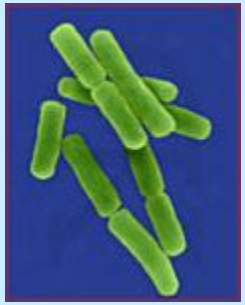
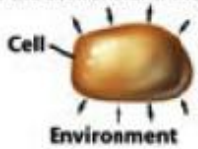


CONCETTI GENERALI

Caratteristiche essenziali dei sistemi viventi

1. Metabolism
Uptake of nutrients from the environment, their transformation within the cell, and elimination of wastes into the environment. The cell is thus an *open* system.



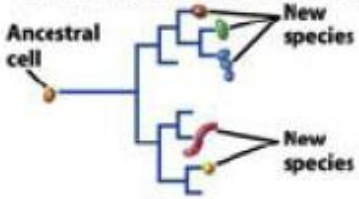
2. Reproduction (growth)
Chemicals from the environment are turned into new cells under the direction of preexisting cells.

3. Differentiation
Formation of a new cell structure such as a spore, usually as part of a cellular *life cycle*.

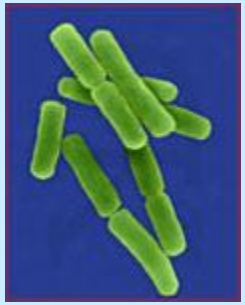
4. Communication
Cells *communicate* or *interact* primarily by means of chemicals that are released or taken up.

5. Movement
Living organisms are often capable of self-propulsion.

6. Evolution
Cells contain genes and *evolve* to display new biological properties. Phylogenetic trees show the evolutionary relationships between cells.

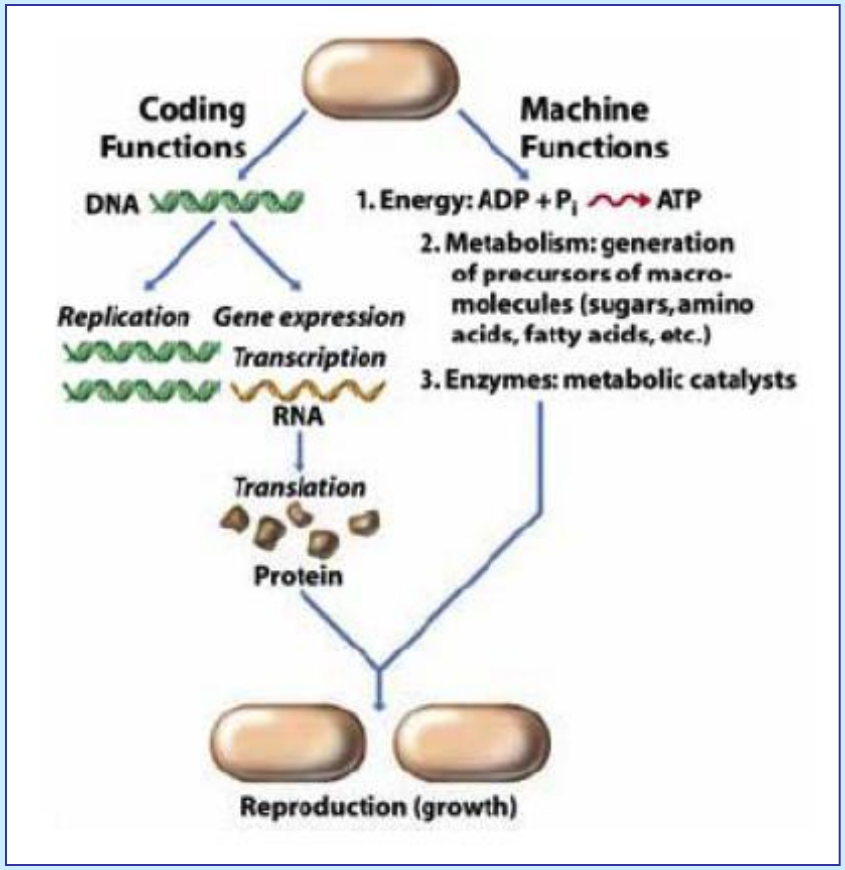


Che cos'è la Microbiologia




CONCETTI GENERALI

Le principali funzioni di una cellula



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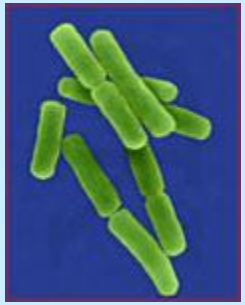
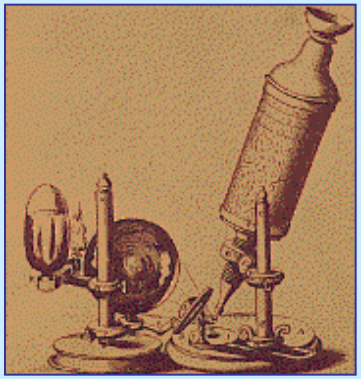
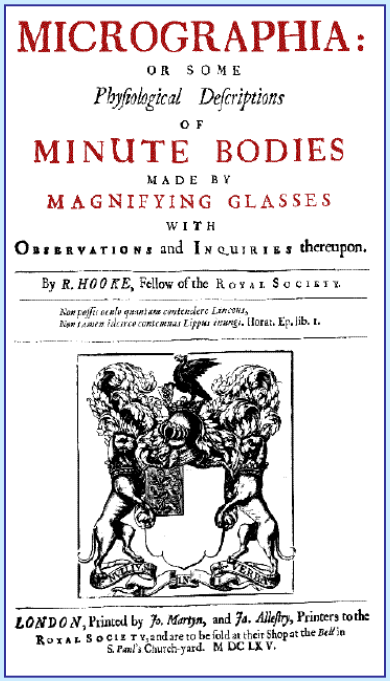



LE TAPPE MILIARI DELLA MICROBIOLOGIA

Hooke memorial window, St. Helen's, Bishopsgate, City of London



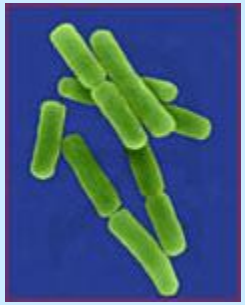
Robert Hooke
(1635 – 1703)



MICROGRAPHIA:
OR SOME
Physiological Descriptions
OF
MINUTE BODIES
MADE BY
MAGNIFYING GLASSES
WITH
OBSERVATIONS and INQUIRIES thereupon.
By *R. HOOKE*, Fellow of the ROYAL SOCIETY.
Non possis oculo quantum contendere Lynceus,
Non tamen idcirco contemnas Lippus inungi. Horat. Ep. lib. 1.
LONDON, Printed by *Jo. Martyn*, and *Ja. Allestry*, Printers to the ROYAL SOCIETY, and are to be sold at their Shop at the *Bell* in S. *Paul's* Church-yard. M DC LX V.

He devised the compound microscope and illumination system, one of the best such microscopes of his time … In 1665 he described the aerial fruiting structures of molds.

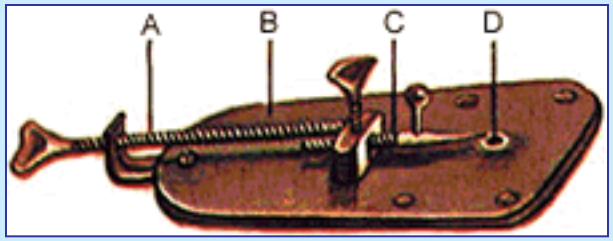
UN PO' DI STORIA

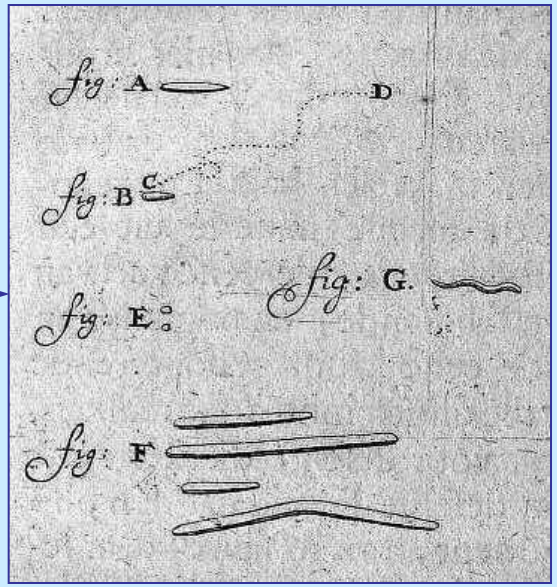


LE TAPPE MILIARI DELLA MICROBIOLOGIA

Antoni Van Leeuwenhoek

(Delft, n. 24-10-**1632** , m. 27-08-**1723**, ottico e naturalista olandese. Autodidatta, è soprattutto conosciuto per le migliorie apportate al microscopio e per avere posto le basi della biologia cellulare e della microbiologia. Fu il primo, nel 1676, ad osservare batteri in alcune infusioni)





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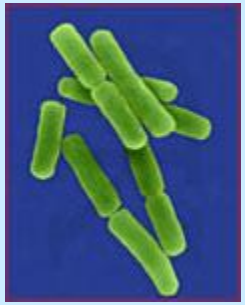


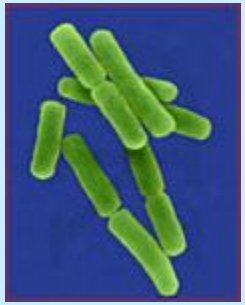

LE TAPPE MILIARI DELLA MICROBIOLOGIA

Ferdinand Julius Cohn

(Breslavia, 24 gennaio **1828** – Breslavia, 25 giugno **1898**)

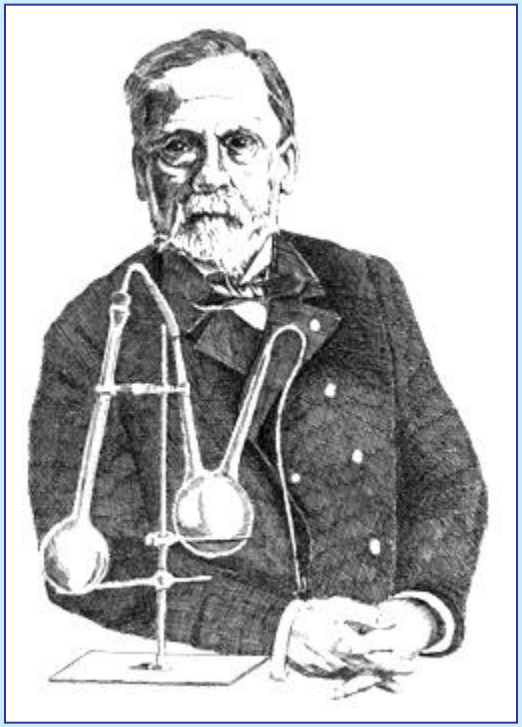
He contributes to the founding of the science of bacteriology. In the publication *Über Bakterien*, he discusses the role of microorganisms in the cycling of elements in nature. In 1875, Cohn will publish an early classification of bacteria, using the genus name *Bacillus* for the first time and describing the **endospore formation** of this microbe.

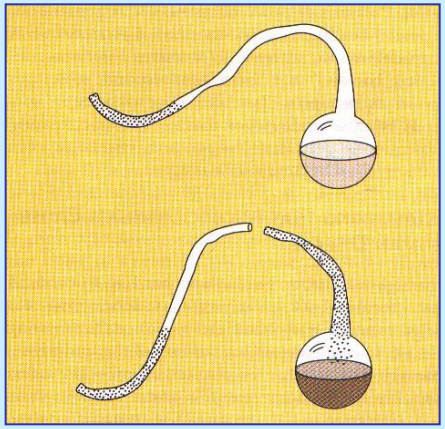
UN PO' DI STORIA




LE TAPPE MILIARI DELLA MICROBIOLOGIA

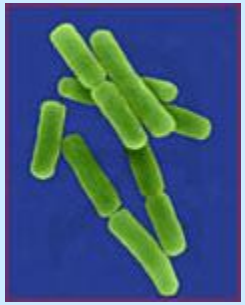
Louis Pasteur (1822-1895)





He debunked the widely accepted myth of **spontaneous generation**, thereby setting the stage for modern biology and biochemistry. He described the scientific basis for fermentation, wine-making, and the brewing of beer …

UN PO' DI STORIA




LE TAPPE MILIARI DELLA MICROBIOLOGIA

Robert Koch (1843-1910)

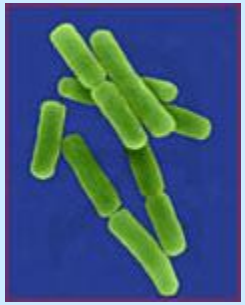
1905 Nobel Prize in Physiology or Medicine
for tuberculosis findings

One of the main founders of Microbiolgy

Koch's postulates

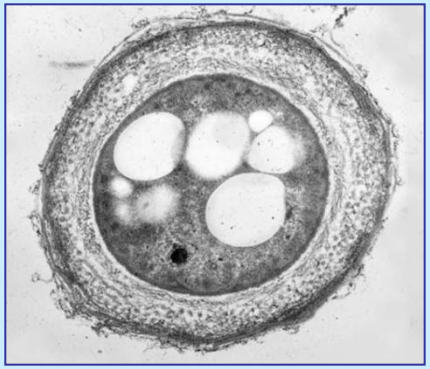
1. The microorganism must be found in abundance in all organisms suffering from the disease, but not in healthy organisms.
2. The microorganism must be isolated from a diseased organism and grown in pure culture.
3. The cultured microorganism should cause disease when introduced into a healthy organism.
4. The microorganism must be re-isolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

UN PO' DI STORIA



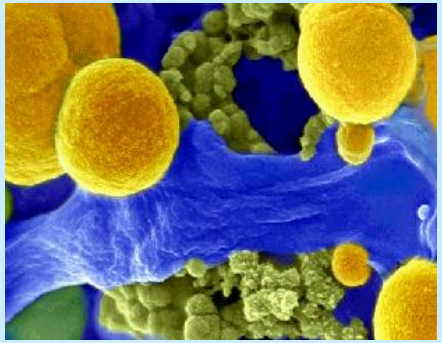
LE TAPPE MILIARI DELLA MICROBIOLOGIA

Martinus W. Beijerinck (1851-1931)



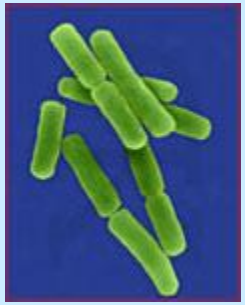
N_2-fixing bacterium
Azotobacter

Root nodules of the N_2-fixing legume-symbiont *Rhizobium*



SO_4^{2-}-reducing bacteria

UN PO' DI STORIA

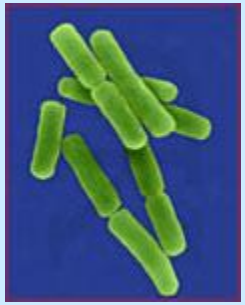



LE TAPPE MILIARI DELLA MICROBIOLOGIA

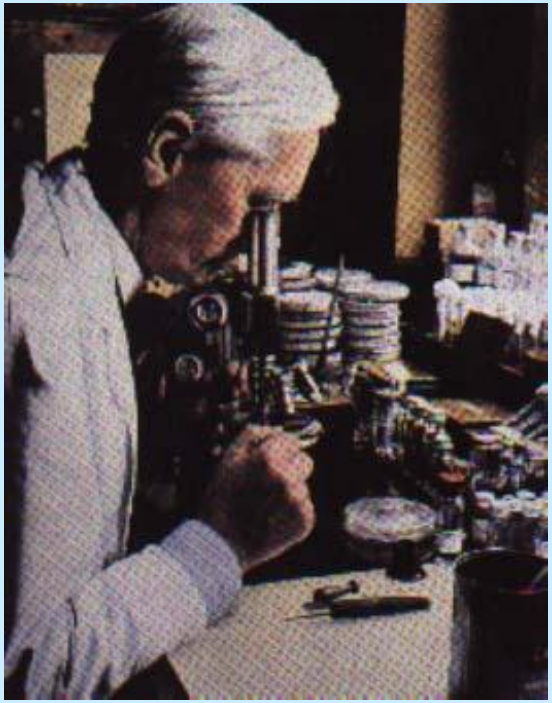
Sergei Winogradsky (1856-1953)

Russian microbiologist and soil scientist who pioneered the concept of biogeochemical cycles of life and discovered the biological process of nitrification, the first known form of chemoautotrophy (**chemolithotrophy**).

UN PO' DI STORIA



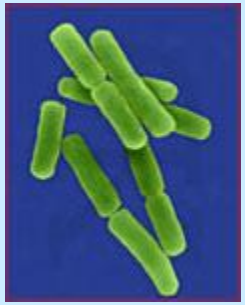

LE TAPPE MILIARI DELLA MICROBIOLOGIA



Alexander Fleming(1881-1955)

Lo scopritore della **penicillina**, il primo antibiotico di origine fungina descritto.

UN PO' DI STORIA



MICROSCOPIA

METODI PER L'OSSERVAZIONE MICROSCOPICA

Light Microscopy

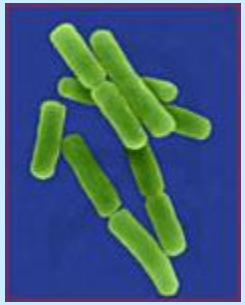
(1) Bright-Field Microscopy
(2) Phase-Contrast Microscopy
(3) Dark-Field Microscopy
(4) Fluorescence Microscopy

Three Dimensional Imaging

(1) Differential Interference Contrast Microscopy (DIC)
(2) Atomic Force Microscopy (AFM)
(3) Confocal Scanning Laser Microscopy (CSLM)

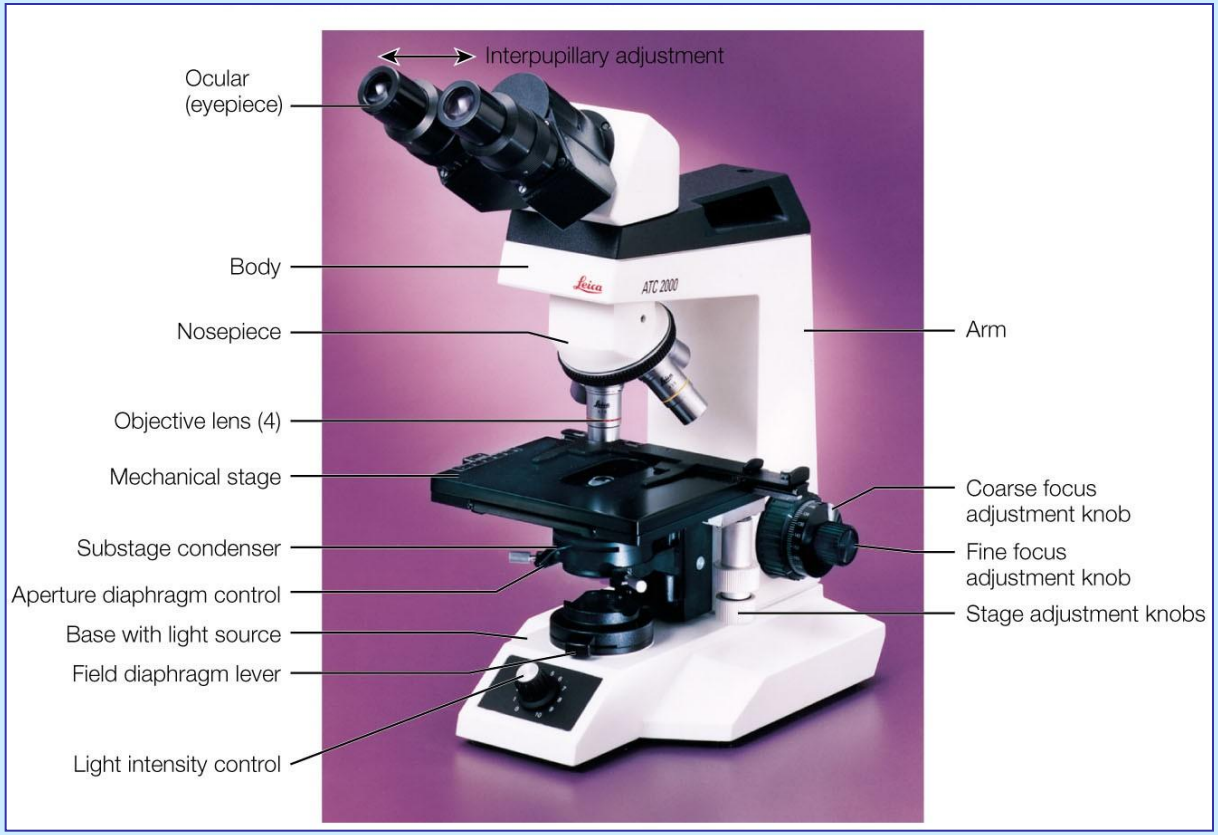
Electron Microscopy

(1) Transmission Electron Microscope (TEM)
(2) Scanning Electron Microscope (SEM)

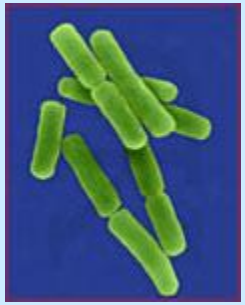


MICROSCOPIA

MICOSCOPIO OTTICO COMPOSTO



Struttura dei microorganismi



MICROSCOPIA

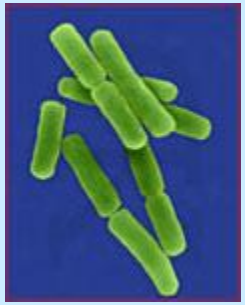
PROPRIETA' CARATTERIZZANTI UN MICROSCOPIO

L'**ingrandimento** (*magnification*) totale in un microscopio composto è il prodotto dell'ingrandimento dell'obbiettivo e dell'oculare.

La **risoluzione** (*resolution*) di un microscopio è l'abilità a distinguere separatamente due oggetti tra loro molto vicini

Il diametro dell'oggetto più piccolo risolvibile da una lente è dato dalla seguente formula:

0.5 λ / luminosità della lente (numero di apertura)




MICOSCOPIO OTTICO COMPOSTO

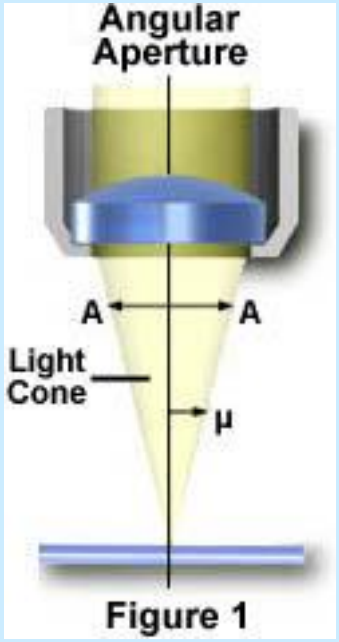


Figure 1

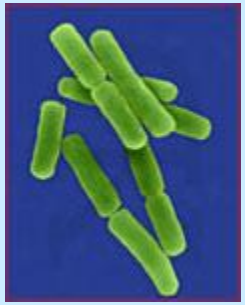
The **numerical aperture** of a microscope objective is a measure of its ability to gather light and resolve fine specimen detail at a fixed object distance. Image-forming light waves pass through the specimen and enter the objective in an inverted cone as illustrated in Figure 1. A longitudinal slice of this cone of light shows the angular aperture, a value that is determined by the focal length of the objective.

The angle μ is one-half the angular aperture (**A**) and is related to the numerical aperture through the following equation**:**

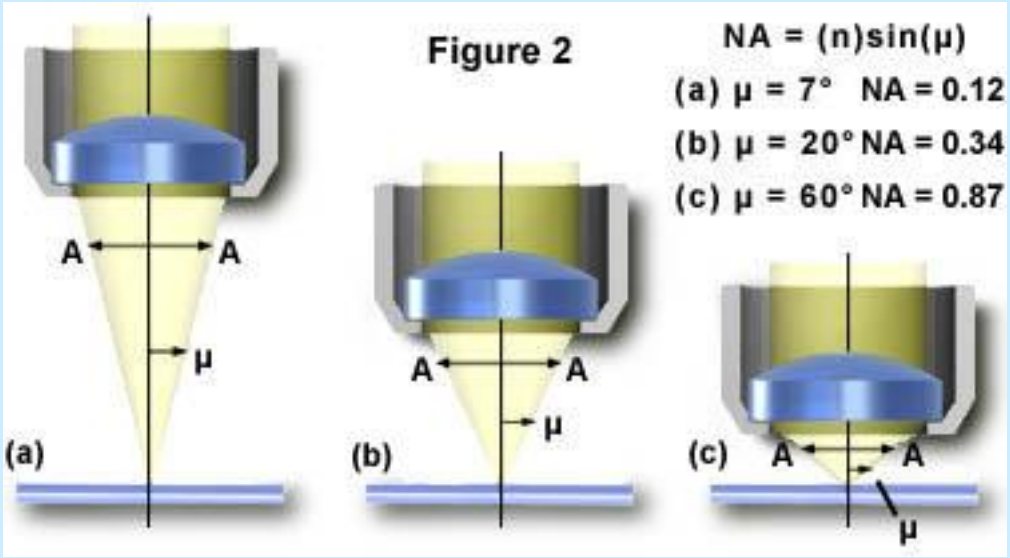
Numerical Aperture (**NA**) **= n (sin μ)**

where **n** is the refractive index of the imaging medium between the front lens of the objective and the specimen cover glass, a value that ranges from 1.00 for air to 1.51 for specialized immersion oils.

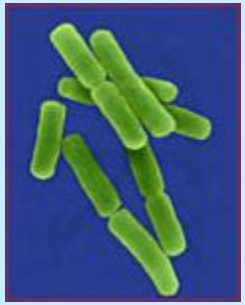
MICROSCOPIA




MICOSCOPIO OTTICO COMPOSTO



In practice, however, it is difficult to achieve numerical aperture values above 0.95 with dry objectives. Figure 2 illustrates a series of light cones derived from objectives of varying focal length and numerical aperture. As the light cones change, the angle μ increases from 7° in Figure 2(a) to 60° in Figure 2(c), with a resulting increase in the numerical aperture from 0.12 to 0.87, nearing the limit when air is the imaging medium.



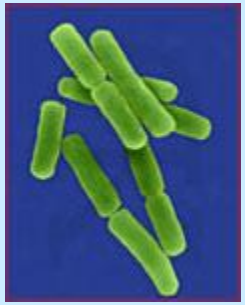

MICOSCOPIO OTTICO COMPOSTO

Objective Numerical Apertures

Magnification	Plan Achromat (NA)	Plan Fluorite (NA)	Plan Apochromat (NA)
0.5x	0.025	n/a	n/a
1x	0.04	n/a	n/a
2x	0.06	n/a	0.10
4x	0.10	0.13	0.20
10x	0.25	0.30	0.45
20x	0.40	0.50	0.75
40x	0.65	0.75	0.95
40x (oil)	n/a	1.30	1.00
60x	0.75	0.85	0.95
60x (oil)	n/a	n/a	1.40
100x (oil)	1.25	1.30	1.40
150x	n/a	n/a	0.90

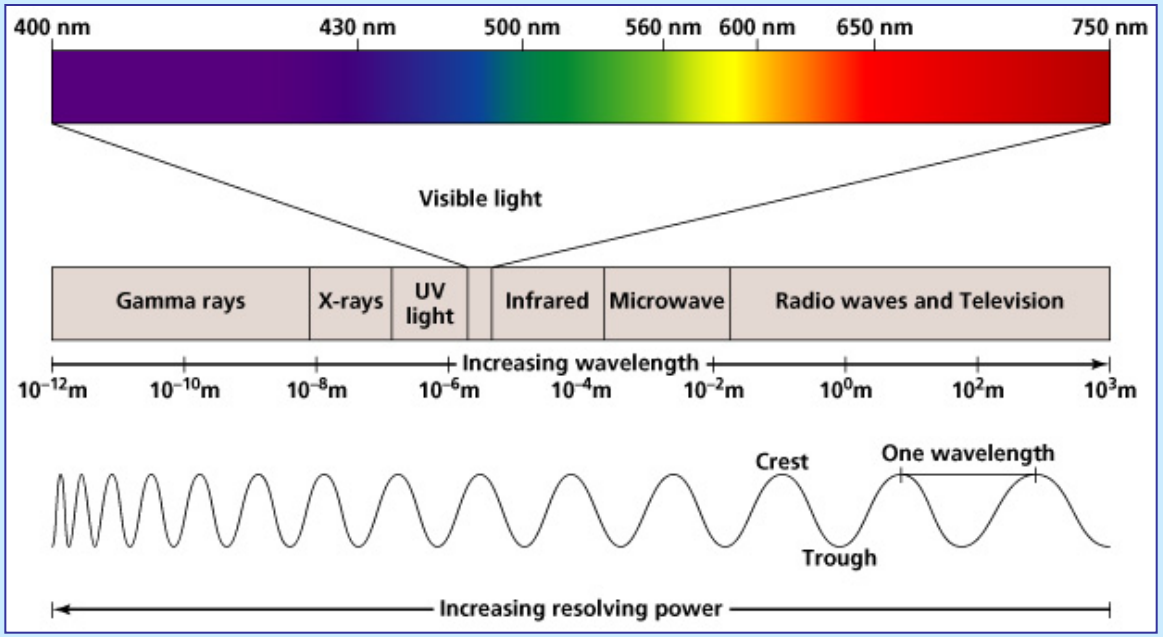
By examining the numerical aperture equation, it is apparent that refractive index is the limiting factor in achieving numerical apertures greater than 1.0. Therefore, in order to obtain higher working numerical apertures, the refractive index of the medium between the front lens of the objective and the specimen must be increased. Microscope objectives are now available that allow imaging in alternative media such as water (refractive index = 1.33), glycerin (refractive index = 1.47), and immersion oil (refractive index = 1.51).

MICROSCOPIA

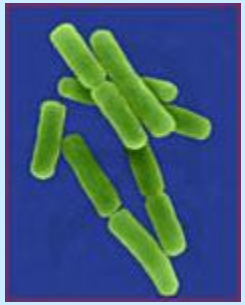


MICROSCOPIA

LO SPETTRO ELETTROMAGNETICO



Struttura dei microorganismi




LA STRUTTURA PROCARIOTICA

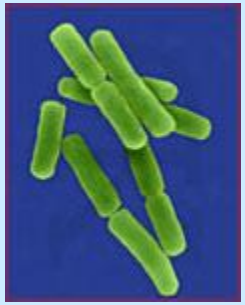
Properties of Microscopes for microbial structure investigation

• Magnification

Light microscope - ~1500X
Electron microscope (TEM) - 1,500-100,000X

• Resolving Power

Light microscope - 0.2 µm
Electron microscope - 1nm (0.001 µm)-15nm

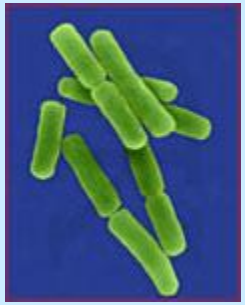


MICROSCOPIA

Bright-Field Microscopy

Consists of two series of lenses (**objective lens** and **ocular lens**) that resolve the image.

Specimens are made visible because of the differences in contrast between them and the surrounding medium.

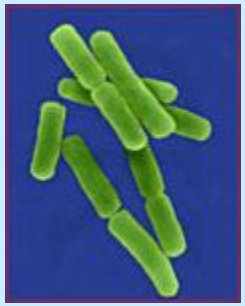



COLORAZIONI DI CONTRASTO
(STAINING)

Purpose:
Increase contrast for bright-field microscopy.

Positively charged (cationic) dyes:
bind to negatively charged cellular components (nucleic acids, acidic polysaccharides, cell surfaces). Examples: methylene blue, crystal violet, safranin.

General procedure:
slide containing a dried suspension of microbes is flooded with a dilute solution of the dye for a minute or two, rinsed in water, and blotted dry. These are often observed with the oil immersion lens.

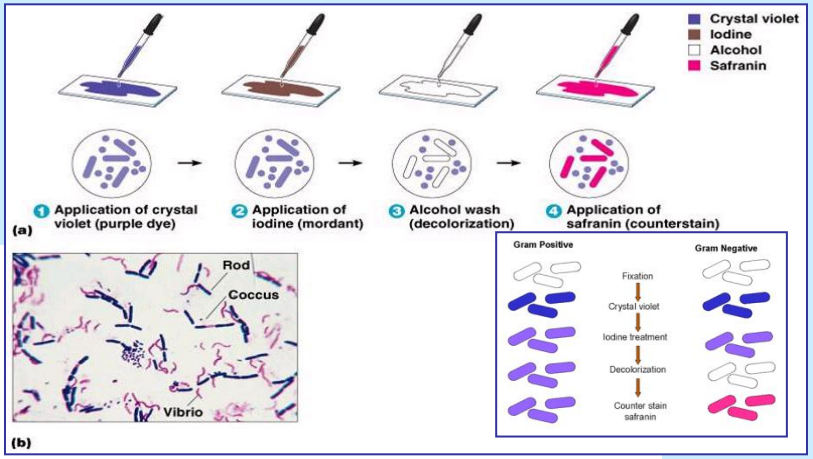


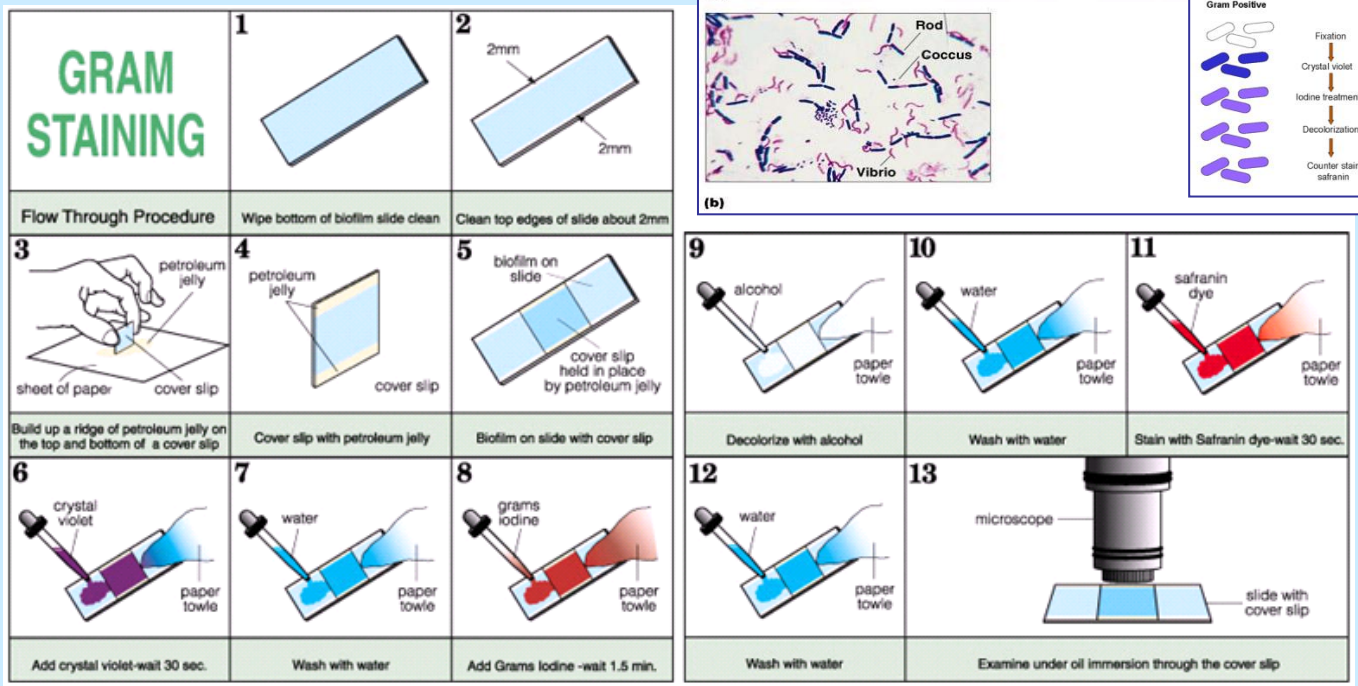
COLORAZIONE DIFFERENZIALE

It does not stain all kinds of cells equally.

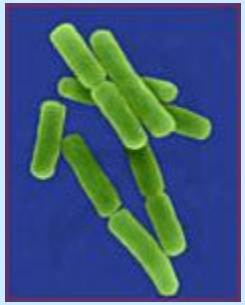
Most important differential stain = **Gram stain**.

This latter is often the first step in identifying unknown bacteria.



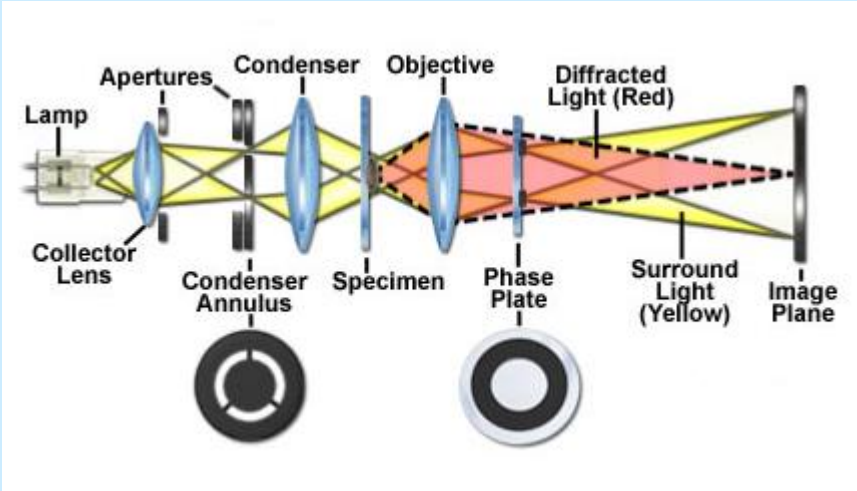


MICROSCOPIA



Phase-Contrast Microscopy, discovered in 1936

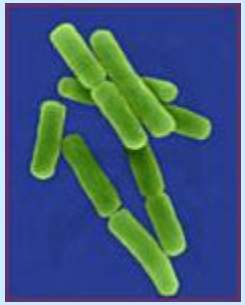
(Frits Zernike, 1888-1966 - Nobel Prize in Physics, 1953)



A special ring in the objective lens causes a dark image to be formed on a light background due to a difference in the refractive index of the specimen from its surrounding.

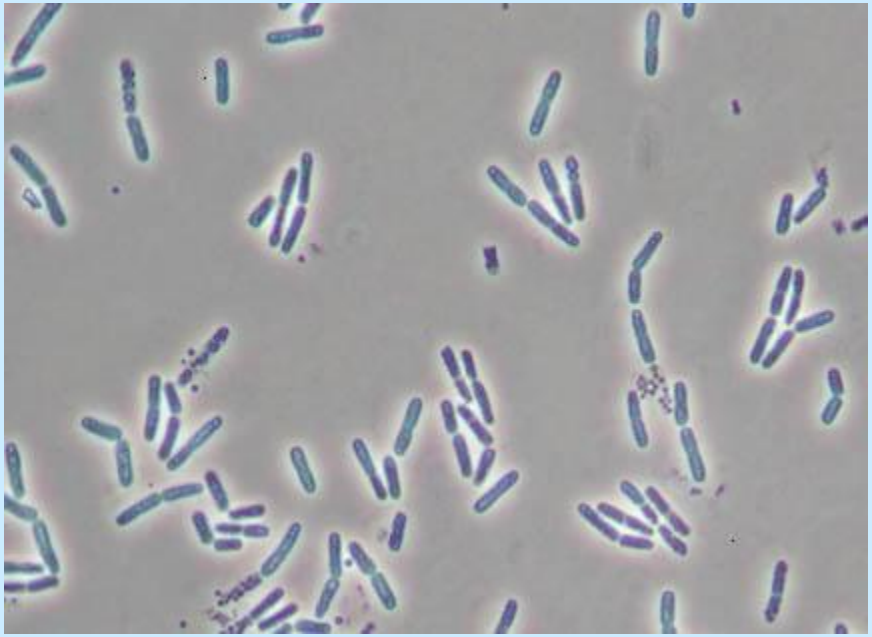
Advantages: developed to increase contrast between cells and the surrounding medium without staining.

MICROSCOPIA

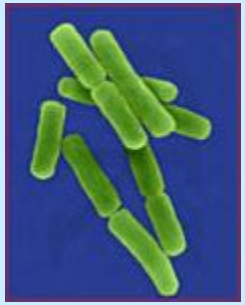



MICROSCOPIA

Phase-Contrast Microscopy



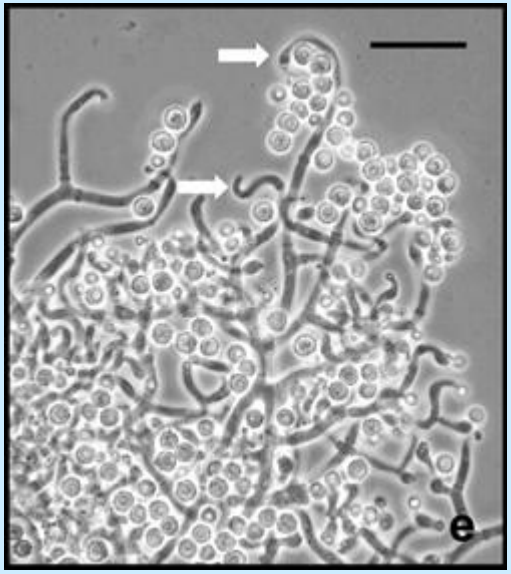
Bacillus thuringiensis observed under phase contrast microscopy with a 100X oil immersion objective



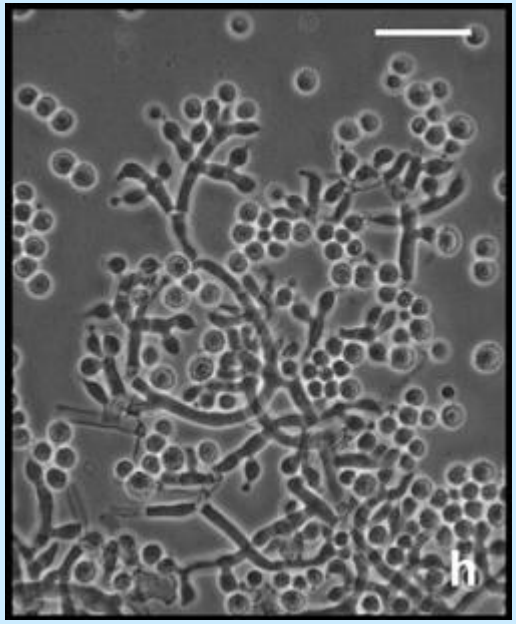
MICROSCOPIA

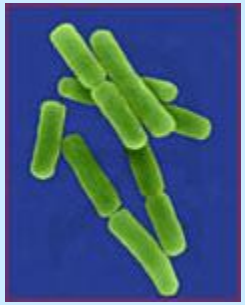
Conidiophores of *Hypocrea rufa*/*Trichoderma viride* anamorph

Bright-field microscopy

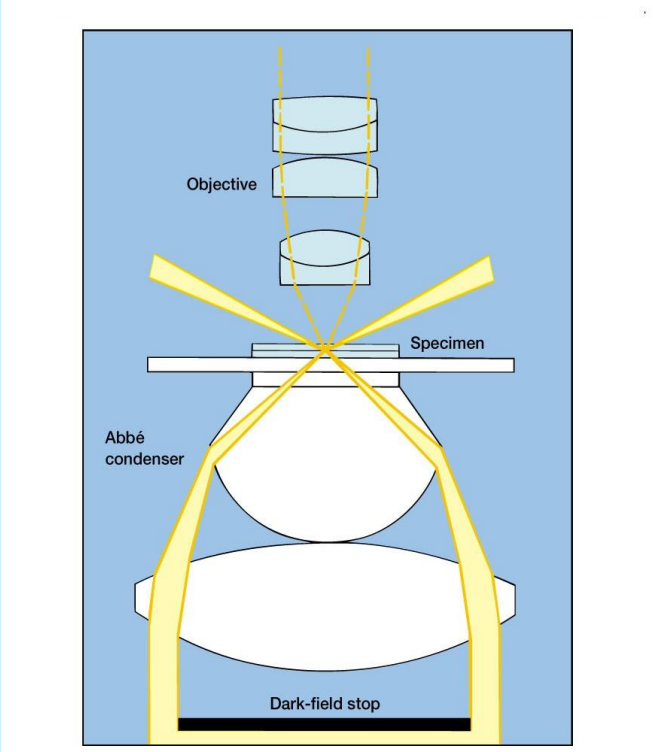


Phase contrast microscopy






Dark-Field Microscopy

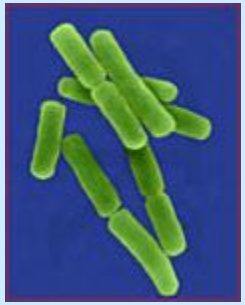


Lighting has been modified to reach the specimen from the sides only.

The only light reaching the lens is light scattered by the specimen.

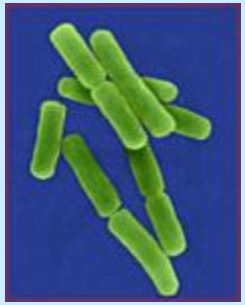
Specimen appears light on a dark background.

Advantages: has higher resolution than bright-field or phase contrast microscopes, good for viewing flagella and motility.




MICROSCOPIA

Beggiatoa observed using dark-field microscopy



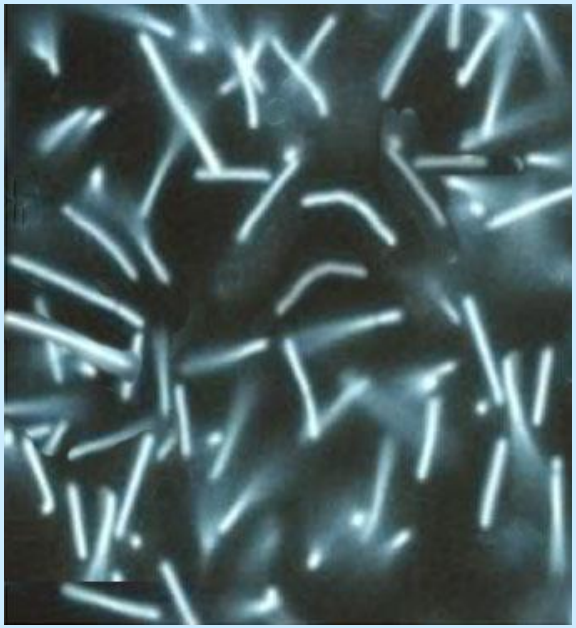
MICROSCOPIA

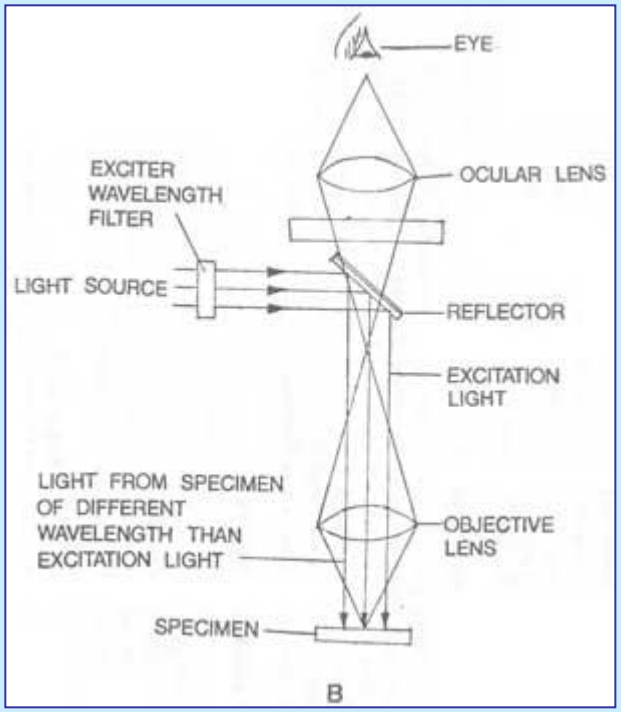
Fluorescence Microscope

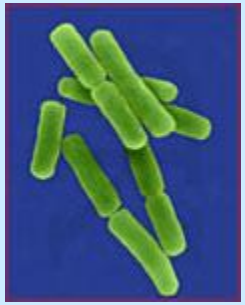
Used to visualize specimens that fluoresce.

Cells fluoresce because: (a) they contain naturally fluorescent substances (e.g. chlorophyll or other fluorescing components), (b) they have been treated with a fluorescent dye.

Uses: clinical diagnostic microbiology and microbial ecology.







MICROSCOPIA

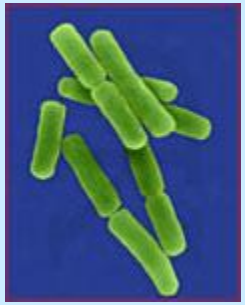
Differential Interference Contrast Microscope (DIC)

Creates three-dimensional images by detecting differences in refractive indices and thickness of different parts of the specimens by employing a polarizer.

Two beams of polarized light are produced that traverse the specimen and then enter the objective lens where they are recombined into one.

The differences of refractive indices of different substances are detected as differences in cell structure.

Excellent way to observe living cells and structures contained in them



MICROSCOPIA

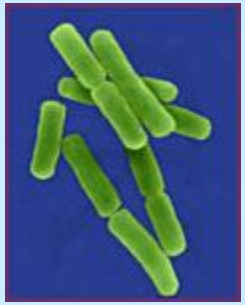
Atomic Force Microscopy (AFM)

Tiny stylus is positioned close to a specimen.

Weak repulsive atomic forces are established between the probe and the specimen.

The pattern is monitored by detectors and images are created that look like SEM images.

Advantages: specimen preparation for AFM is like that for light microscopy instead of SEM. Also, hydrated specimens can be viewed, which cannot be done by SEM.



MICROSCOPIA

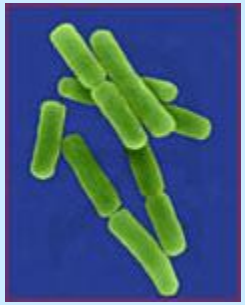
Confocal Scanning Laser Microscopy (CSLM)

Computerized microscope that couples a laser light source to a light microscope.

Relatively thick specimens can be observed in terms of not only the surface, but the layers as well, by adjusting the plane of focus of the laser beam.

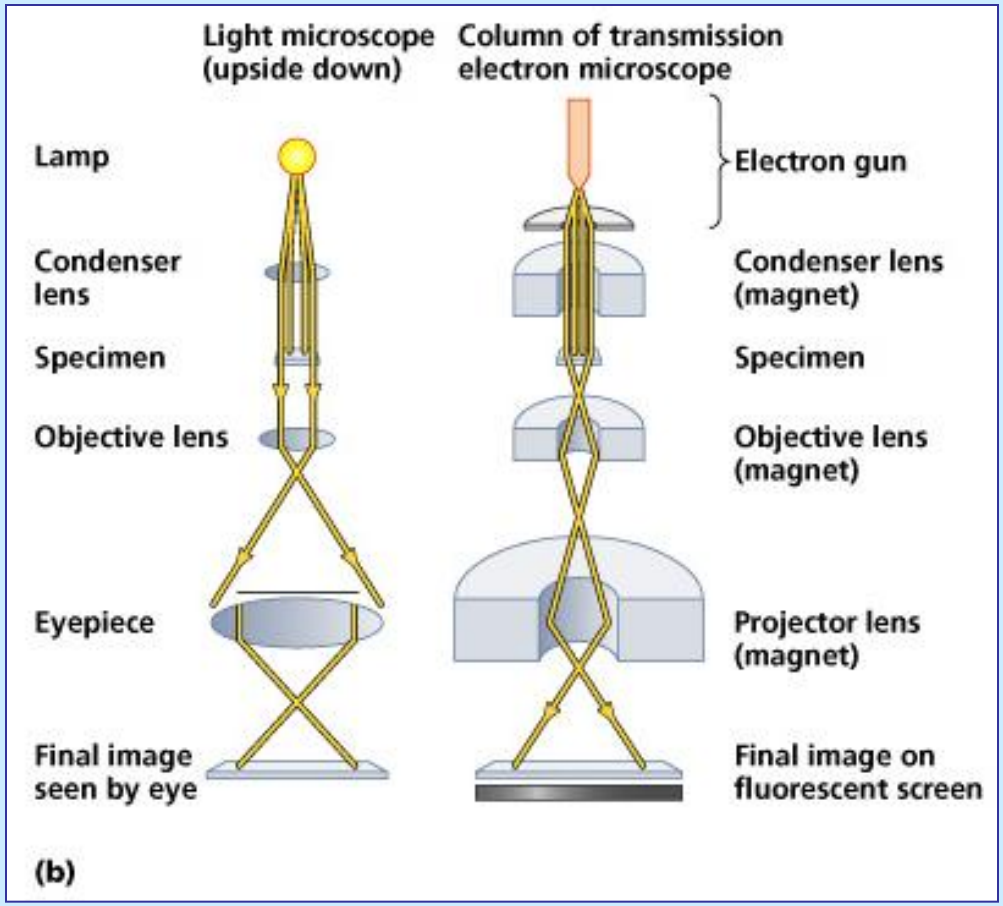
Cells may be stained with fluorescent dyes or false color images can be generating by adjusting the microscope so that different layers take on different colors.

Advantages: images stored digitally, used in microbial ecology, and for thick specimens.

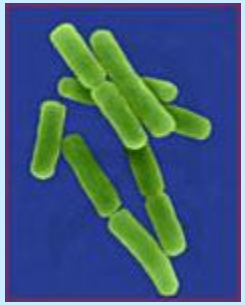


MICROSCOPIA

Differences between light and electron (TEM or SEM) microscopes

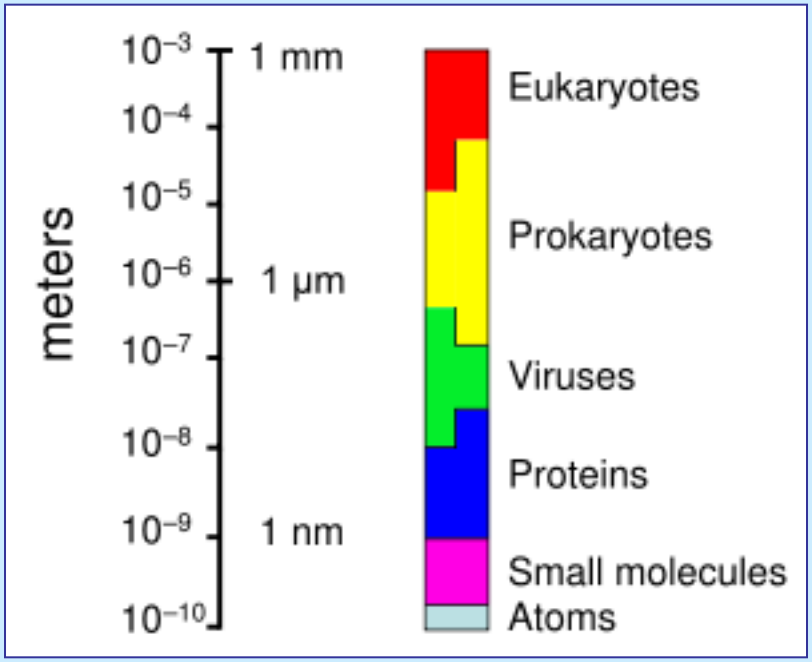


Struttura dei microorganismi

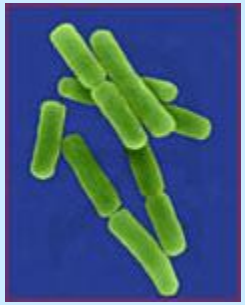


LA STRUTTURA PROCARIOTICA

The sizes of prokaryotes relative to other organisms and biomolecules

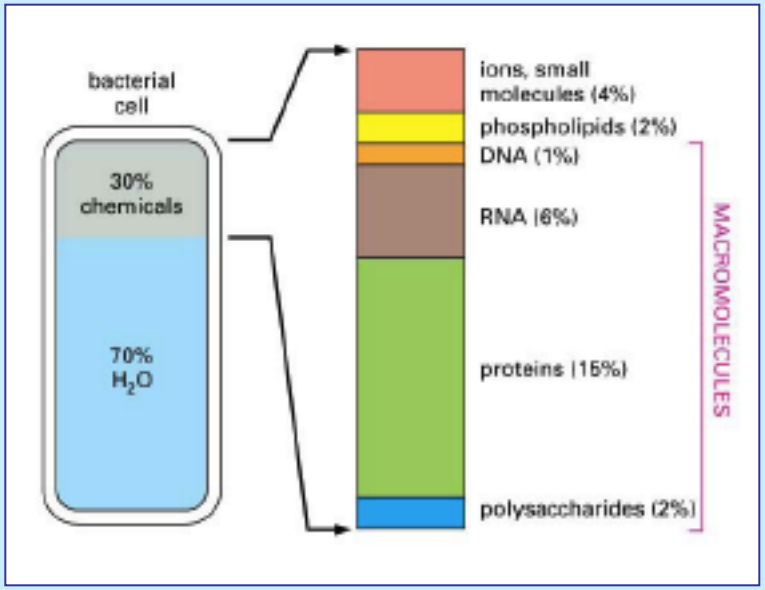


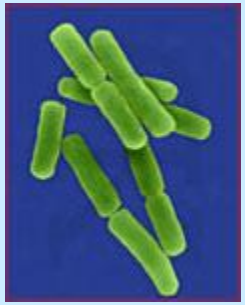
Struttura dei microorganismi



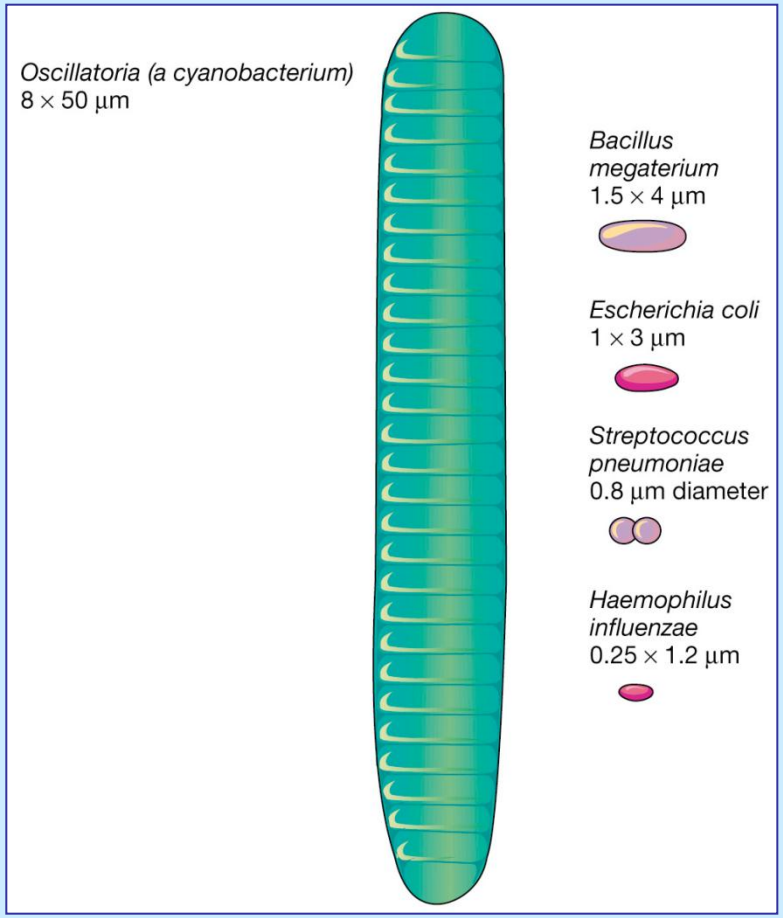

LA STRUTTURA PROCARIOTICA

All cells are composed by the same classes of macromolecules

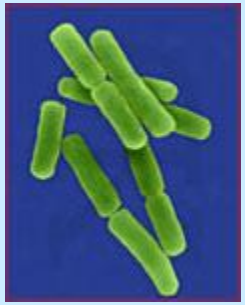




LE DIMENSIONI DEI PROCARIOTI

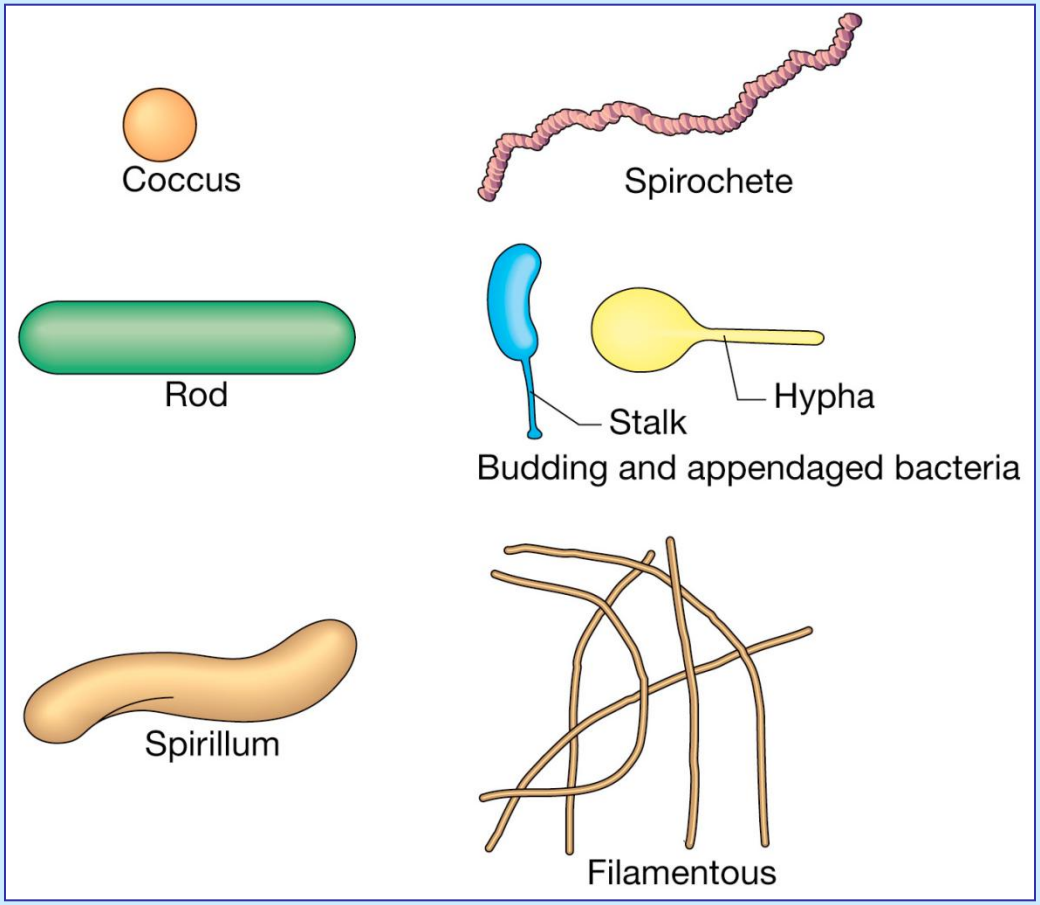


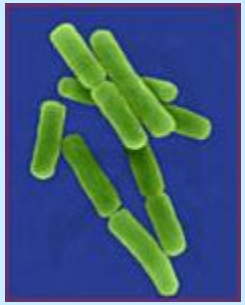
LA STRUTTURA PROCARIOTICA



LA STRUTTURA PROCARIOTICA

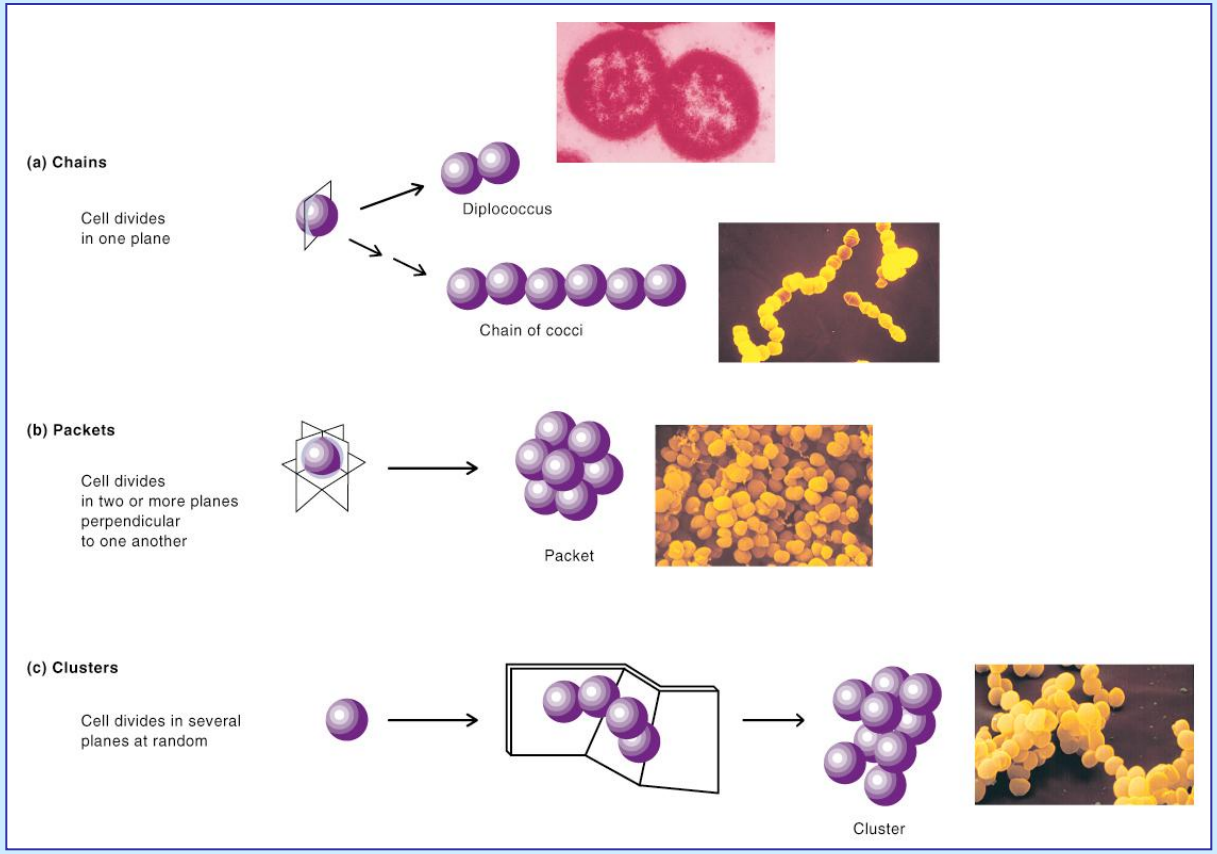
LE FORME DEI PROCARIOTI

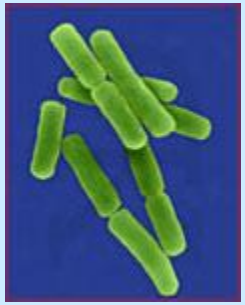




LA STRUTTURA PROCARIOTICA

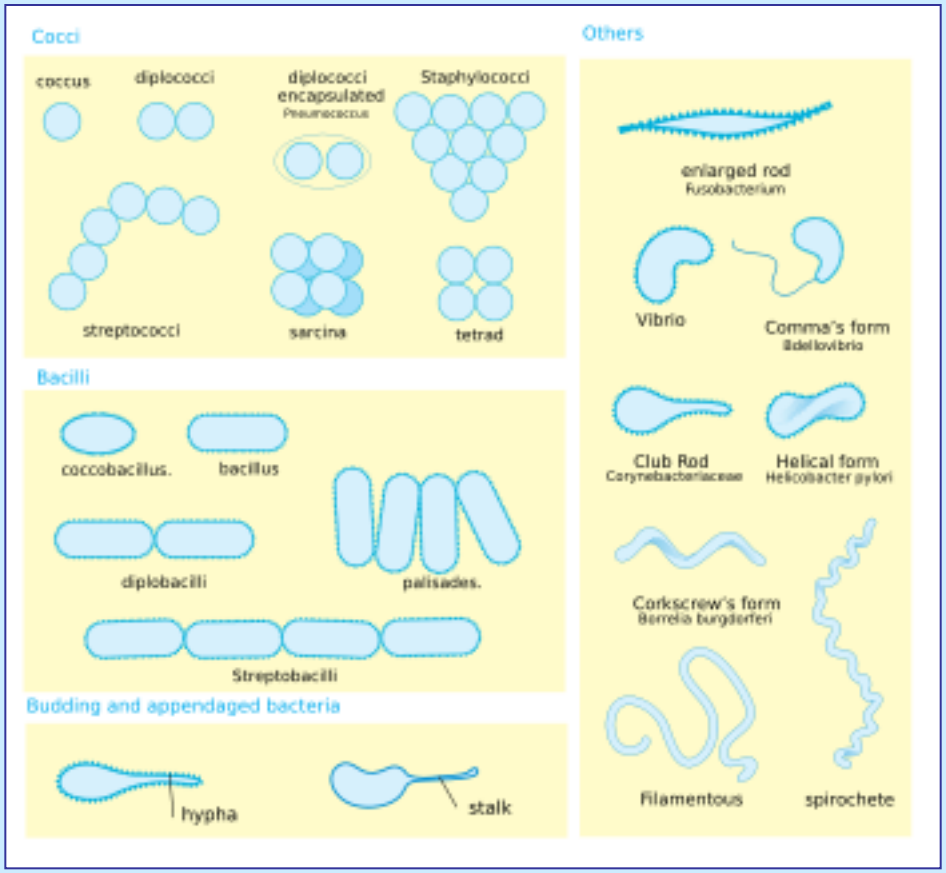
ARRANGIAMENTI AGGREGATIVI DEI PROCARIOTI



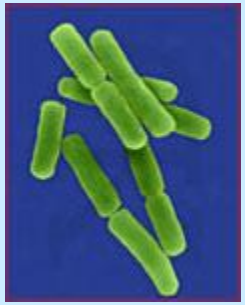


LA STRUTTURA PROCARIOTICA

Bacteria display a large diversity of cell morphologies and arrangements



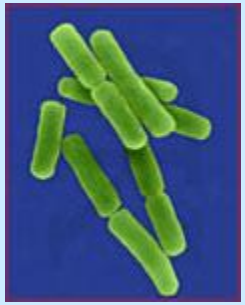
Struttura dei microorganismi



LA STRUTTURA PROCARIOTICA

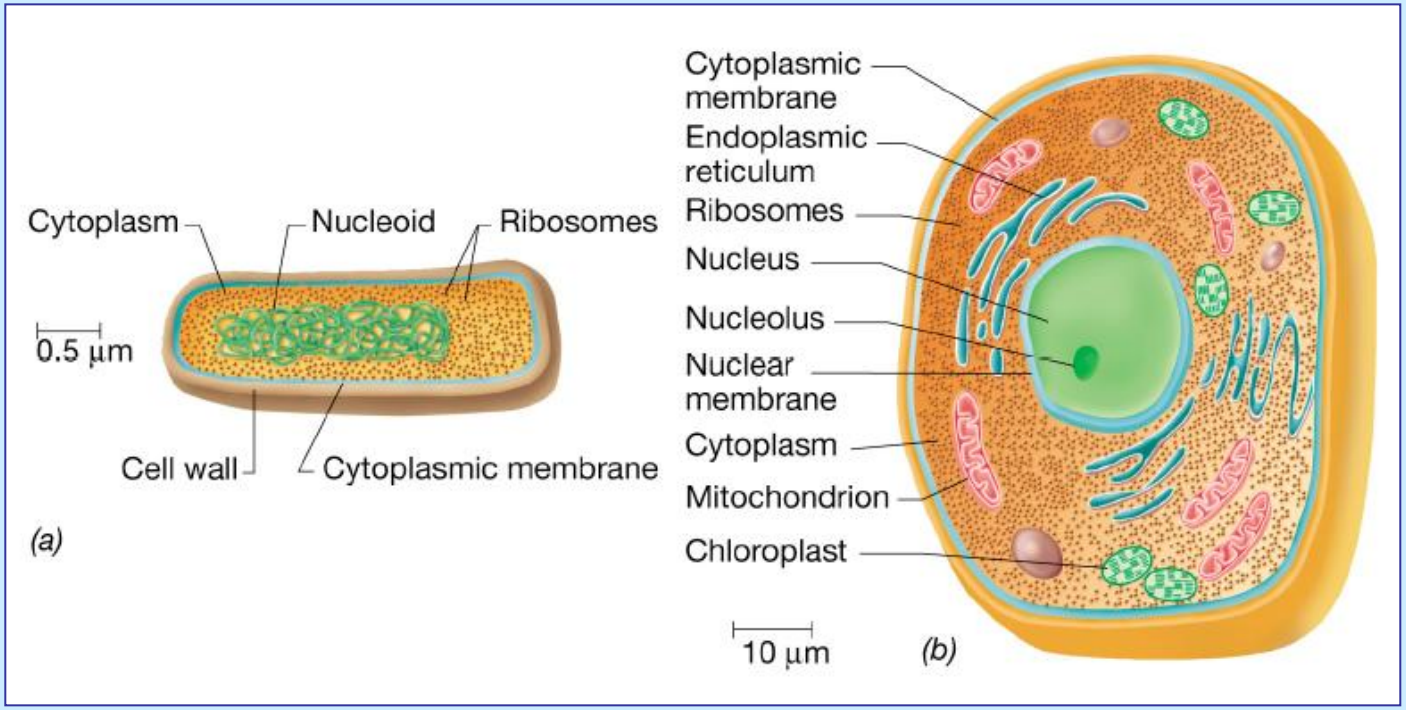
PRINCIPALI GRUPPI DI MICROORGANISMI

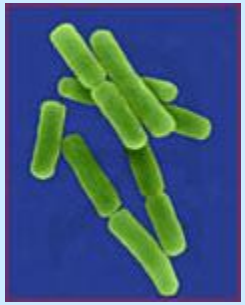
GRUPPO MICROBICO	STRUTTURA
Virus	non cellulare
Archebatteri	procariotica
Eubatteri	procariotica
Funghi	eucariotica
Alghe	eucariotica
Protozoi	eucariotica



LA STRUTTURA PROCARIOTICA

CELLULE PROCARIOTICA *(a)* ED EUCARIOTICA *(b)* A CONFRONTO



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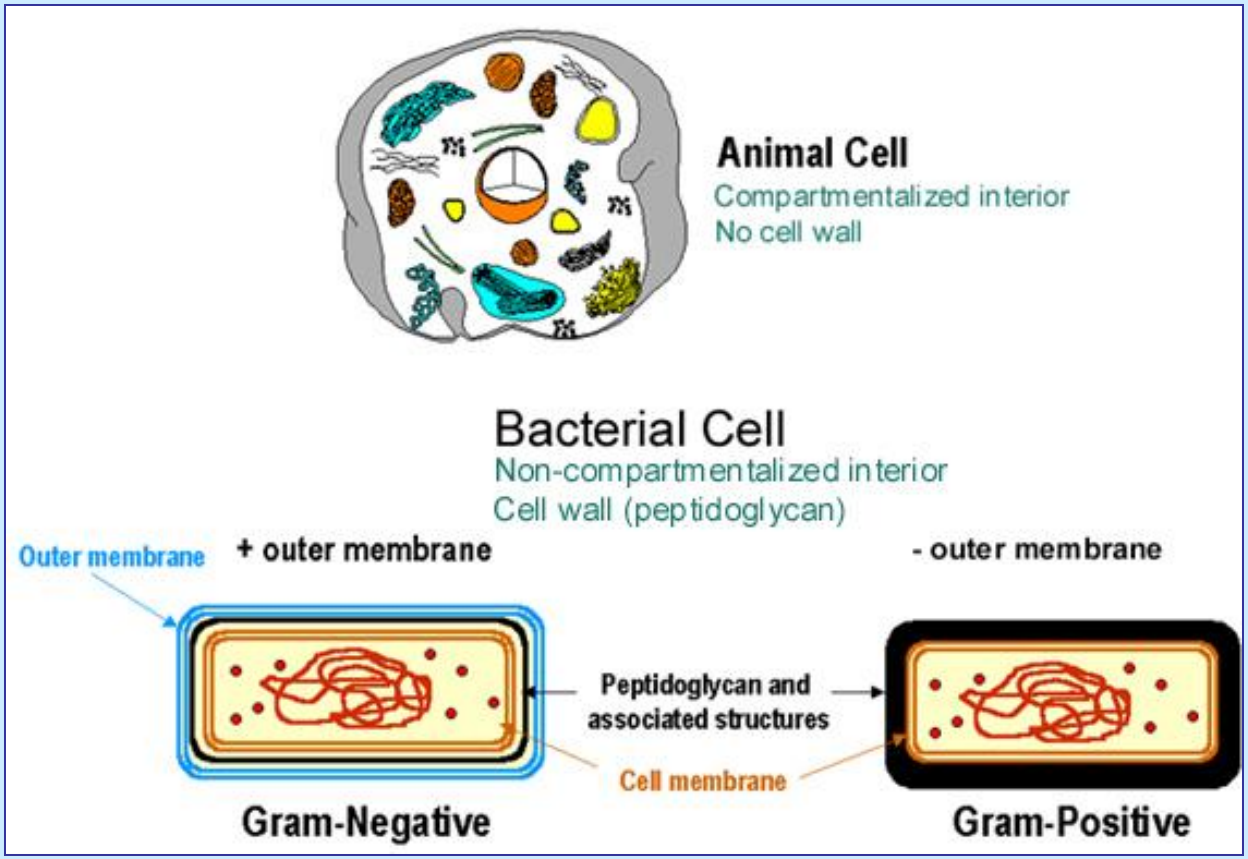
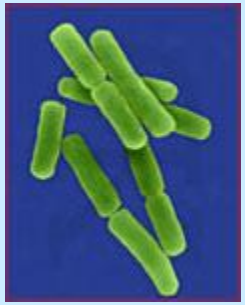
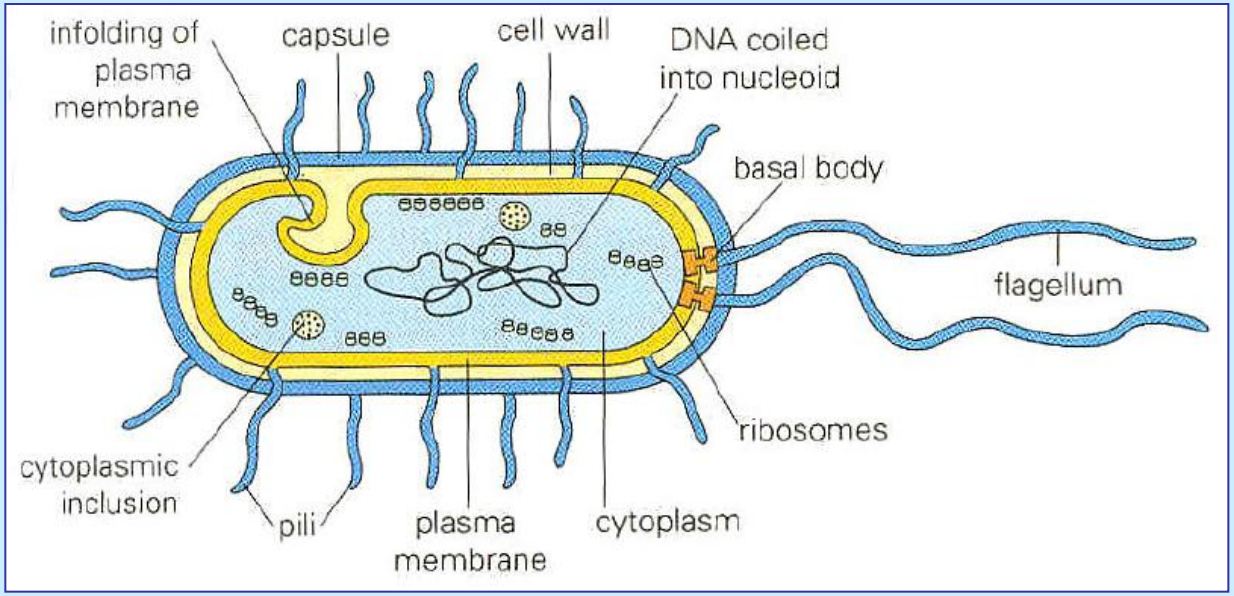


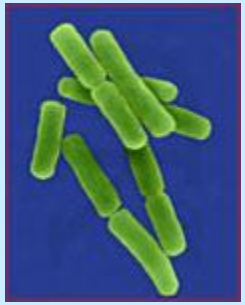
Struttura dei microorganismi



RAPPRESENTAZIONE DIAGRAMMATICA DI UNA CELLULA BATTERICA



LA STRUTTURA PROCARIOTICA



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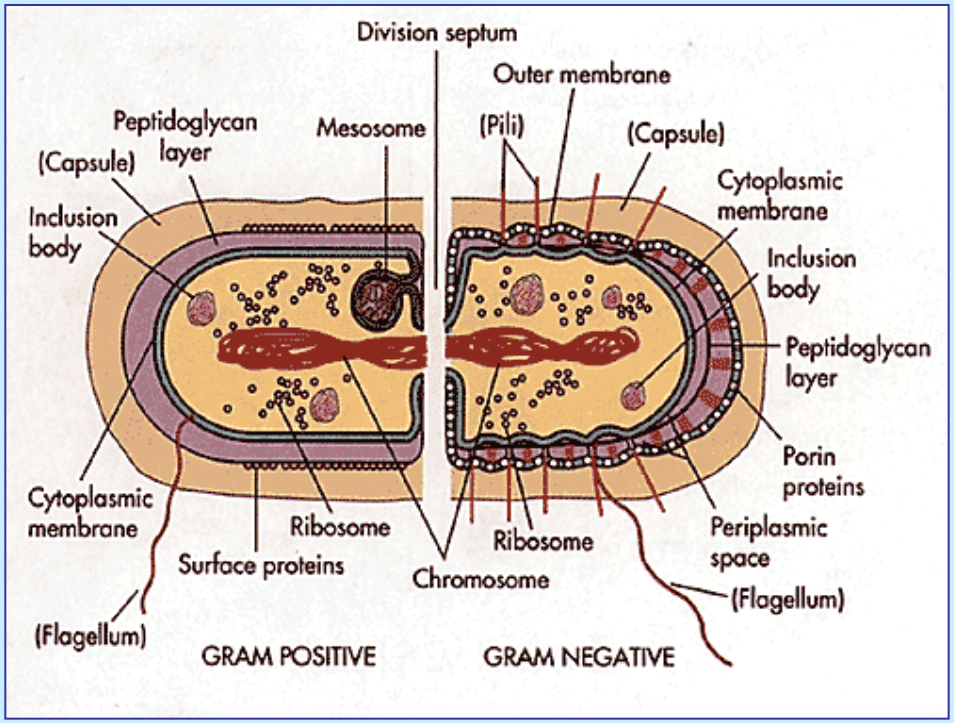
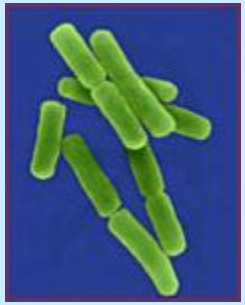


Struttura dei microorganismi



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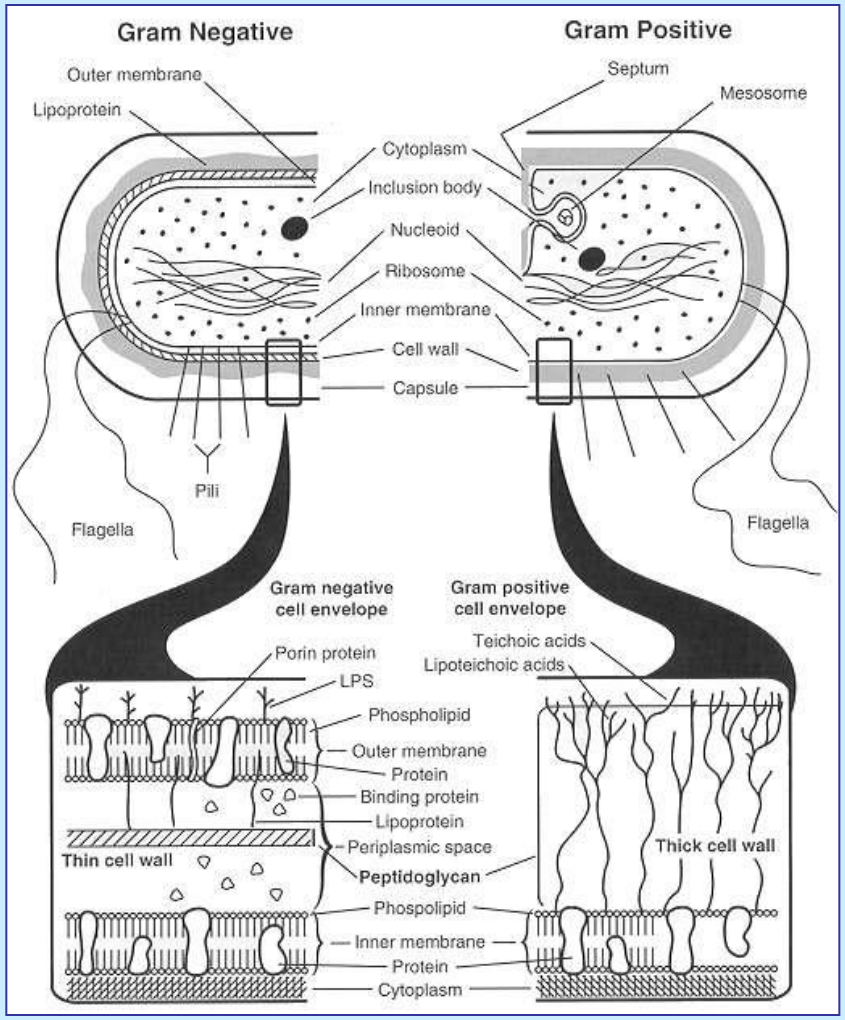
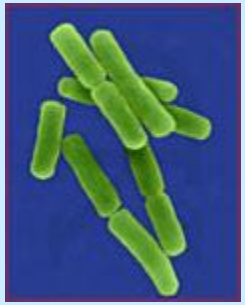
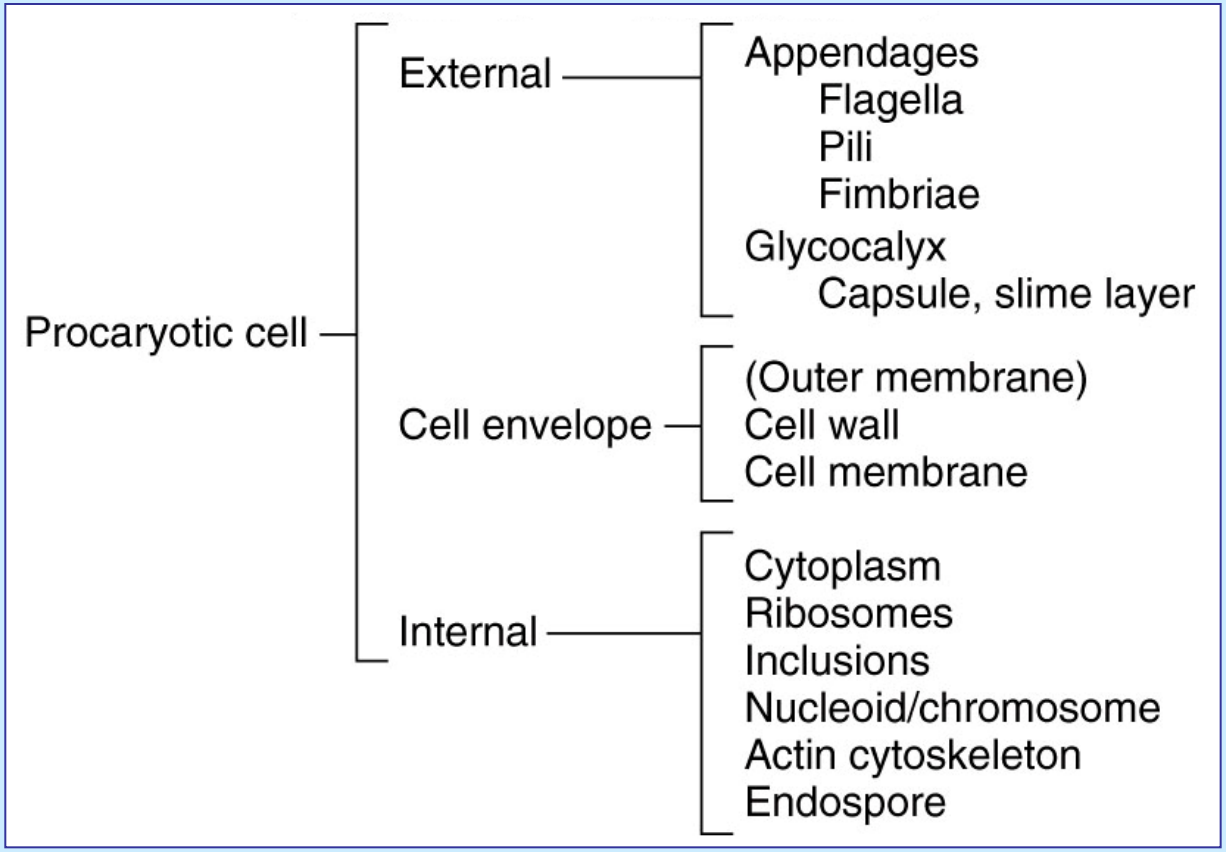


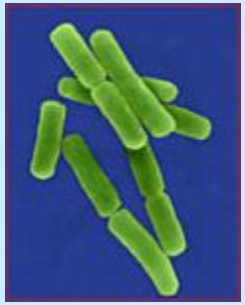
Struttura dei microorganismi



LA STRUTTURA PROCARIOTICA

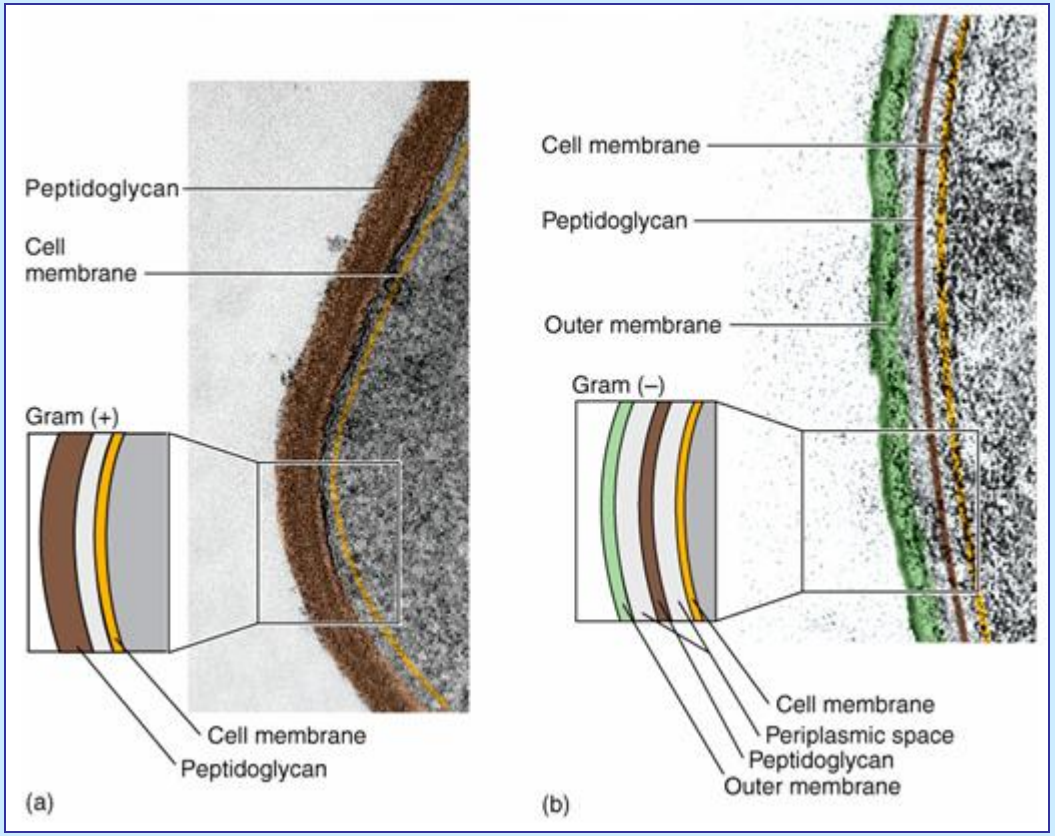
PRINCIPALI COMPONENTI DELLA CELLULA PROCARIOTICA

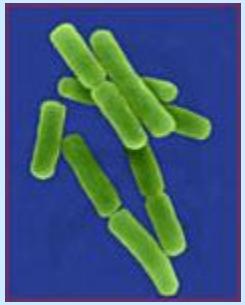




LA STRUTTURA PROCARIOTICA

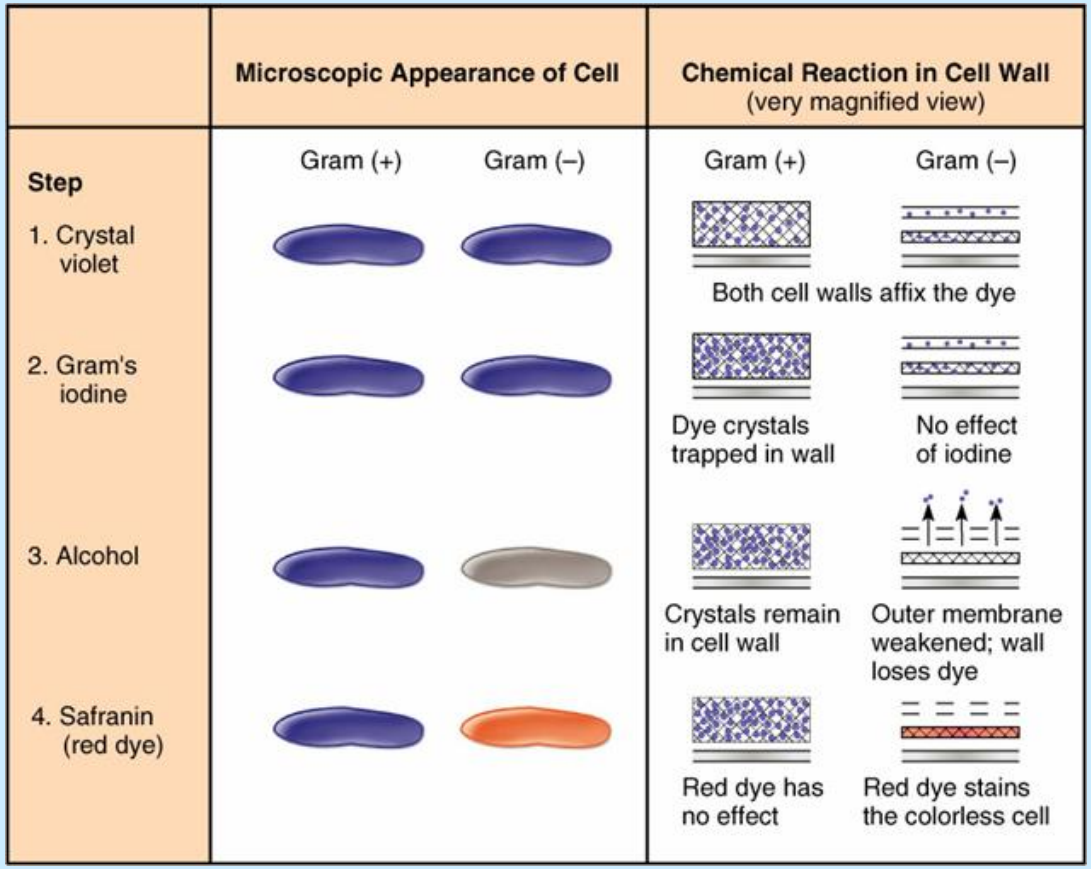
STRUTTURA DELLA PARETE CELLULARE BATTERICA

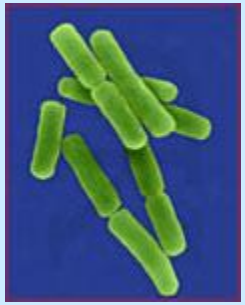




LA STRUTTURA PROCARIOTICA

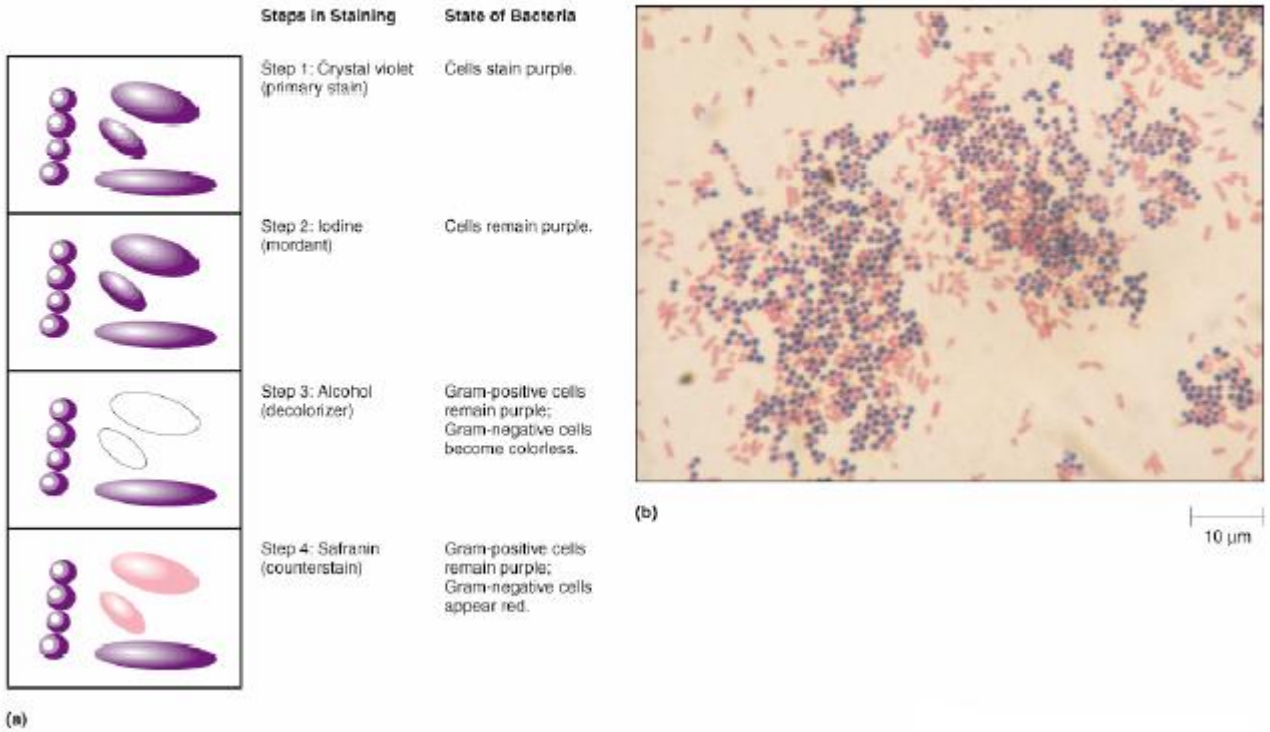
RISPOSTA DELLA PARETE BATTERICA ALLA COLORAZIONE DI GRAM



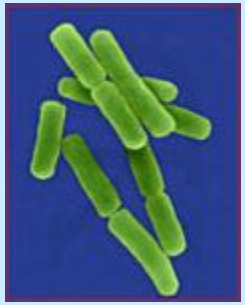


LA STRUTTURA PROCARIOTICA

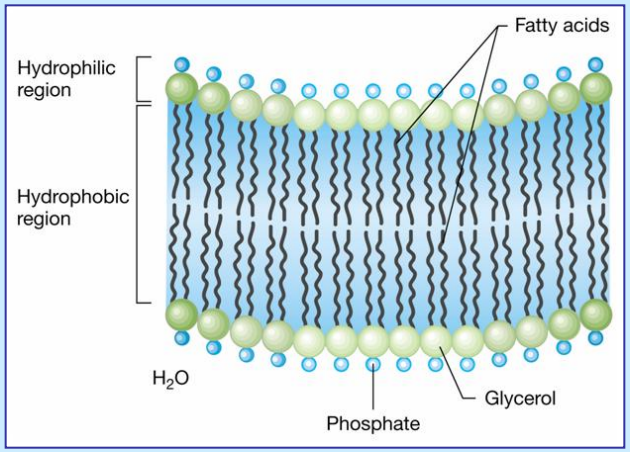
Colorazione di Gram nei batteri

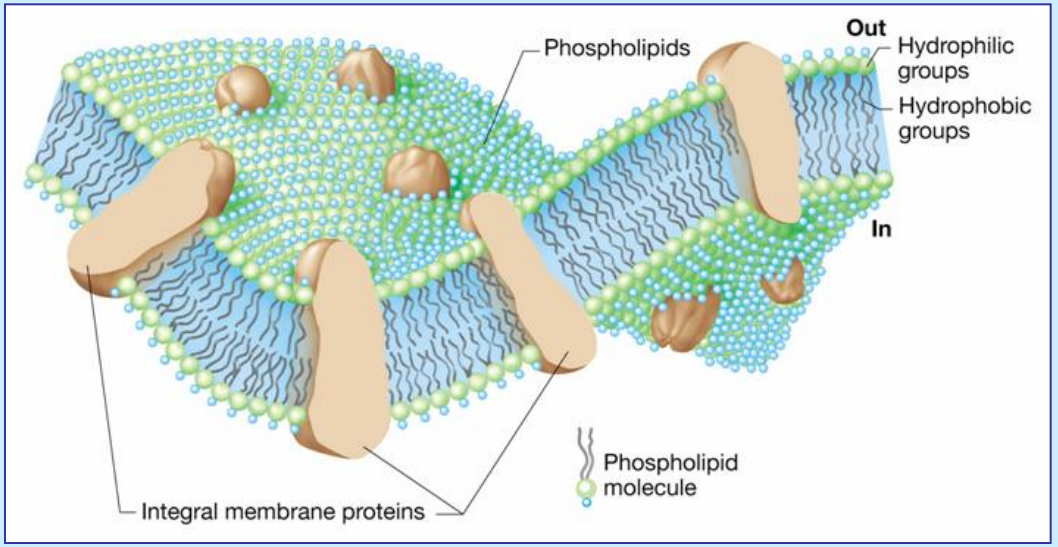


Struttura dei microorganismi



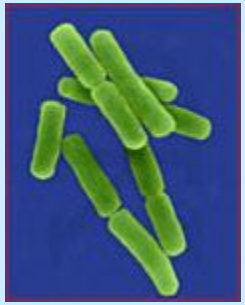
MEMBRANA CELLULARE BATTERICA





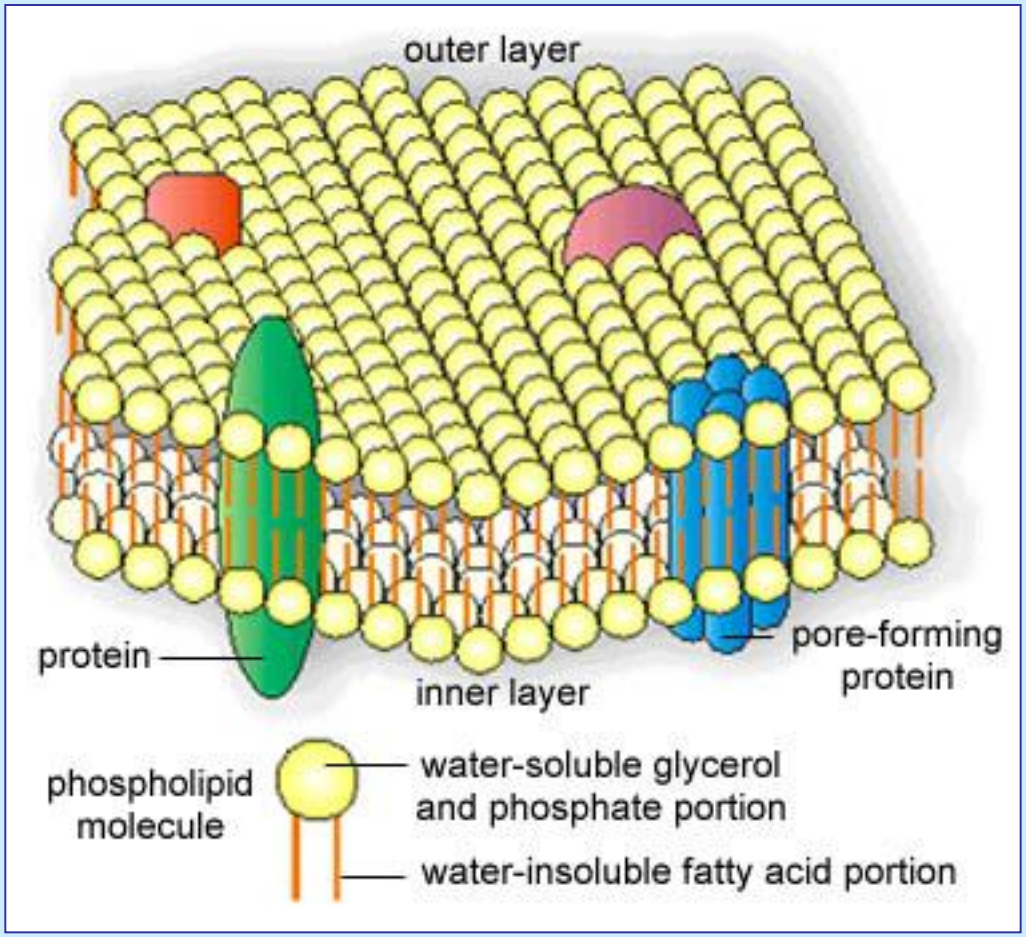
LA STRUTTURA PROCARIOTICA

Struttura dei microorganismi

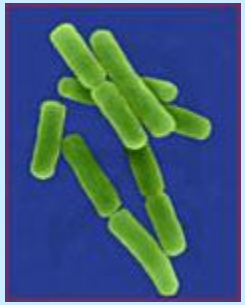


LA STRUTTURA PROCARIOTICA

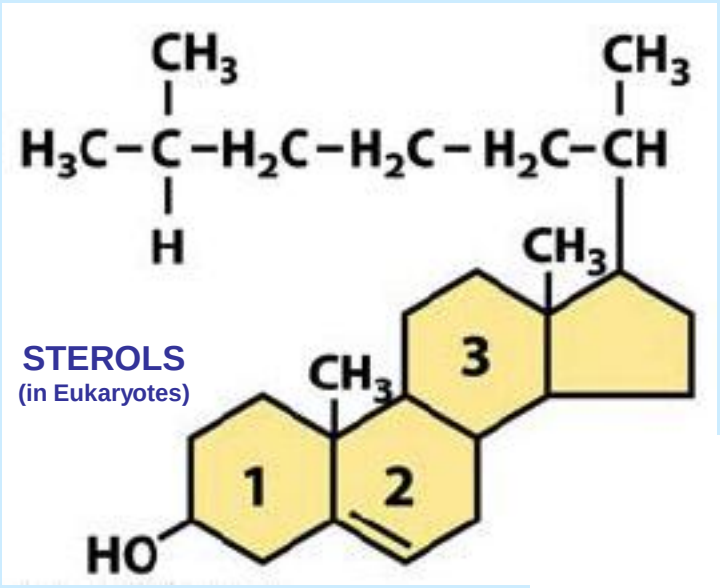
Rappresentazione schematica di membrana citoplasmatica



Struttura dei microorganismi

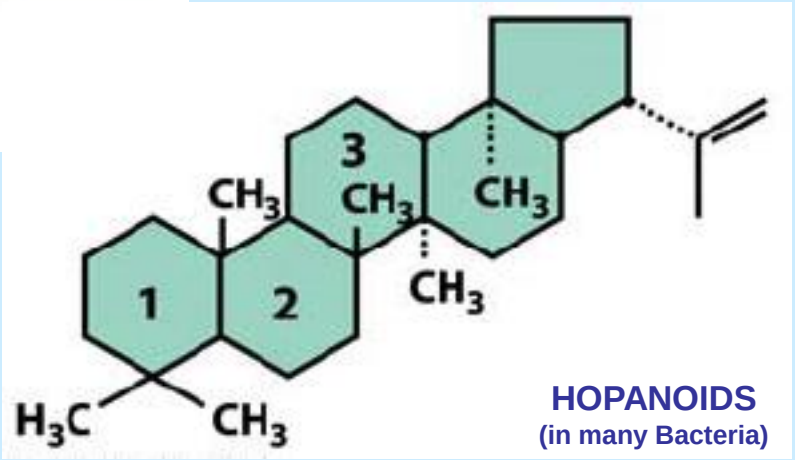



LA STRUTTURA PROCARIOTICA



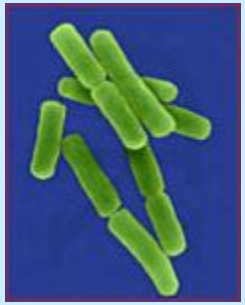
STEROLS
(in Eukaryotes)

COMPONENTI di MEMBRANA



HOPANOIDS
(in many Bacteria)

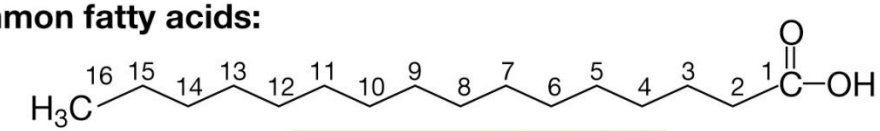
Struttura dei microorganismi



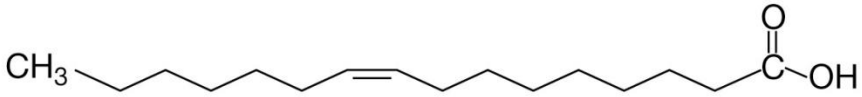
LA STRUTTURA PROCARIOTICA

Lipidi di membrana negli Eubatteri e negli Eucarioti

Common fatty acids:

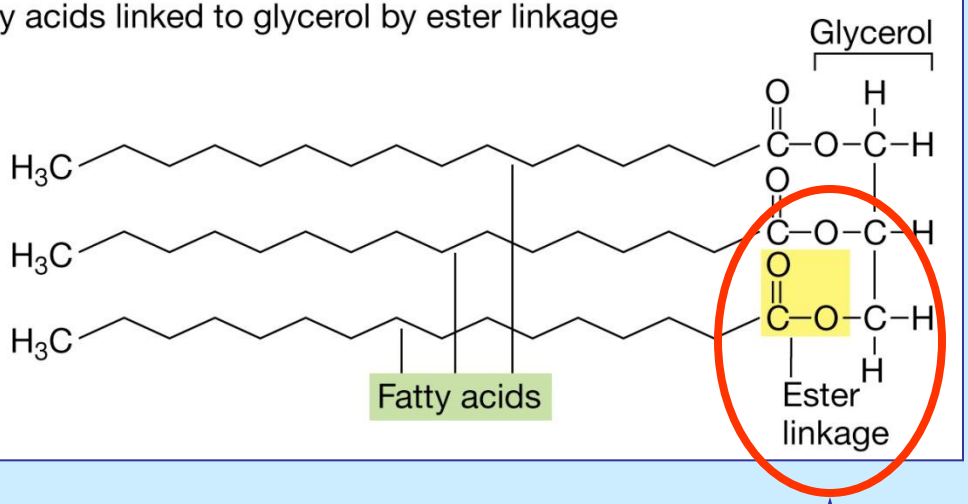


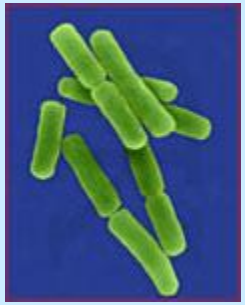
C_{16} saturated (palmitic)



C_{16} monounsaturated (palmitoleic)

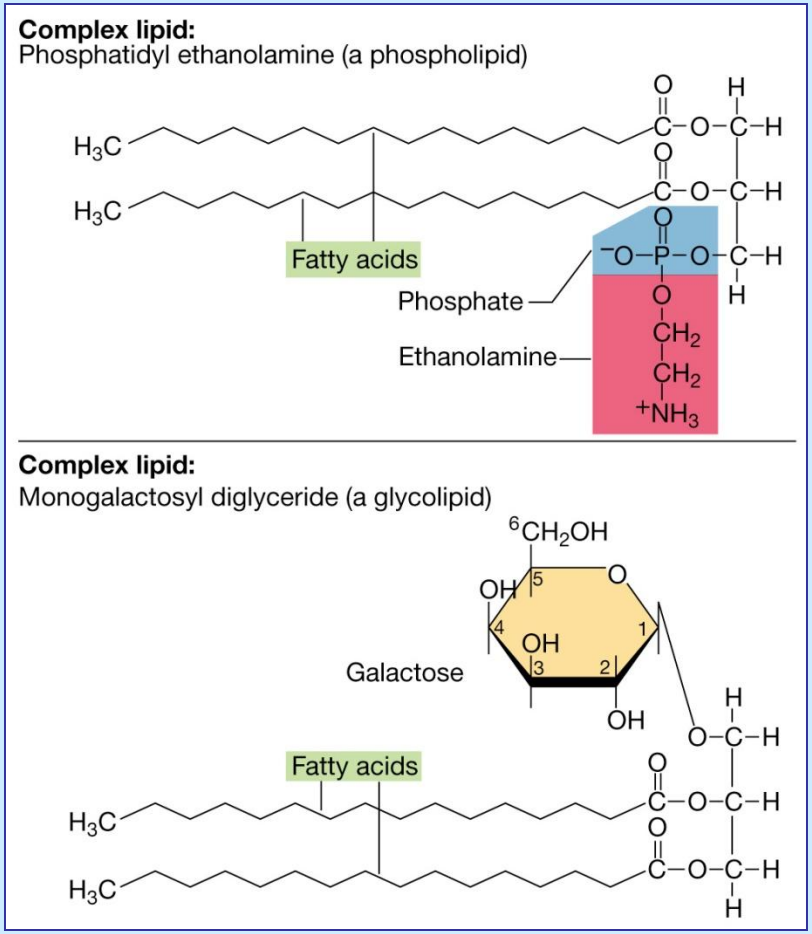
Simple lipids (triglycerides):
Fatty acids linked to glycerol by ester linkage



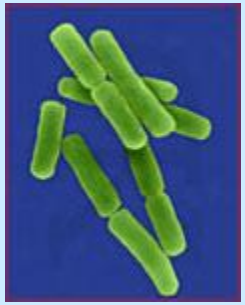


LA STRUTTURA PROCARIOTICA

Lipidi di membrana complessi

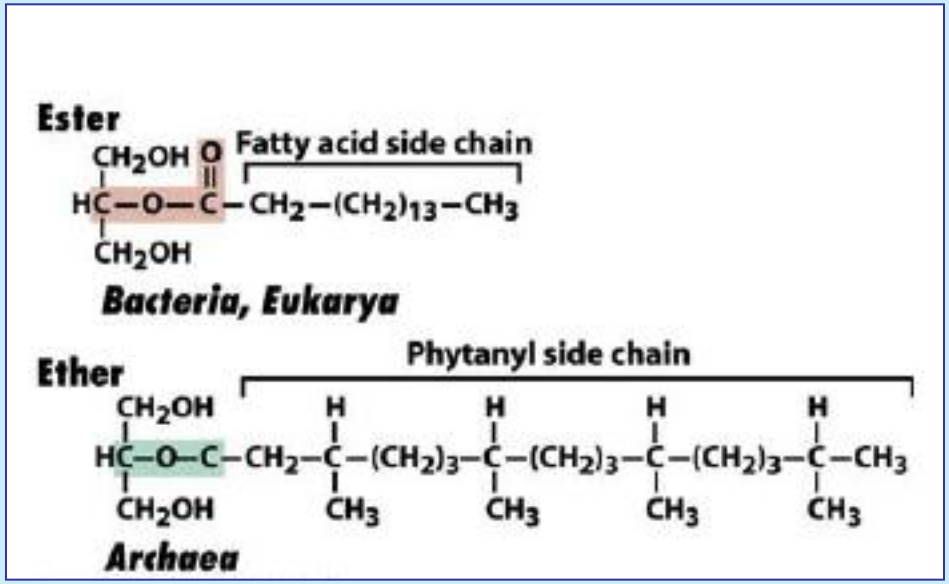


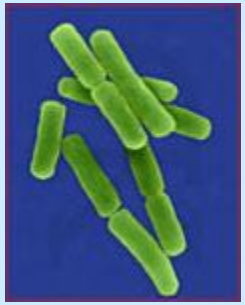
Struttura dei microorganismi



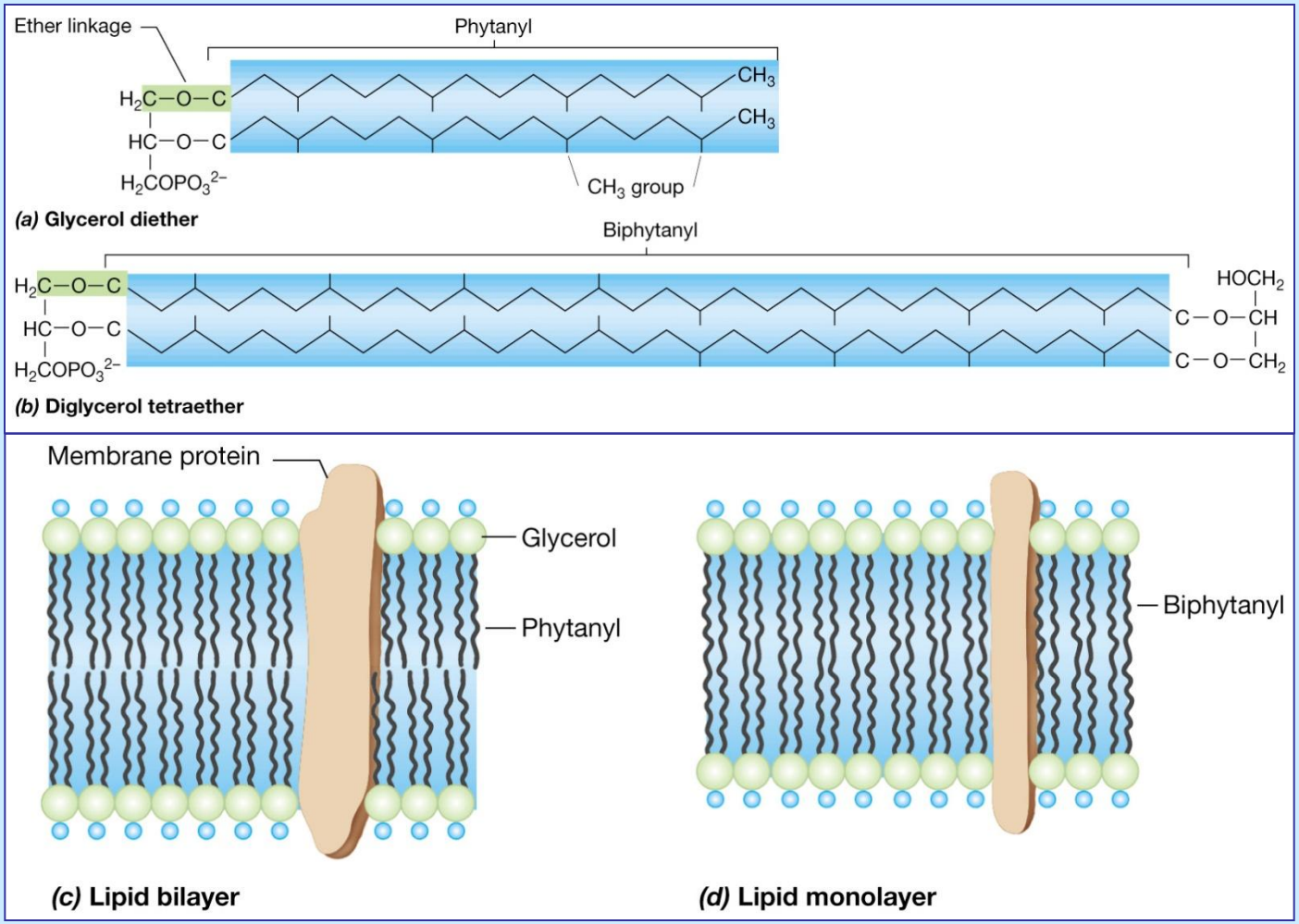
LA STRUTTURA PROCARIOTICA

Differenza di legame tra glicerolo ed acidi grassi nei Batteri (ex Eubatteri) e negli Eucarioti rispetto agli Archebatteri





Principali lipidi di membrana negli Archaea



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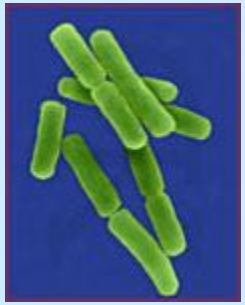
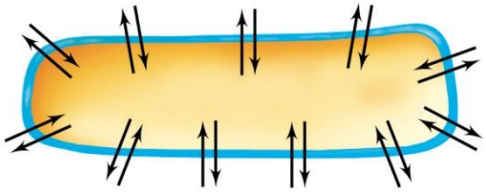
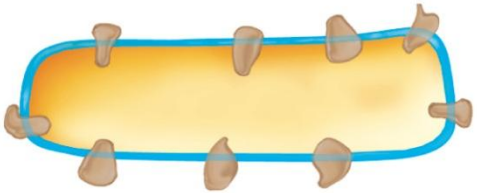



LA STRUTTURA PROCARIOTICA

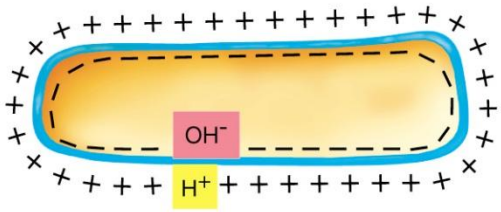
PRINCIPALI FUNZIONI DELLA MEMBRANA CELLULARE



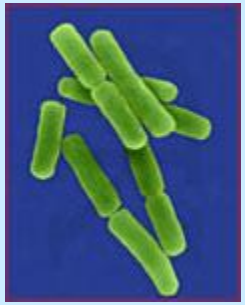
Permeability Barrier — Prevents leakage and functions as a gateway for transport of nutrients into and out of the cell



Protein Anchor — Site of many proteins involved in transport, bioenergetics, and chemotaxis



Energy Conservation — Site of generation and use of the proton motive force

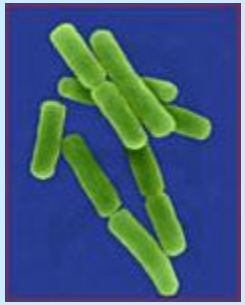



LA STRUTTURA PROCARIOTICA

Table 4.2 Comparative permeability of membranes to various molecules

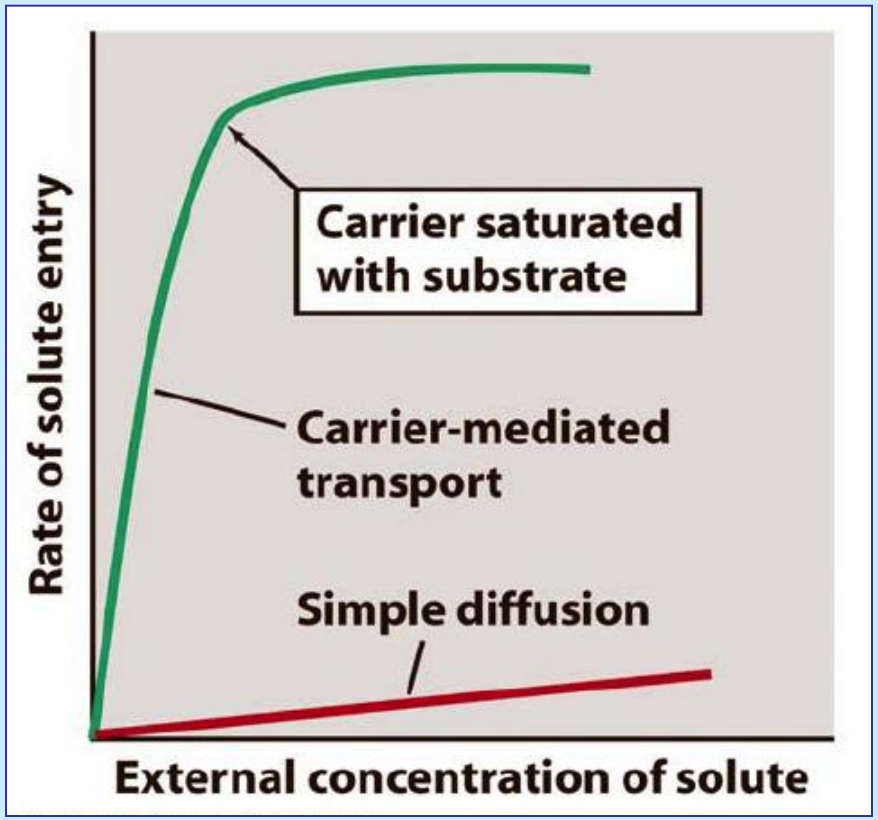
Substance	Rate of permeability [a]
Water	100
Glycerol	0.1
Tryptophan	0.001
Glucose	0.001
Chloride ion (Cl^-)	0.000001
Potassium ion (K^+)	0.0000001
Sodium ion (Na^+)	0.00000001

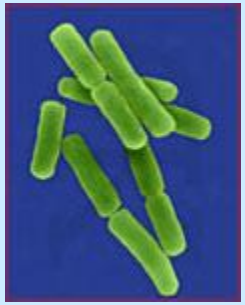
[a] Relative scale—permeability with respect to permeability of water given as 100. Permeability of the membrane to water may be affected by aquaporins (see text).




LA STRUTTURA PROCARIOTICA

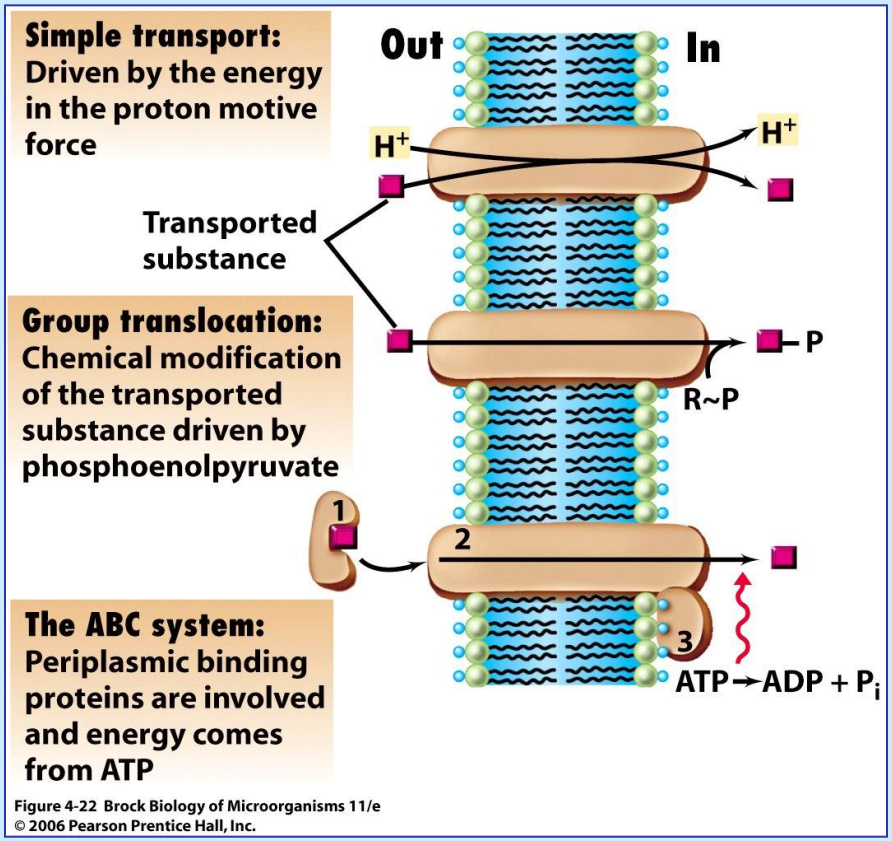
Relazione tra tasso di assorbimento (*uptake*) e concentrazione esterna






LA STRUTTURA PROCARIOTICA

Classi dei sistemi di trasporto transmembrana



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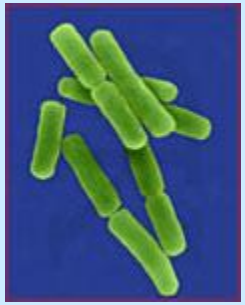
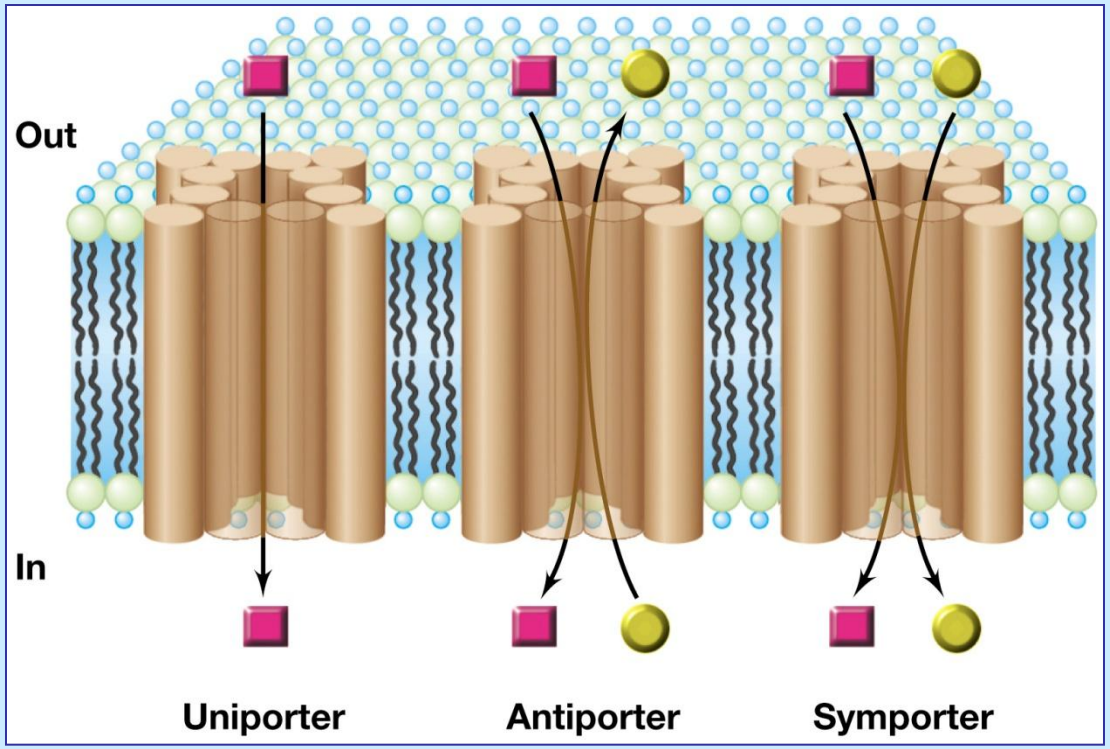
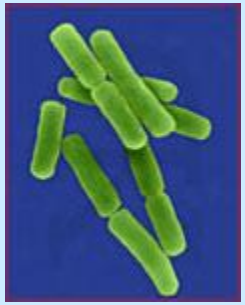



Diversi meccanismi di trasporto semplice mediati da proteine di membrana

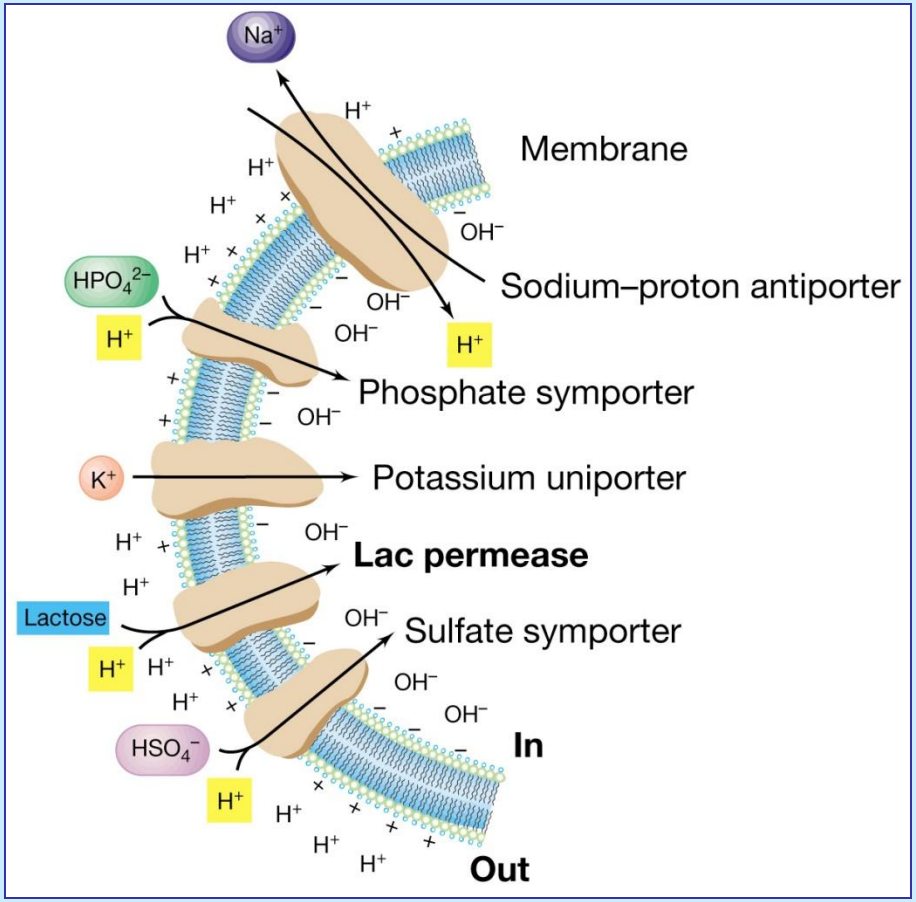


Structure of membrane-spanning transporters and types of transport events. In prokaryotes, membrane-spanning transporters typically contain 12 α helices that align with each other in a circle to form a channel through the membrane. Shown here are three individual transporters, each showing a different type of transport event. For antiporters and symporters, the co-transported molecule is shown in yellow.

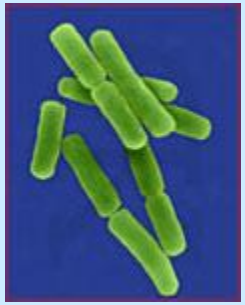


LA STRUTTURA PROCARIOTICA

Uso della separazione spaziale degli ioni nella PMF (*Proton Motive Force*) per il trasporto transmembrana di ioni inorganici e lattosio

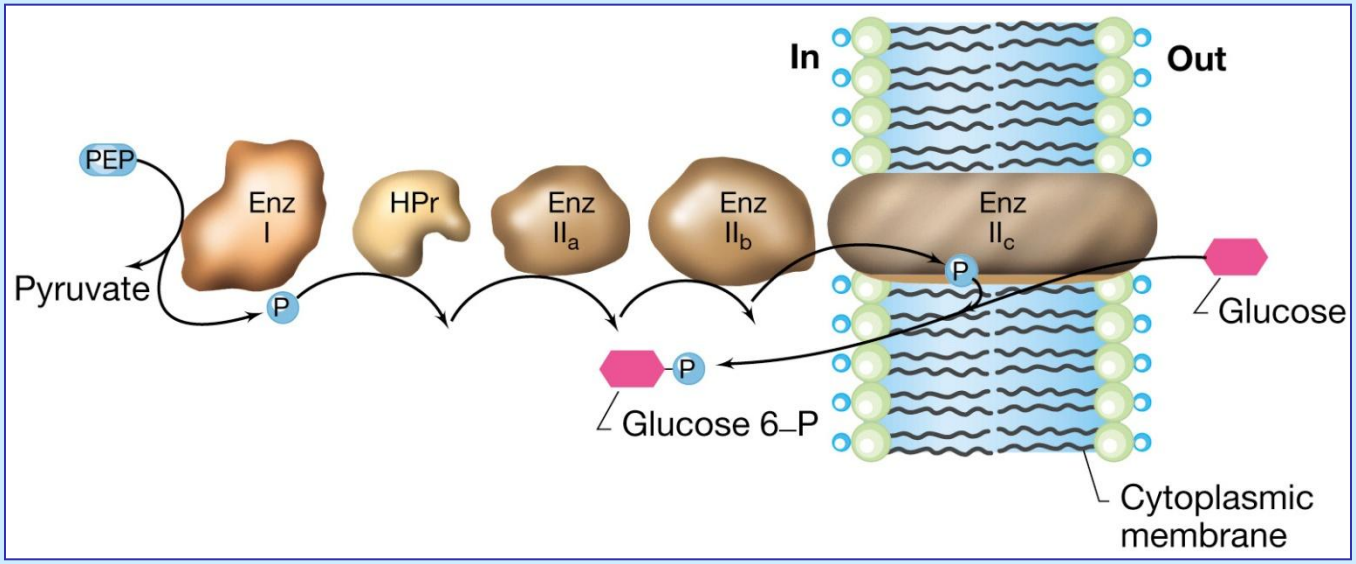


Function of the Lac permease (a symporter) of *Escherichia coli*, and several other well-characterized simple transporters.

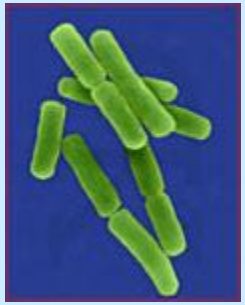



LA STRUTTURA PROCARIOTICA

Meccanismo del sistema di fosfotransferasi in *E. coli*

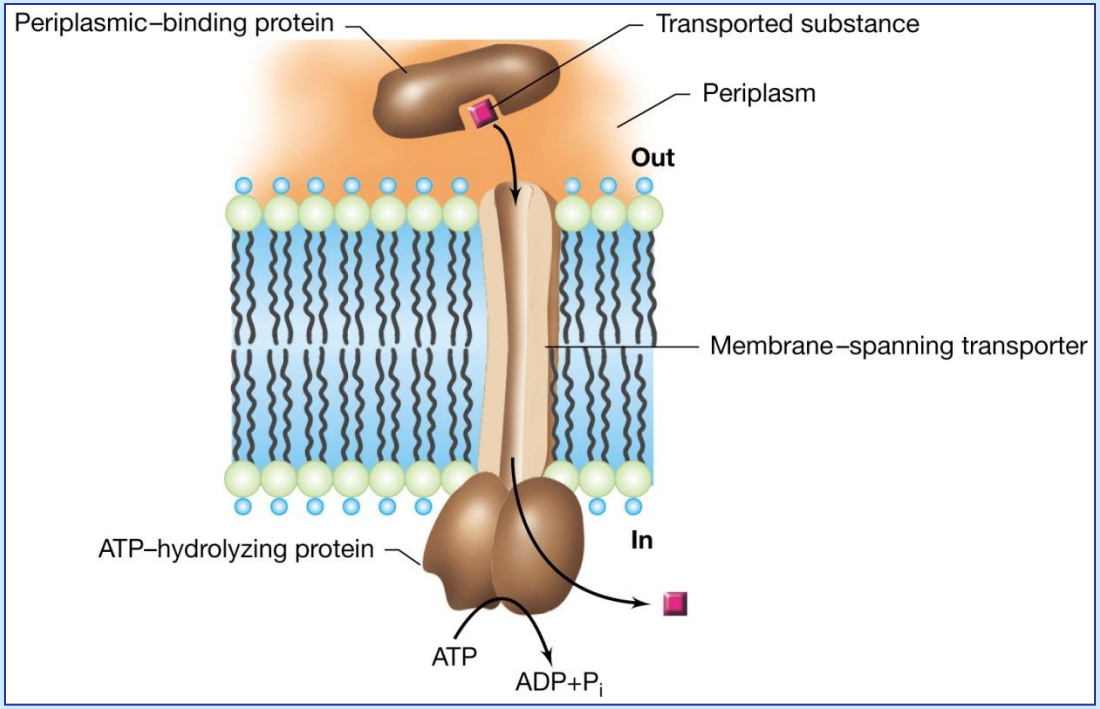


For glucose uptake, the system consists of five proteins: Enzyme (Enz) I; Enzymes II_a, II_b, and II_c, and HPr. Sequential phosphate transfer occurs from phosphoenolpyruvate (PEP) through the proteins shown to Enzyme II_c. The latter actually transports (and phosphorylates) the sugar.

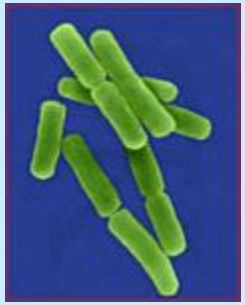



LA STRUTTURA PROCARIOTICA

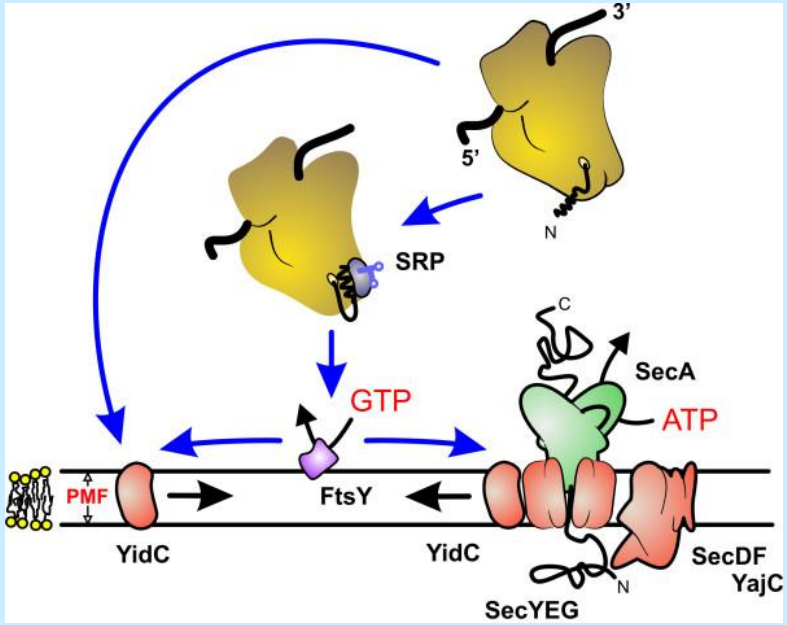
Meccanismo di trasporto transmembrana mediante il sistema di tipo ABC (ATP-Binding Cassette)



Mechanism of an ATP-Binding Cassette (ABC-type) transporter. The periplasmic binding protein has high affinity for substrate, the membrane-spanning protein is the transport channel, and the cytoplasmic ATP-hydrolyzing protein supplies the energy for the transport event. In *Escherichia coli*, the maltose (a disaccharide sugar) transport system is an example of an ABC system.

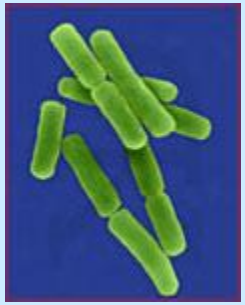


Meccanismo di esportazione delle proteine mediante il sistema di tipo SecYEG (translocasi)



The bacterial Sec translocase is a protein complex in the cytoplasmic membrane, which comprises a peripheral motor domain SecA, the protein-conducting channel SecYEG, and the accessory proteins SecDF(yajC) and YidC. Membrane proteins are cotranslationally targeted to the Sec translocase as ribosome-bound nascent chains by the SRP and the SRP-receptor FtsY. FtsY associates with the SecY subunit of the Sec translocase, and associates with SRP in a GTP-dependent fashion. GTP hydrolysis at FtsY and SRP effects the release of the ribosome-nascent chain complex from SRP to the SecY subunit of the Sec translocase. Next, chain elongation at the ribosome is directly coupled to the SecY-mediated insertion of the nascent membrane protein into the cytoplasmic membrane. During membrane insertion, newly synthesized transmembrane segments of nascent membrane proteins contact YidC, which may facilitate the lateral release of these hydrophobic segments into the lipid bilayer and/or assist in their folding and assembly. Translocation of large polar extracellular regions through the SecYEG translocation pore is effected by SecA at the expense of ATP. Abbreviation: PMF, proton motive force.

LA STRUTTURA PROCARIOTICA

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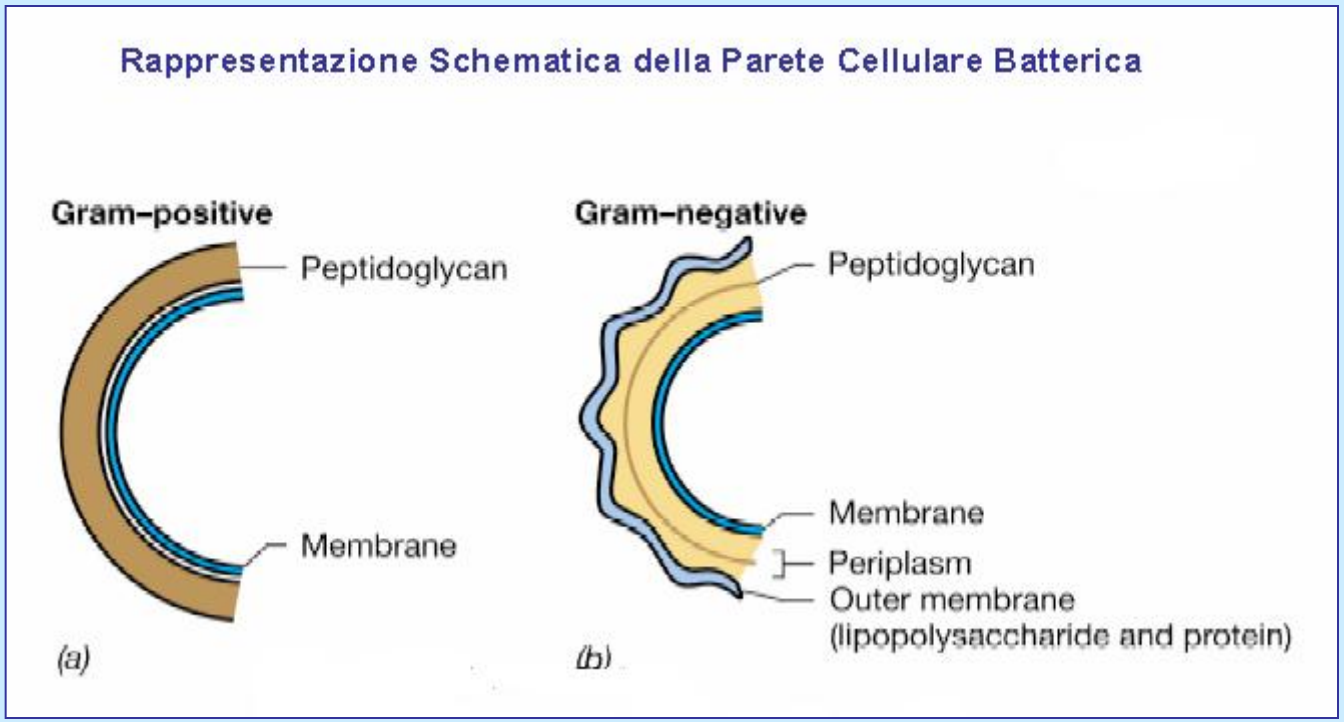
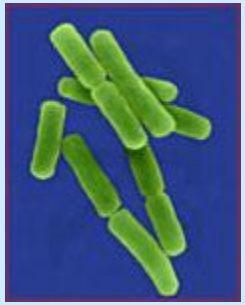


Struttura dei microorganismi

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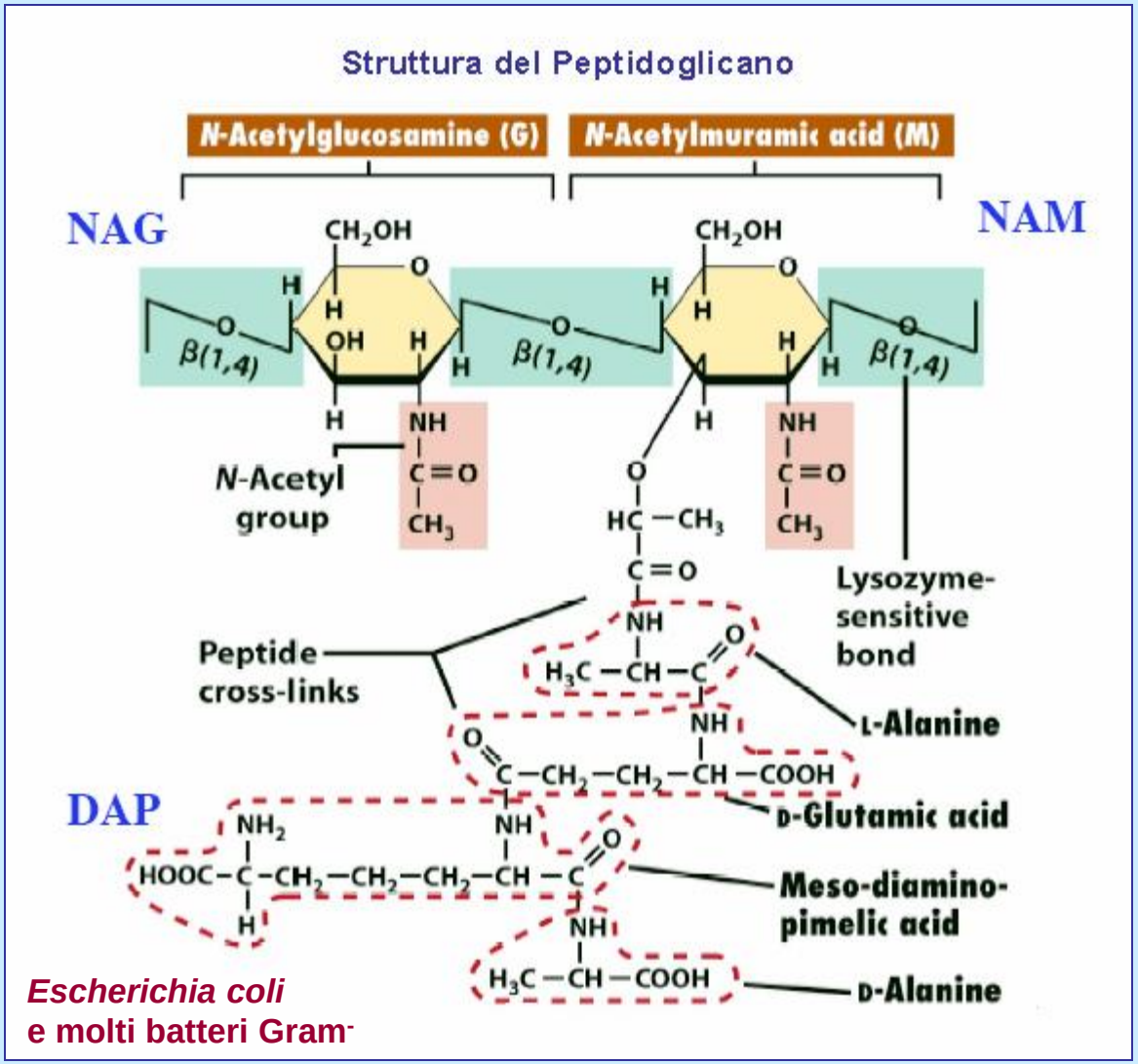
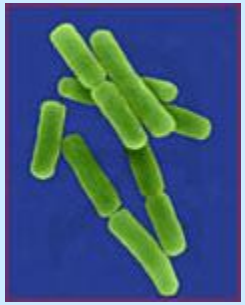


Escherichia coli
e molti batteri Gram$^-$

Struttura dei microorganismi



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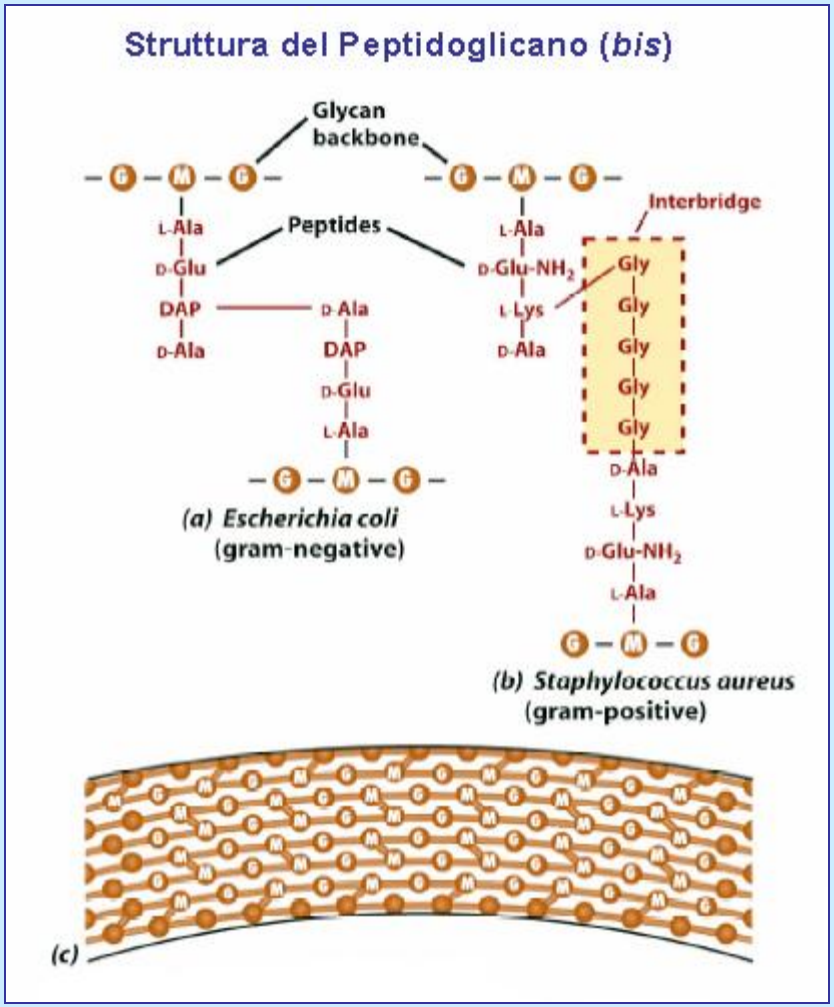
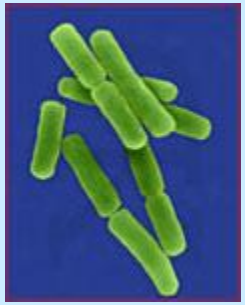


Struttura dei microorganismi



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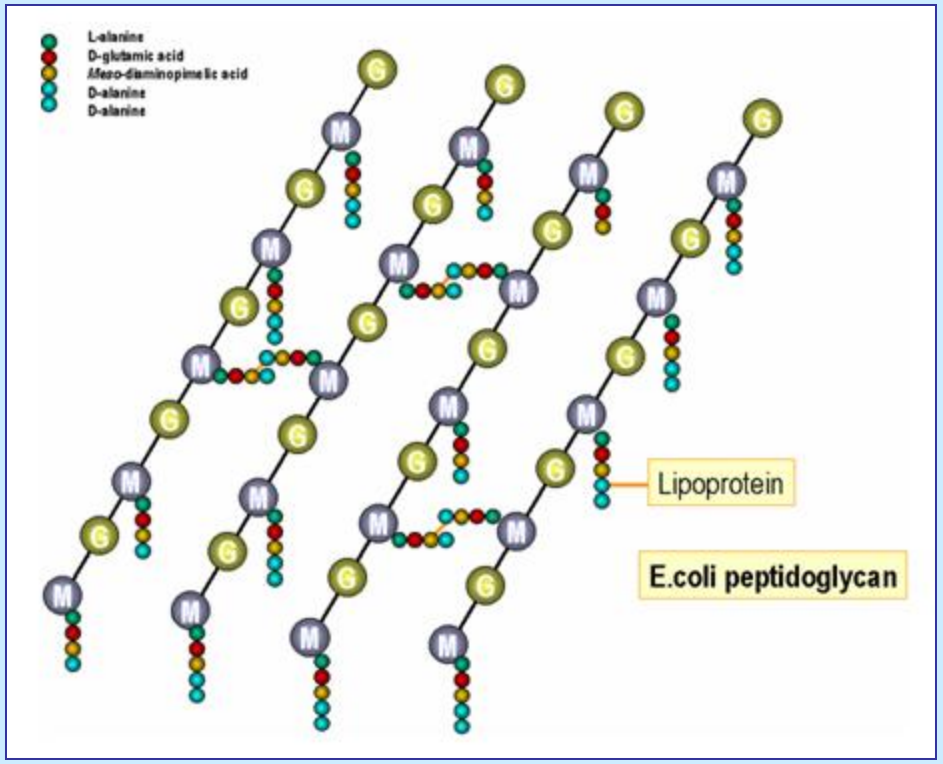
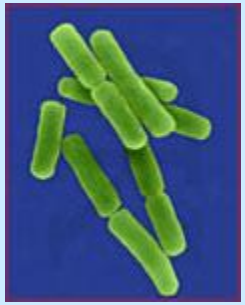


Struttura dei microorganismi



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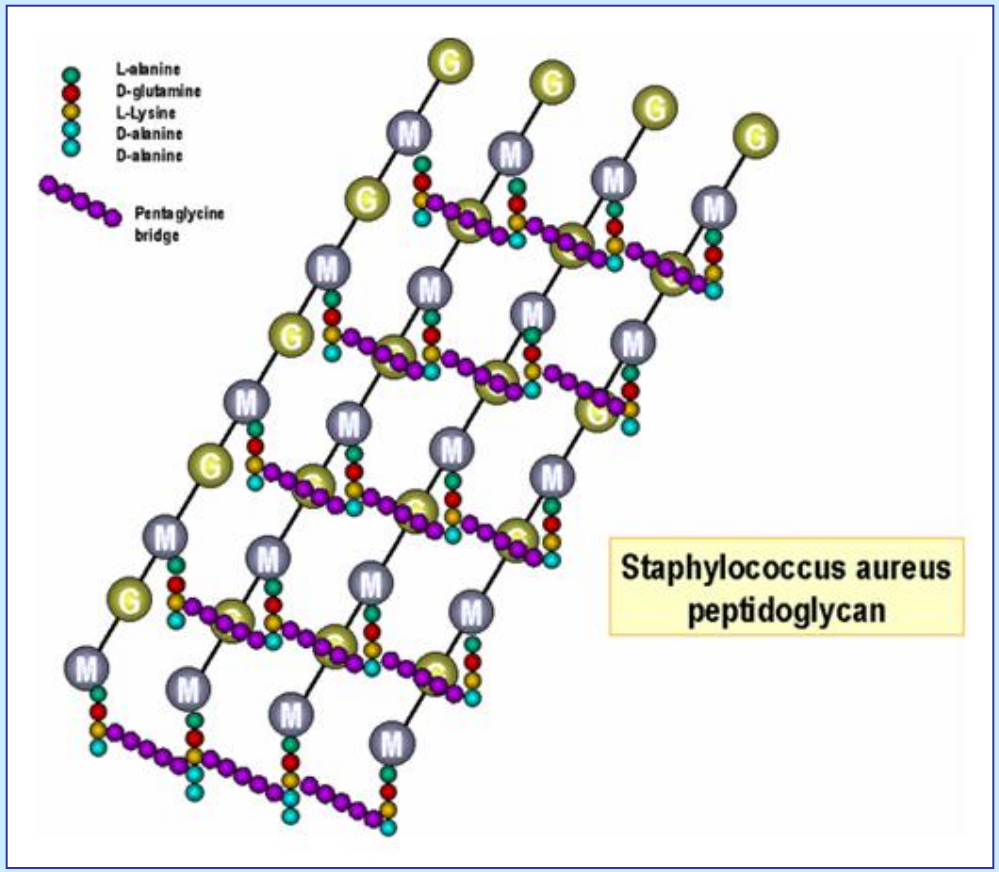
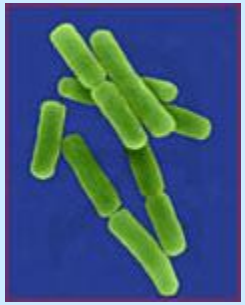
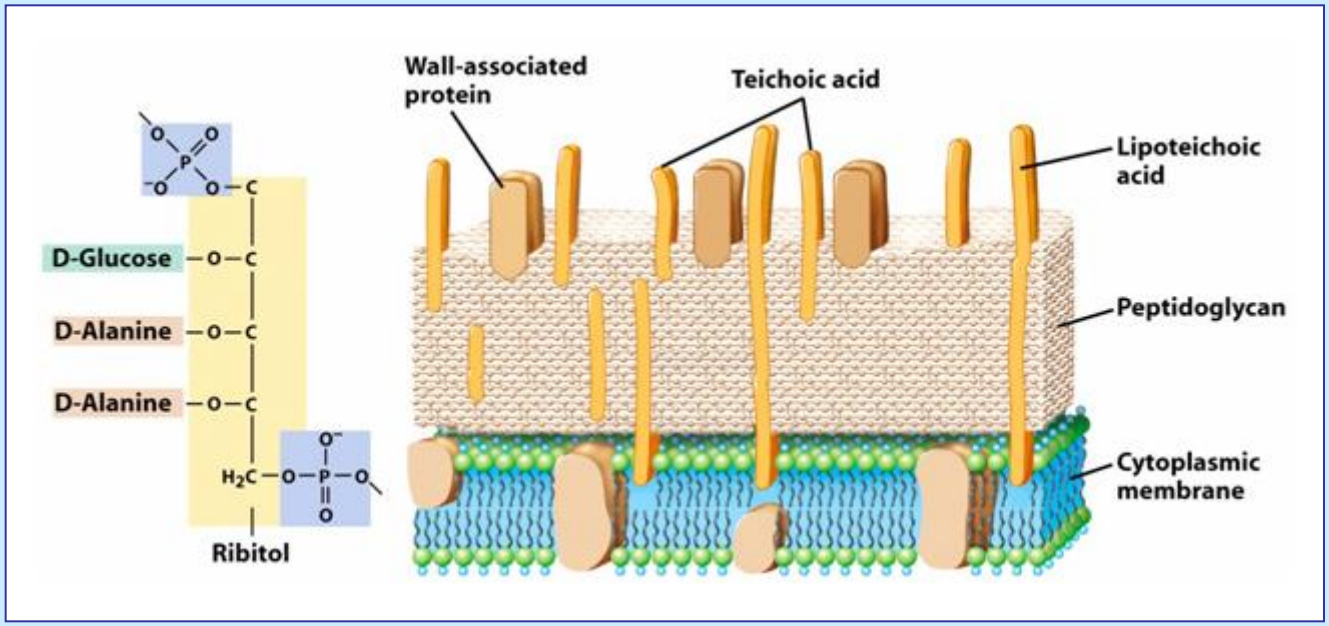


Struttura dei microorganismi

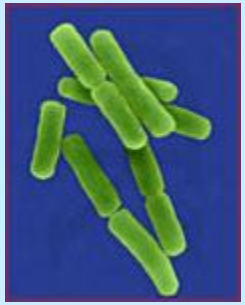



LA STRUTTURA PROCARIOTICA

Cell Envelope organization in Gram-positive bacteria

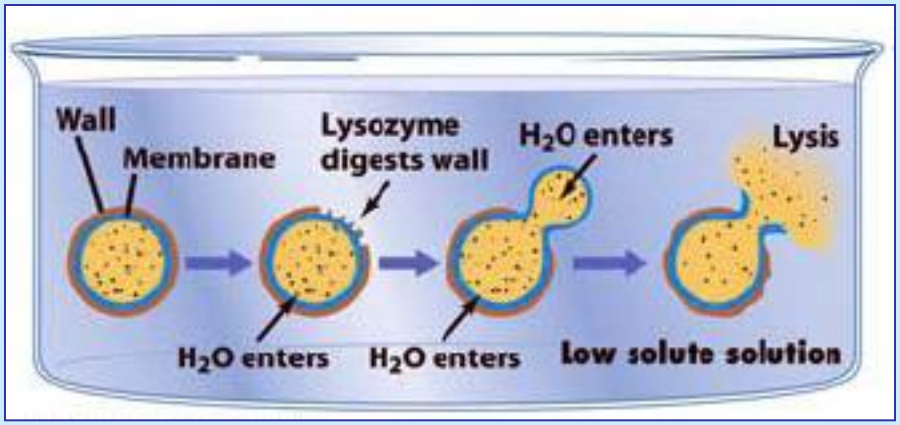


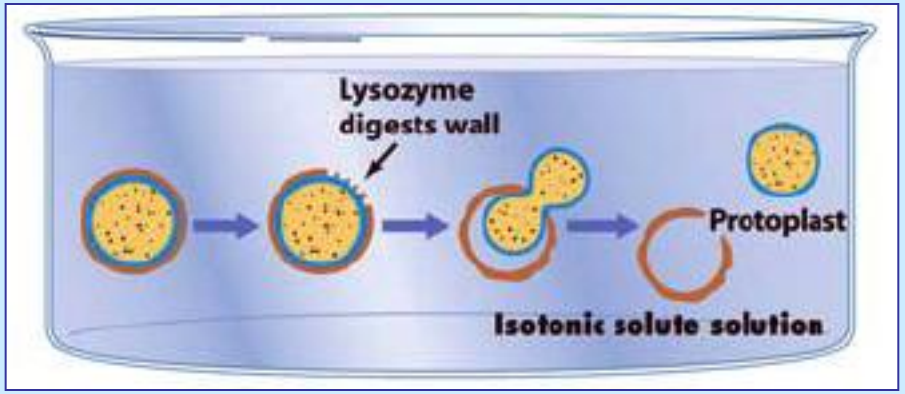
Teichoic acids (from Greek τειχος, teichos, "wall")
are bacterial polysaccharides of glycerol phosphate or ribitol phospate
linked via phosphodiester bonds.



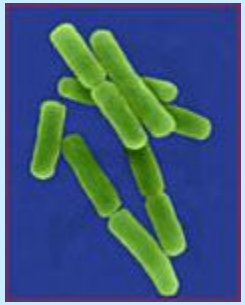

LA STRUTTURA PROCARIOTICA

Formazione di protoplasti





Struttura dei microorganismi



LA STRUTTURA PROCARIOTICA

Pseudomureina tipica della parete degli *Archaea*

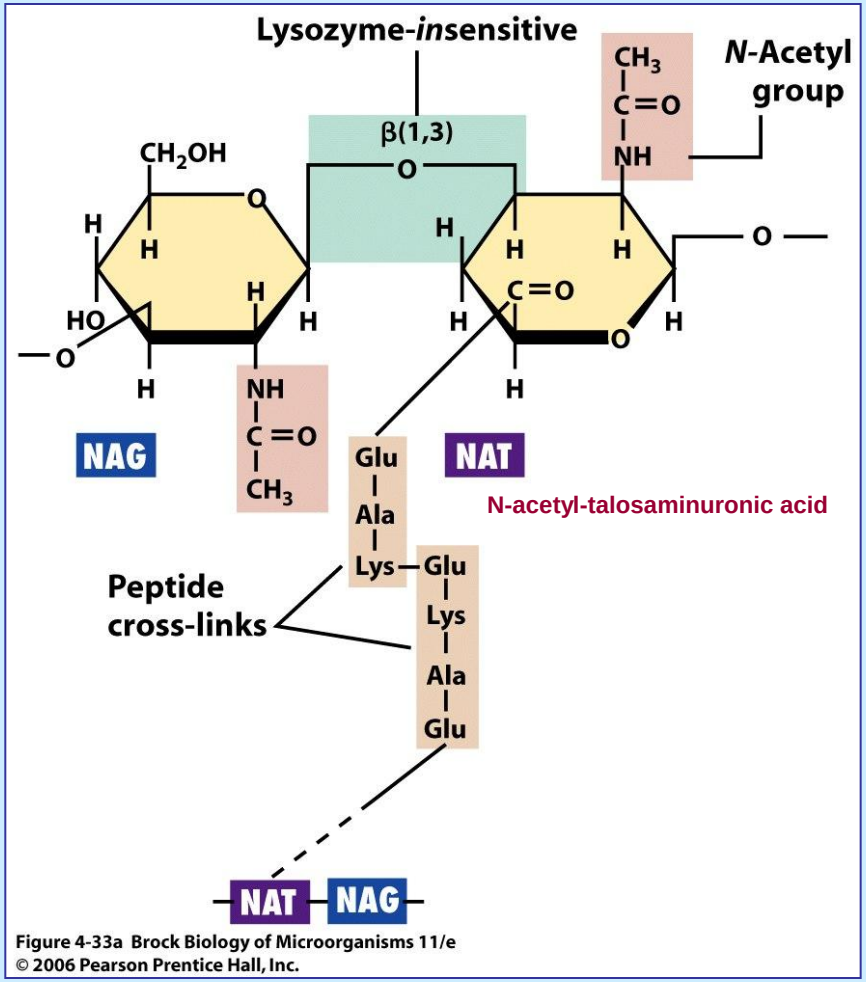
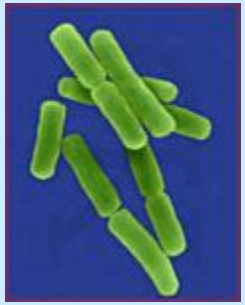
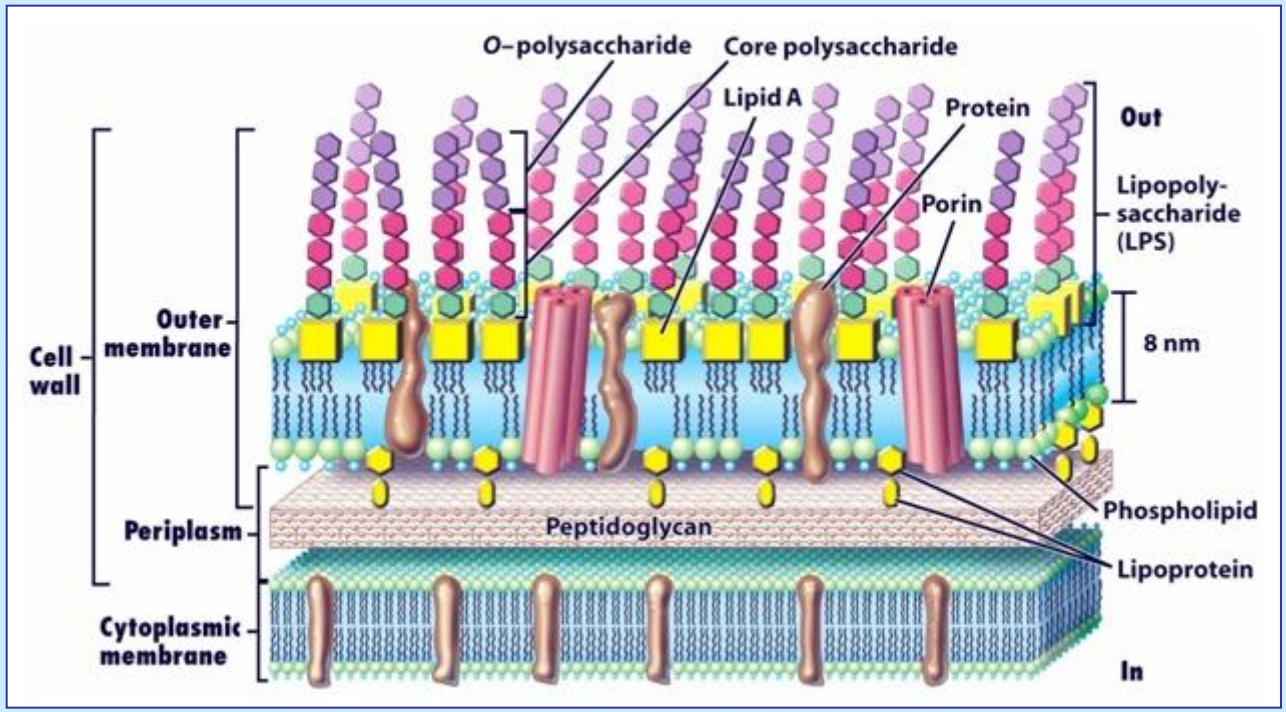


Figure 4-33a Brock Biology of Microorganisms 11/e

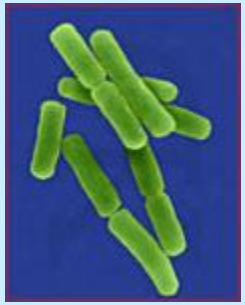



LA STRUTTURA PROCARIOTICA

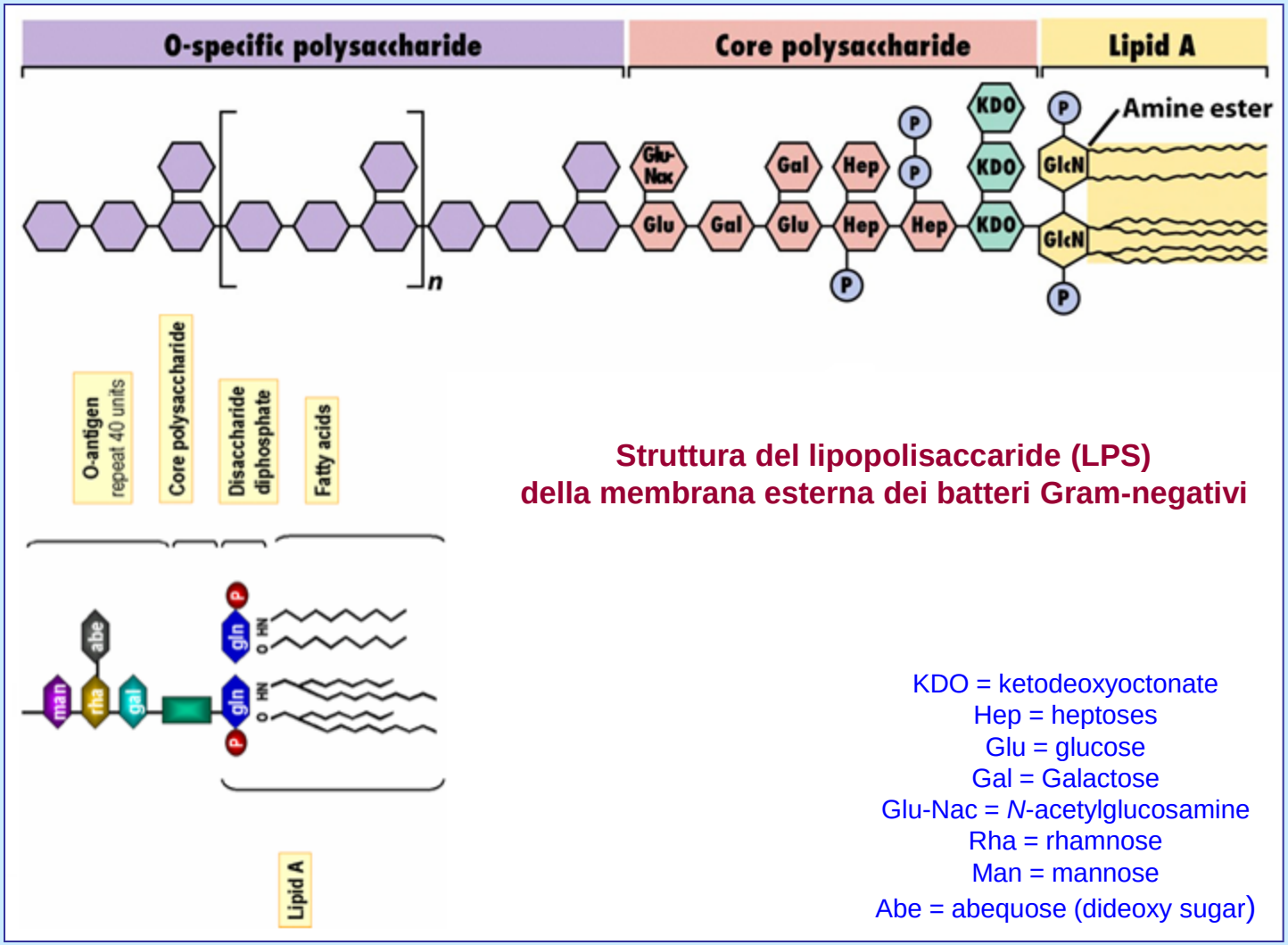
Cell Envelope organization in Gram-negative bacteria



Struttura dei microorganismi



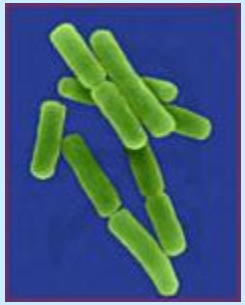

LA STRUTTURA PROCARIOTICA



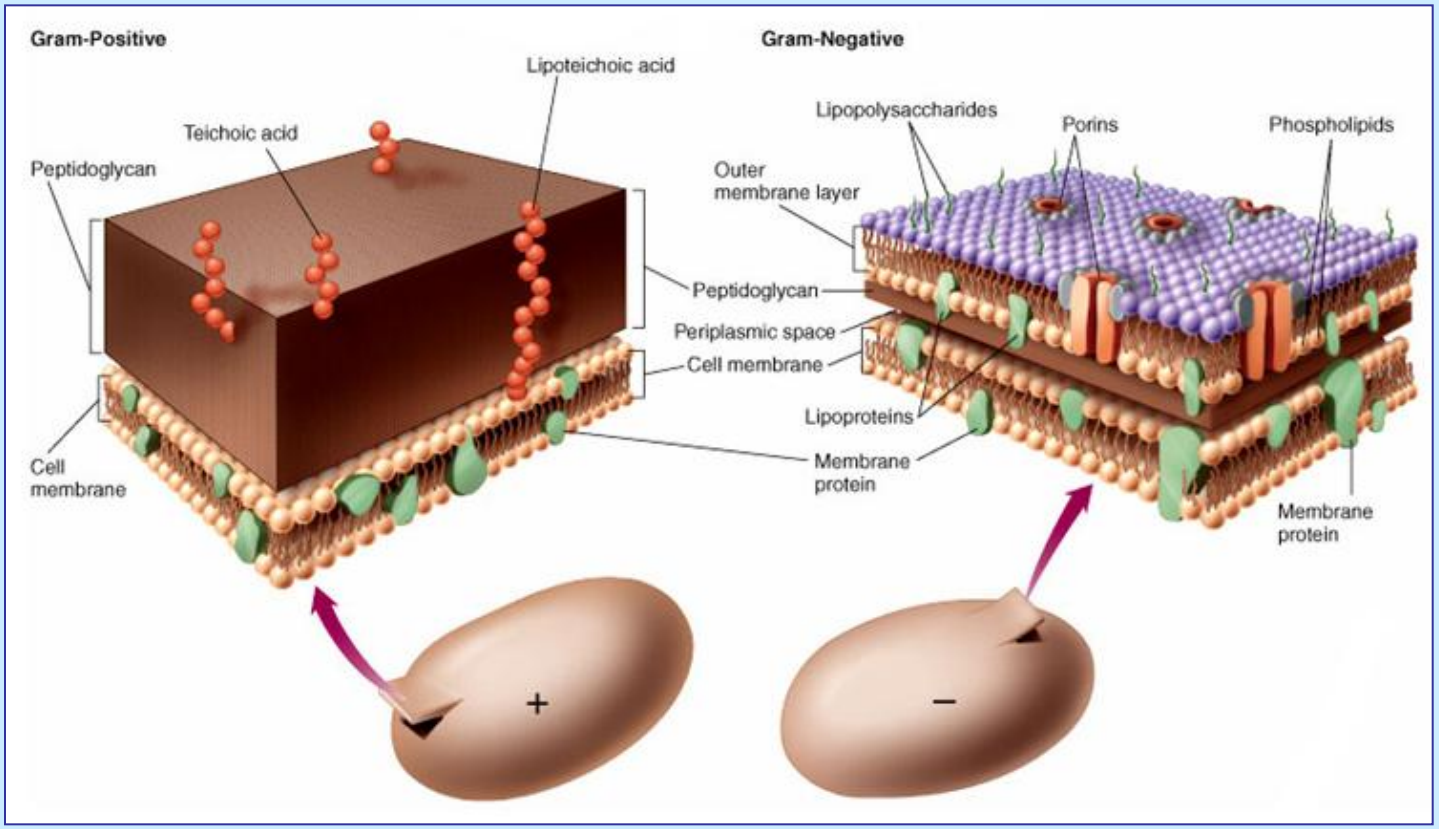
Struttura del lipopolisaccaride (LPS)
della membrana esterna dei batteri Gram-negativi

KDO = ketodeoxyoctonate
Hep = heptoses
Glu = glucose
Gal = Galactose
Glu-Nac = *N*-acetylglucosamine
Rha = rhamnose
Man = mannose
Abe = abequose (dideoxy sugar)

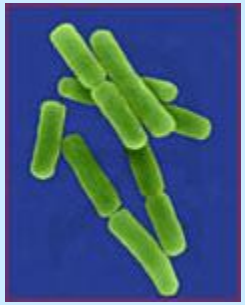
Struttura dei microorganismi




LA STRUTTURA PROCARIOTICA



Struttura dei microorganismi



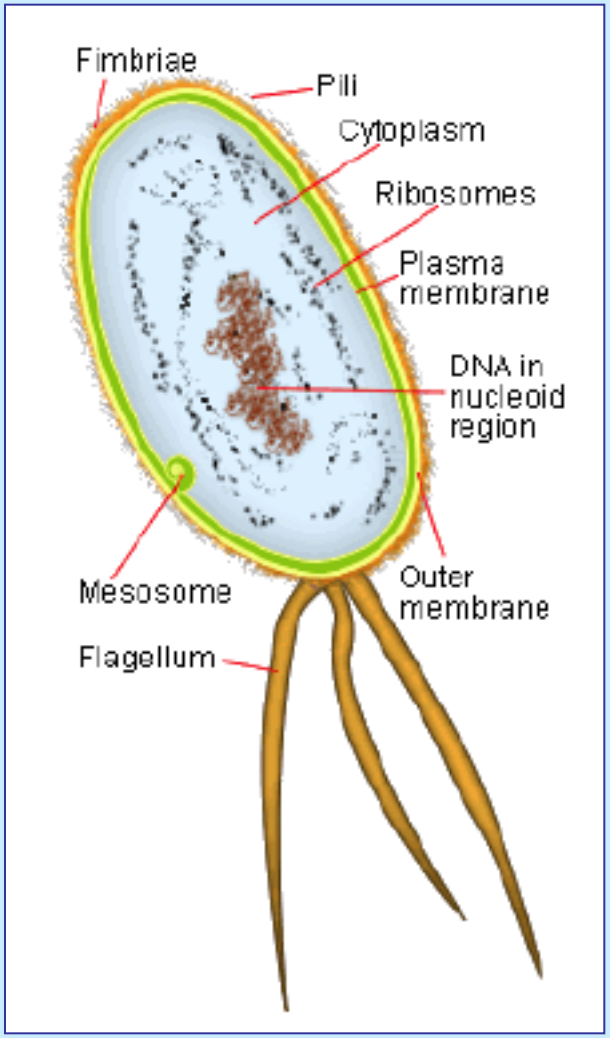

LA STRUTTURA PROCARIOTICA

Constituents of bacterial cell components

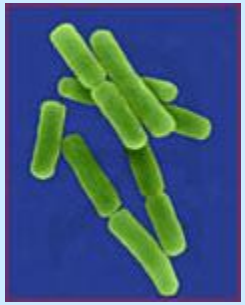
Cell Appendages	Cell Envelope	Cell Protoplasm (Plasma membrane)
Flagella	Glycocalyx	Ribosomes
Pili	Cell wall	Mesosomes
Fimbriae	Cell membrane	Granules
		Nucleoid

All bacterial cells have a:	Not all bacterial cells have:

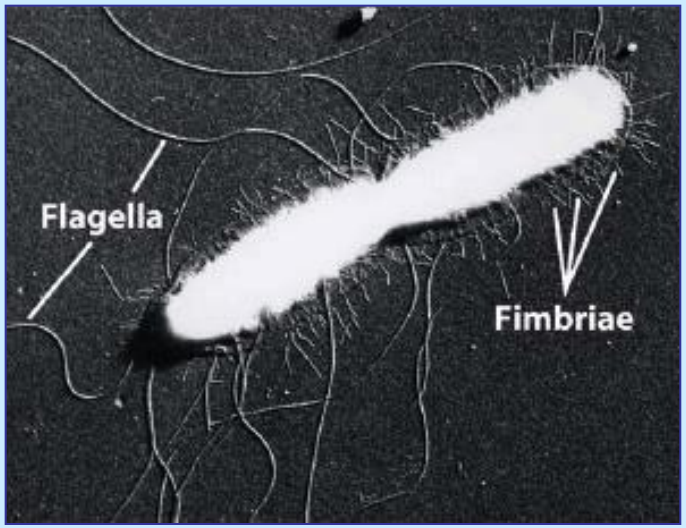
• Cell envelope
• Protoplasm that contains:
  ○ Cell membrane
  ○ Cytoplasm (cell pool)
  ○ Ribosomes
  ○ Nucleoid
	• Cell wall (most have them)
	• Flagella
	• Pili

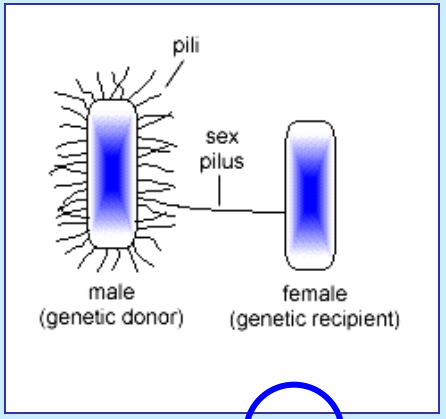


Struttura dei microorganismi

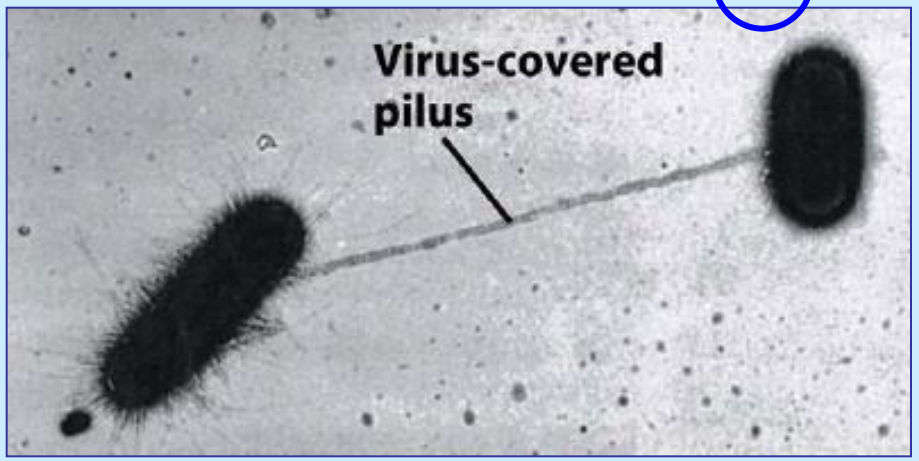



LA STRUTTURA PROCARIOTICA

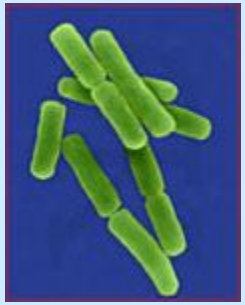




FIMBRIAE e PILI

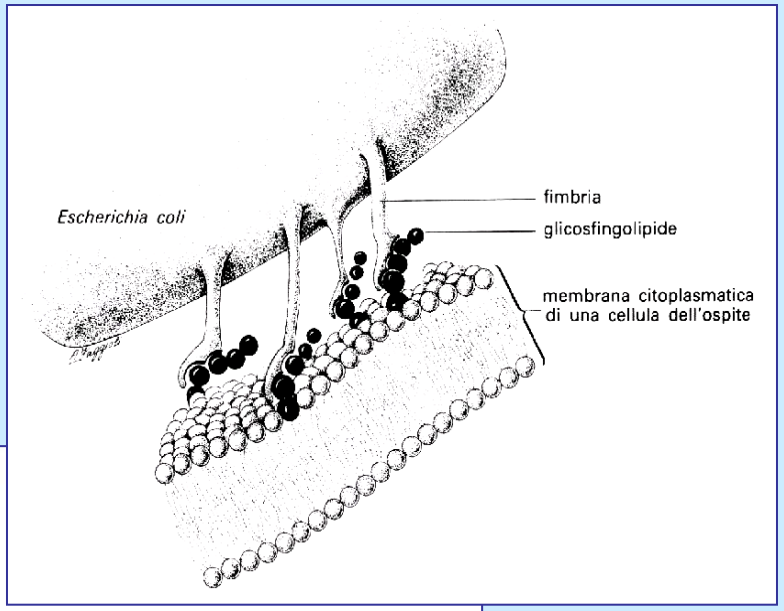


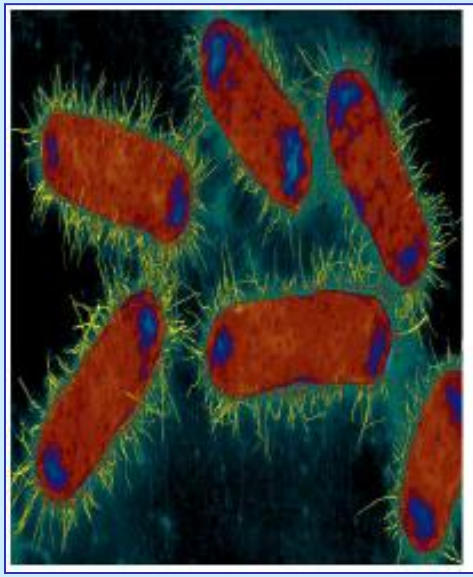
Struttura dei microorganismi

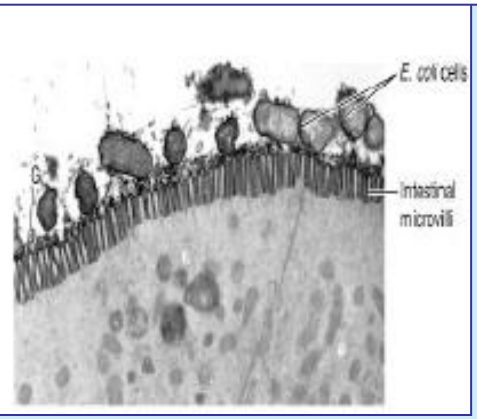


LA STRUTTURA PROCARIOTICA

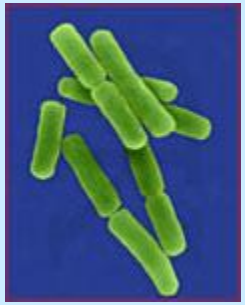
Adesività di *E. coli* mediante *fimbriae* alle cellule della mucosa urinaria e intestinale







Struttura dei microorganismi

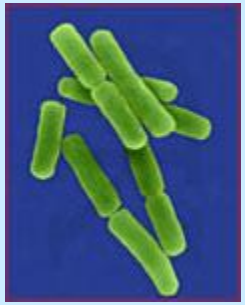



LA STRUTTURA PROCARIOTICA

Bacterial glycocalyx

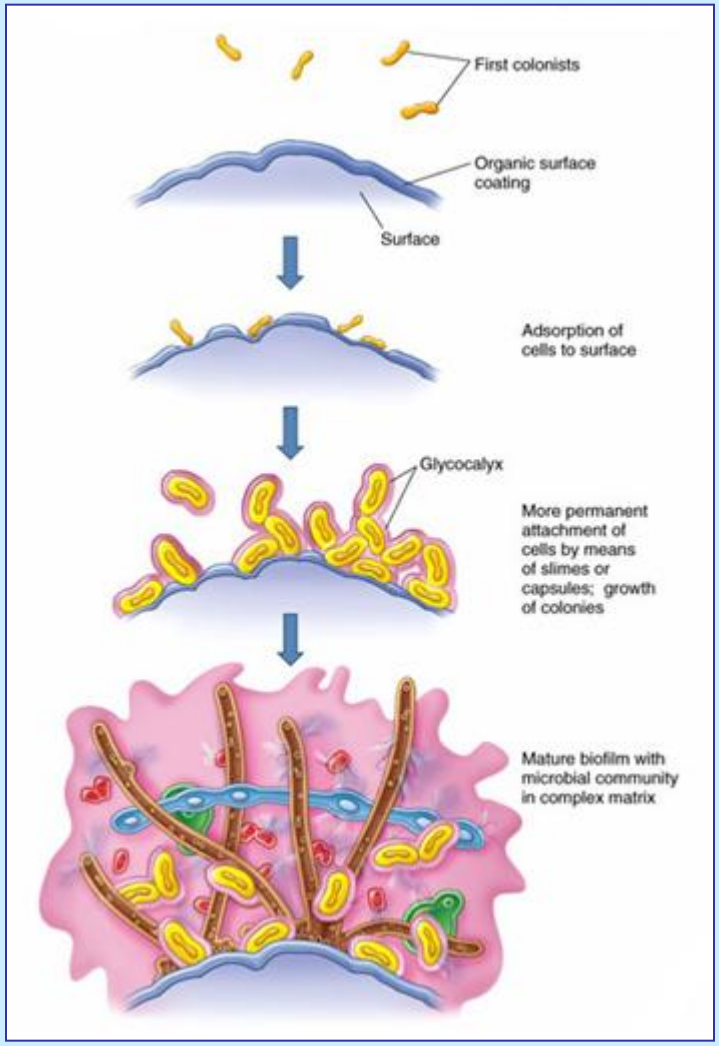
A viscous (sticky), gelatinous polymer that is external to the cell wall and is composed of polysaccharide, polypeptide, or both. All bacteria probably have at least some glycocalyx. A glycocalyx can serve a number of functions including:

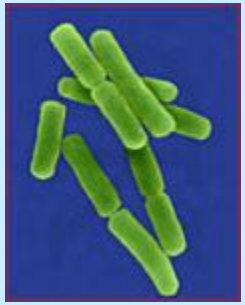
1. bacterial attachment to surfaces
2. protection against desiccation
3. nutrient trap
4. protection from phagocytosis
5. protection from viruses
6. protection from certain toxins (e.g. detergents)



LA STRUTTURA PROCARIOTICA

DINAMICA DELLA FORMAZIONE DI FILM MICROBICI

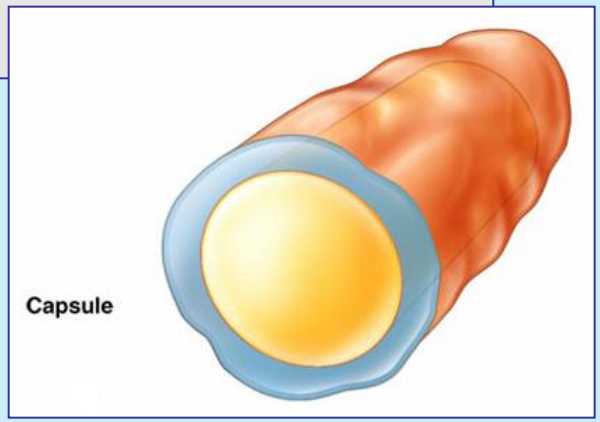


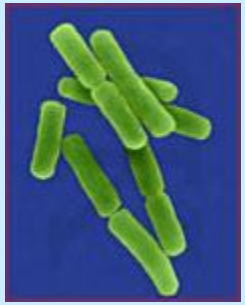



LA STRUTTURA PROCARIOTICA

Capsule

A well organized bacterial glycocalyx that is firmly attached to the bacterial cell wall. When the layer is well organized and **not easily washed off**, it is called a capsule.
Note that **the capsule can be associated with the virulence displayed by a bacteria**. This at least in part is because **bacteria displaying capsules can resist phagocytosis**.
Although capsulues are not required for bacterial growth and reproduction in laboratory cultures, they do confer several advantages when bacteria grow in their normal habitats (e.g. resistance to phagocytosis by host phagocytic cells). In addition 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. The glycocalyx also aids bacterial attachment to surfaces of solid objects in aquatic environments or to tissue surfaces in plant and animal hosts.



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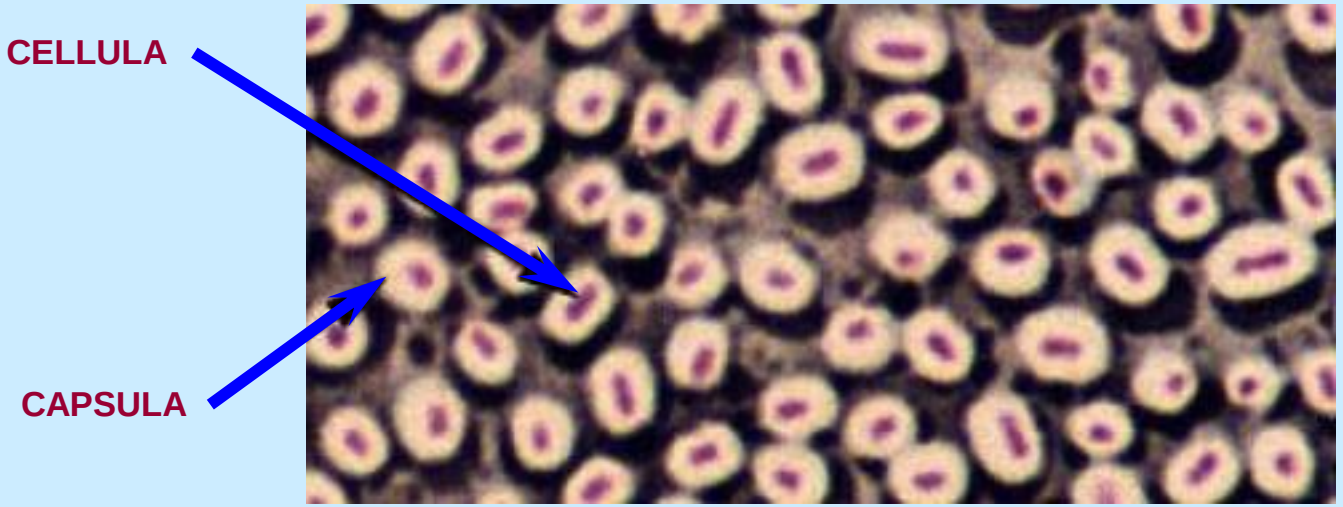
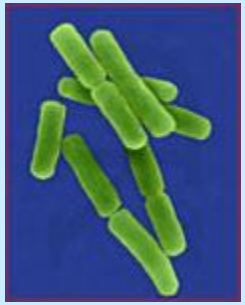
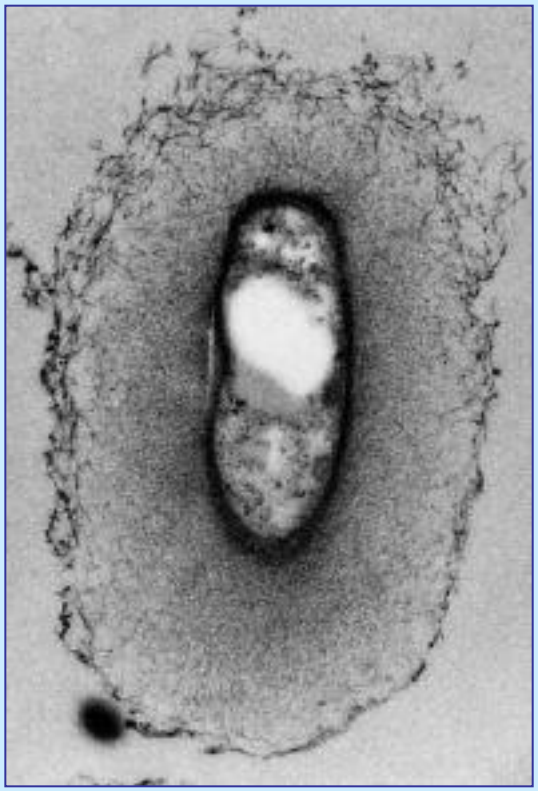


Struttura dei microorganismi




Cellula di *Phyllobacterium trifolii* (già *Rhizobium trifolii*) contornata da una spessa capsula polisaccaridica



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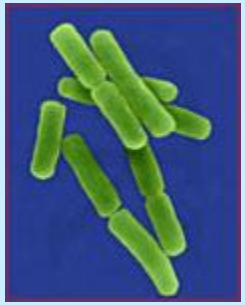
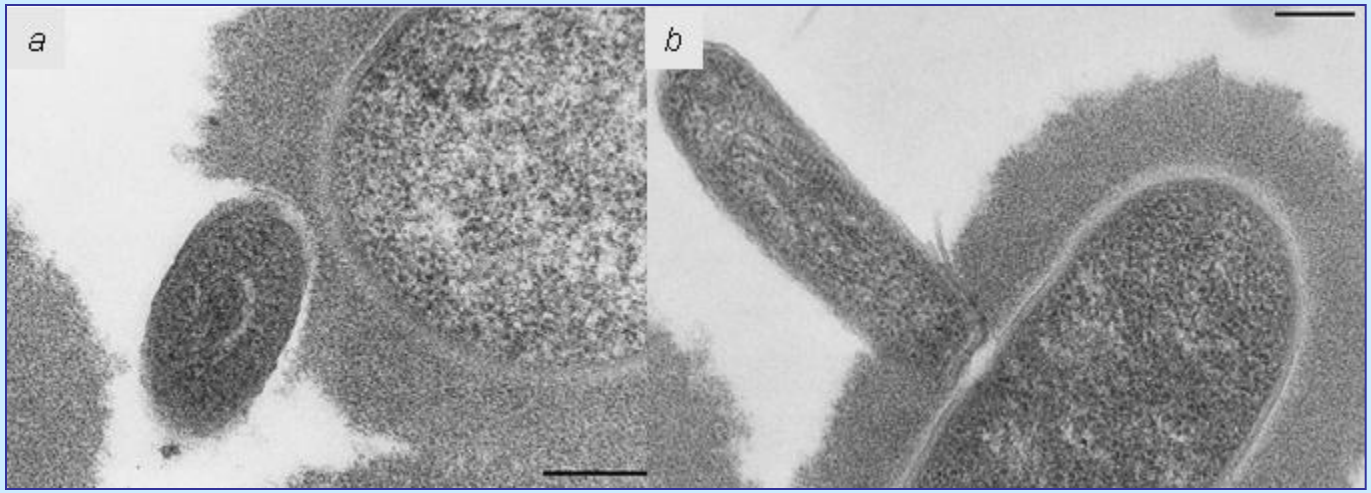
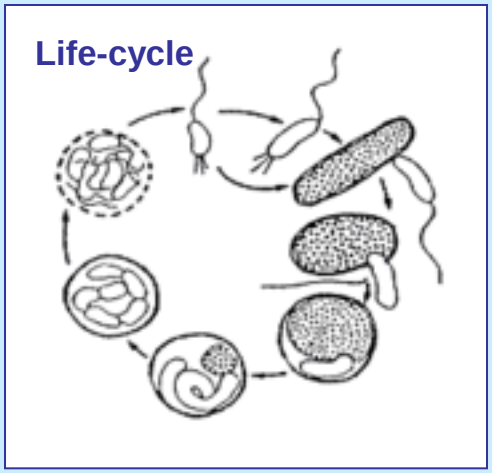
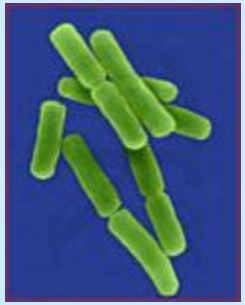


LA STRUTTURA PROCARIOTICA

Bdellovibrio bacteriovorus nell'atto di predare una cellula capsulata di *E. coli* K29



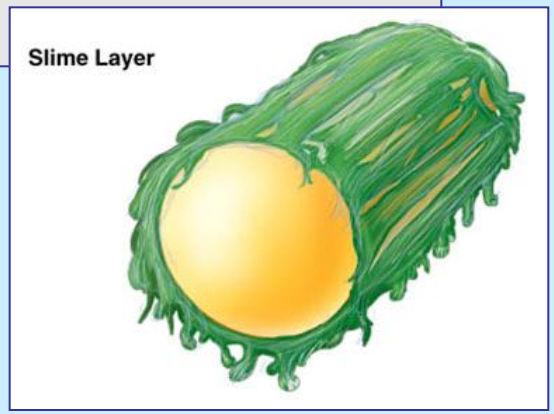


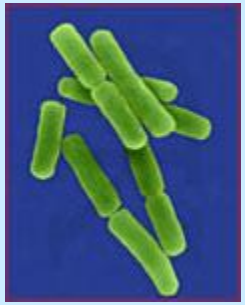



LA STRUTTURA PROCARIOTICA

Slime layer

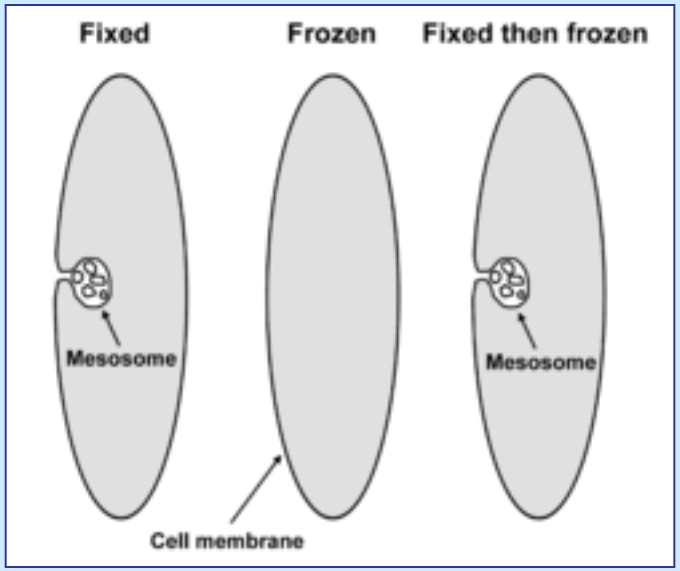
Equivalent to a capsule except this glycocalyx is not firmly attached to the cell wall. A slime layer is a zone of diffuse, unorganized material **that is removed easily**.
Despite their looseness, slime layers nevertheless play important roles in the attachment of bacteria to surfaces. For example, bacteria can attach to teeth via slime layers. Slime layers can also bind cells together. Slime layers can trap nutrients and water, acting, for example, as a seal over a nutritious substrate, thus allowing a bacteria to use exoenzymes (extracellular enzymes) in a limited area containing high concentrations of substrate.

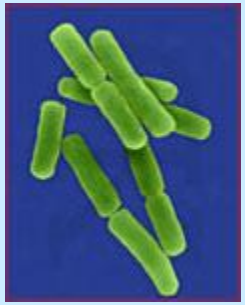




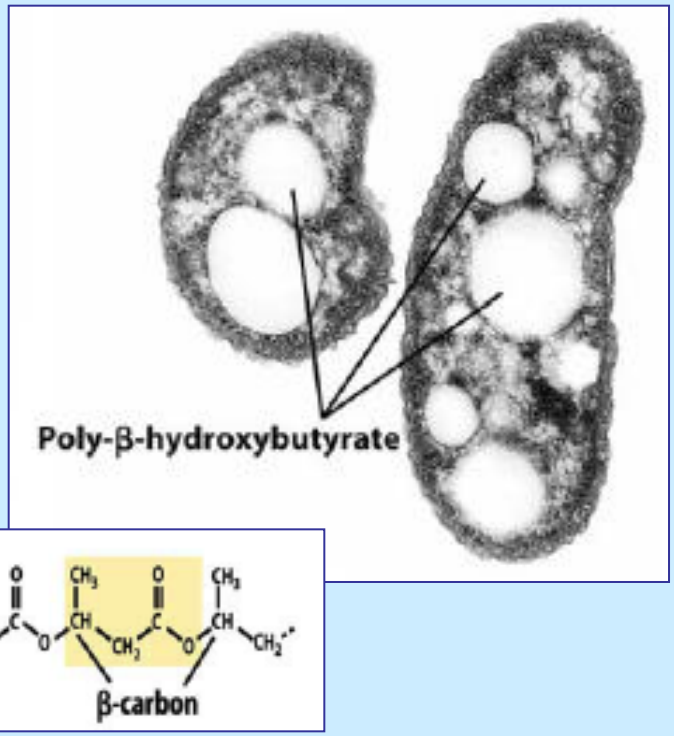
LA STRUTTURA PROCARIOTICA

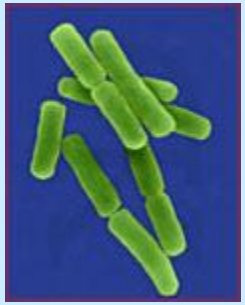
IPOTESI CIRCA L'ESISTENZA DEL MESOSOMA





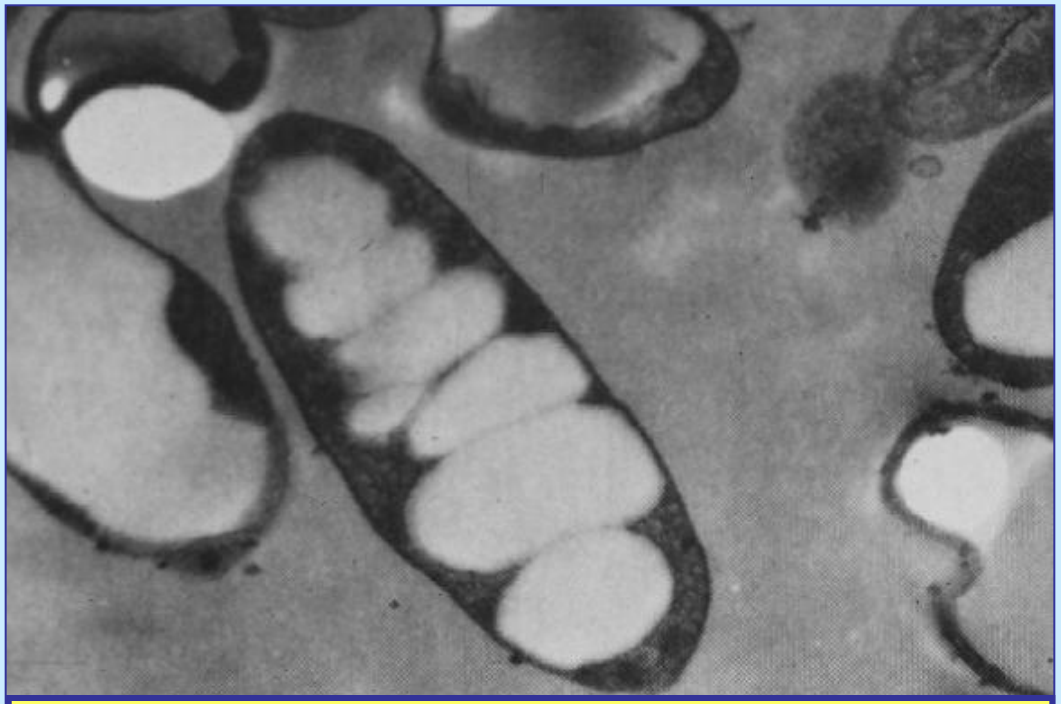
INCLUSIONI (granuli) DI POLI-β-IDROSSIBUTIRRATO NEL BATTERIO *Rhodospirillum sodomense*





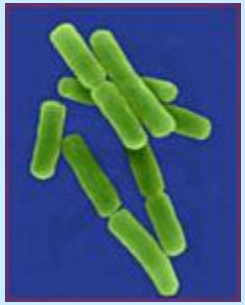
LA STRUTTURA EUCARIOTICA

INCLUSIONI CELLULARI

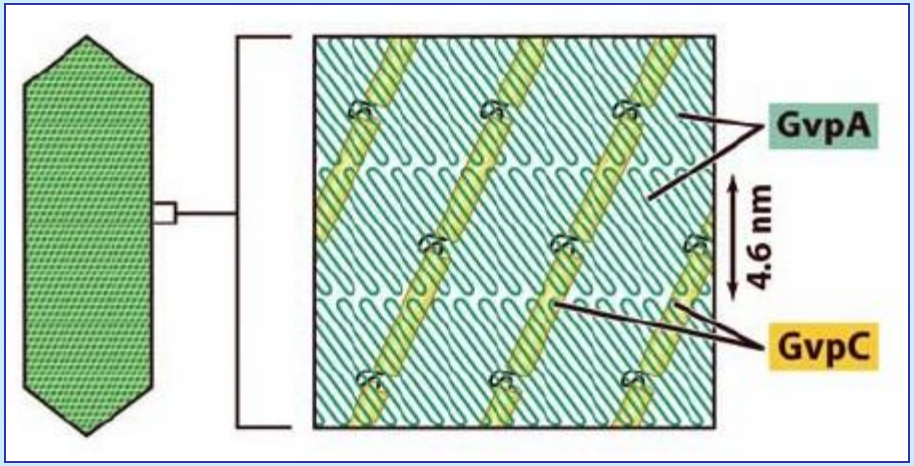


Accumulation of PHA granules in *Rhodobacter sphaeroides*

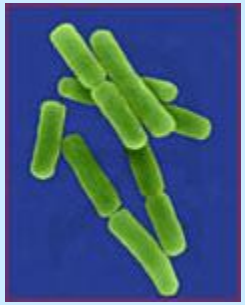
Granuli di poliidrossialcanoato (es. PHB) come materiale di riserva



VESCICOLE GASSOSE NEL CIANOBATTERIO *Anabena flos-aquae*

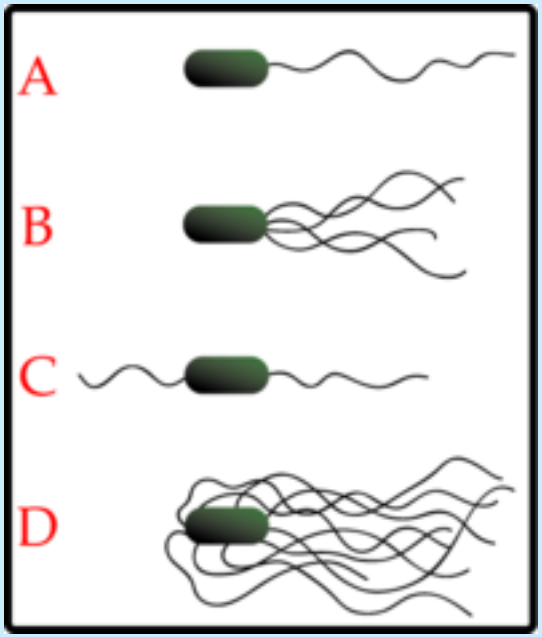


LA STRUTTURA PROCARIOTICA

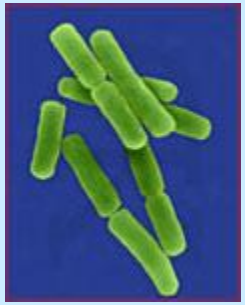



LA STRUTTURA PROCARIOTICA

CELLULE BATTERICHE FLAGELLATE



A-Monotrichous; B-Lophotrichous;
C-Amphitrichous; D-Peritrichous



LA STRUTTURA PROCARIOTICA

STRUTTURA DEL FLAGELLO PROCARIOTICO
tipico di batteri Gram-negativi quali *E. coli*

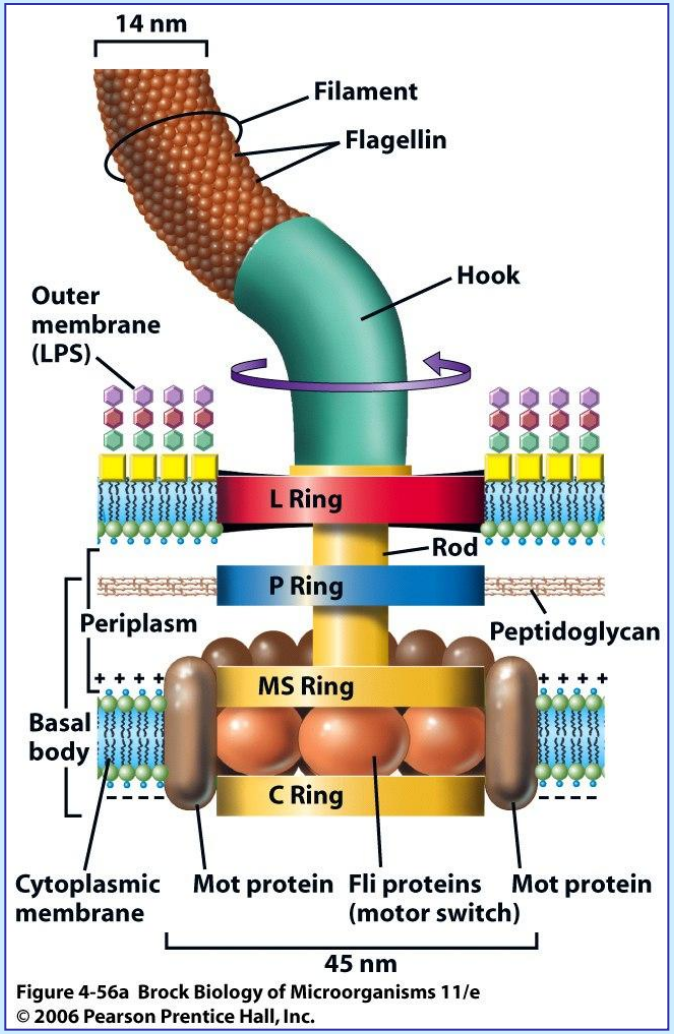
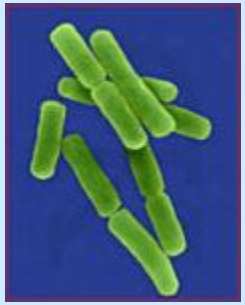
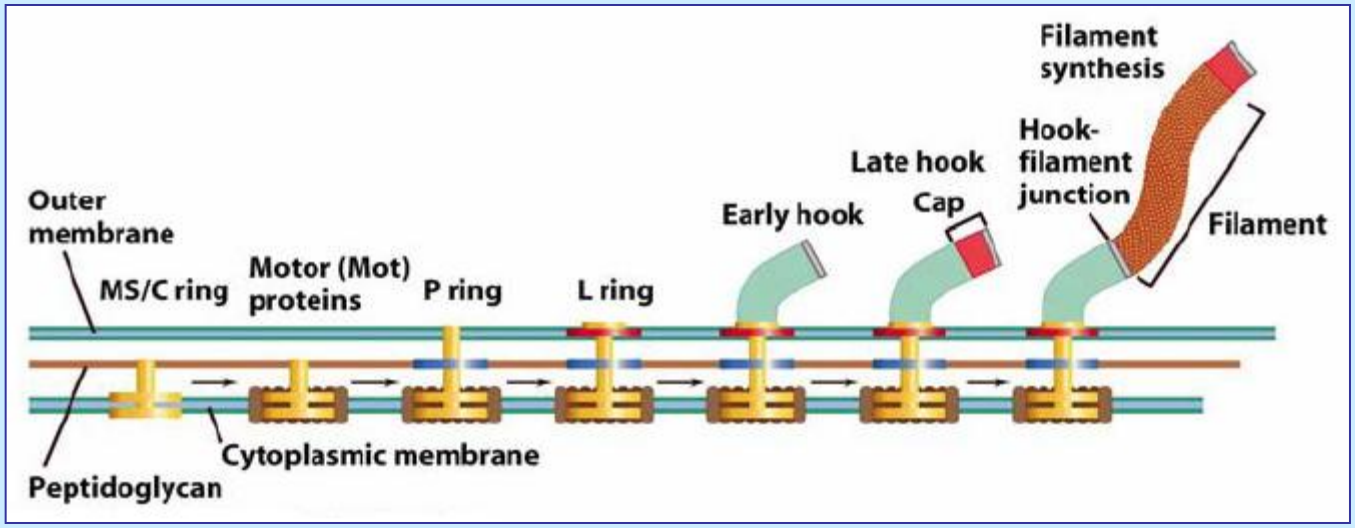


Figure 4-56a Brock Biology of Microorganisms 11/e

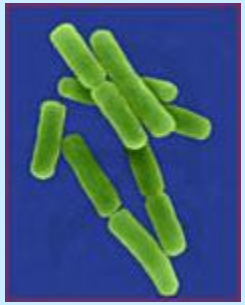


FASI DI ASSEMBLAGGIO DEL FLAGELLO



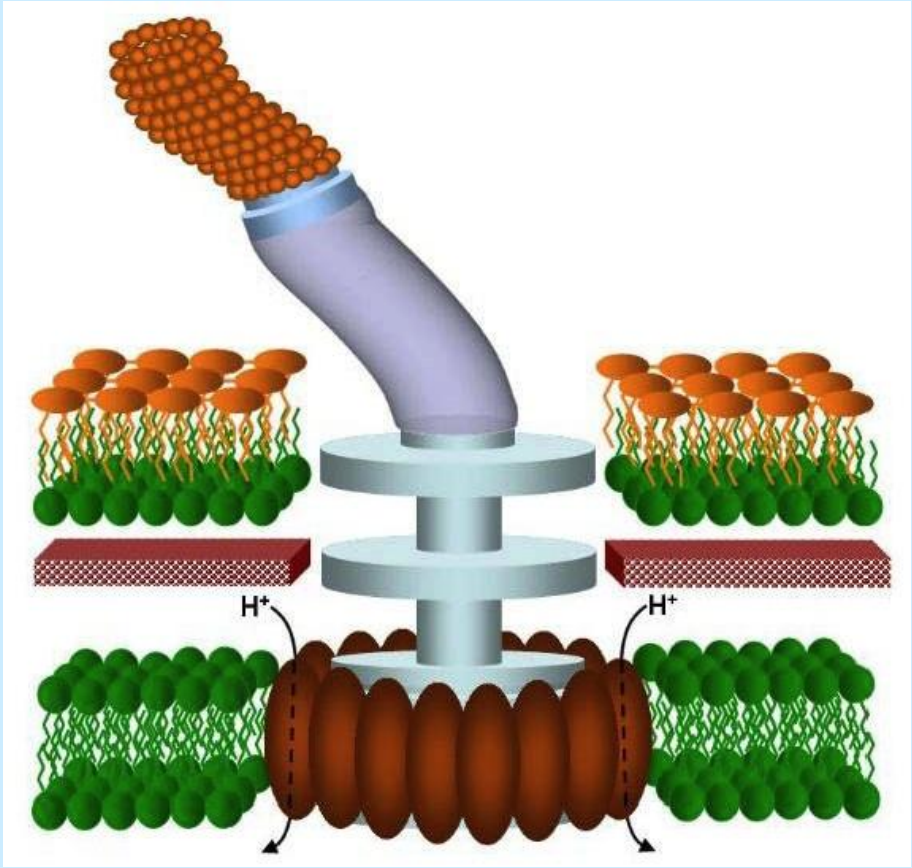
LA STRUTTURA PROCARIOTICA

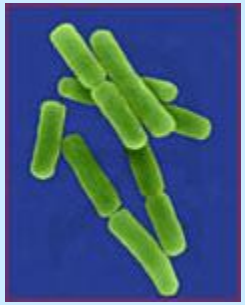
Struttura dei microorganismi



LA STRUTTURA PROCARIOTICA

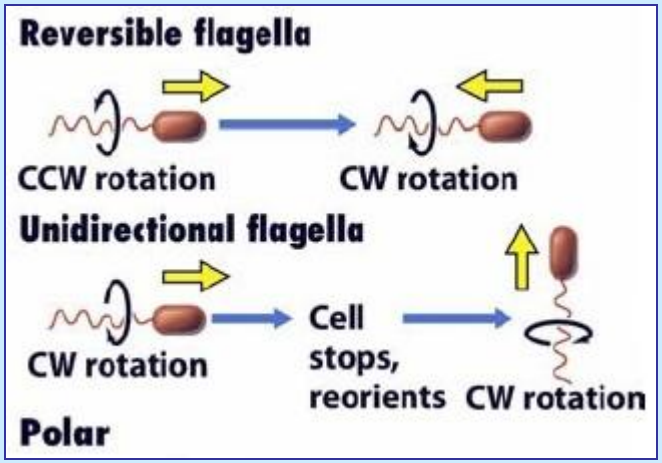
SISTEMA di PROPULSIONE del FLAGELLO

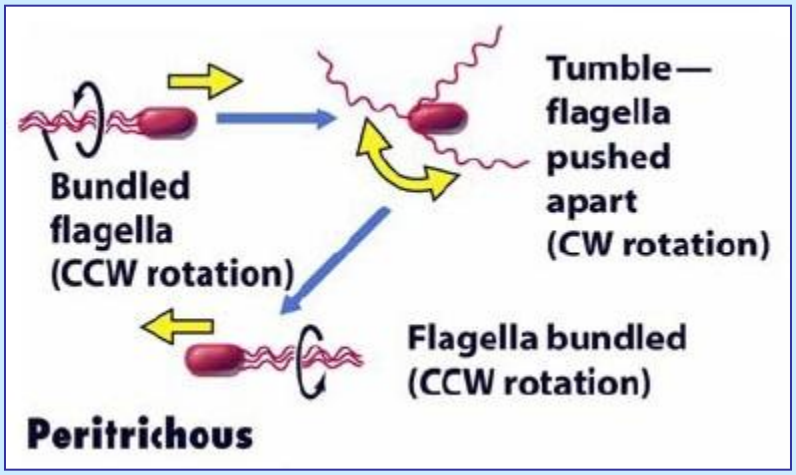


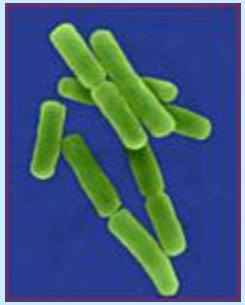


LA STRUTTURA PROCARIOTICA

MOVIMENTO DEI BATTERI MEDIANTE FLAGELLI

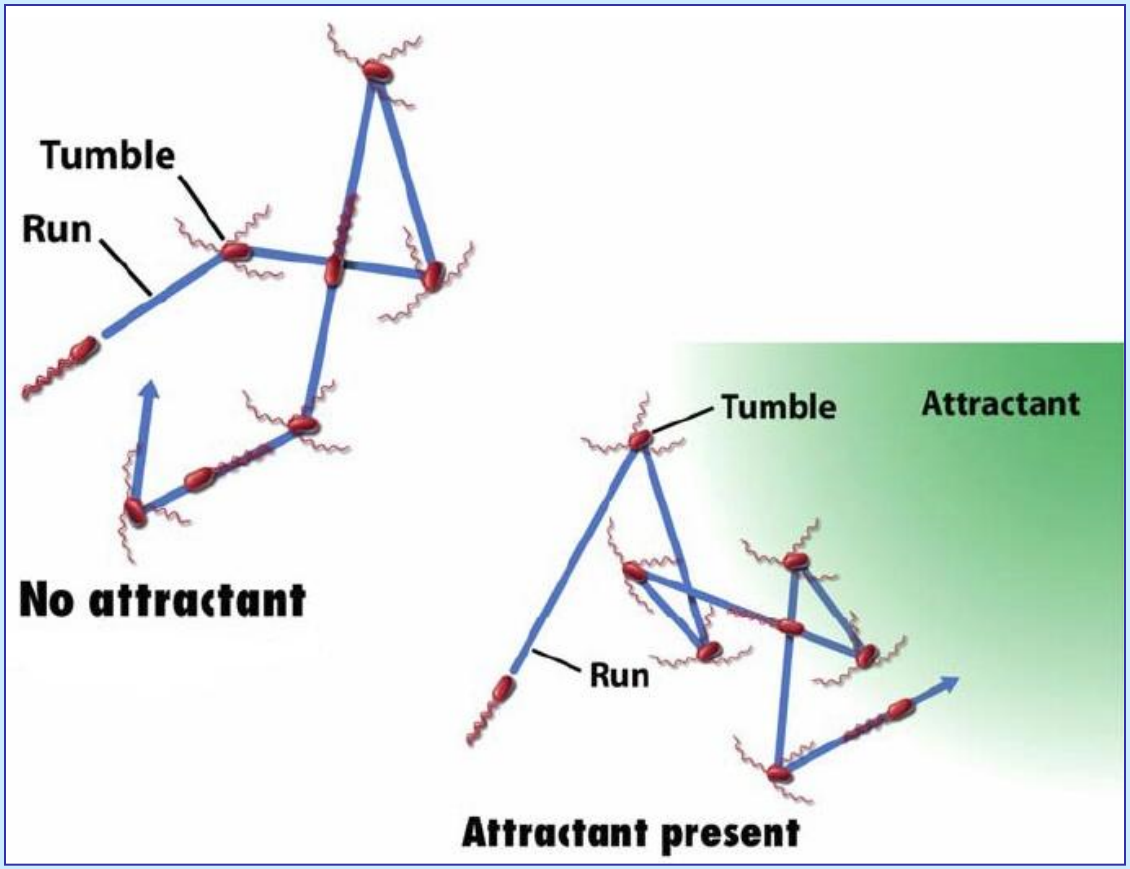


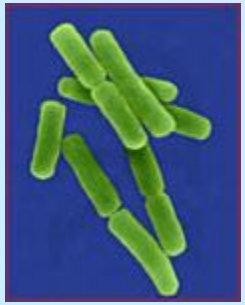





LA STRUTTURA PROCARIOTICA

CHEMOTASSI BATTERICA



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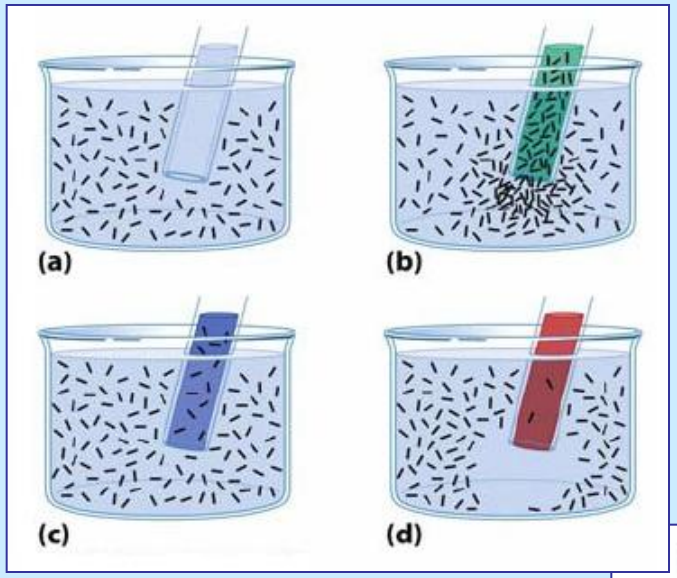
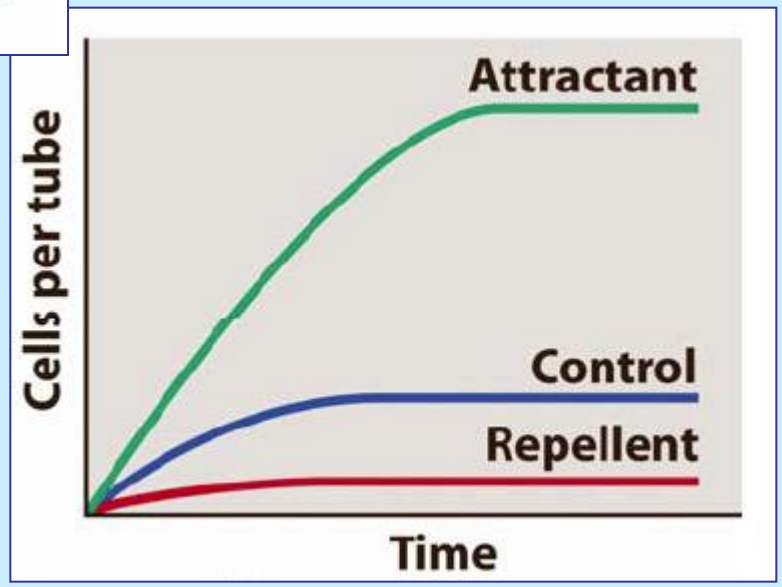
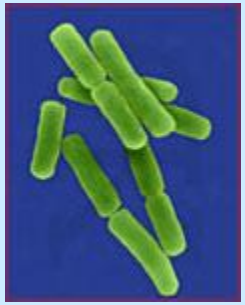


VERIFICA SPERIMENTALE DELLA CHEMOTASSI BATTERICA





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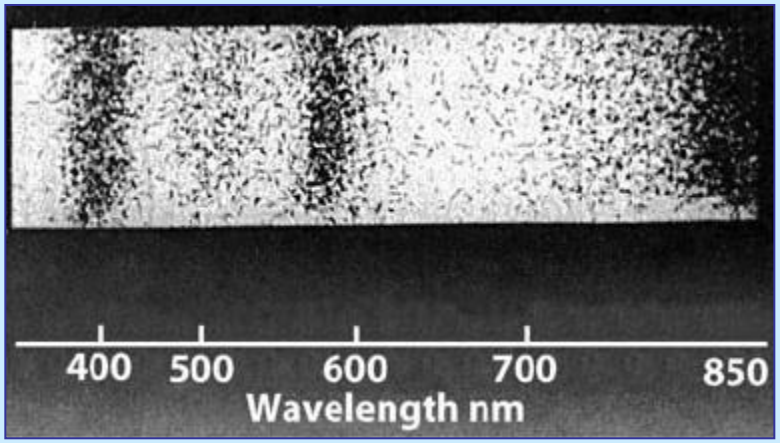

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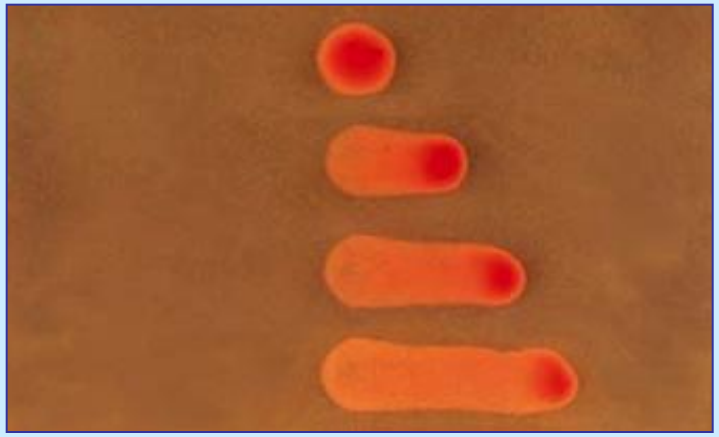
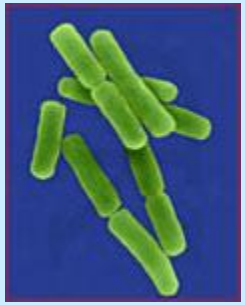
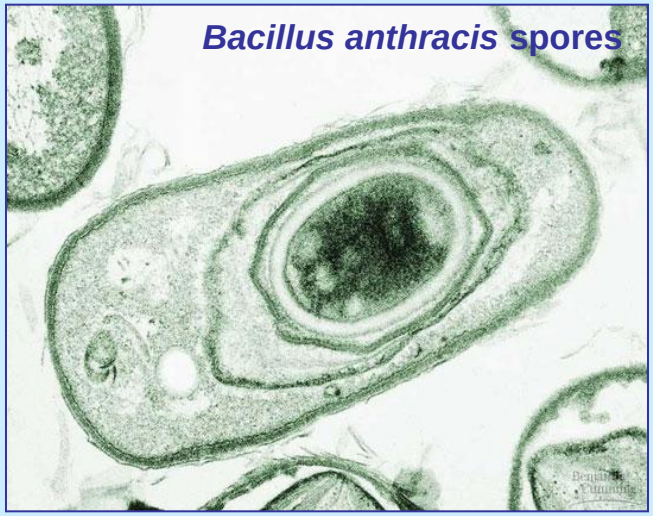
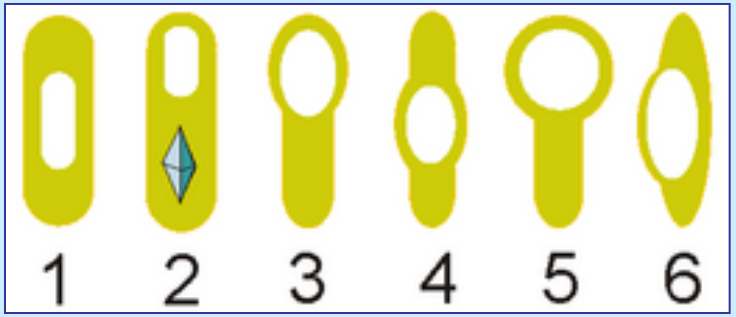




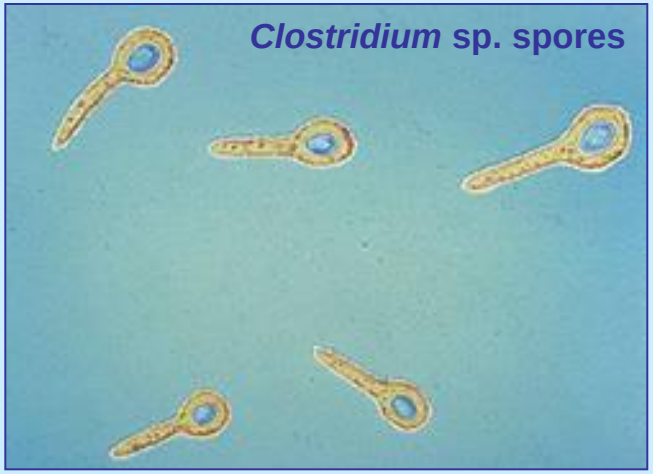

LA STRUTTURA PROCARIOTICA

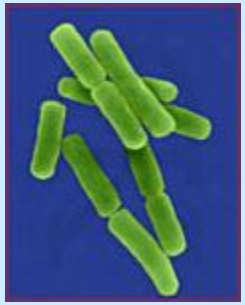
SPORE BATTERICHE





Possibili caratteristiche morfologiche di spore batteriche



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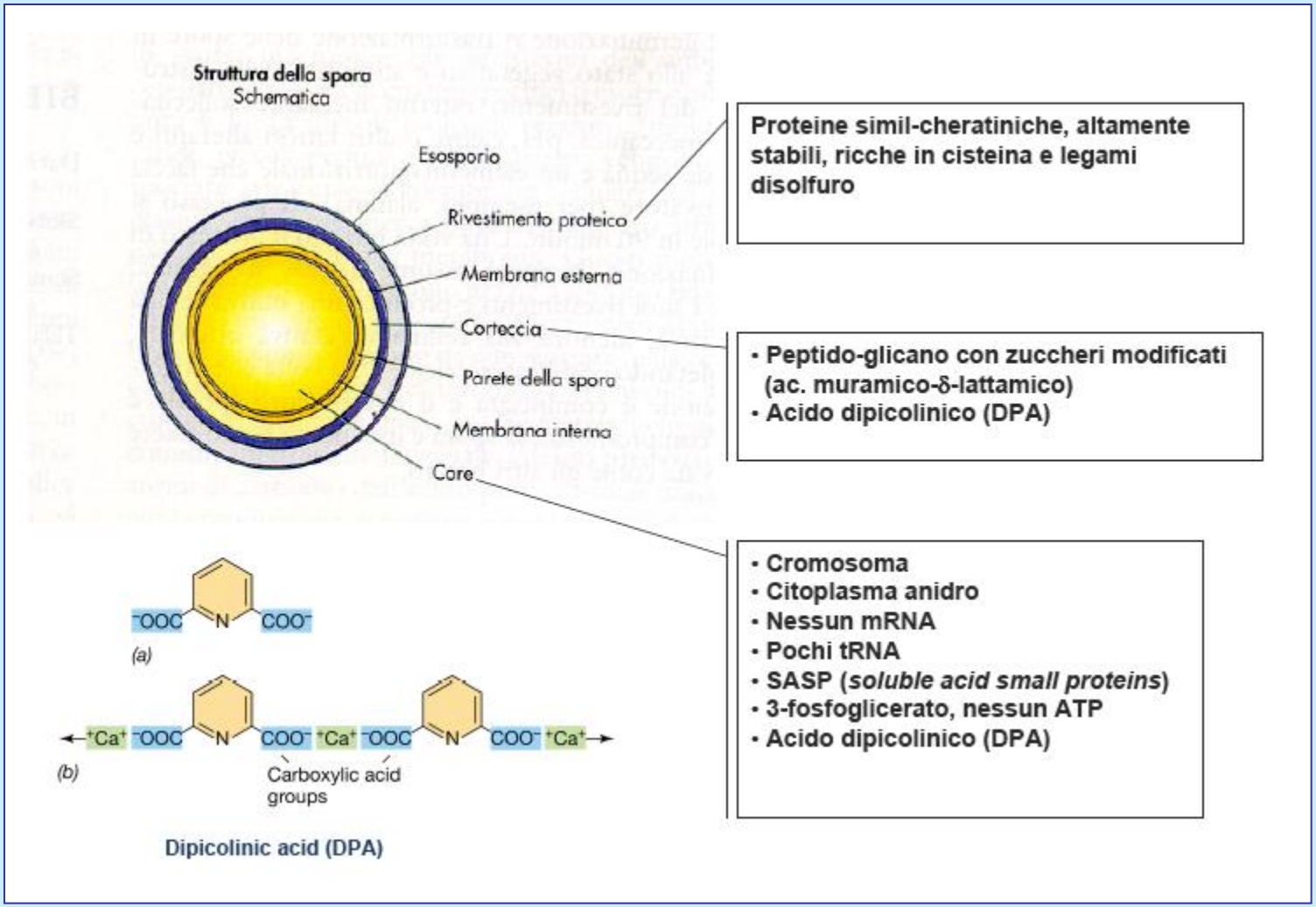
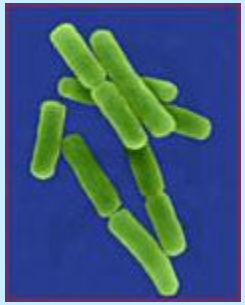




LA STRUTTURA PROCARIOTICA

DINAMICA DELLA FORMAZIONE DELLA SPORA
in alcuni batteri Gram-positivi quali *Bacillus* sp. e *Clostridium* sp..

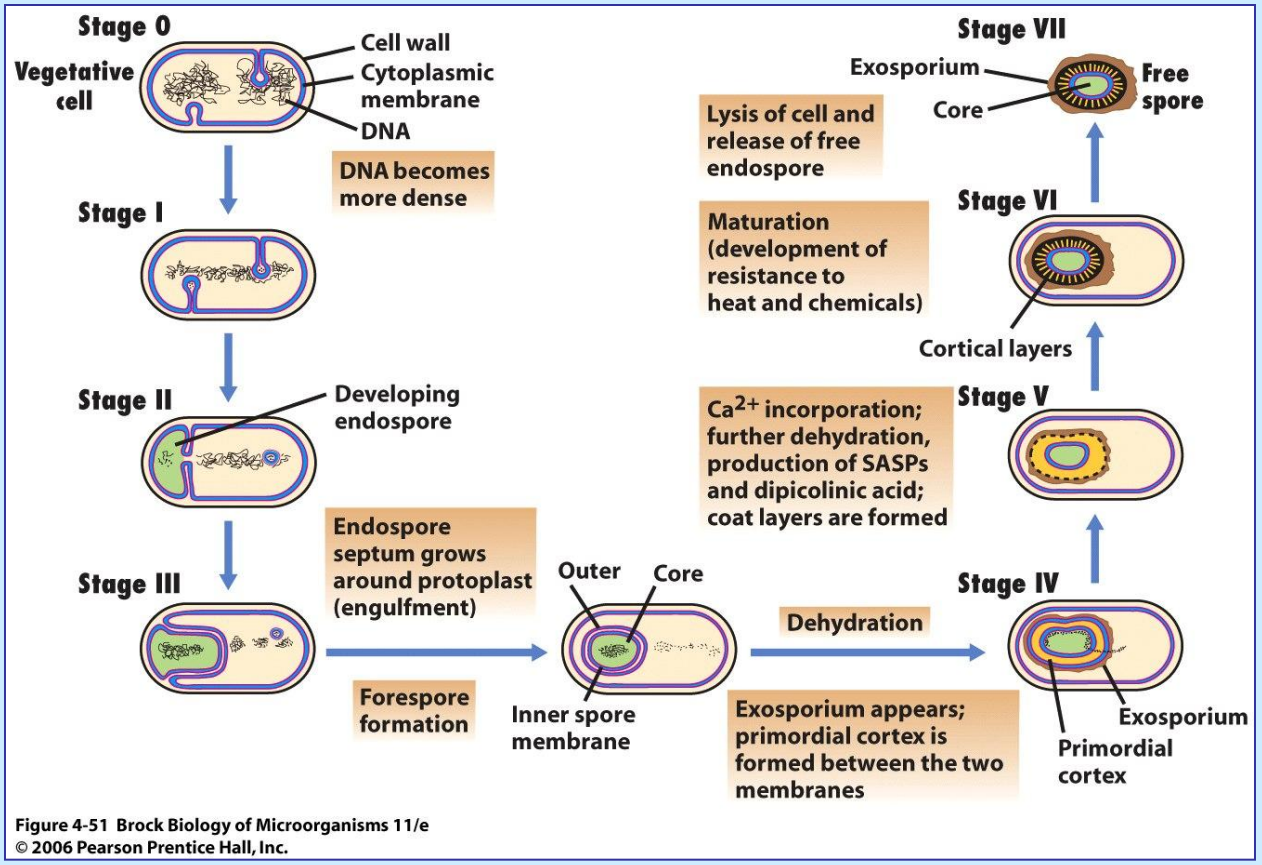
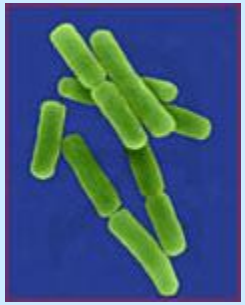


Figure 4-51 Brock Biology of Microorganisms 11/e

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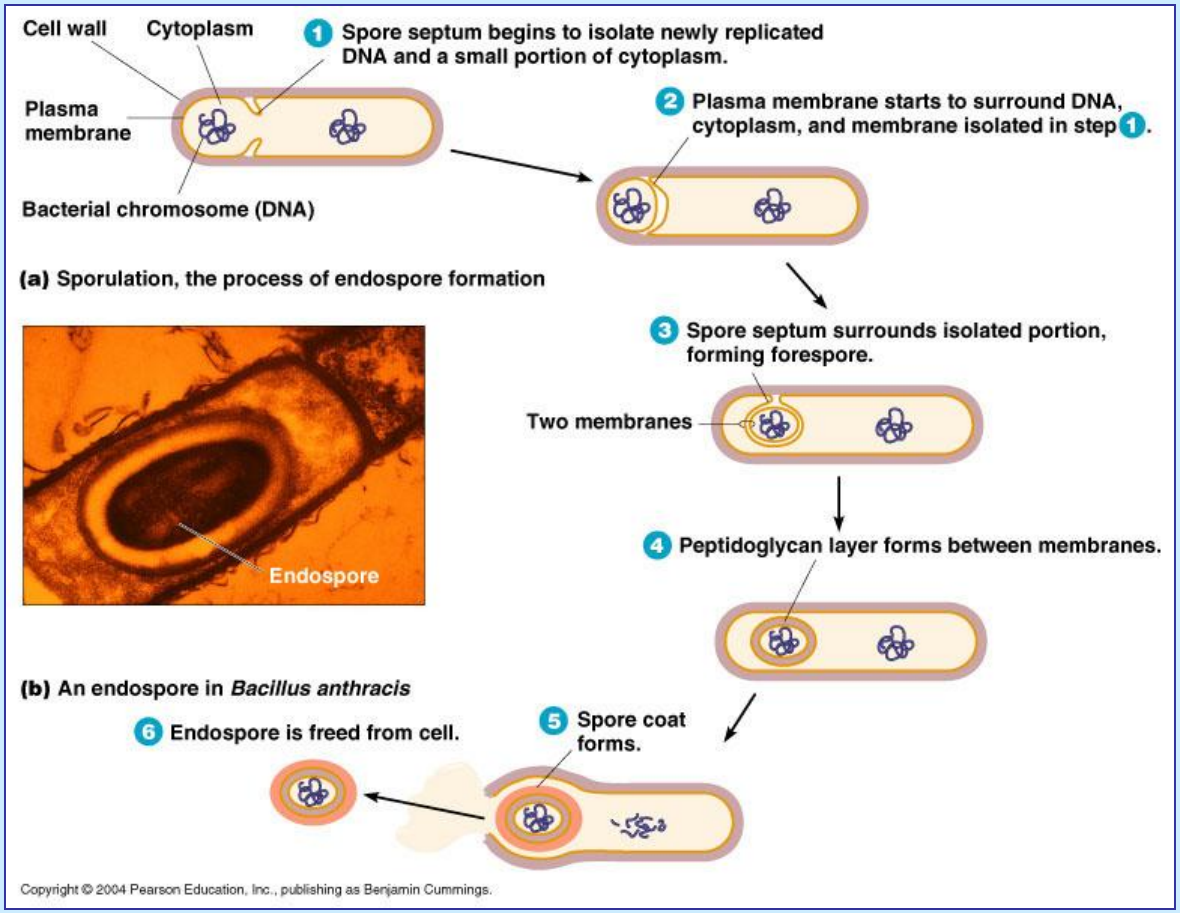
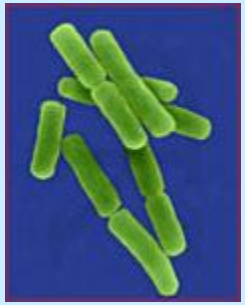


Struttura dei microorganismi



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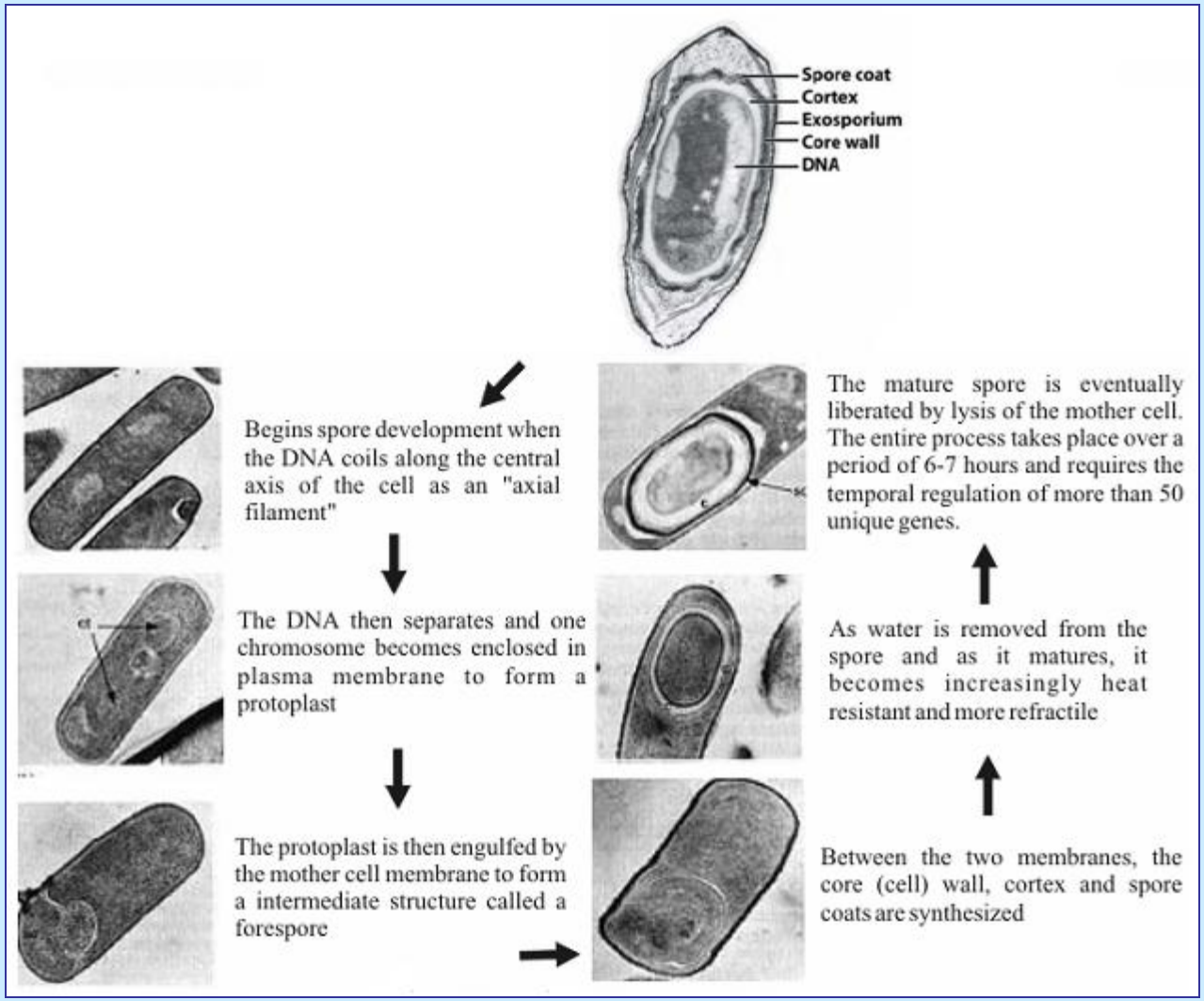

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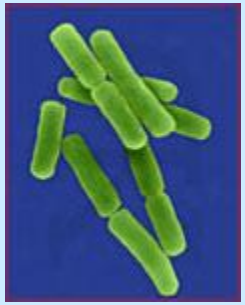

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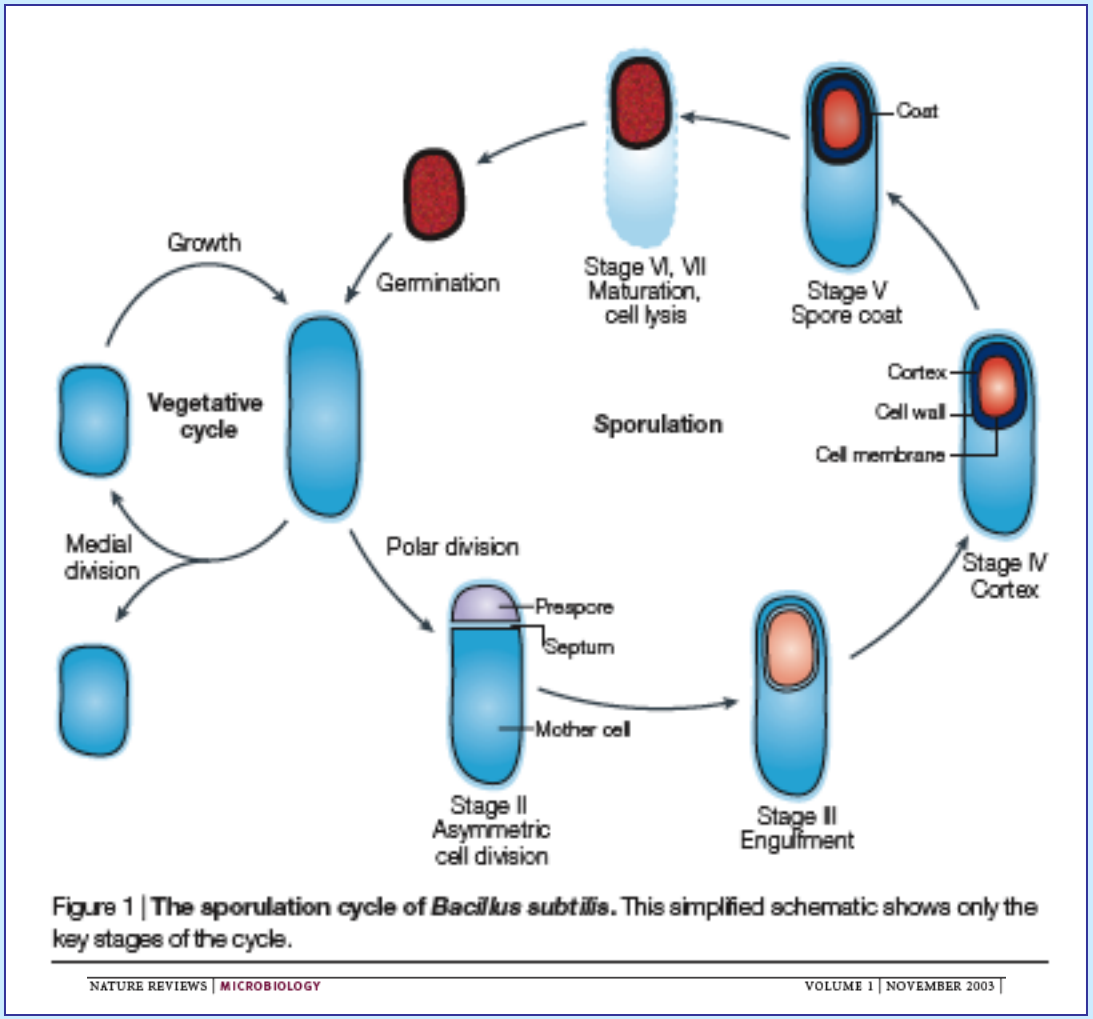
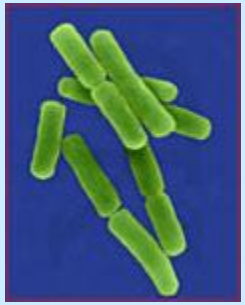


Figure 1 | **The sporulation cycle of *Bacillus subtilis*.** This simplified schematic shows only the key stages of the cycle.

Struttura dei microorganismi

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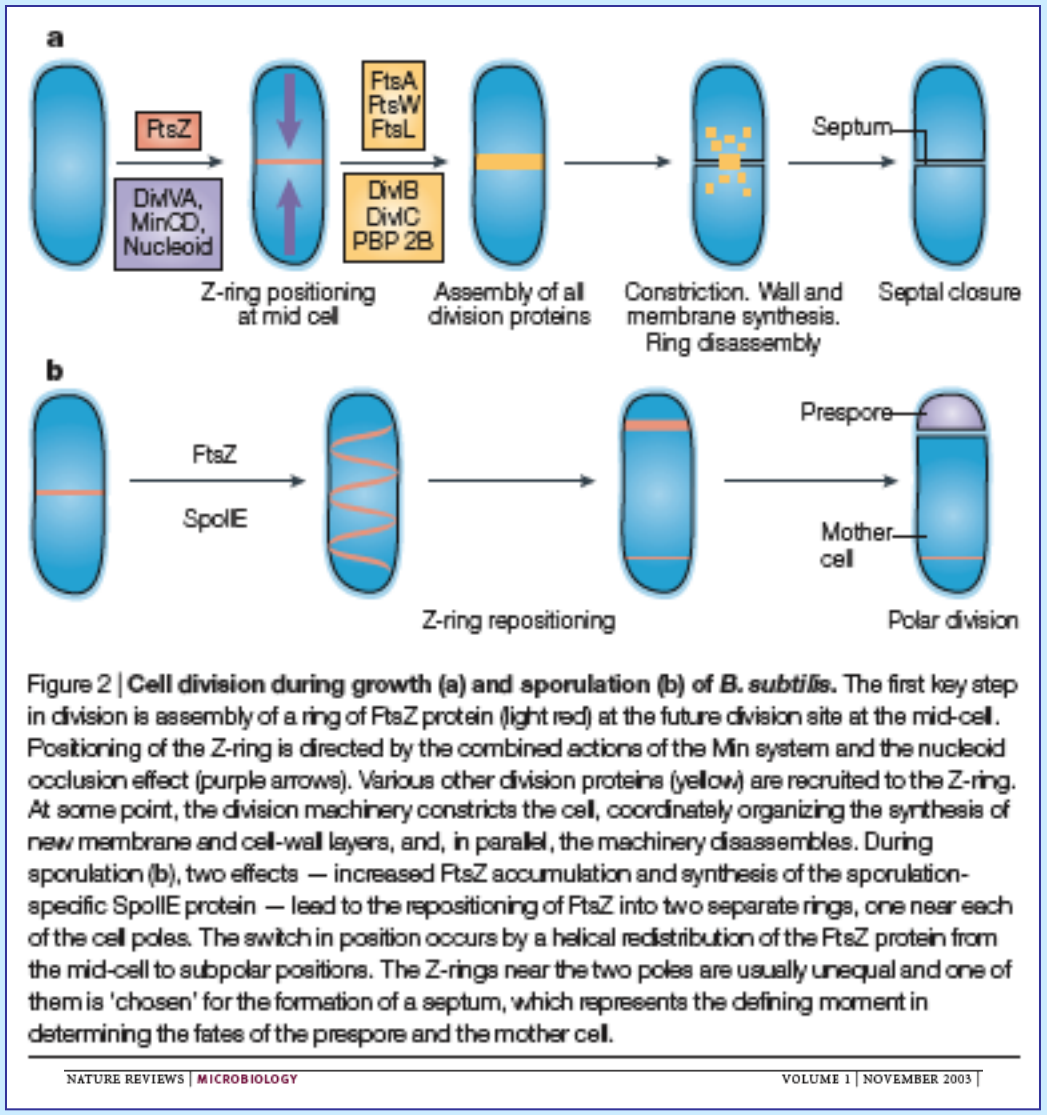

Figure 2 | **Cell division during growth (a) and sporulation (b) of *B. subtilis*.** The first key step in division is assembly of a ring of FtsZ protein (light red) at the future division site at the mid-cell. Positioning of the Z-ring is directed by the combined actions of the Min system and the nucleoid occlusion effect (purple arrows). Various other division proteins (yellow) are recruited to the Z-ring. At some point, the division machinery constricts the cell, coordinately organizing the synthesis of new membrane and cell-wall layers, and, in parallel, the machinery disassembles. During sporulation (b), two effects — increased FtsZ accumulation and synthesis of the sporulation-specific SpoIIE protein — lead to the repositioning of FtsZ into two separate rings, one near each of the cell poles. The switch in position occurs by a helical redistribution of the FtsZ protein from the mid-cell to subpolar positions. The Z-rings near the two poles are usually unequal and one of them is 'chosen' for the formation of a septum, which represents the defining moment in determining the fates of the prespore and the mother cell.

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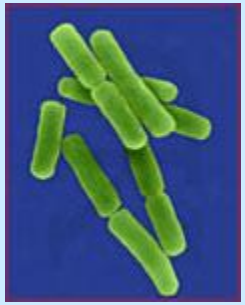

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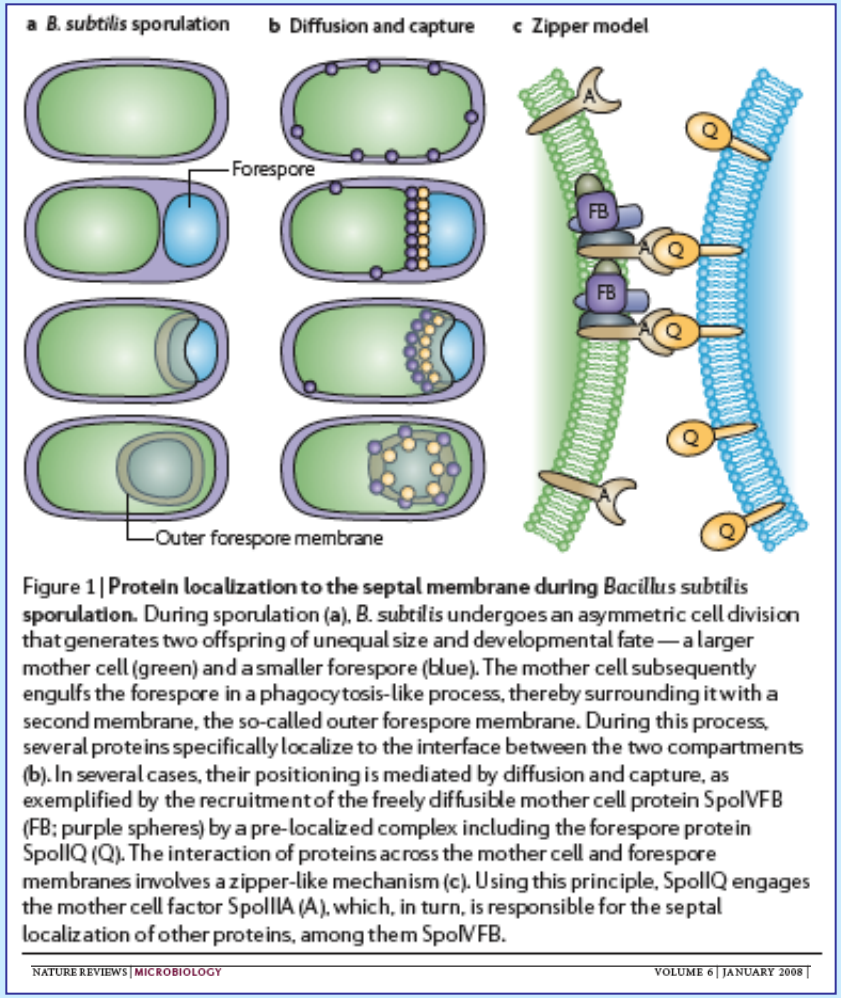

Figure 1 | **Protein localization to the septal membrane during *Bacillus subtilis* sporulation.** During sporulation (a), *B. subtilis* undergoes an asymmetric cell division that generates two offspring of unequal size and developmental fate — a larger mother cell (green) and a smaller forespore (blue). The mother cell subsequently engulfs the forespore in a phagocytosis-like process, thereby surrounding it with a second membrane, the so-called outer forespore membrane. During this process, several proteins specifically localize to the interface between the two compartments (b). In several cases, their positioning is mediated by diffusion and capture, as exemplified by the recruitment of the freely diffusible mother cell protein SpoIVFB (FB; purple spheres) by a pre-localized complex including the forespore protein SpoIIQ (Q). The interaction of proteins across the mother cell and forespore membranes involves a zipper-like mechanism (c). Using this principle, SpoIIQ engages the mother cell factor SpoIIIA (A), which, in turn, is responsible for the septal localization of other proteins, among them SpoIVFB.

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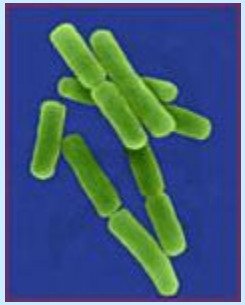

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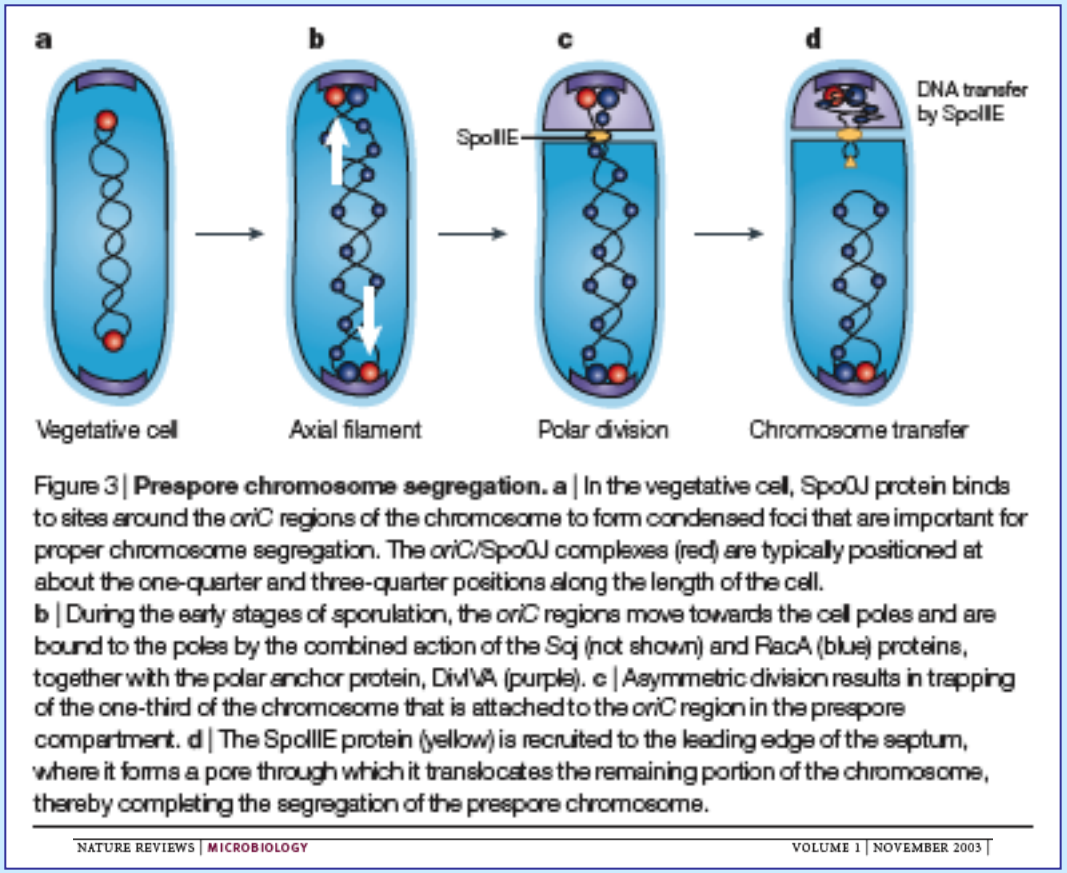

Figure 3 | **Prespore chromosome segregation. a** | In the vegetative cell, Spo0J protein binds to sites around the *oriC* regions of the chromosome to form condensed foci that are important for proper chromosome segregation. The *oriC*/Spo0J complexes (red) are typically positioned at about the one-quarter and three-quarter positions along the length of the cell. **b** | During the early stages of sporulation, the *oriC* regions move towards the cell poles and are bound to the poles by the combined action of the Soj (not shown) and RacA (blue) proteins, together with the polar anchor protein, DivIVA (purple). **c** | Asymmetric division results in trapping of the one-third of the chromosome that is attached to the *oriC* region in the prespore compartment. **d** | The SpoIIIE protein (yellow) is recruited to the leading edge of the septum, where it forms a pore through which it translocates the remaining portion of the chromosome, thereby completing the segregation of the prespore chromosome.

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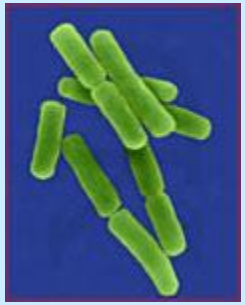
Struttura dei microorganismi

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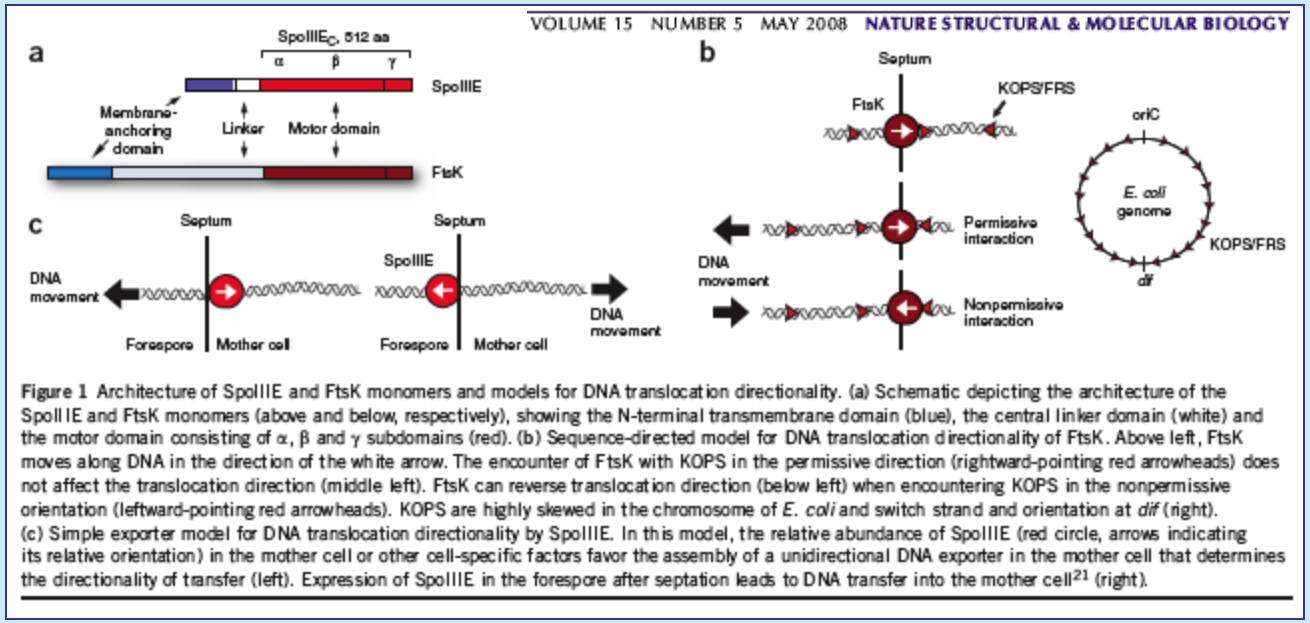
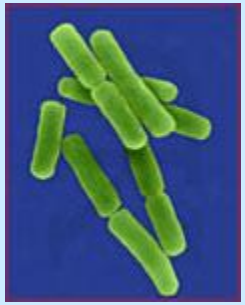


Figure 1 Architecture of SpoIIIE and FtsK monomers and models for DNA translocation directionality. (a) Schematic depicting the architecture of the SpoIIIE and FtsK monomers (above and below, respectively), showing the N-terminal transmembrane domain (blue), the central linker domain (white) and the motor domain consisting of α, β and γ subdomains (red). (b) Sequence-directed model for DNA translocation directionality of FtsK. Above left, FtsK moves along DNA in the direction of the white arrow. The encounter of FtsK with KOPS in the permissive direction (rightward-pointing red arrowheads) does not affect the translocation direction (middle left). FtsK can reverse translocation direction (below left) when encountering KOPS in the nonpermissive orientation (leftward-pointing red arrowheads). KOPS are highly skewed in the chromosome of *E. coli* and switch strand and orientation at *dif* (right). (c) Simple exporter model for DNA translocation directionality by SpoIIIE. In this model, the relative abundance of SpoIIIE (red circle, arrows indicating its relative orientation) in the mother cell or other cell-specific factors favor the assembly of a unidirectional DNA exporter in the mother cell that determines the directionality of transfer (left). Expression of SpoIIIE in the forespore after septation leads to DNA transfer into the mother cell[21] (right).



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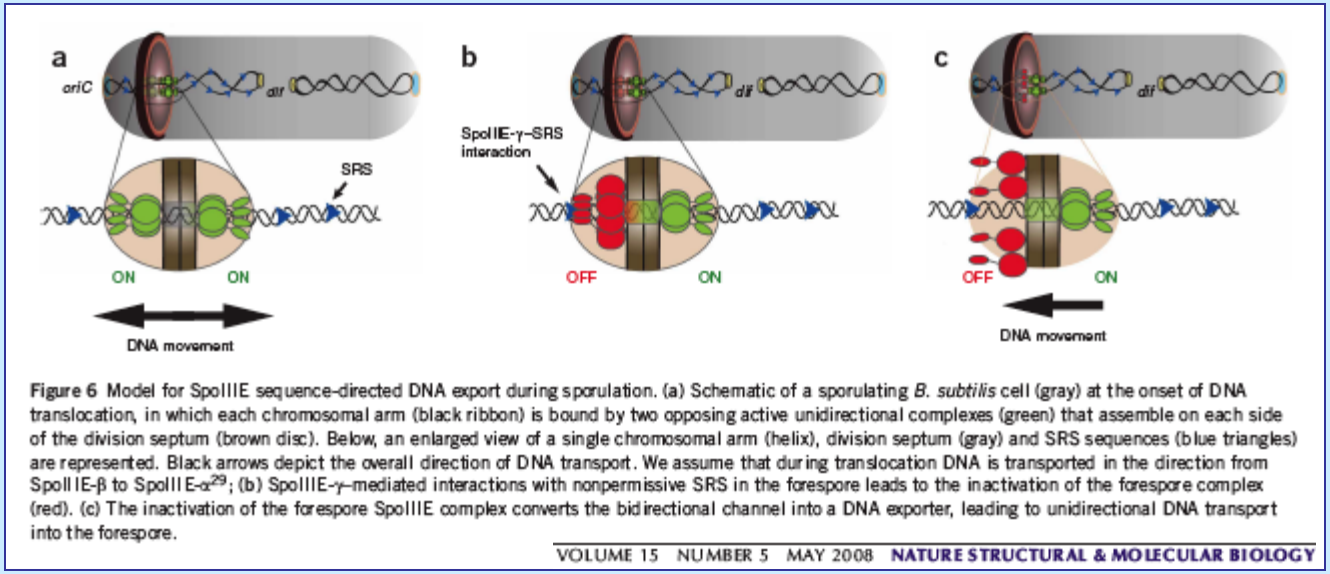

Figure 6 Model for SpoIIIE sequence-directed DNA export during sporulation. (a) Schematic of a sporulating *B. subtilis* cell (gray) at the onset of DNA translocation, in which each chromosomal arm (black ribbon) is bound by two opposing active unidirectional complexes (green) that assemble on each side of the division septum (brown disc). Below, an enlarged view of a single chromosomal arm (helix), division septum (gray) and SRS sequences (blue triangles) are represented. Black arrows depict the overall direction of DNA transport. We assume that during translocation DNA is transported in the direction from SpoIIIE-β to SpoIIIE-α^{29}; (b) SpoIIIE-γ–mediated interactions with nonpermissive SRS in the forespore leads to the inactivation of the forespore complex (red). (c) The inactivation of the forespore SpoIIIE complex converts the bidirectional channel into a DNA exporter, leading to unidirectional DNA transport into the forespore.

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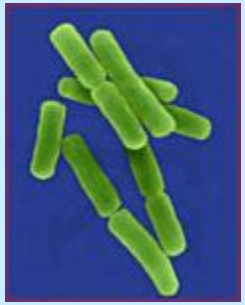


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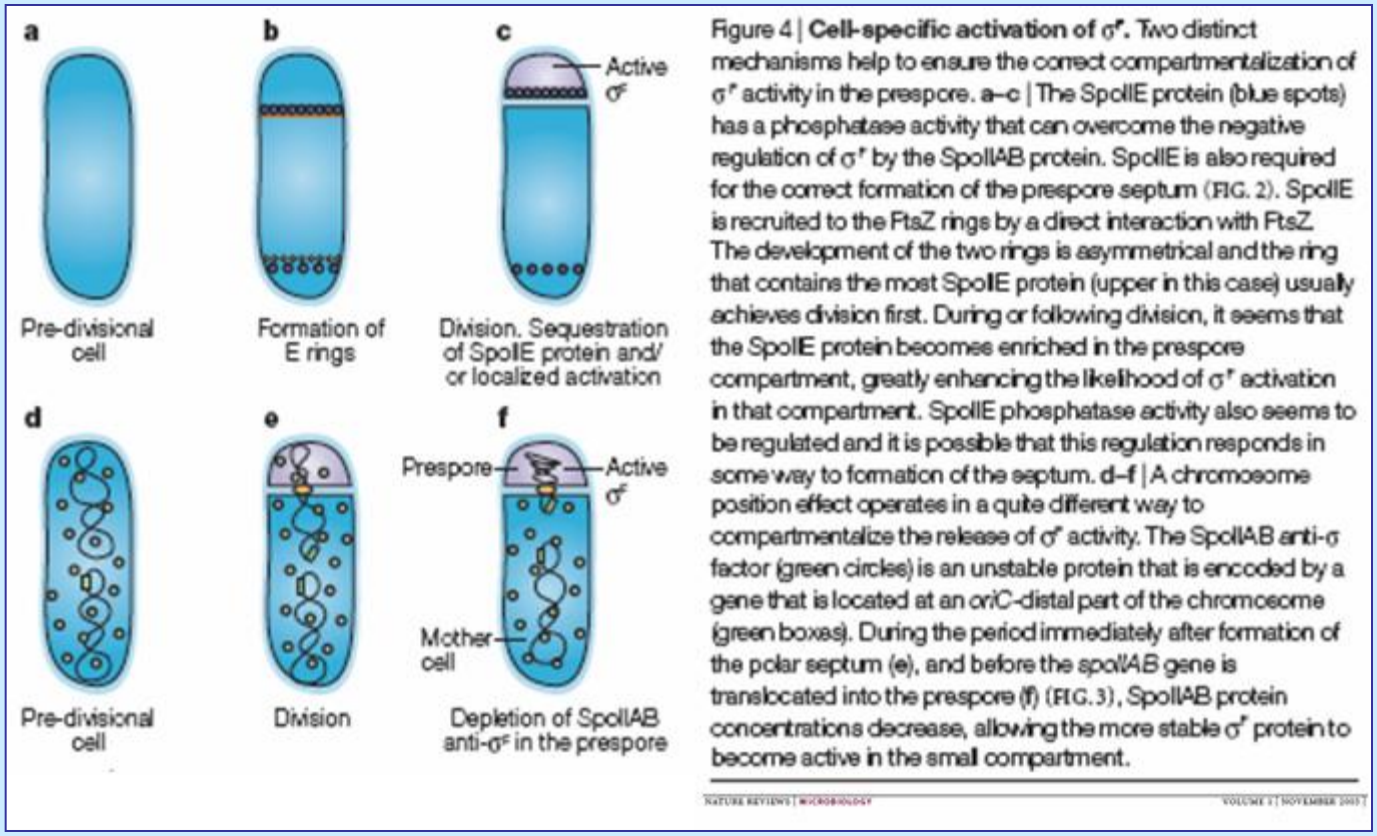
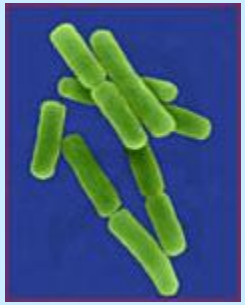


Figure 4 | **Cell-specific activation of σF.** Two distinct mechanisms help to ensure the correct compartmentalization of σ^F activity in the prespore. **a–c** | The SpoIIE protein (blue spots) has a phosphatase activity that can overcome the negative regulation of σ^F by the SpoIIAB protein. SpoIIE is also required for the correct formation of the prespore septum (FIG. 2). SpoIIE is recruited to the FtsZ rings by a direct interaction with FtsZ. The development of the two rings is asymmetrical and the ring that contains the most SpoIIE protein (upper in this case) usually achieves division first. During or following division, it seems that the SpoIIE protein becomes enriched in the prespore compartment, greatly enhancing the likelihood of σ^F activation in that compartment. SpoIIE phosphatase activity also seems to be regulated and it is possible that this regulation responds in some way to formation of the septum. **d–f** | A chromosome position effect operates in a quite different way to compartmentalize the release of σ^F activity. The SpoIIAB anti-σ factor (green circles) is an unstable protein that is encoded by a gene that is located at an *oriC*-distal part of the chromosome (green boxes). During the period immediately after formation of the polar septum (e), and before the *spoIIAB* gene is translocated into the prespore (f) (FIG. 3), SpoIIAB protein concentrations decrease, allowing the more stable σ^F protein to become active in the small compartment.

Struttura dei microorganismi



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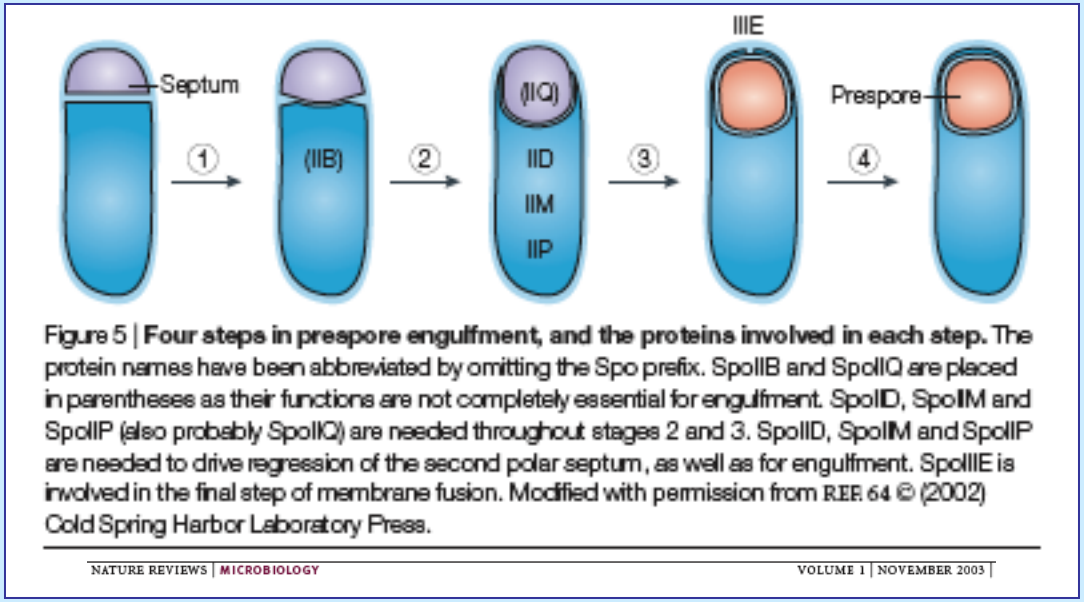

Figure 5 | **Four steps in prespore engulfment, and the proteins involved in each step.** The protein names have been abbreviated by omitting the Spo prefix. SpoIIB and SpoIIQ are placed in parentheses as their functions are not completely essential for engulfment. SpoIID, SpoIIM and SpoIIP (also probably SpoIIQ) are needed throughout stages 2 and 3. SpoIID, SpoIIM and SpoIIP are needed to drive regression of the second polar septum, as well as for engulfment. SpoIIIE is involved in the final step of membrane fusion. Modified with permission from REF. 64 © (2002) Cold Spring Harbor Laboratory Press.

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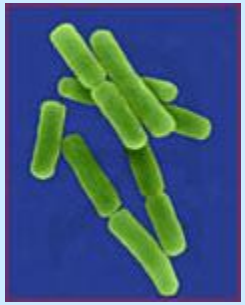
Struttura dei microorganismi



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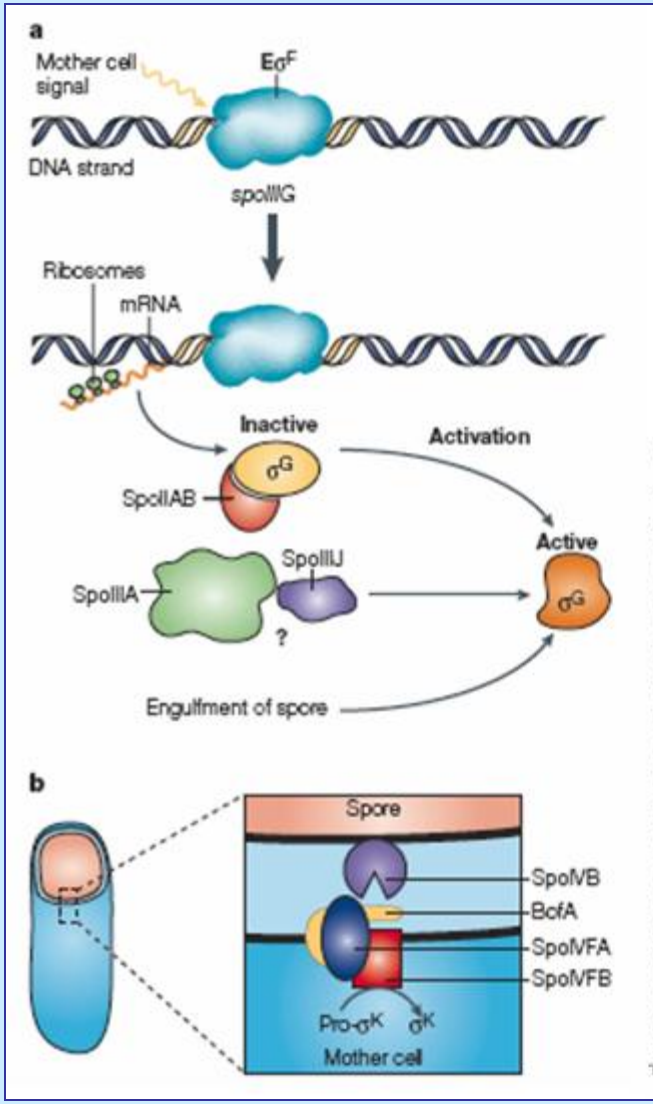
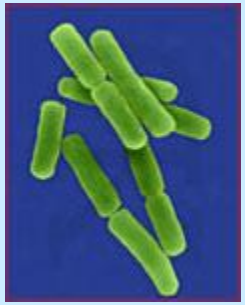


Figure 6 | **Regulation of the late stages of sporulation.** **a** | Regulation of σ^G synthesis and activity. Transcription of the *spoIIIG* gene is directed by the σ^F form of RNA polymerase ($E\sigma^F$). It also requires an as-yet-undefined signal from the mother cell, which is dependent on σ^E. σ^G protein is initially inactive (yellow), possibly due to the action of the SpoIIAB anti-σ factor. Activation depends on the completion of prespore engulfment, as well as on the SpoIIIA and SpoIIIJ proteins. **b** | Regulation of σ^K activity. σ^K is synthesized as a precursor protein with an amino-terminal pro-sequence. It is processed by a membrane-associated protease, SpoIVFB, which is recruited to the outer prespore membrane by SpoIVFA protein. BofA is also recruited to this complex by SpoIVFA. BofA is probably an inhibitor of SpoIVFB. Processing is released by an intercellular signal that comes from the σ^G-dependent SpoIVB protein. SpoIVB is secreted into the space between the two membranes and is a protease that probably acts by cleaving BofA and/or SpoIVFA to release the SpoIVFB pro-σ^K processing enzyme.

Struttura dei microorganismi




LA STRUTTURA PROCARIOTICA

Resistenza di spore batteriche al calore secco (minuti)

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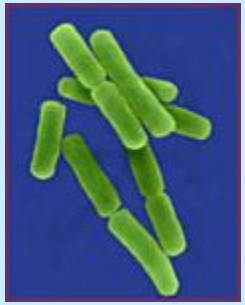
B. anthracis	-	180	90	-
C. tetani	-	15	12	1
C. botulinum	120	50	20	5
Specie ambientali	-	-	60	15

Resistenza di spore batteriche al calore umido (minuti)

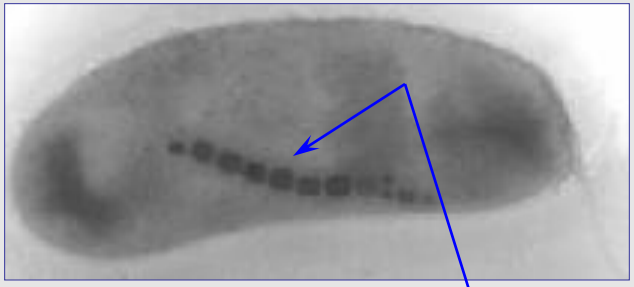
Specie microbica	100 °C	110 °C	115 °C	121 °C
B. anthracis	2-15	5	-	-
B. subtilis	Ore	40	-	-
C. tetani	5-90	5-25	-	-
C. botulinum	500	120	40	20
Specie ambientali	Ore	420	15	4



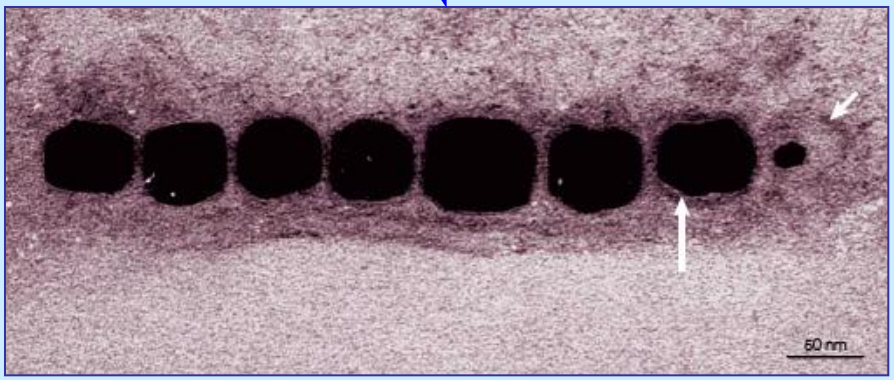

LA STRUTTURA PROCARIOTICA

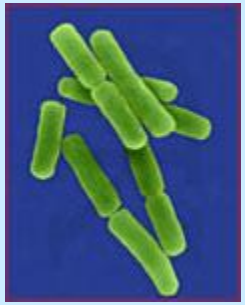
MAGNETOSOMA

Some bacteria (e.g. *Magnetospirillum magneticum*, *Magnetospirillum magnetotacticum*) are magnetotactic and contain chains of crystals (each less than 70 nm) of either magnetite (Fe_3O_4) or greigite (Fe_3S_4).



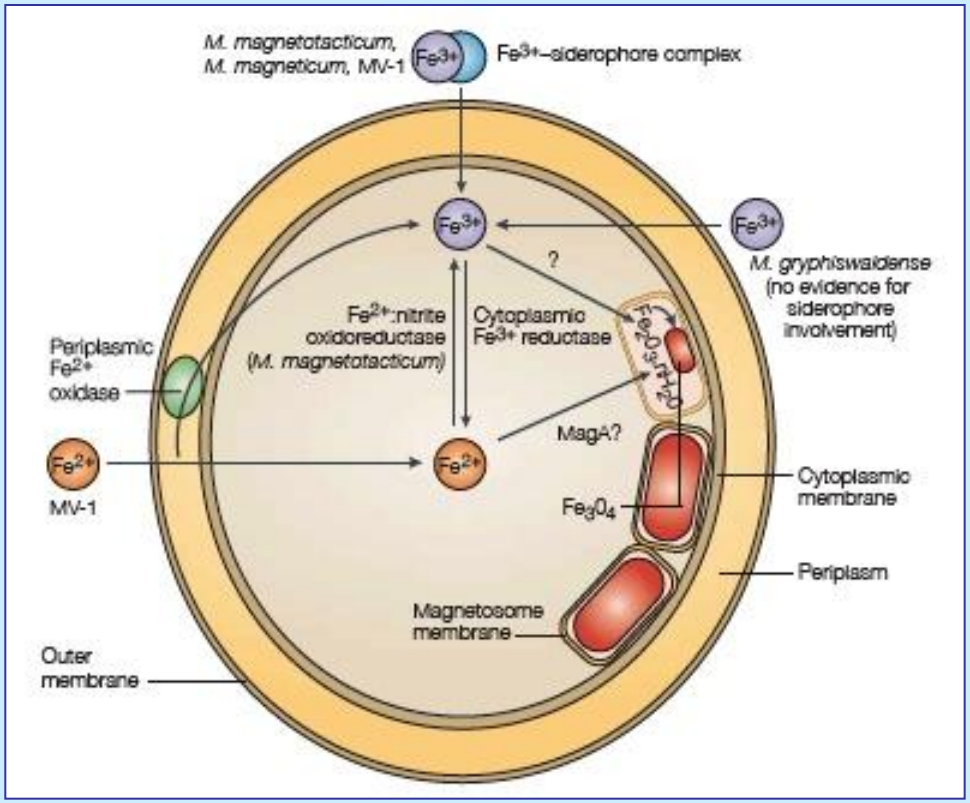
Even dead cells will act as passive compasses.



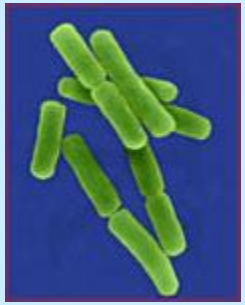


LA STRUTTURA PROCARIOTICA

Rappresentazione schematica delle possibili reazioni per la biomineralizzazione della magnetite in specie di batteri magnetotattici

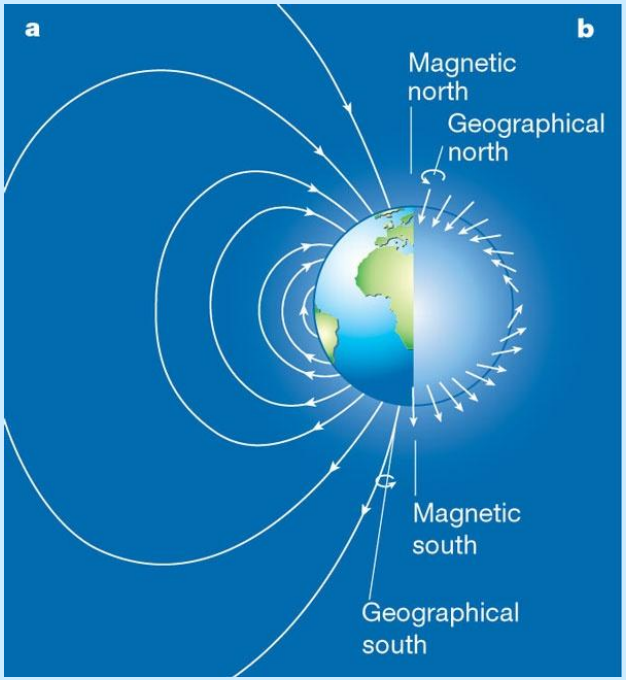


Struttura dei microorganismi

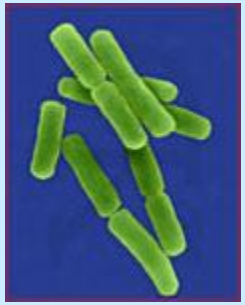



LA STRUTTURA PROCARIOTICA

MAGNETOTACTIC BACTERIA



(a) The overall field lines of the magnetic field. (b) The resulting magnetic inclination, or dip angle, and field strength at Earth's surface (indicated by arrow angle and length) vary in a consistent way. In theory these parameters make it possible for an organism to determine its position from magnetic coordinates. Magnetic declination (or variation) is the angular difference between magnetic north and geographical north. So it cannot be estimated from magnetic information alone.

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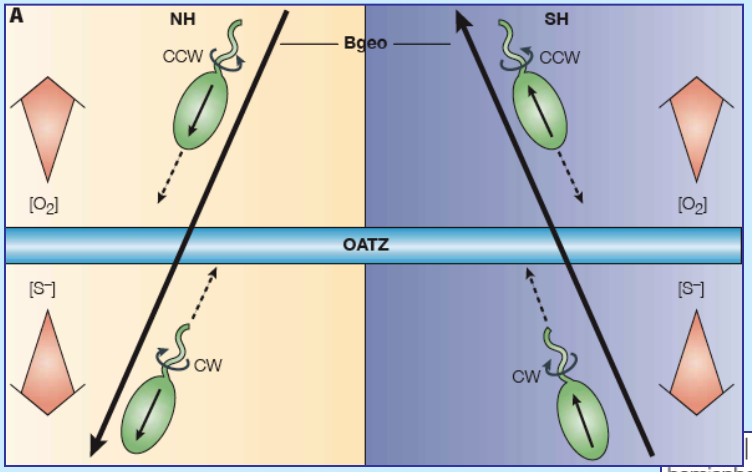
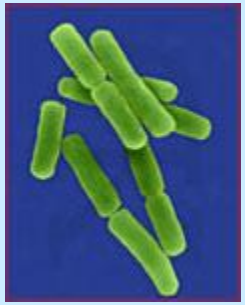


MAGNETOTACTIC BACTERIA

Magneto-aerotaxis. A | Magneto-aerotaxis in the northern (NH) and southern (SH) hemispheres aids cells in efficiently finding their optimum oxygen concentration ($[O_2]$) at the microaerobic oxic–anoxic transition zone (OATZ) in water columns or sediments with horizontal chemical stratification (inverse concentration gradients of oxygen and hydrogen sulphide). In both hemispheres, cells on the oxic side of the OATZ swim down along the geomagnetic field lines (B_{geo}) by rotating their flagella counterclockwise (CCW), whereas those on the anoxic side swim up along B_{geo} by rotating their flagella clockwise (CW). This requires polar magneto-aerotactic cells in the NH and SH to have opposite magnetic polarity (shown by arrows inside cells). This means they exhibit north-seeking and south-seeking behaviour, respectively, when examined in oxic water droplets in a magnetic field. Axial magneto-aerotactic cells swim in both directions along the magnetic field.



LA STRUTTURA PROCARIOTICA

STRUTTURA del NUCLEOIDE

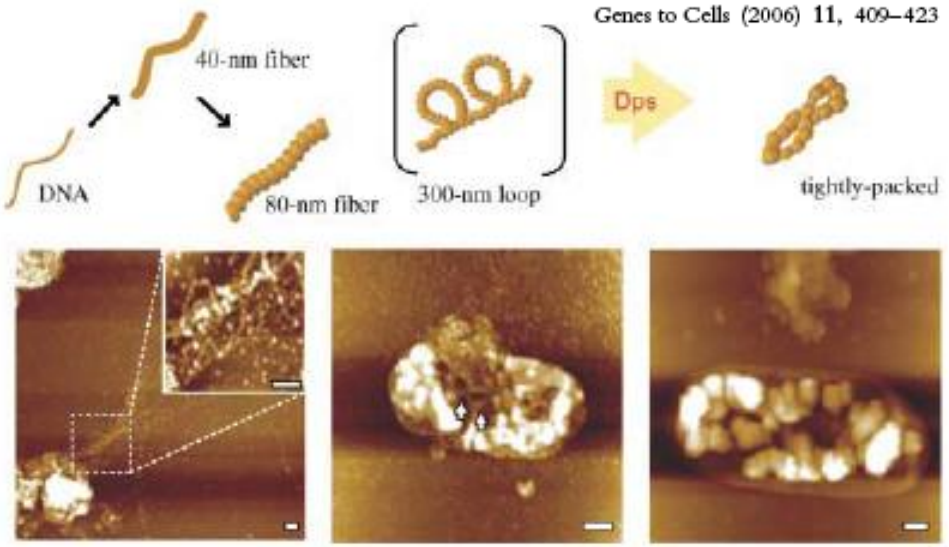
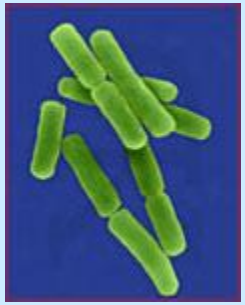


Figure 1 A model of the architectural hierarchy in *E. coli* nucleoid (Kim *et al.* 2004). The DNA and nucleoid proteins form a 40 nm fiber structure. The 40 nm fiber is super-solenoided into an 80 nm fiber (their AFM image is shown in left panel). These fiber structures are commonly found in the bacterial nucleoid. The 80 nm fiber, then, forms a loop structure (middle panel, arrows). The nucleoid undergoes a series of drastic structural changes into a tightly compacted state (right panel). The nucleoid compaction is mainly mediated via a nucleoid protein, Dps. In the present study, the loop and coral reef structures were not detected in *S. aureus*. Scale bars, 500 nm.



LA STRUTTURA PROCARIOTICA

INTERAZIONE PROTEINE-DNA per la formazione del NUCLEOIDE

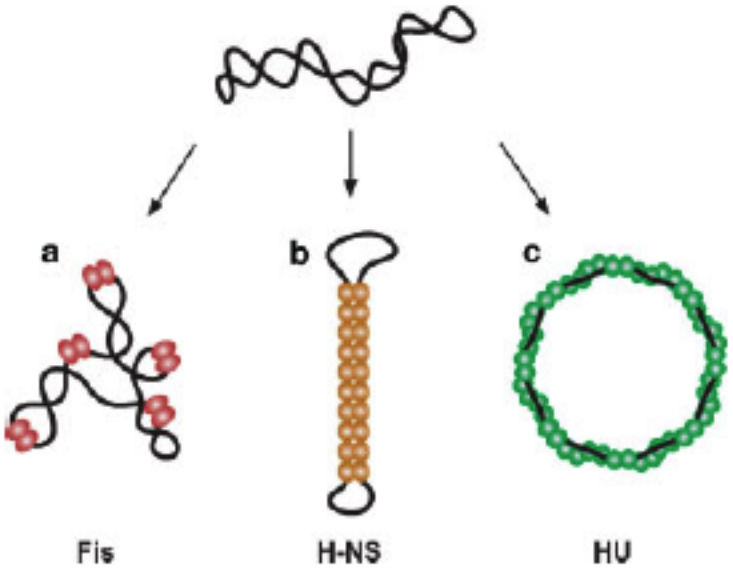
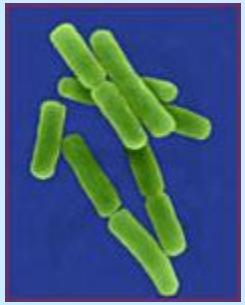


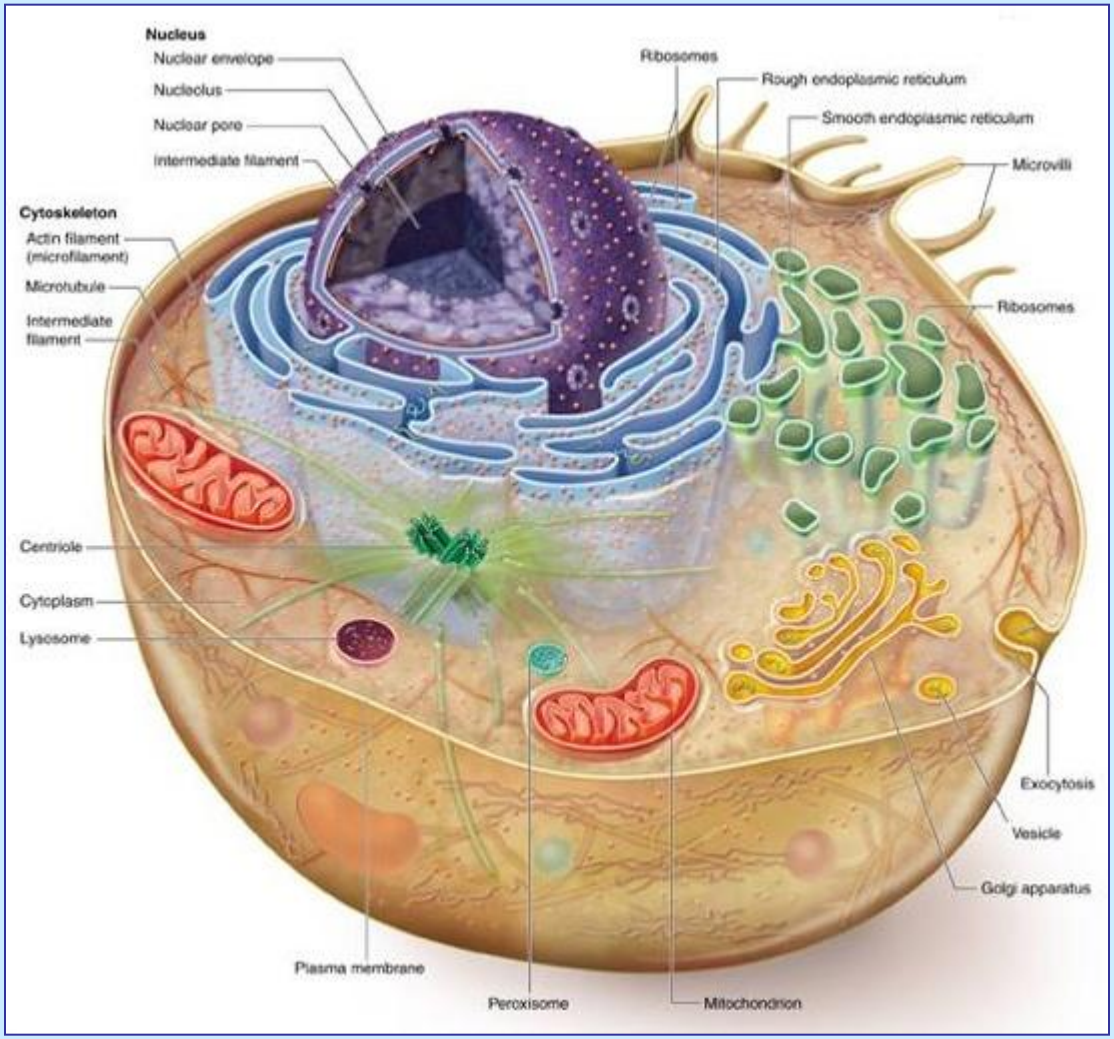
Fig. 1. Effect of histone-like proteins on the conformation of a supercoiled plasmid. a: Binding of Fis promotes branching of supercoiled circular DNA substrates. b: At elevated concentrations, H-NS assembles into patches of oligomers that interact with each other, thereby converting supercoiled plasmids into dumbbell-shaped structures. c: At high concentrations, HU assembles into rigid nucleoprotein filaments that open up supercoiled DNA into a ring-like conformation.

Journal of Cellular Biochemistry 96:506–521 (2005)

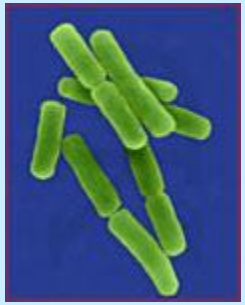


LA STRUTTURA EUCARIOTICA

CELLULA EUCARIOTICA ANIMALE



Struttura dei microorganismi

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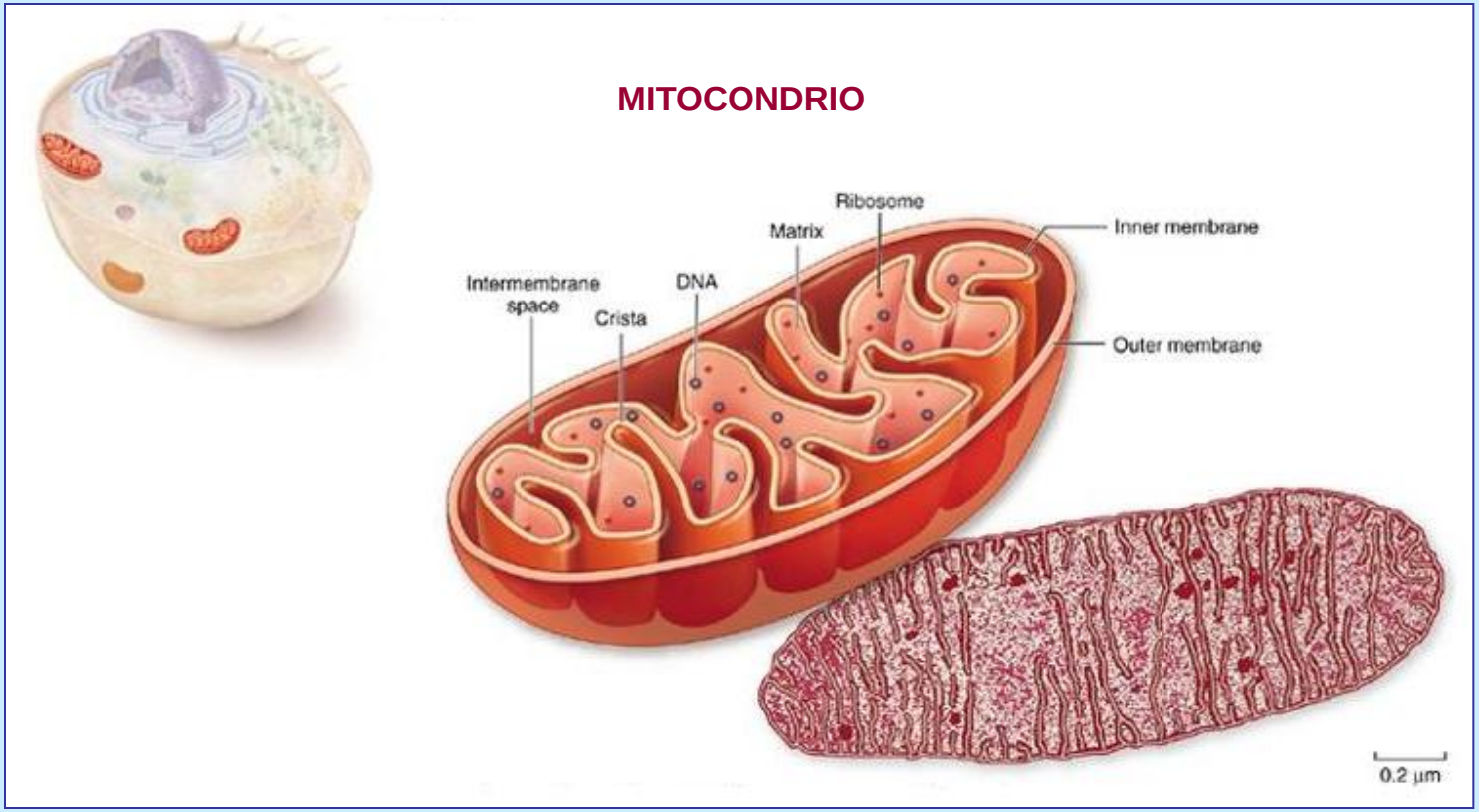
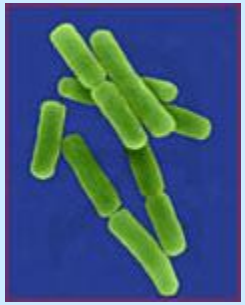


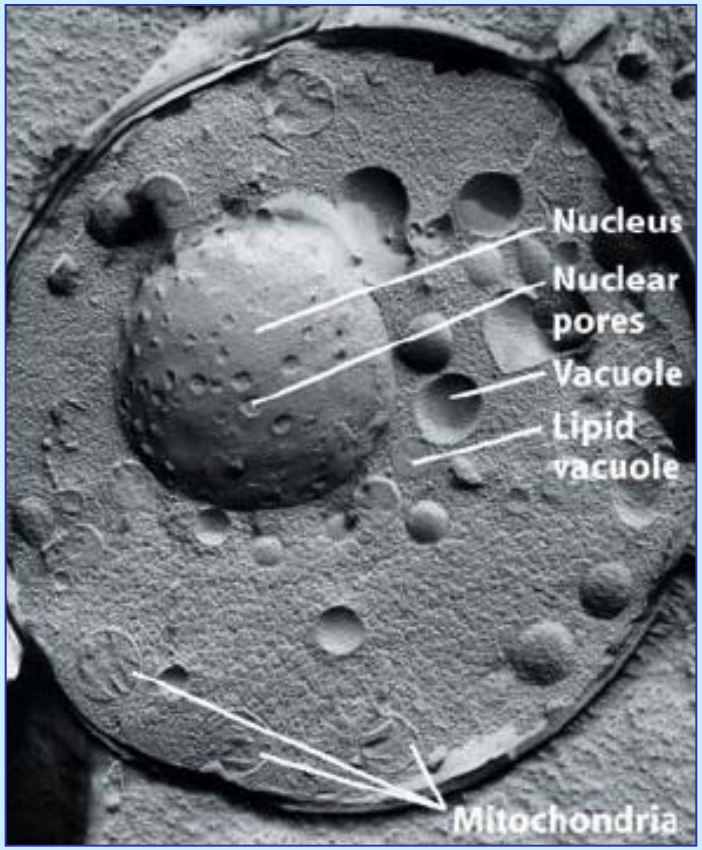
Struttura dei microorganismi

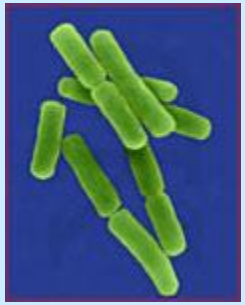


LA STRUTTURA EUCARIOTICA

LA STRUTTURA NUCLEARE DELLE CELLULE EUCARIOTICHE

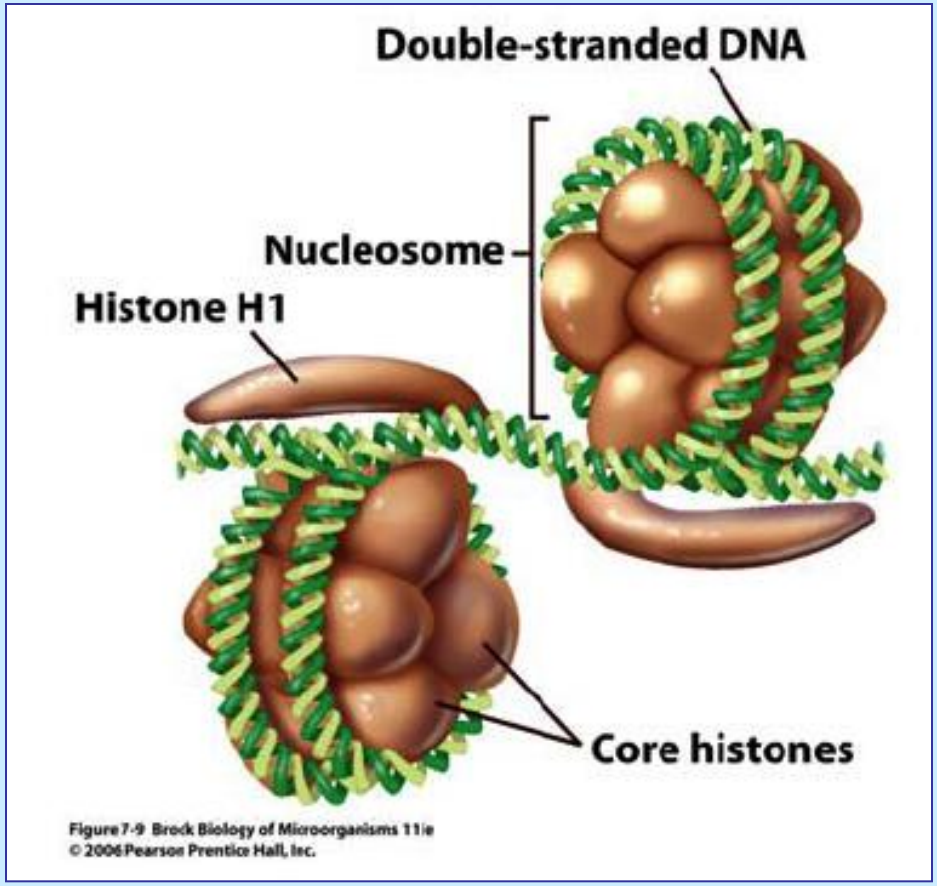
(cellula di lievito al microscopio elettronico preparata con la tecnica di frattura per congelamento)



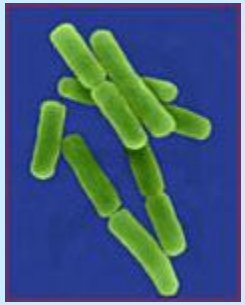


LA STRUTTURA EUCARIOTICA

TIPICO ARRANGIAMENTO DEL DNA NELLE CELLULE EUCARIOTICHE

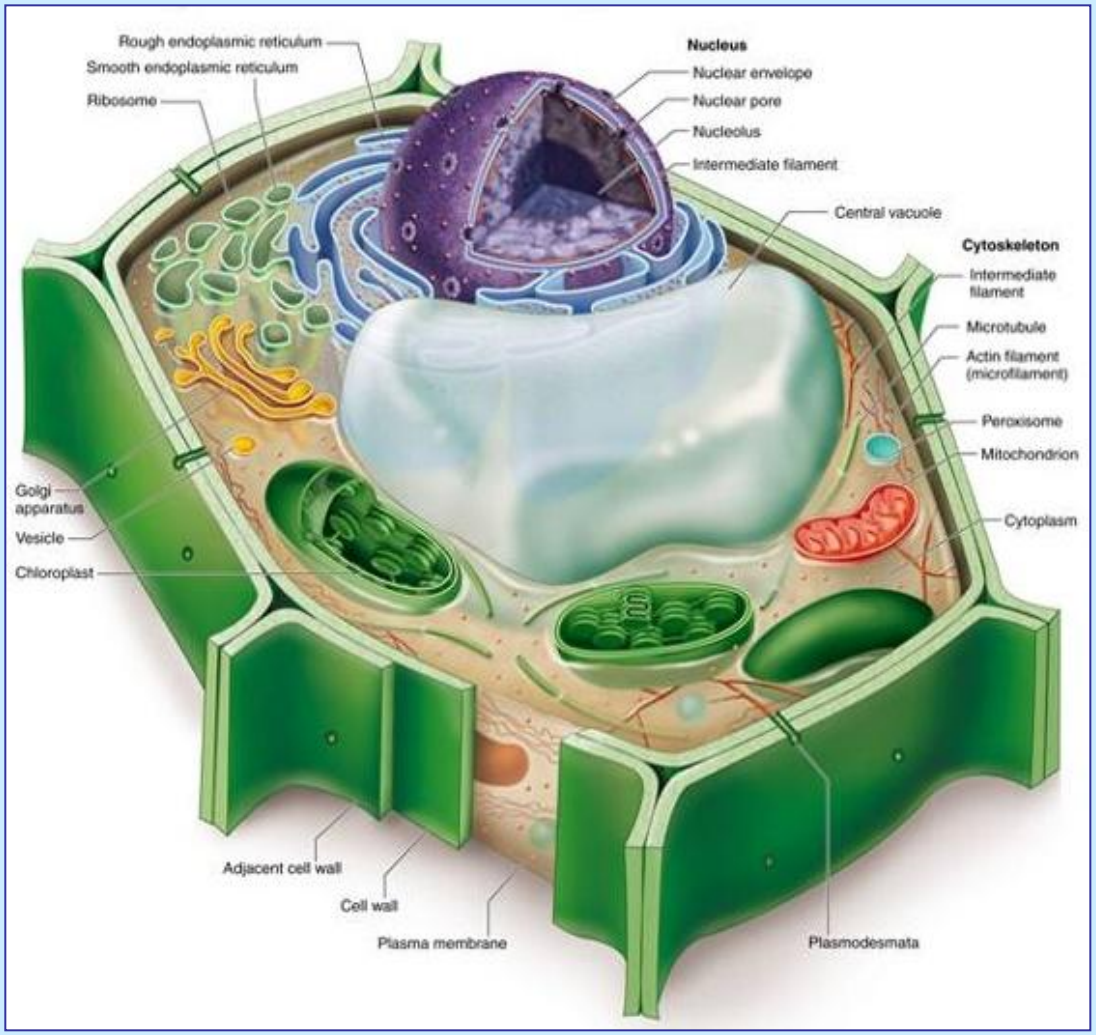


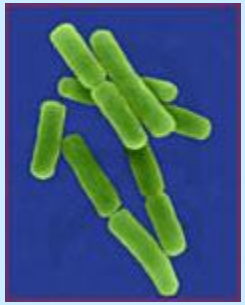
Struttura dei microorganismi



LA STRUTTURA EUCARIOTICA

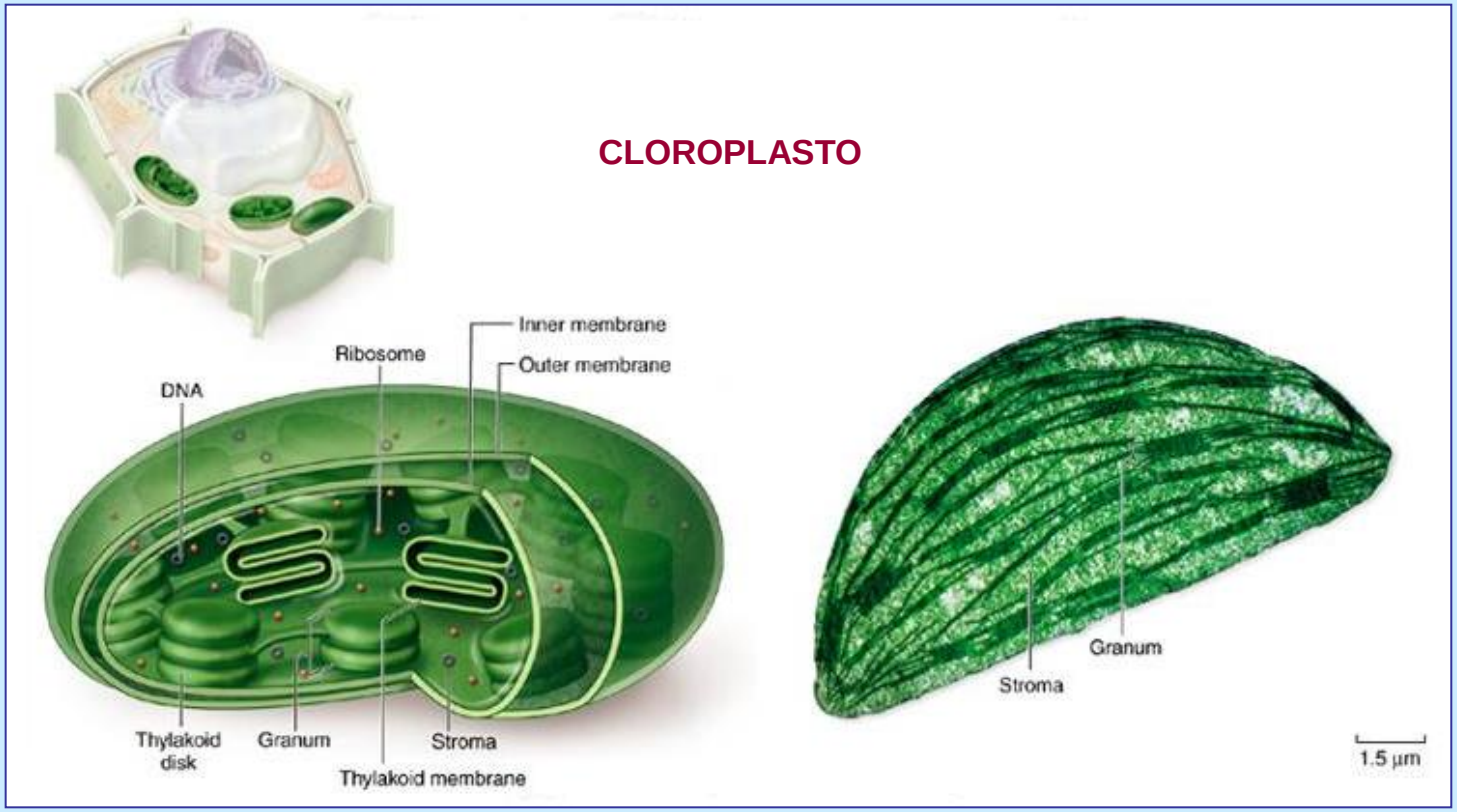
CELLULA EUCARIOTICA VEGETALE



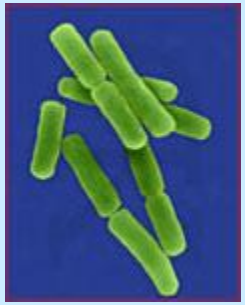



LA STRUTTURA EUCARIOTICA

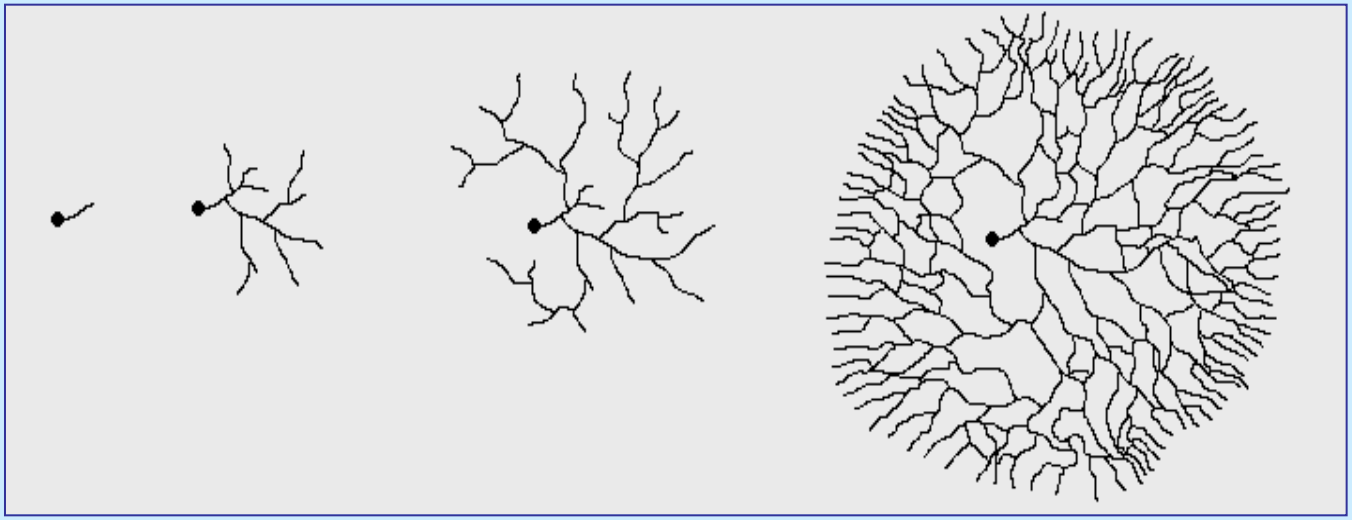
CLOROPLASTO



Struttura dei microorganismi

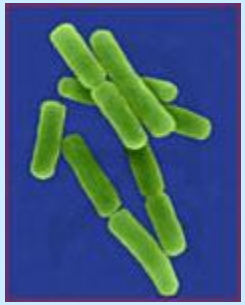


FORMAZIONE DI UN MICELIO FUNGINO



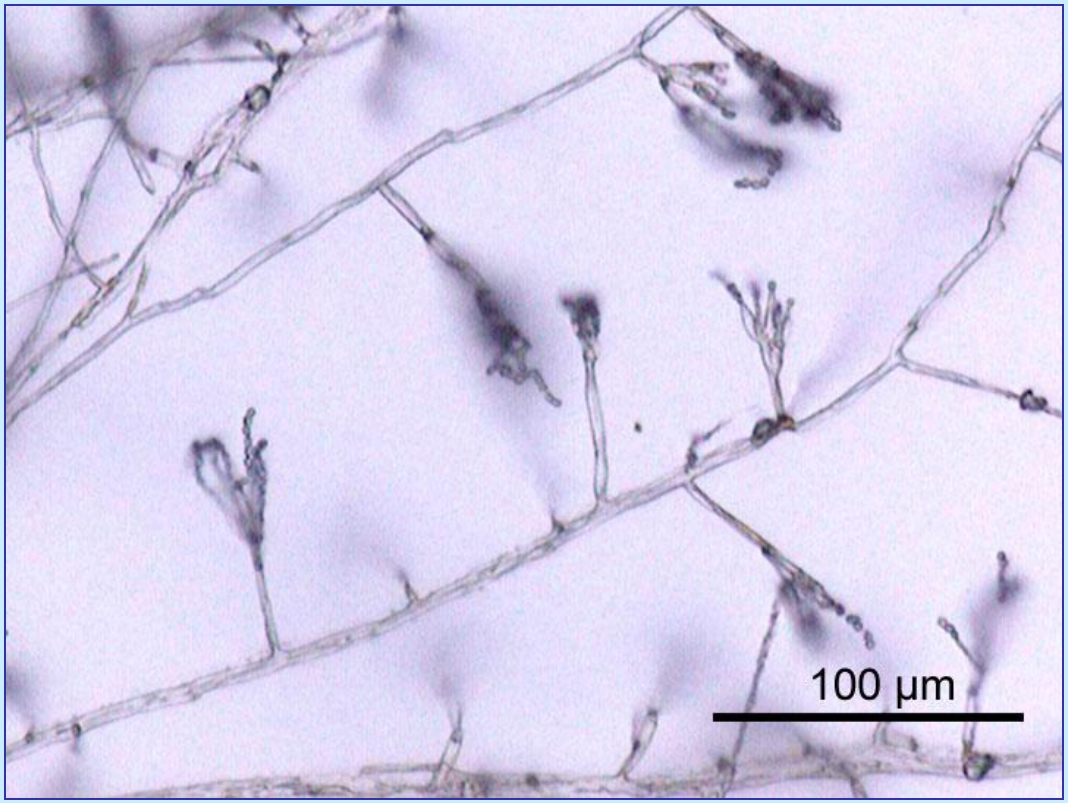
LA STRUTTURA EUCARIOTICA

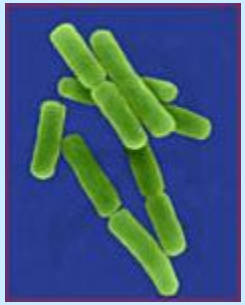
Struttura dei microorganismi



LA STRUTTURA EUCARIOTICA

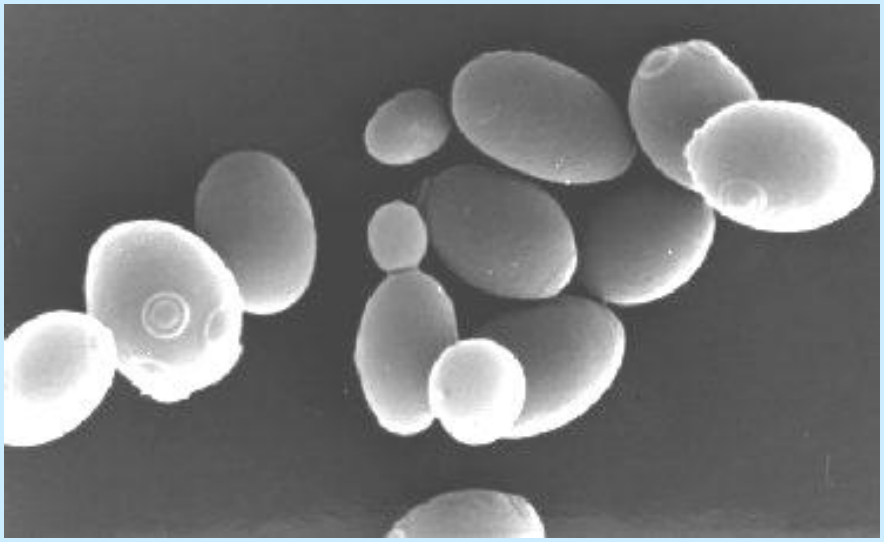
Micelio di Penicillium con ife conidiofore

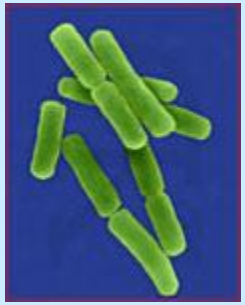




LA STRUTTURA EUCARIOTICA

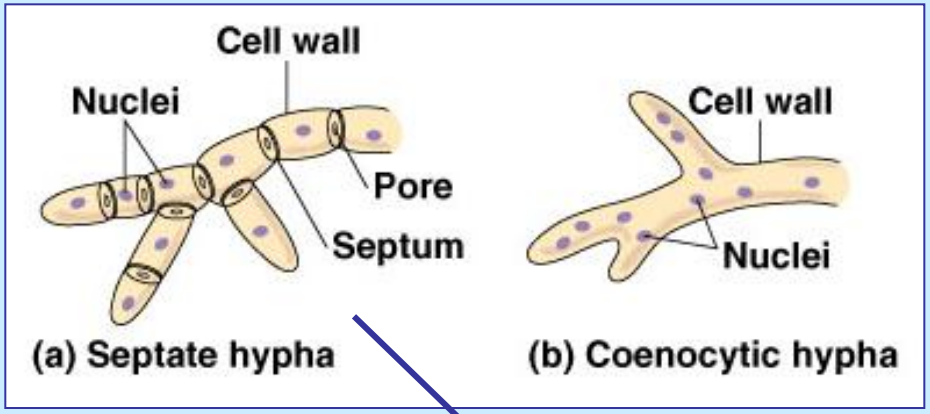
CELLULE DI LIEVITO *Saccharomyces cerevisiae*

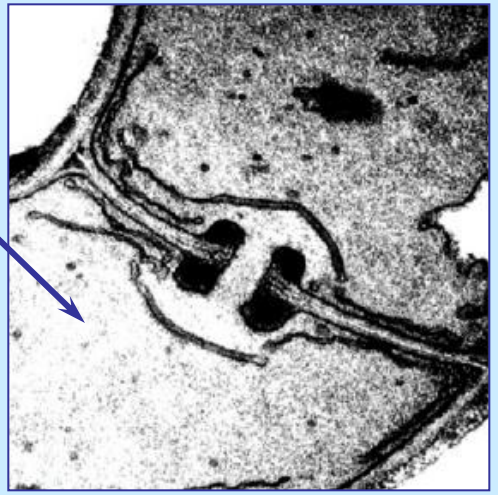


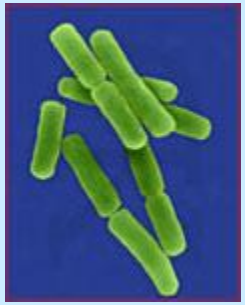


LA STRUTTURA EUCARIOTICA

STRUTTURA DEL MICELIO FUNGINO







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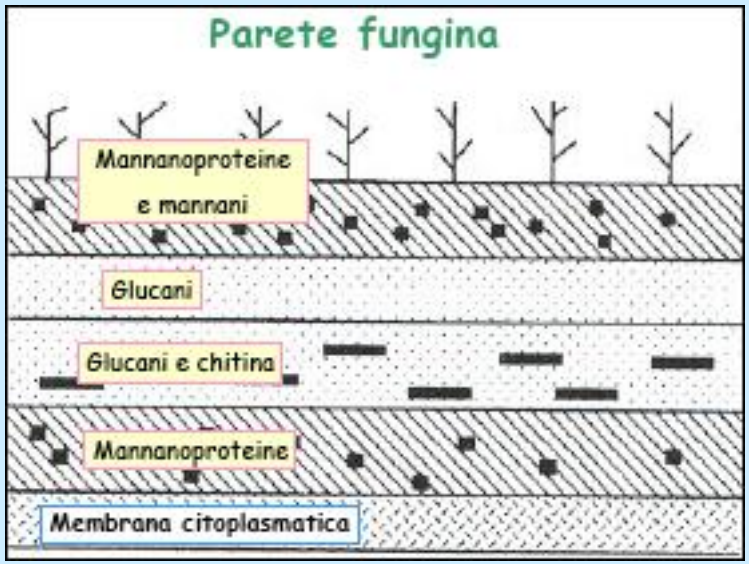
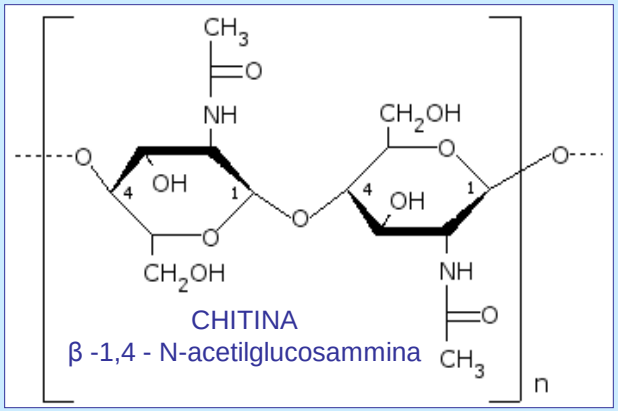
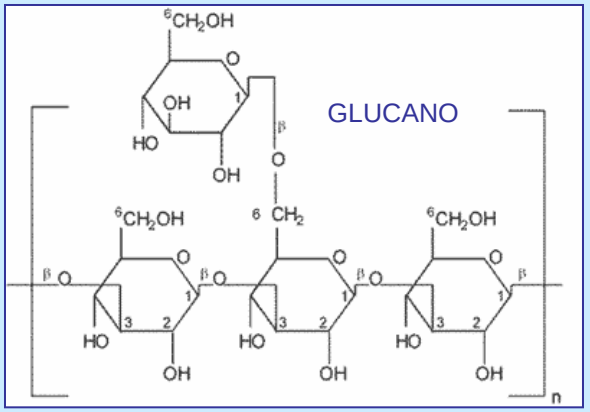
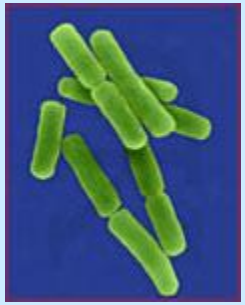




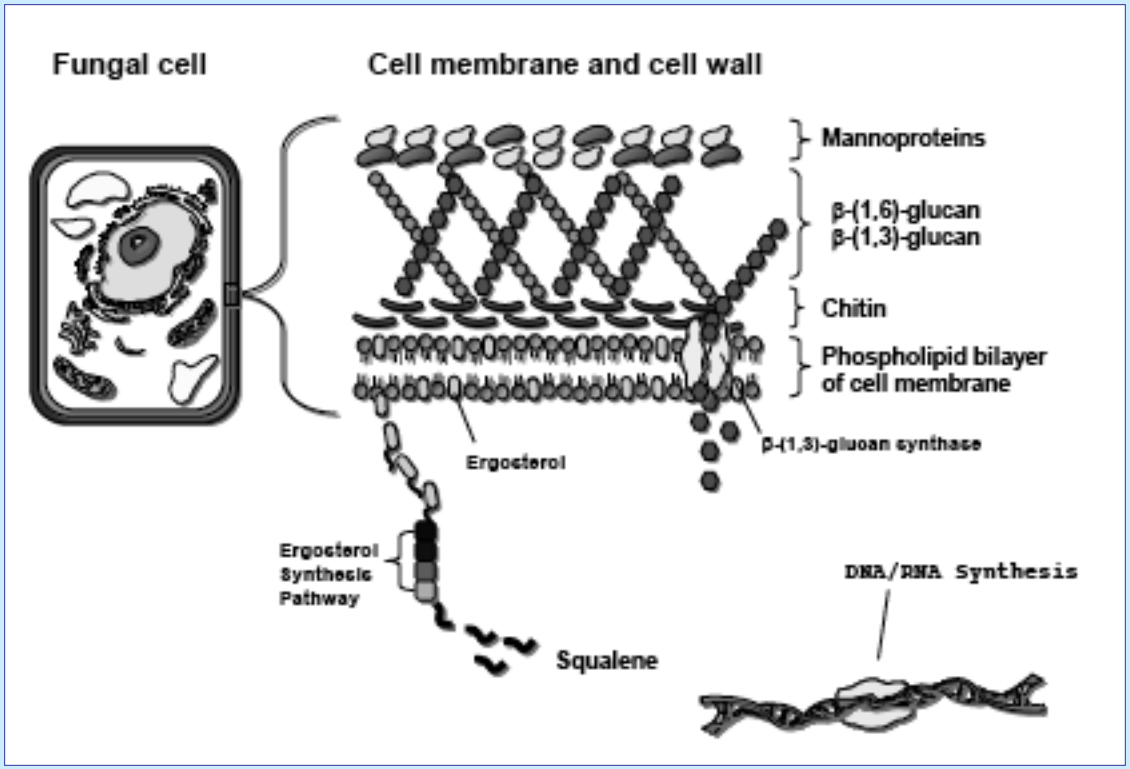


Struttura dei microorganismi

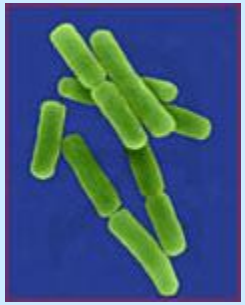



LA STRUTTURA EUCARIOTICA

STRUTTURA DI CELLULA FUNGINA

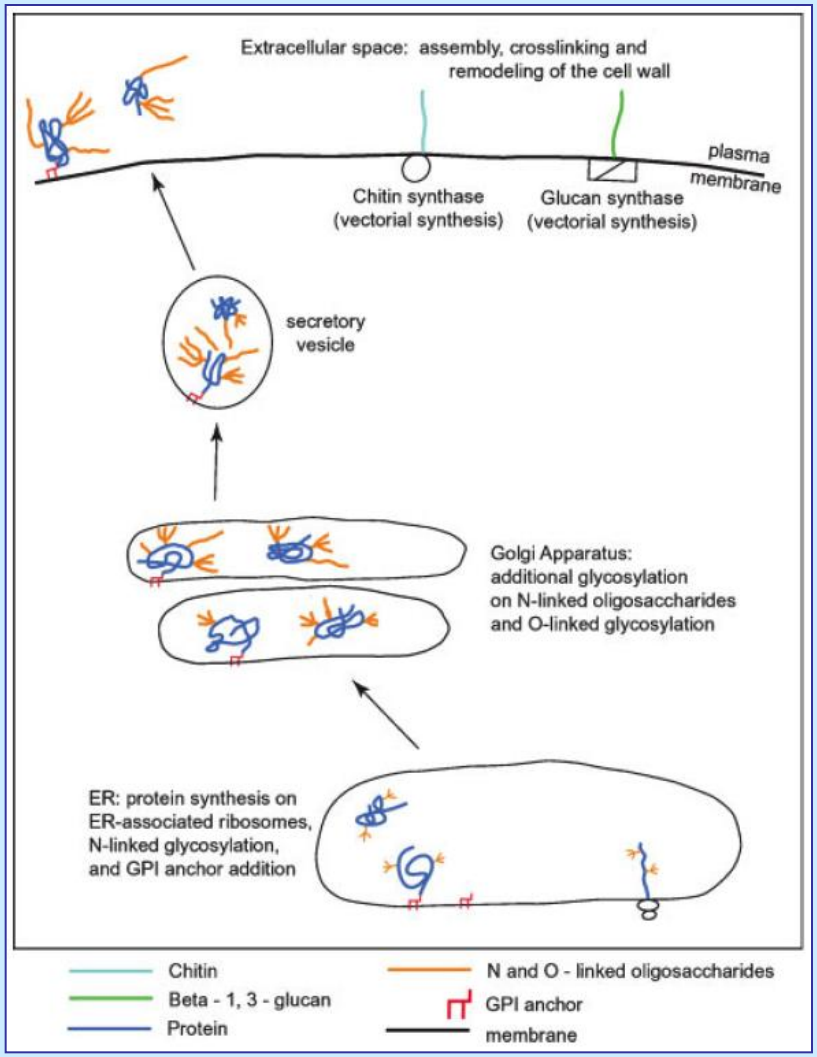


Struttura dei microorganismi



LA STRUTTURA EUCARIOTICA

BIOSINTESI DELLA PARETE FUNGINA



Struttura dei microorganismi