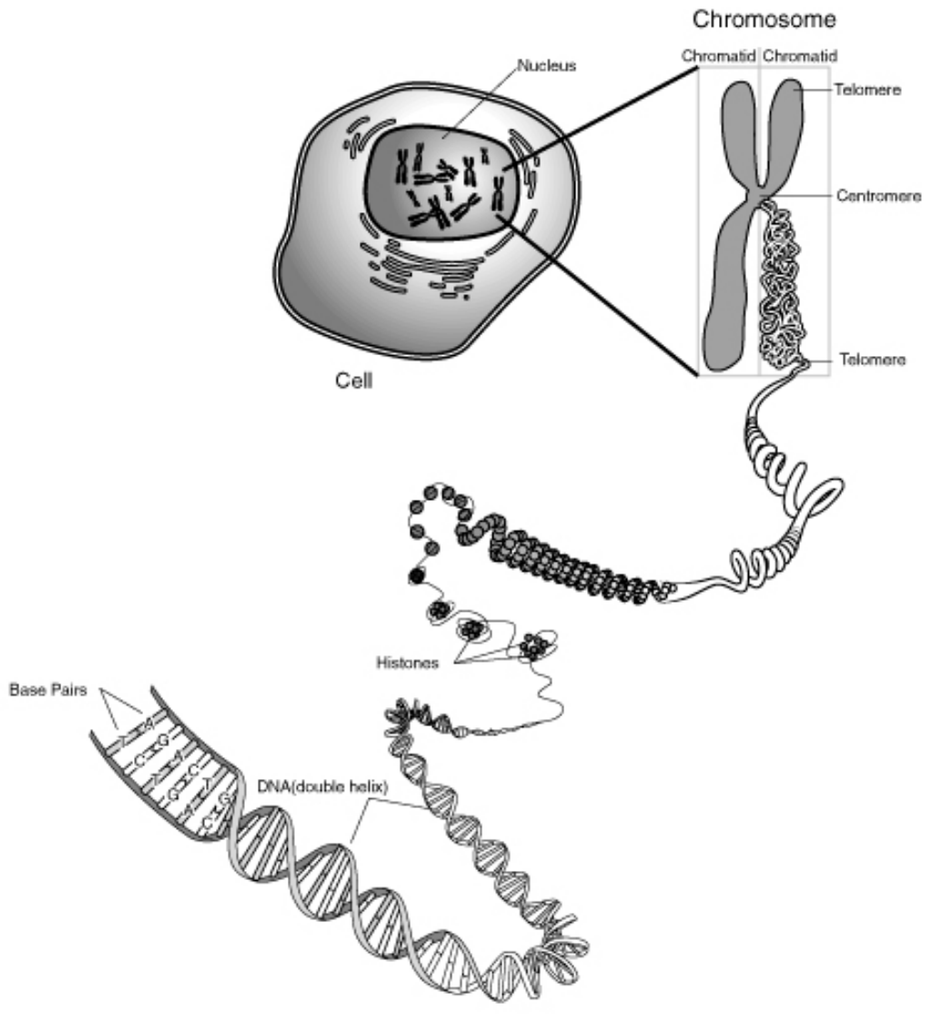
fimbriae (s., fimbria) short, thin, hairlike, proteinaceous appendages up to 1,000/cell mediate attachment to surfaces

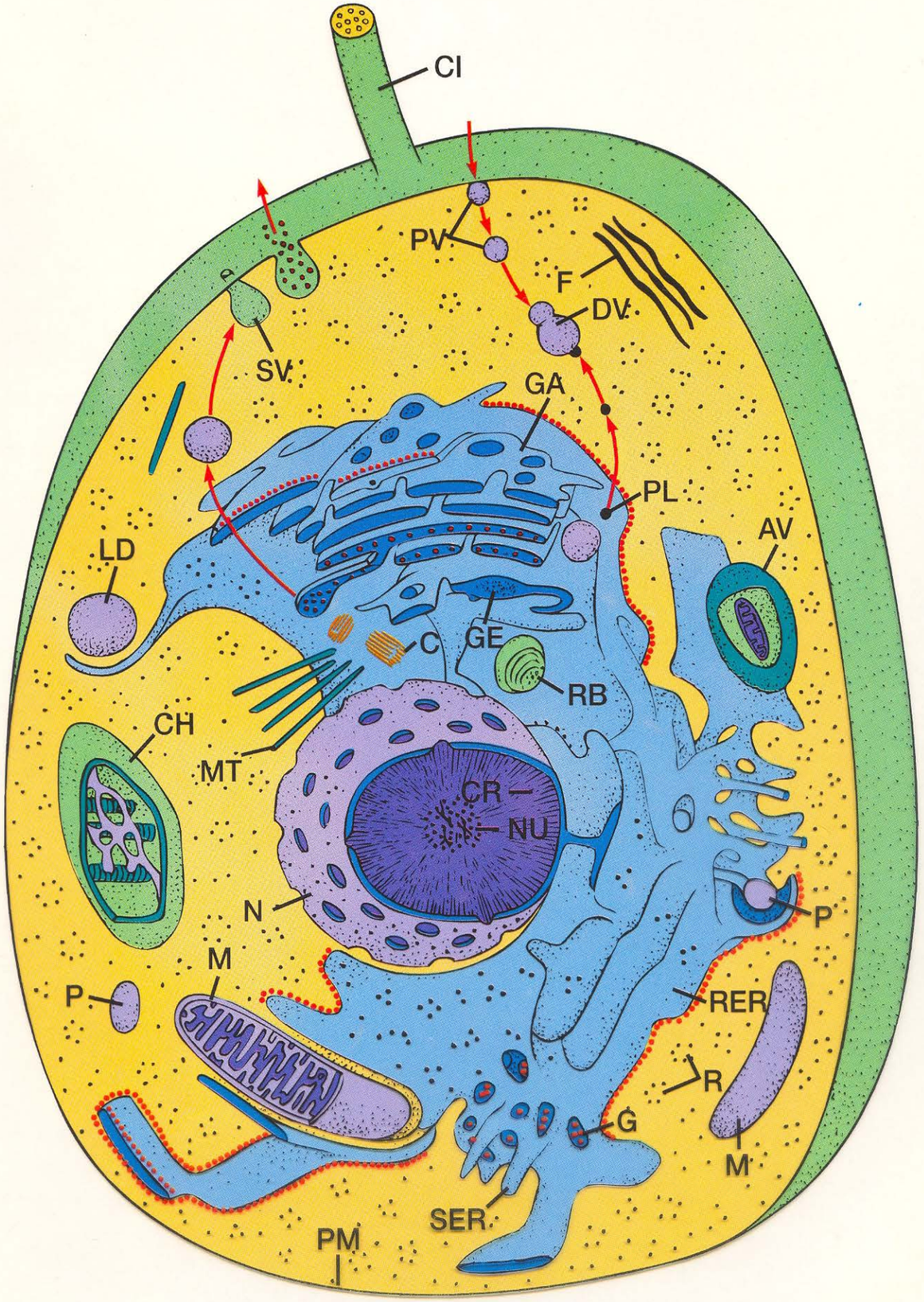
Proteus vulgaris

flagellum rotates like a propeller in general, counterclockwise rotation causes forward motion (run)

The genetic material

- Deoxyribonucleic acid (DNA)
- Nucleoid = prokaryotes
- Nucleus = eukaryotes
- Haploid/diploid (chromosomes)
- Plasmids
- Proviruses





10 **Eucaryotic Cell Ultrastructure**
Figure 4.3

Membrane-bound organelles that perform specific functions

Table 4.1 Functions of Eucaryotic Organelles

Plasma membrane

Cytoplasmic matrix

Microfilaments, intermediate filaments, and microtubules

Endoplasmic reticulum

Ribosomes

Golgi apparatus

Lysosomes

Mitochondria

Chloroplasts

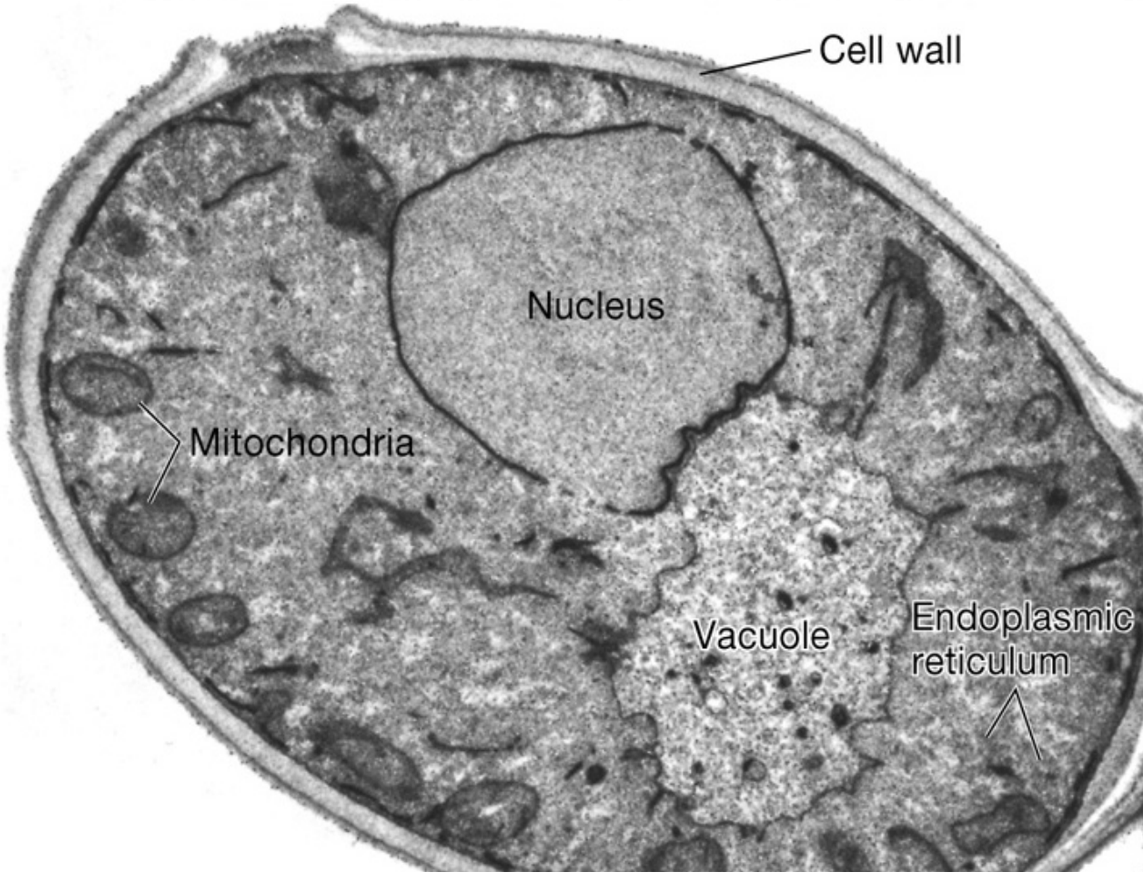
Nucleus

Nucleolus

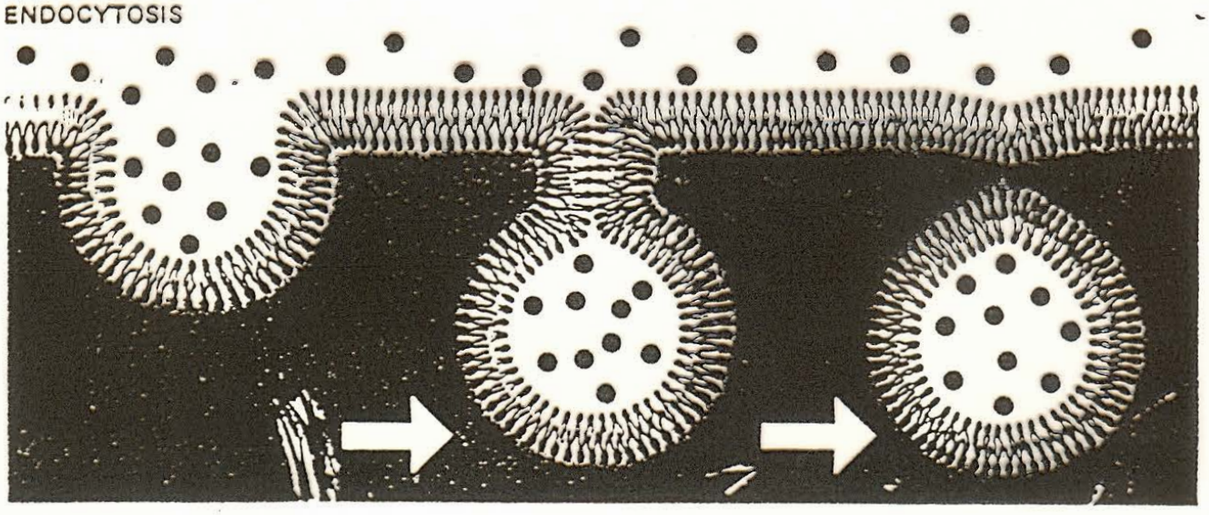
Cell wall and pellicle

Cilia and flagella

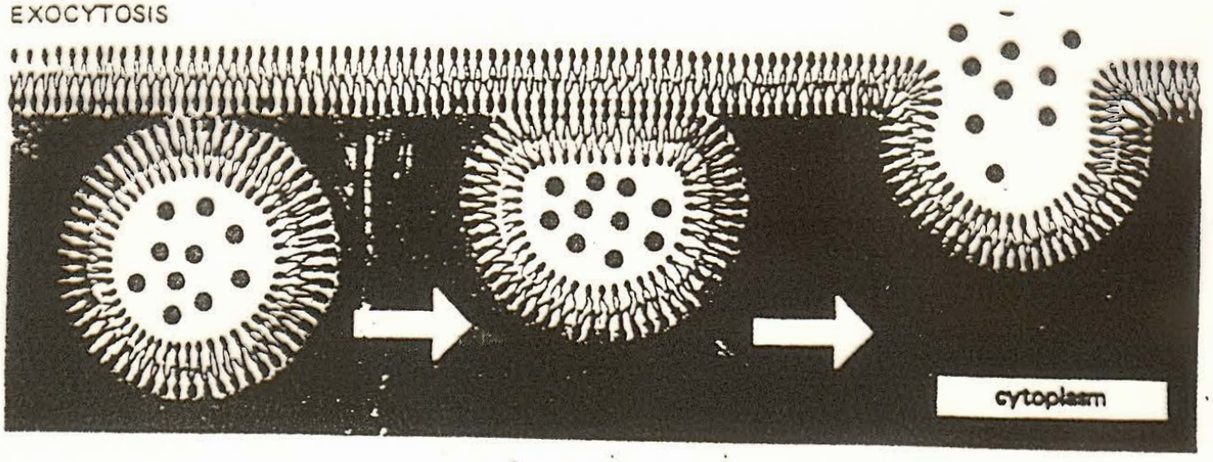
Vacuole



ENDOCYTOSIS



EXOCYTOSIS



BUDDING