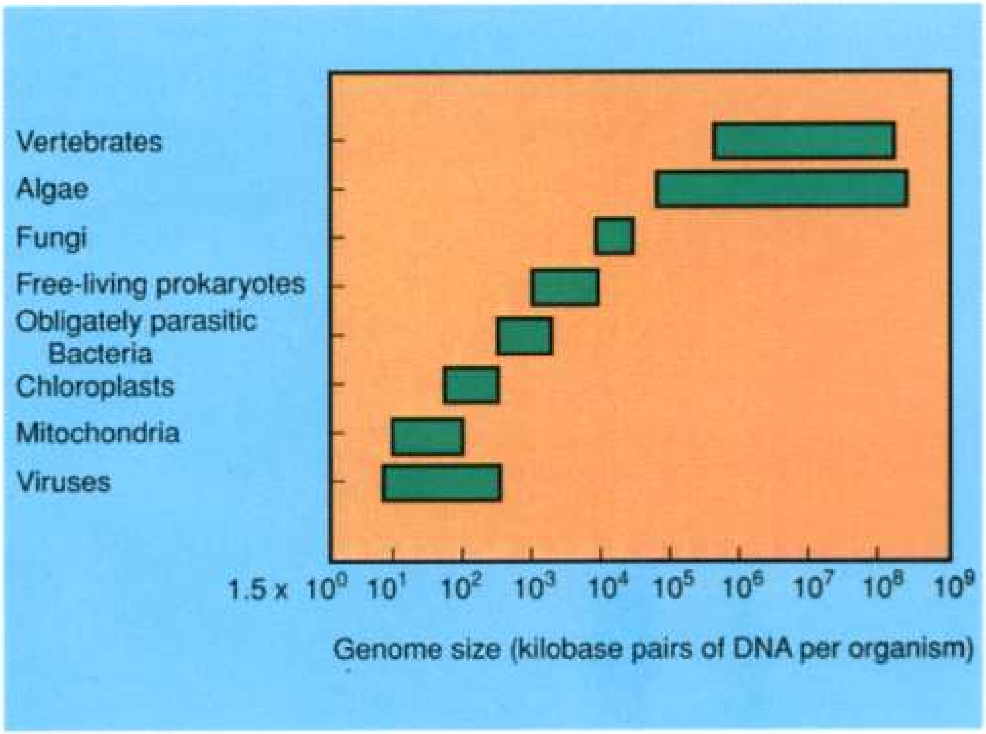
MICROBIOLOGIA GENERALE

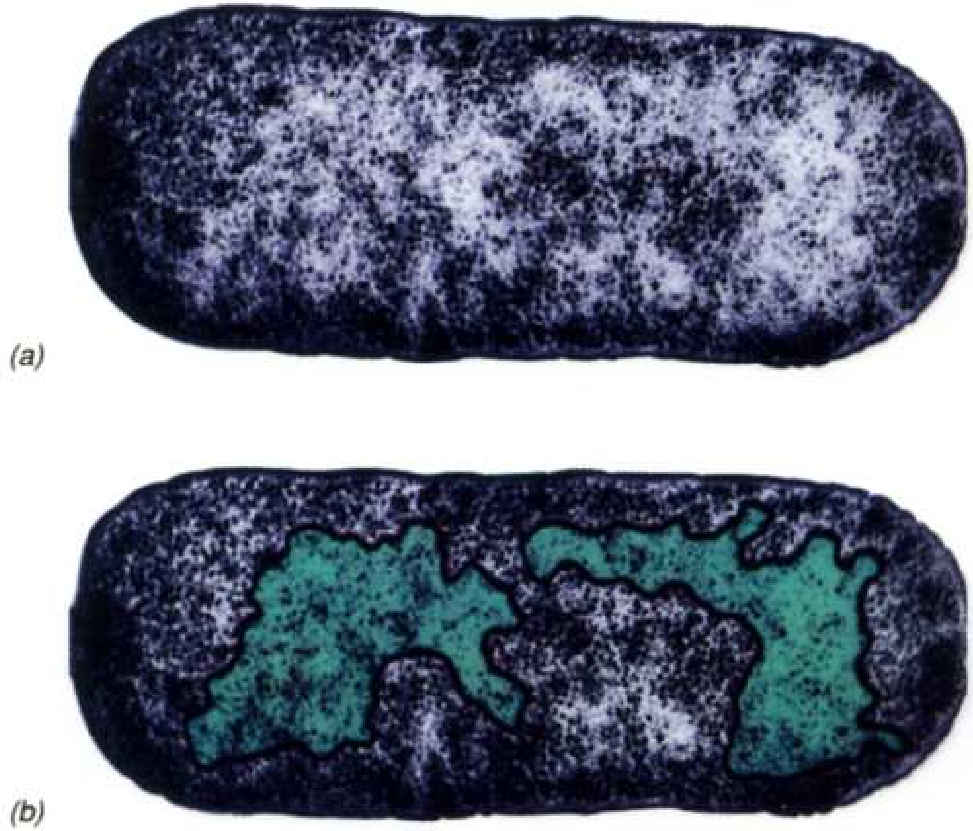
Structure and function of prokaryotic cells 3

Structure and function of prokaryotic cells:

in the cytosol

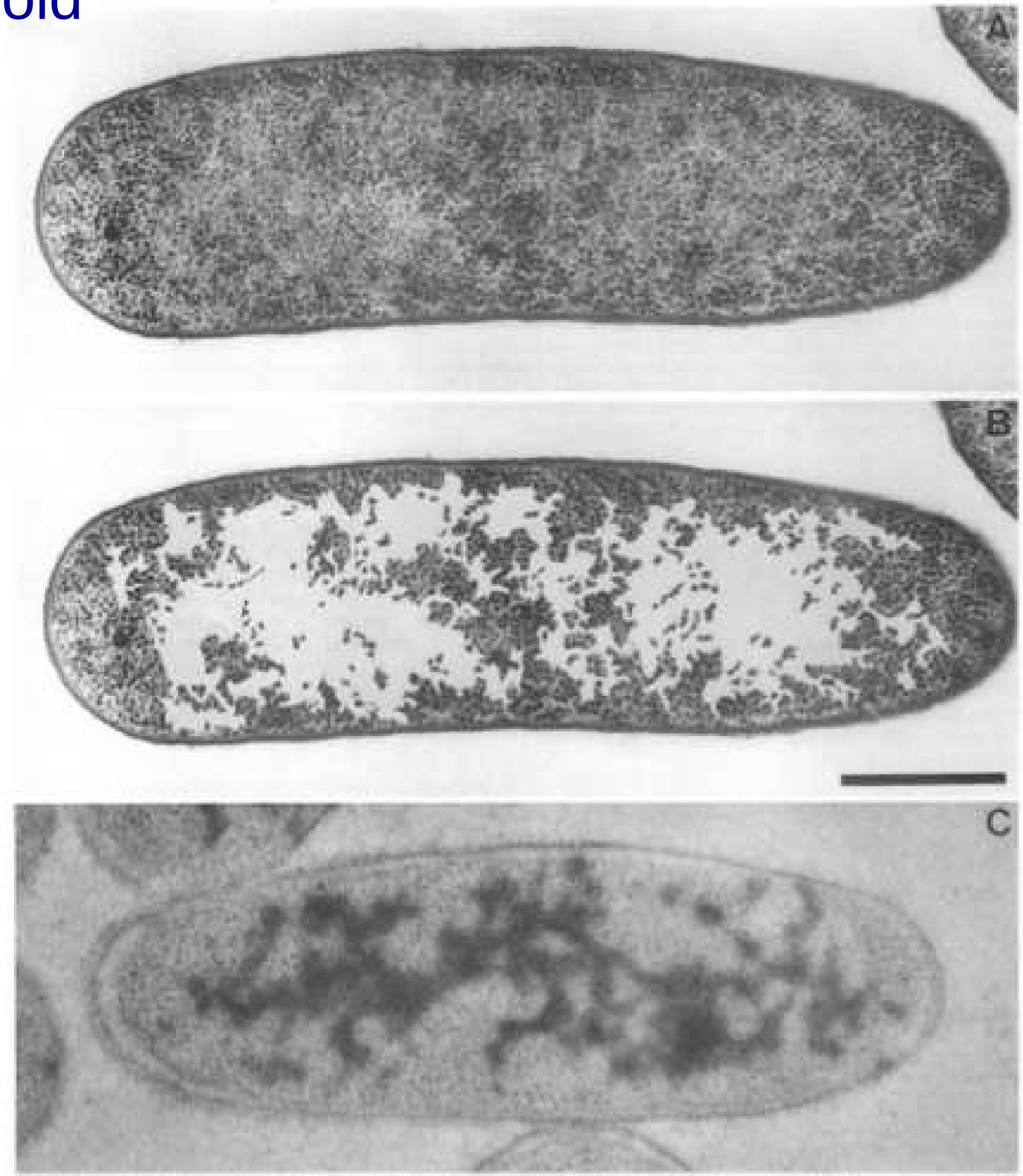
The bacterial chromosome is typically one large circular molecule of DNA free in the cytoplasm



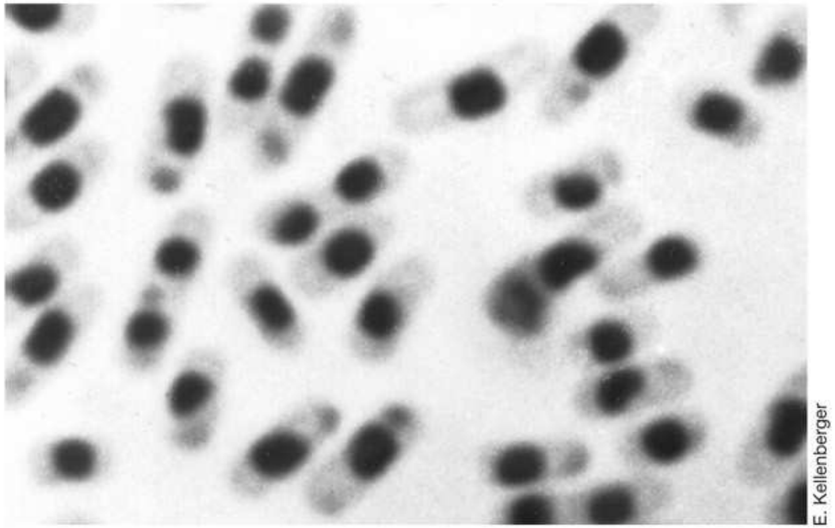


Prokaryotes sometimes possess smaller extrachromosomal pieces of DNA called plasmids.The total DNA content of a prokaryote is referred to as the cell genome

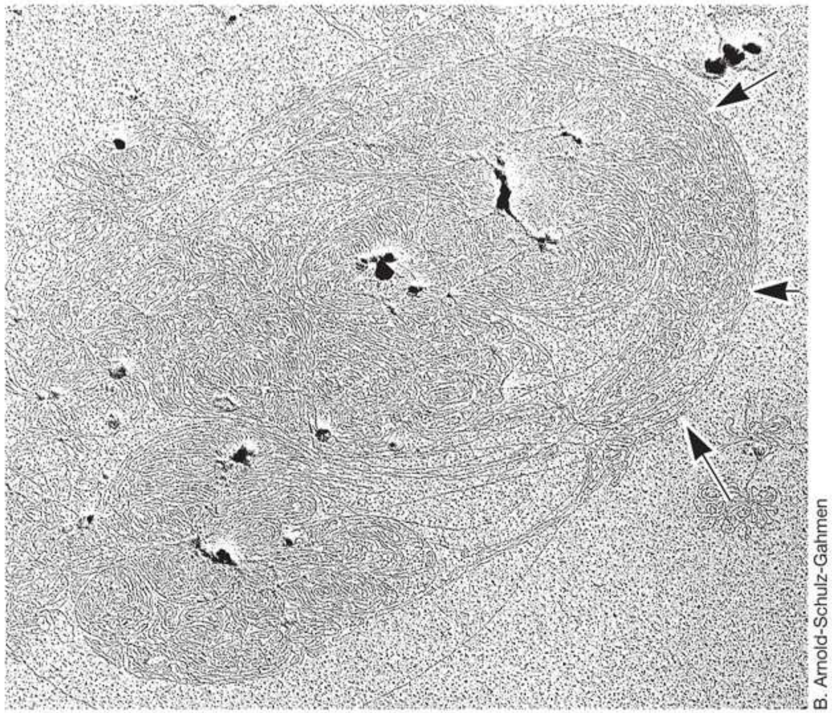
The *Escherichia coli* nucleoid



The prokaryotic nucleoid



(a)

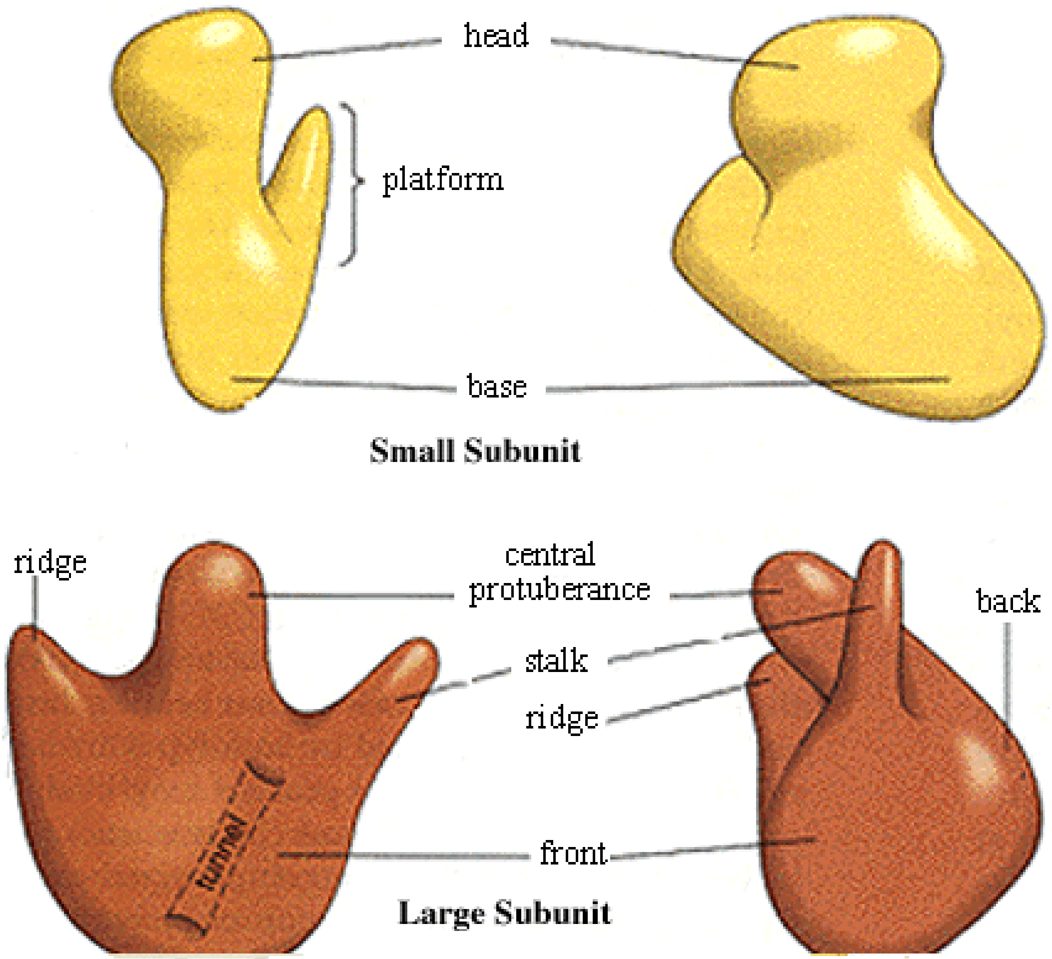


(b)

The bacterial ribosome

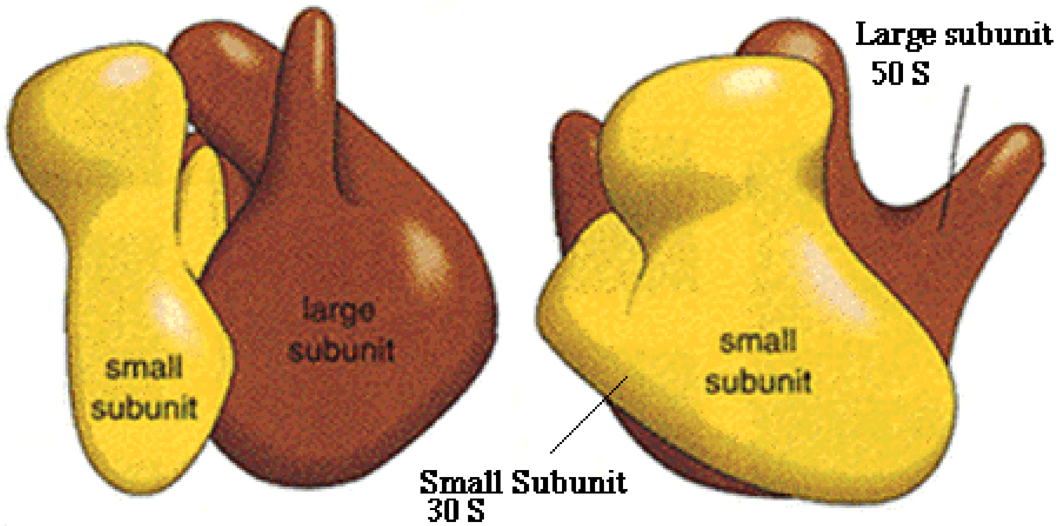
30 S

Type of rRNA	Nt	Subunit location
16 S	1542	30 S
5 S	120	50 S
23 S	2904	50 S



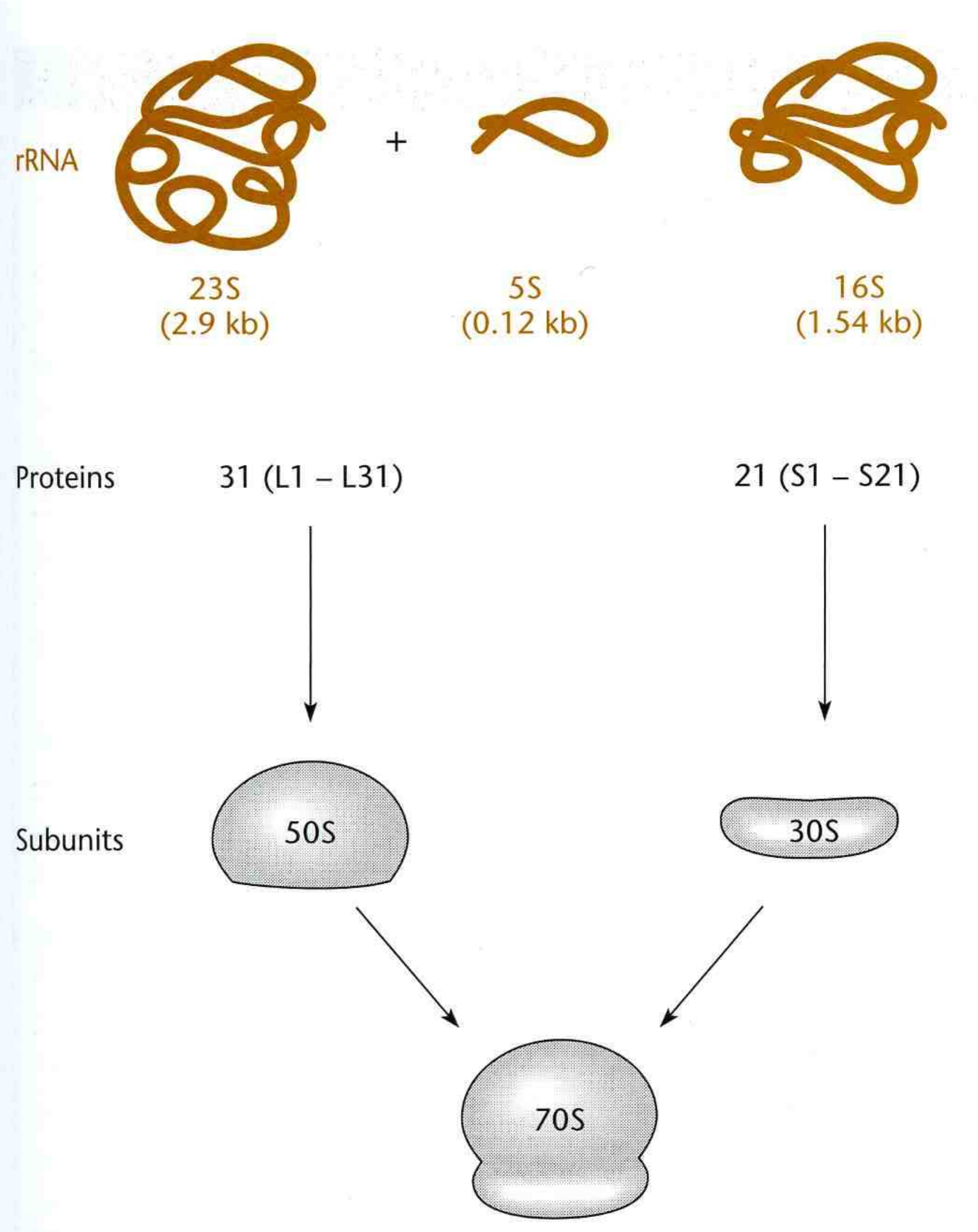
Prokaryotic Ribosomes (70 S)

50 S



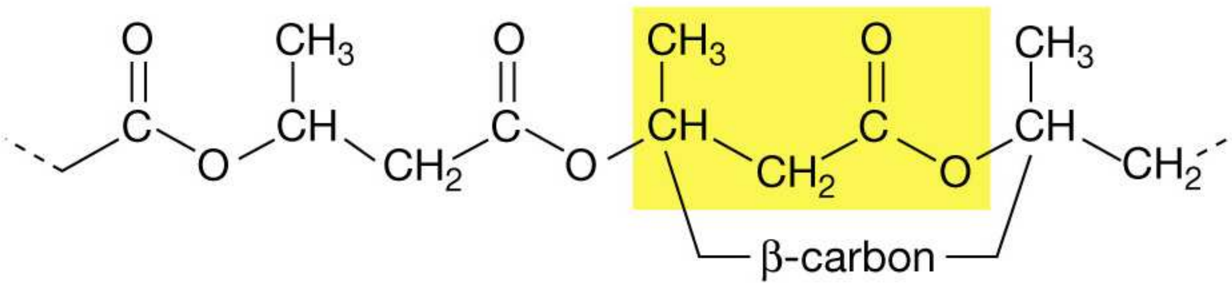
Prokaryotic Ribosomes (70 S)

The composition of a bacterial ribosome

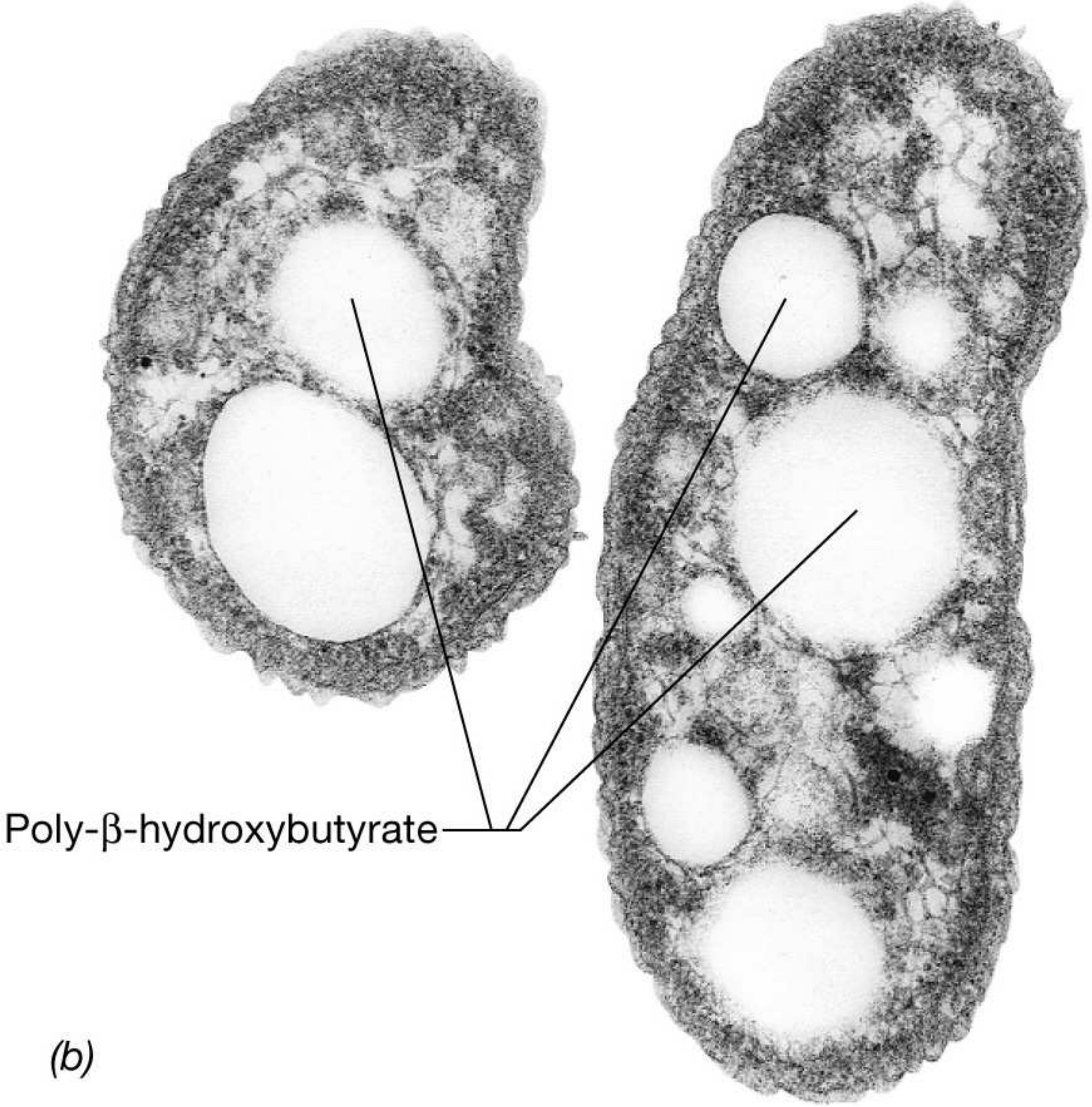


The bacterial inclusions

Inclusions	Where found	Composition	Function
Glycogen	*Escherichia*	polyglucose	reserve C and E
PHB	*Pseudomonas*	polyhydroxy butyrate	reserve C and E
Polyphosphate	*Corynebacterium*	PO_4 polymers	reserve P
Sulfur globes	sulfur bacteria	S	reserve e^- and E
Gas vesicles	aquatic bacteria	shell with gas	floatation
Magnetosomes	aquatic bacteria	Magnetite Fe_3O_4	orienting
Carboxysomes	autotrophic bacteria	enzymes for CO_2 fixation	site of CO_2 fixation
Phycobilisome	cyanobacteria	phycobiliproteins	light-harvesting pigments
Chlorosomes	green bacteria	Lipid, protein, bchl	light-harvesting pigments



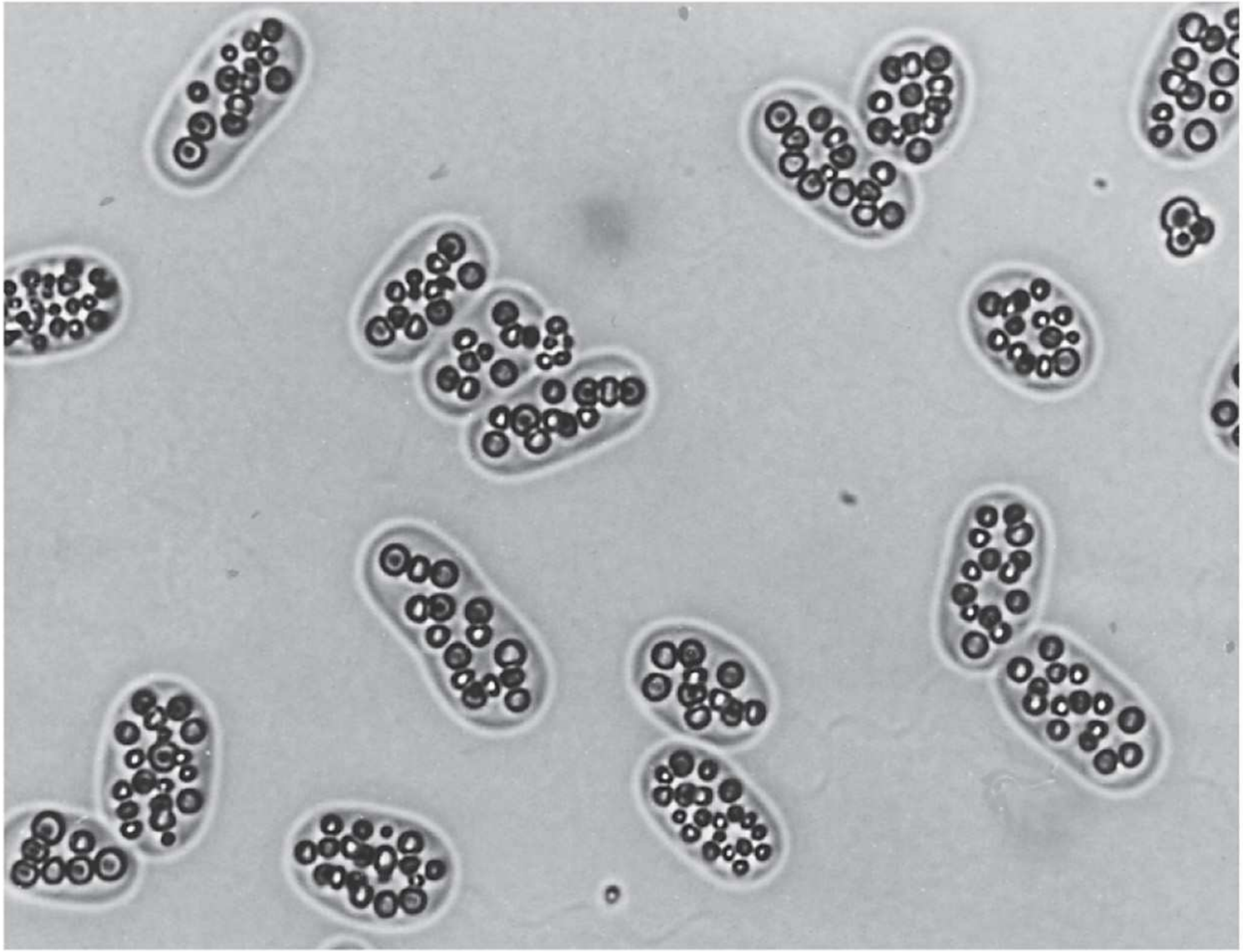
(a)



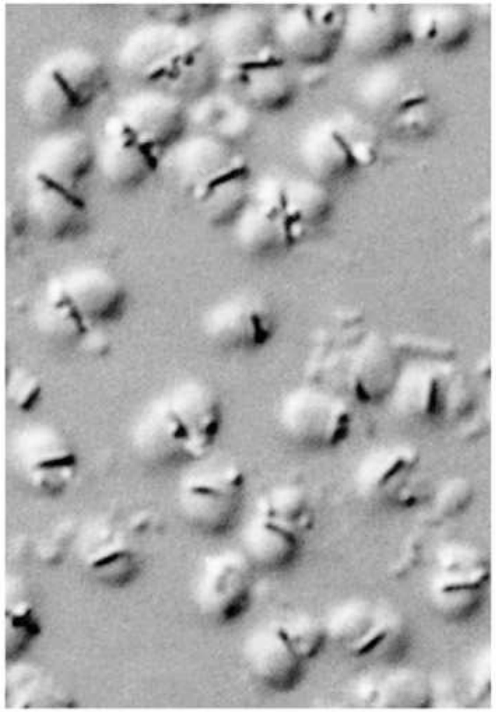
(b)

F. R. Turner and M. T. Madigan

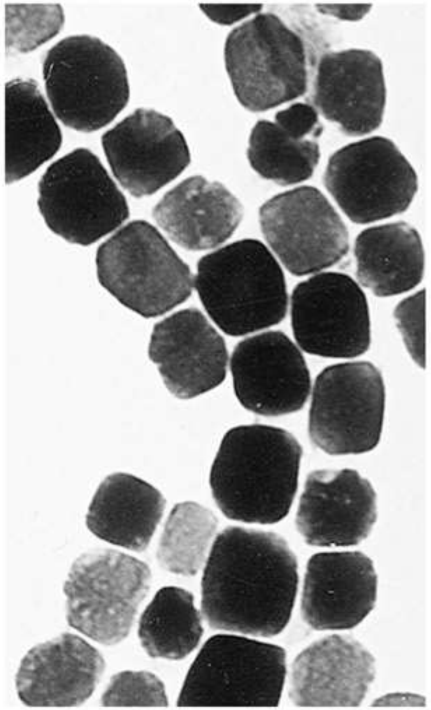
Sulphur globules in the cells of a purple sulfur bacterium



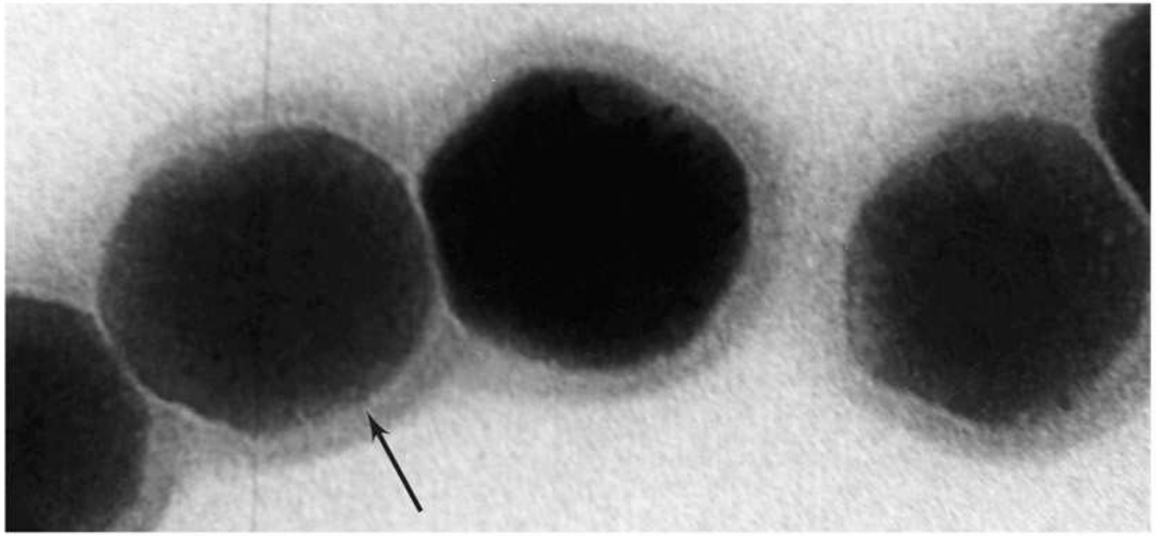
Norbert Pfennig


Stefan Spring

(a)


R. Blakemore and W. O'Brien

(b)

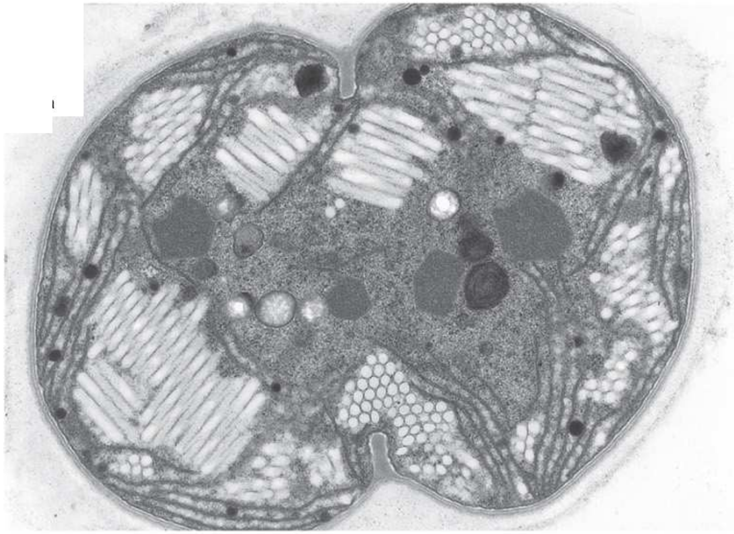

Dennis Bazylinski

(c)

Magnetotactic bacteria and magnetosomes

T. D. Brock

A. E. Walsby

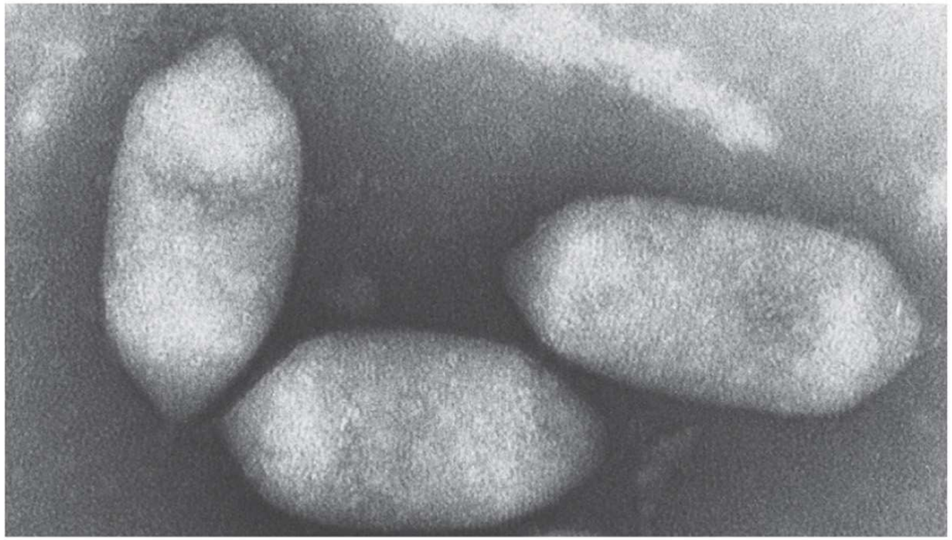


S. Pellegrini and M. Grilli Caiola

(b)

ıa

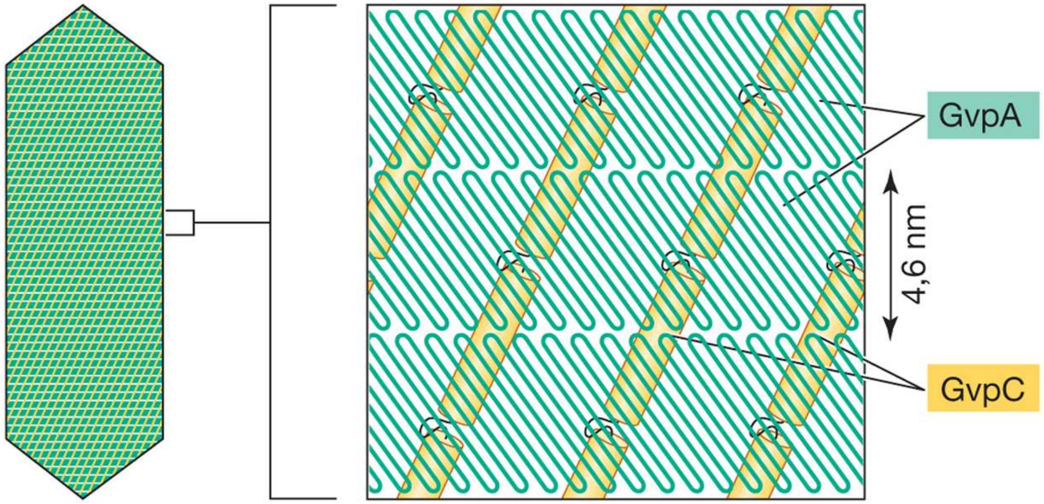
Gas vesiscles of the cyanobacteria *Anabaena* and *Microcystis*



A. E. Konopka and J.T. Staley

Isolated gas vesicles

Gas vesicles proteins

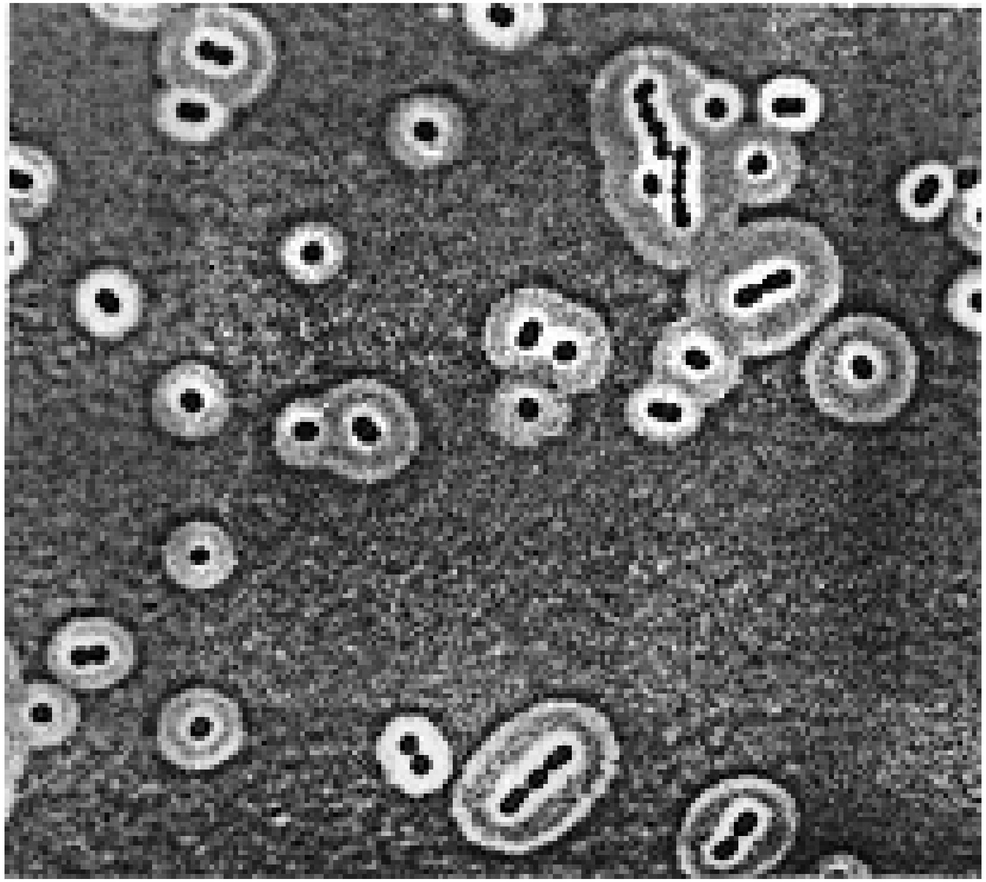


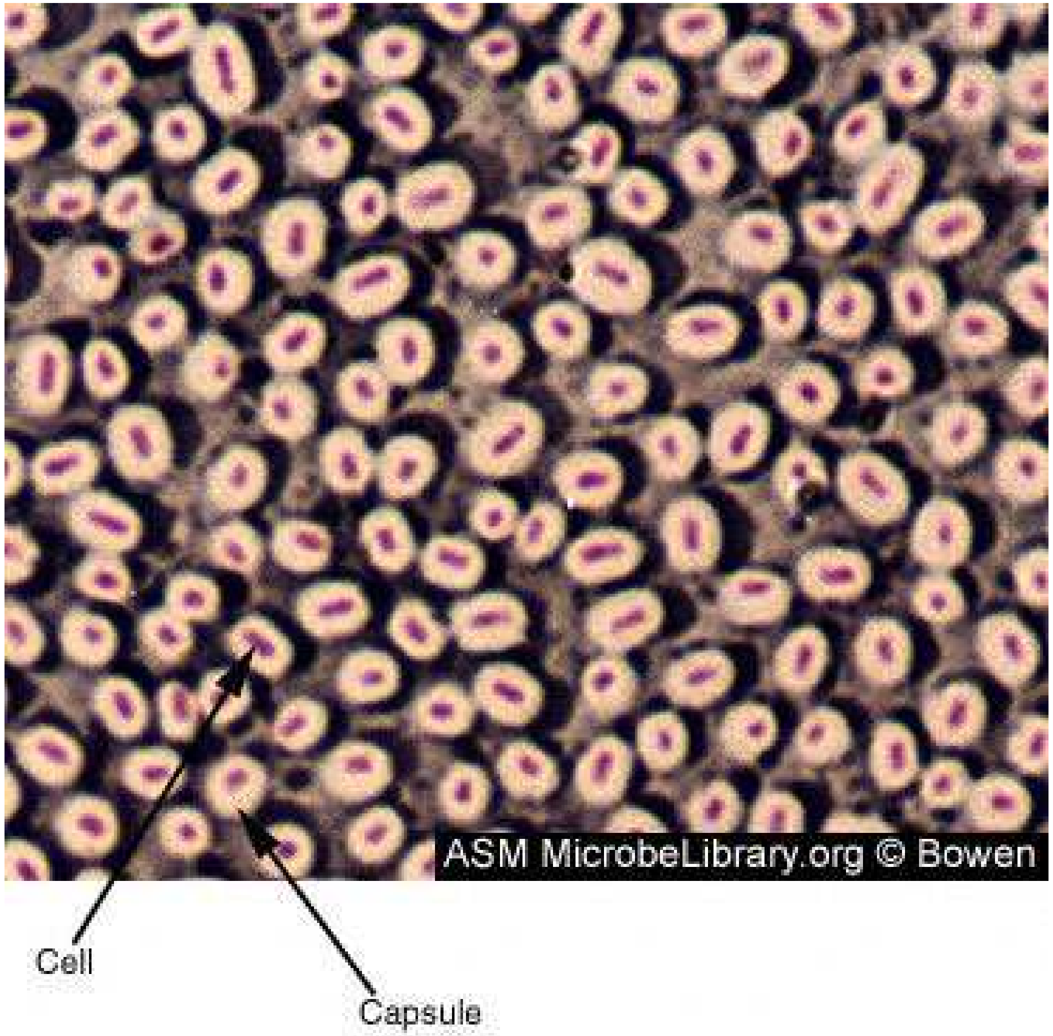
Model of how the two proteins that make up the gas vesicle, GvpA and GvpC,interact to form a watertight but gas-permeable structure. GvpA makes up the rib and is a rigid β-sheet. GvpC is the cross-linker and is of an a-helix structure

Structure and function of prokaryotic cells:

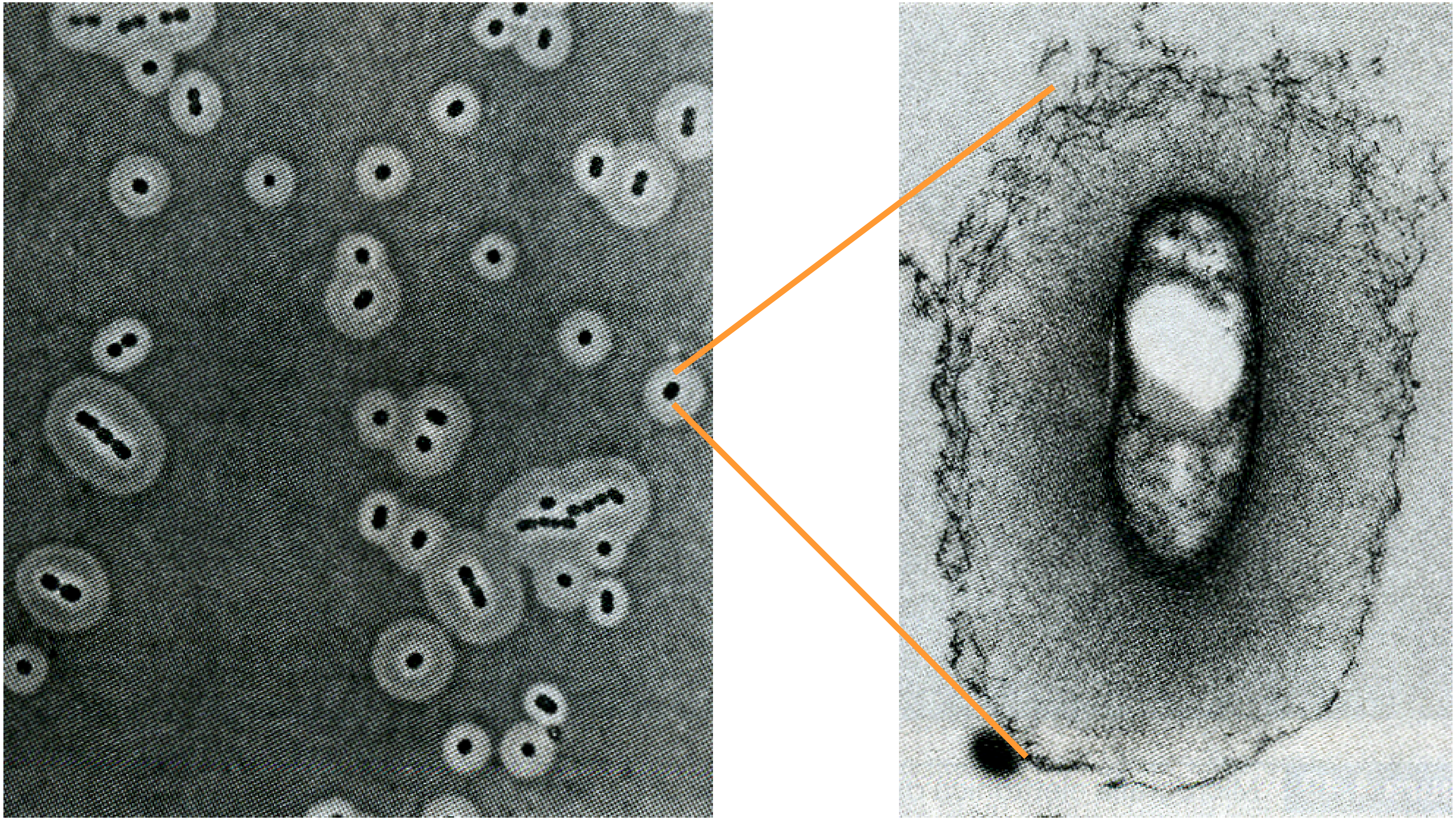
the capsule

Bacterial capsule outlined by India ink stain

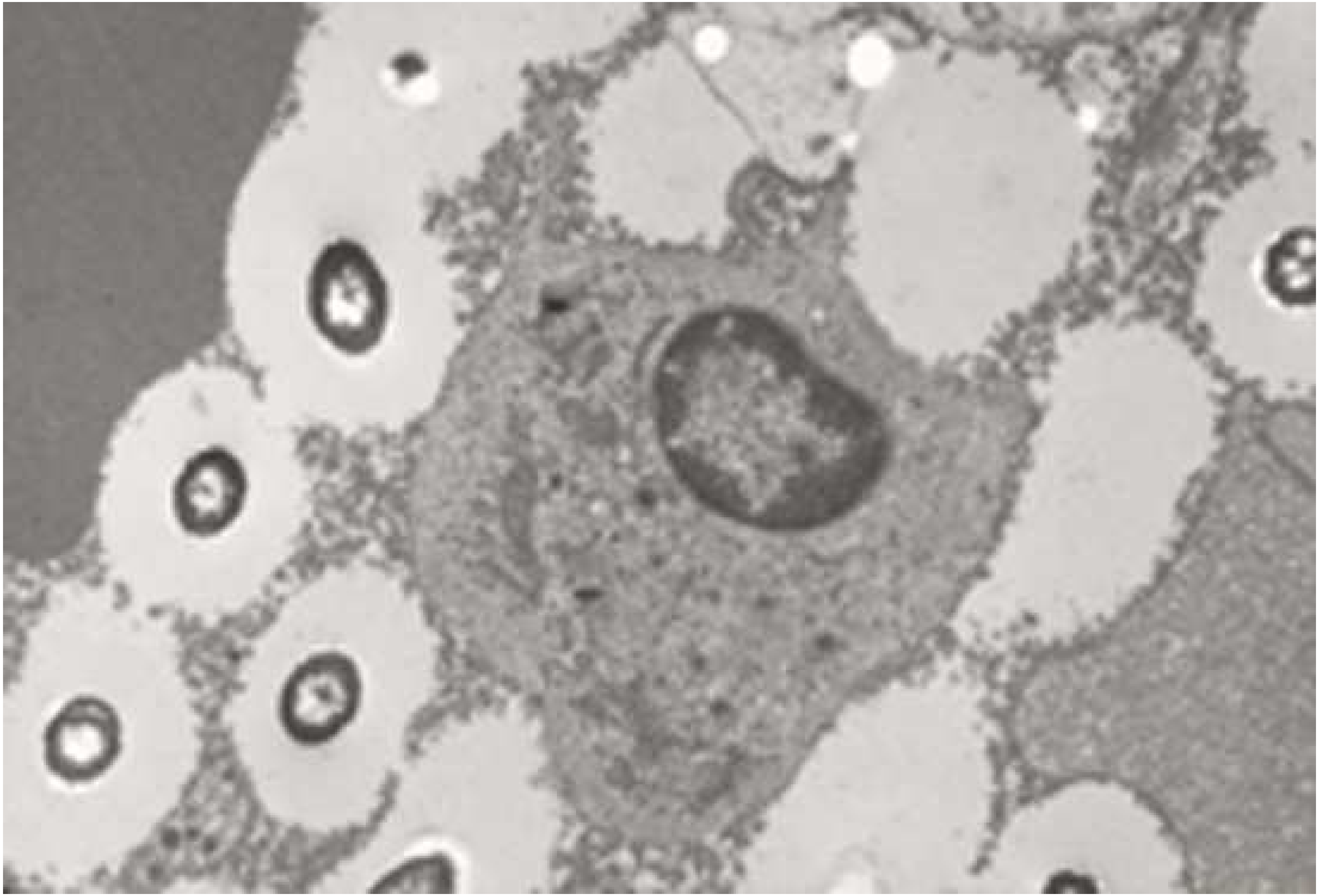




The bacterial capsule



A macrophage surrounded by *Bacillus anthracis*. Clear spaces represent capsule material that prevents uptake by the cell and killing of bacteria.



The bacterial capsule functions

A true capsule is a discrete detectable layer of polysaccharides or peptides deposited outside the cell wall

- Like fimbriae, capsules mediate cell adherence to surfaces

- Capsules protect bacteria from engulfment by predatory protozoa or phagocytes, or from attack by antimicrobial agents of plant or animal origin

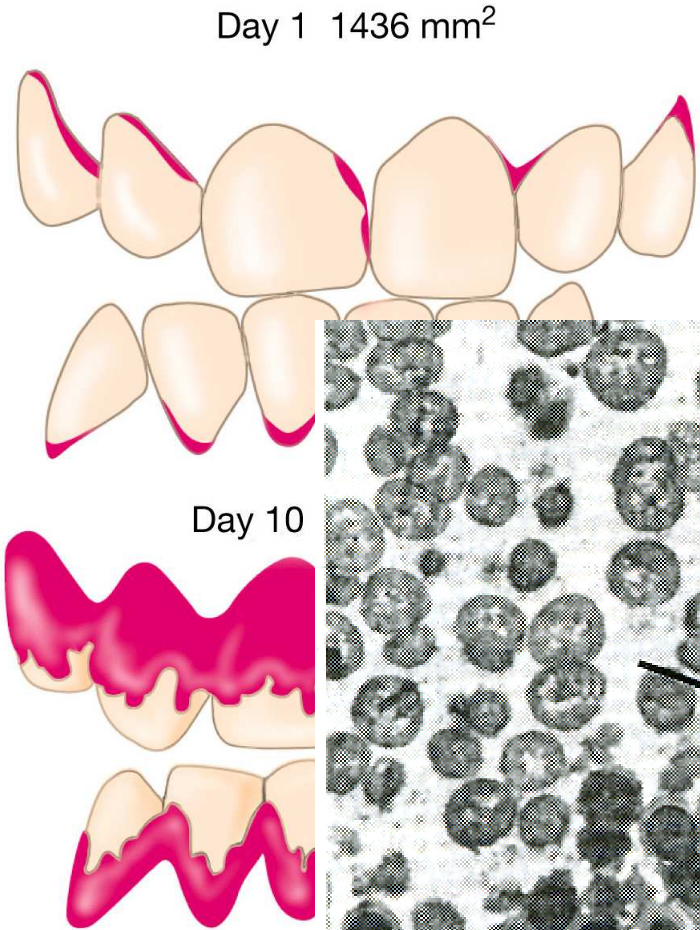
- Capsules in certain sole bacteria protect them from driyng or desiccation

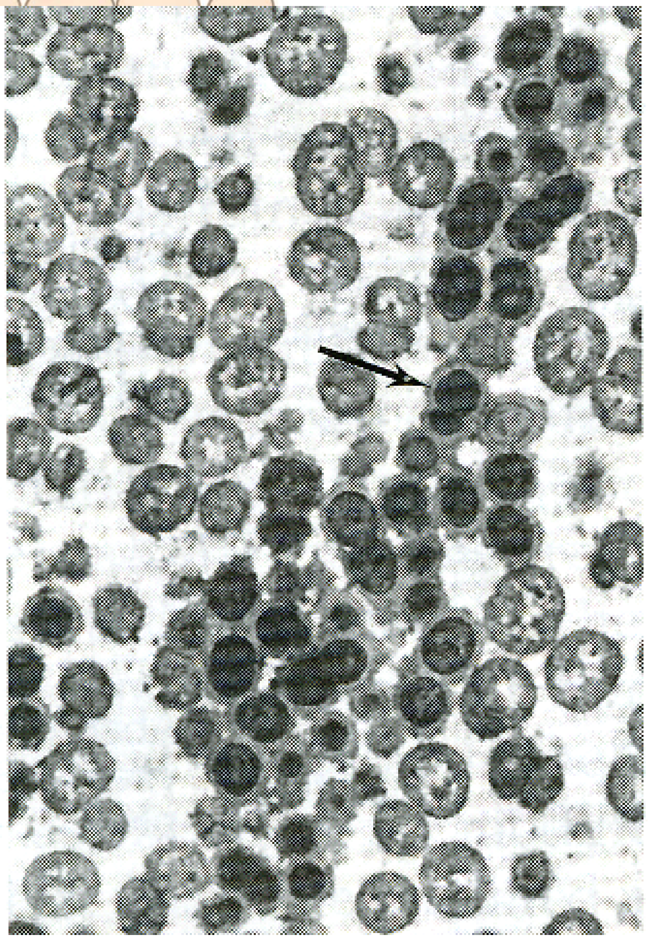
- Capsular materials may be overproduced when bacteria are fed with sugars to become reserve of carbohydrate

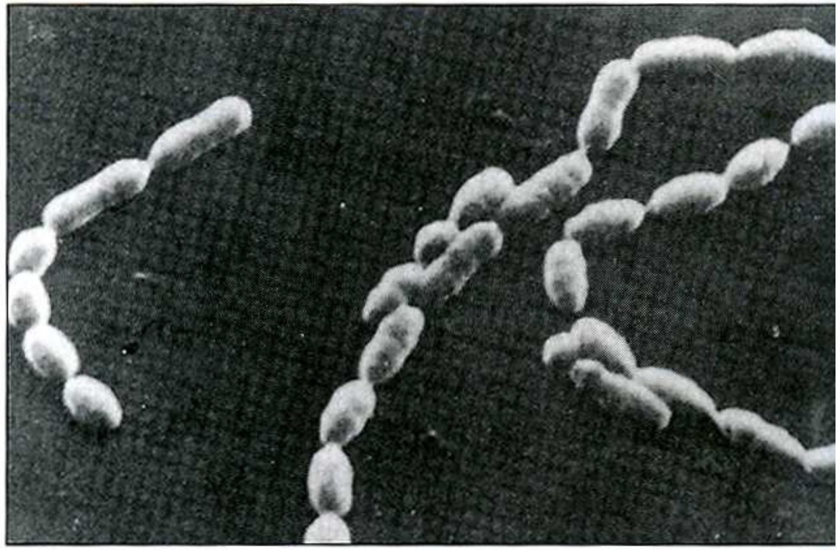
Chemical composition of some bacterial capsules

Bacterium	Capsule	Structural subunits
Gram-positive		
Bacillus anthracis	polypeptide	D-glutamic acid
Streptococcus mutans	polysaccharyde	(dextran) glucose
Streptococcus pyogenes	polysaccharyde	NAG, glucuronic acid
Streptococcus pneumoniae	polysaccharyde	sugars, amino sugars, uronic acis
Gram-negative		
Escherichia coli	polysaccharyde	glucose, galactose
Pseudomonas aeruginosa	polysaccharyde	mannuronic acid

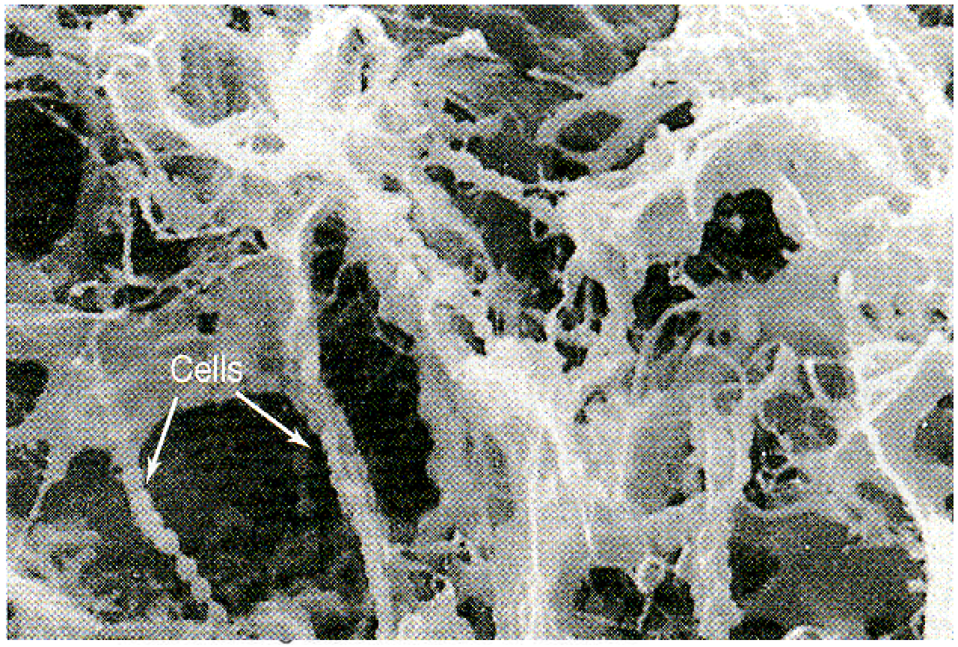
The dental plaque and dental caries







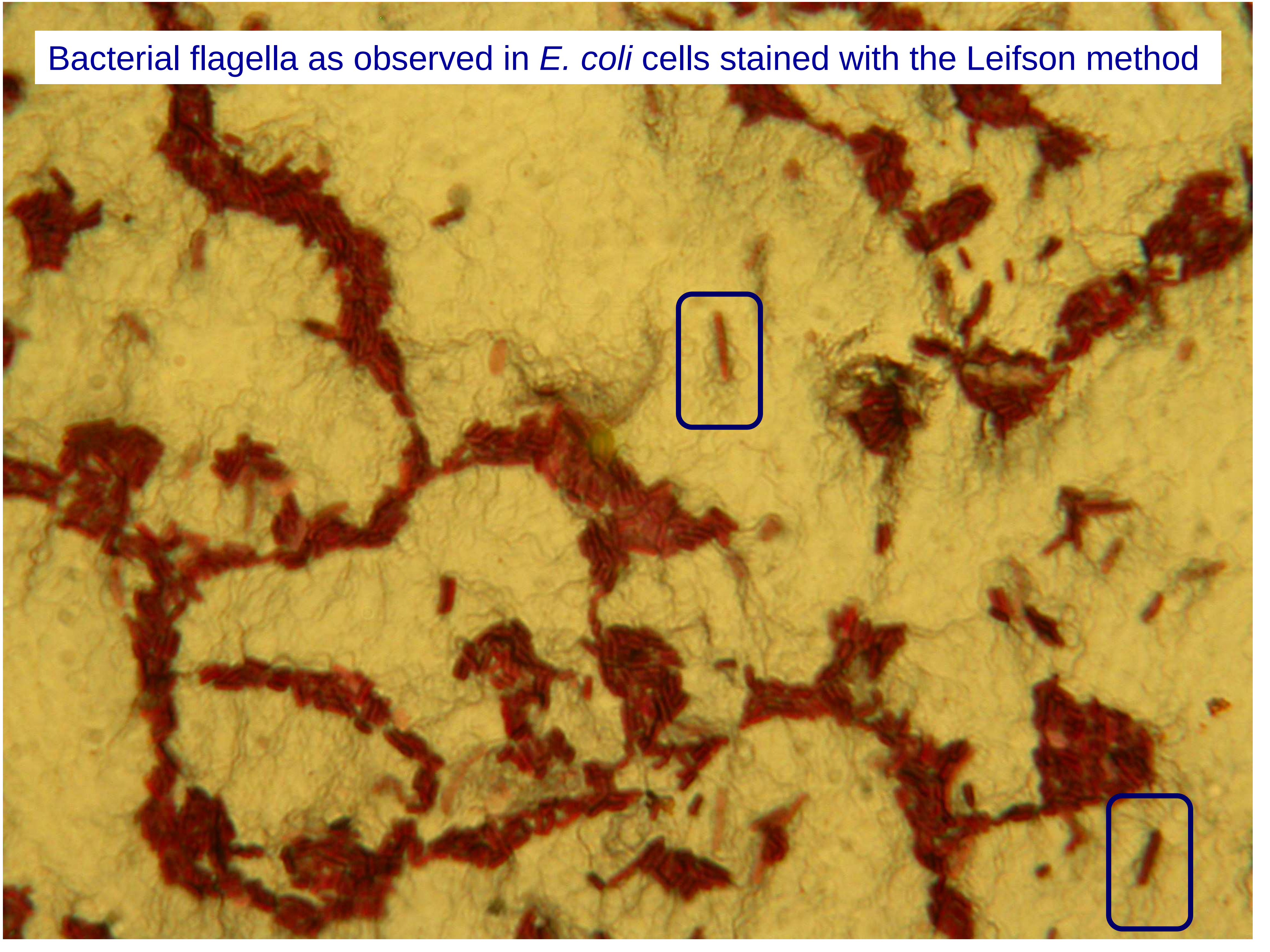
(a) *S. mutans* growing in glucose broth.



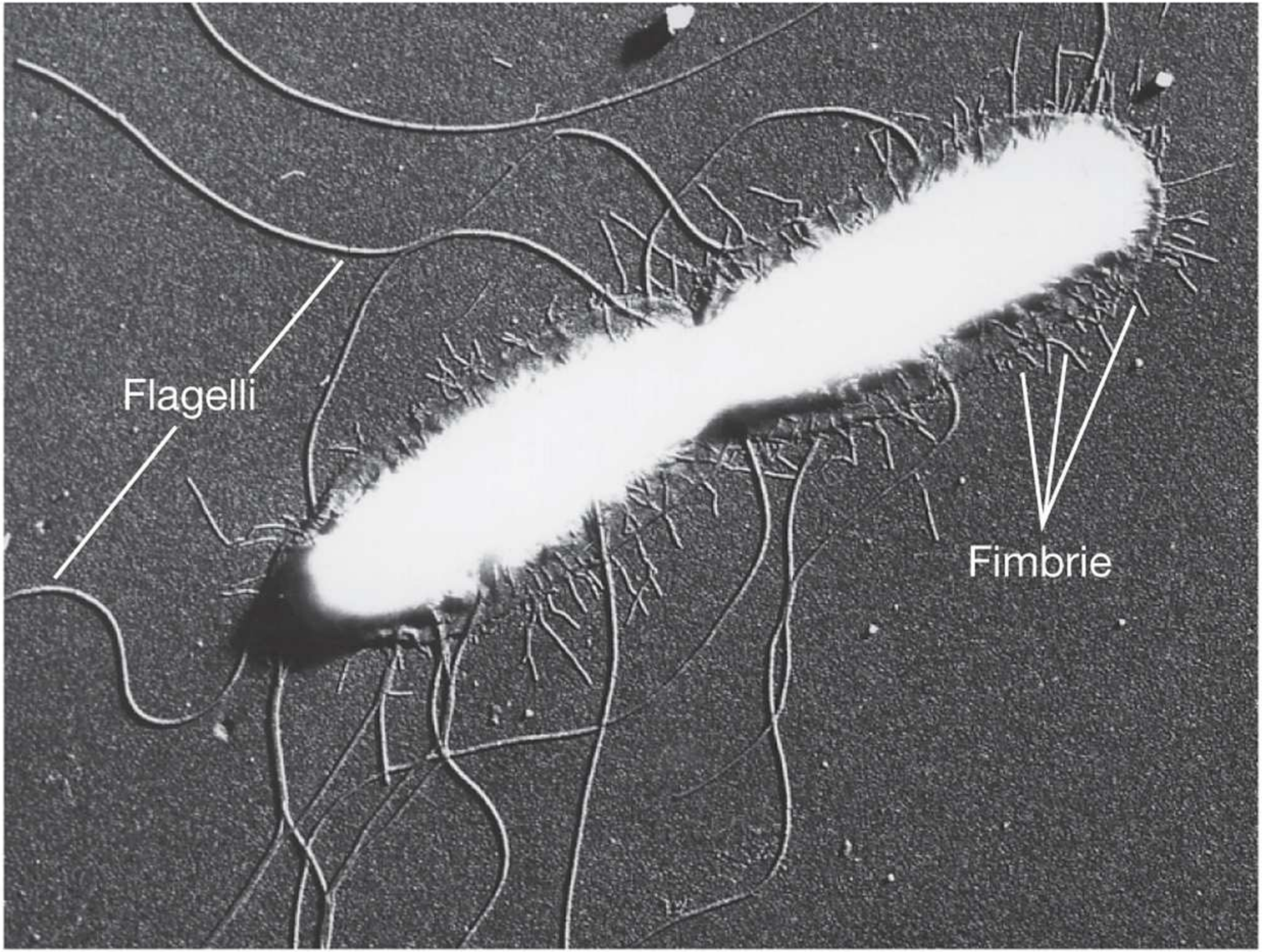
Structure and function of prokaryotic cells:

flagella and mobility

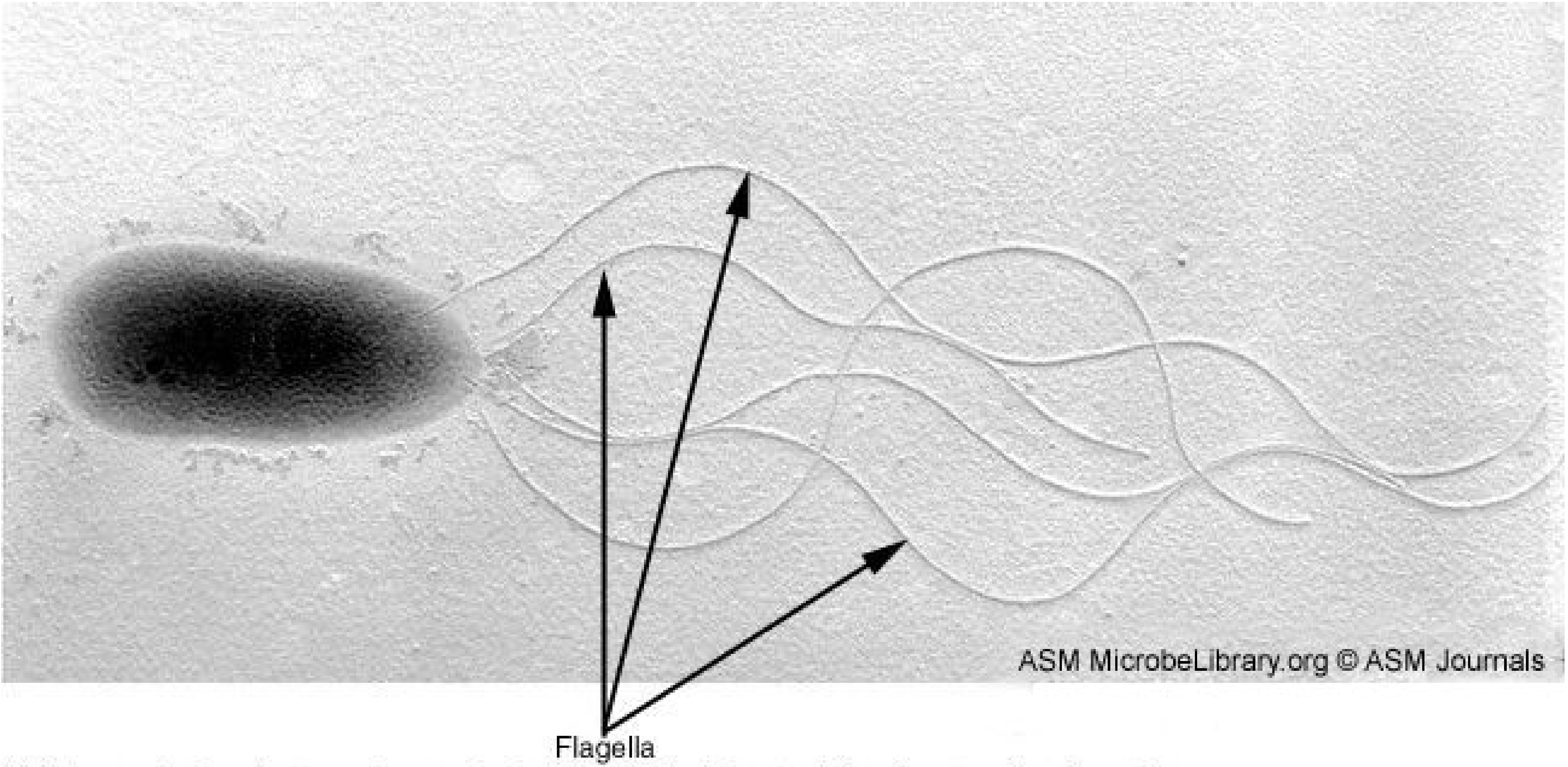
Bacterial flagella as observed in *E. coli* cells stained with the Leifson method



EM of a dividing *Salmonella typhi* showing flagella and fimbriae

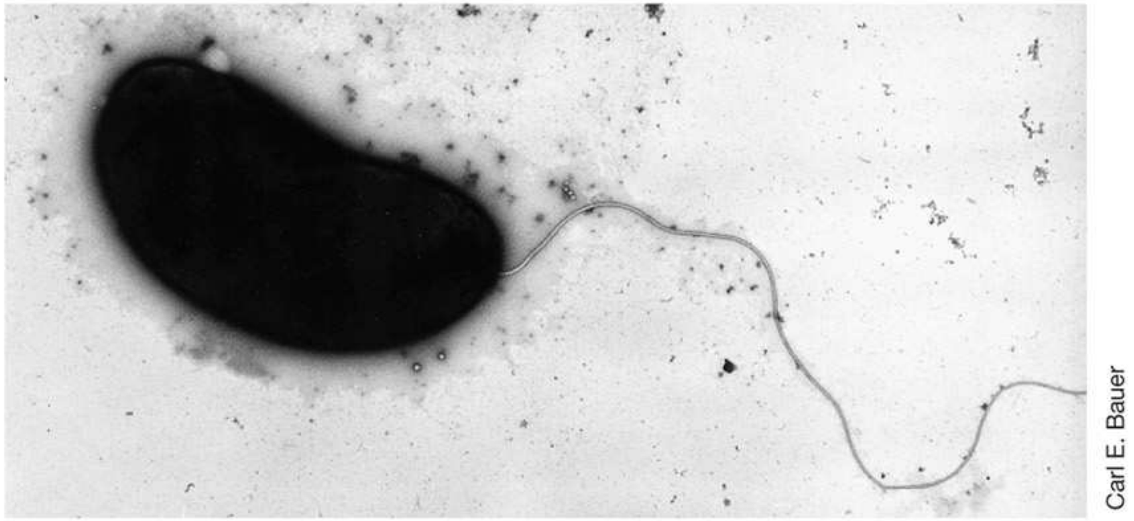


J. P. Duguid and J. F. Wilkinson

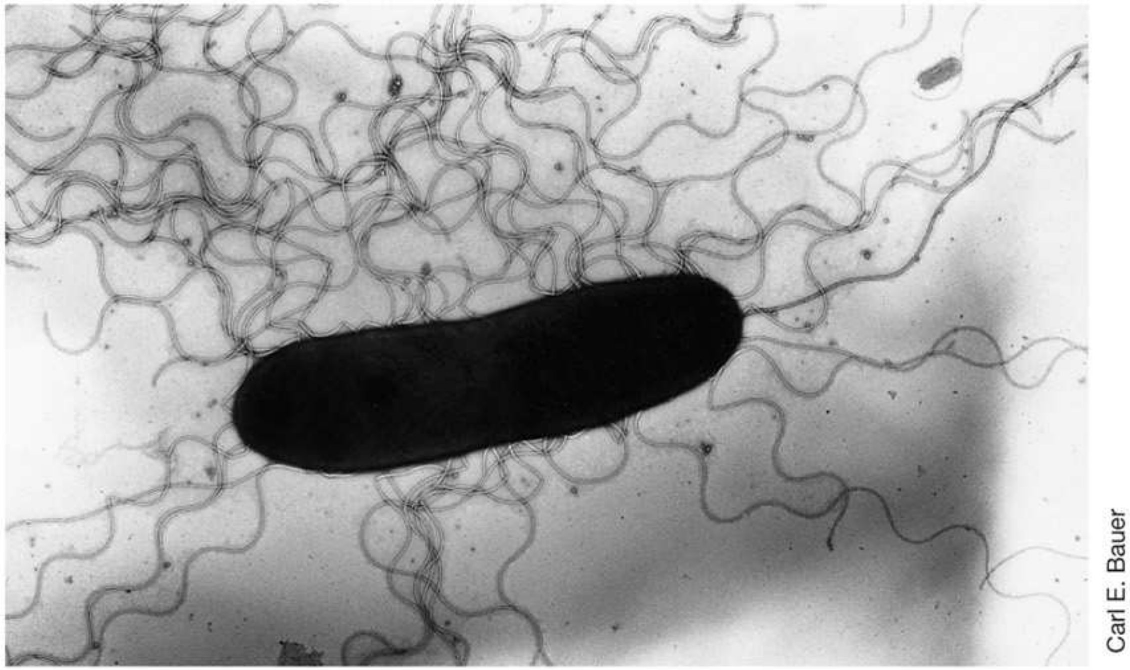


This transmission electron micrograph shows six polarly located flagella extending from the bacterium, *Pseudomonas putida*. In this case, the cell is 2 μm in length, and each flagellum is ~5 to 7 μm long.

Fine structure of bacterial flagella

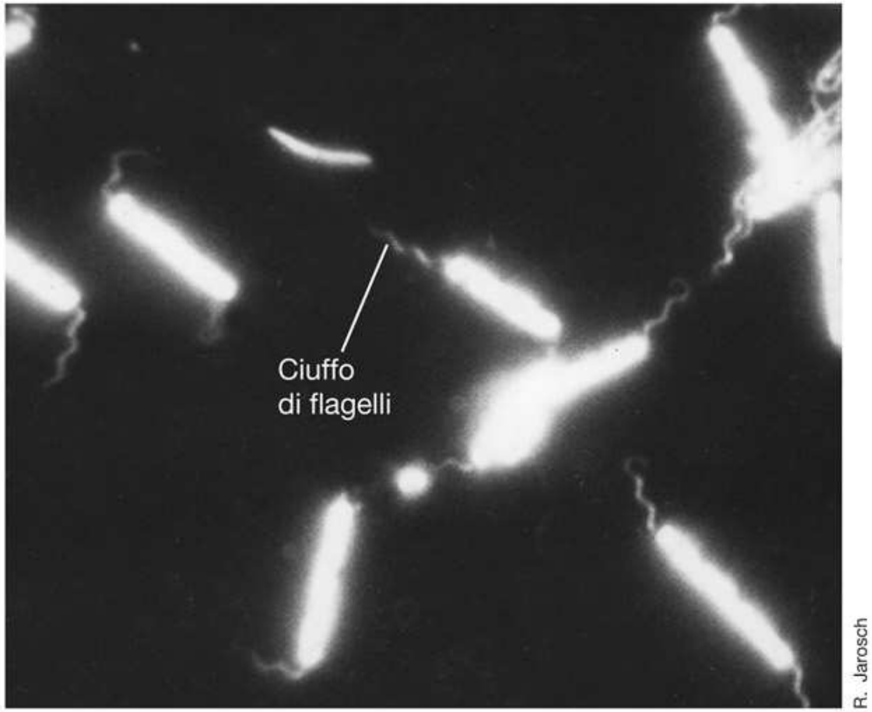


(a)



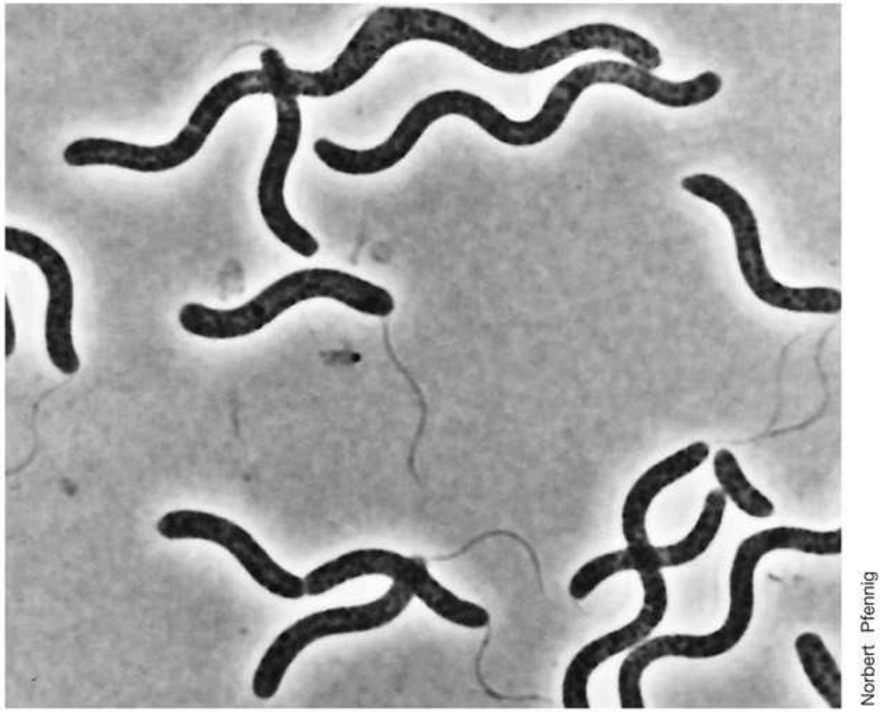
(b)

Bacterial flagella as observed in living cells



(a)

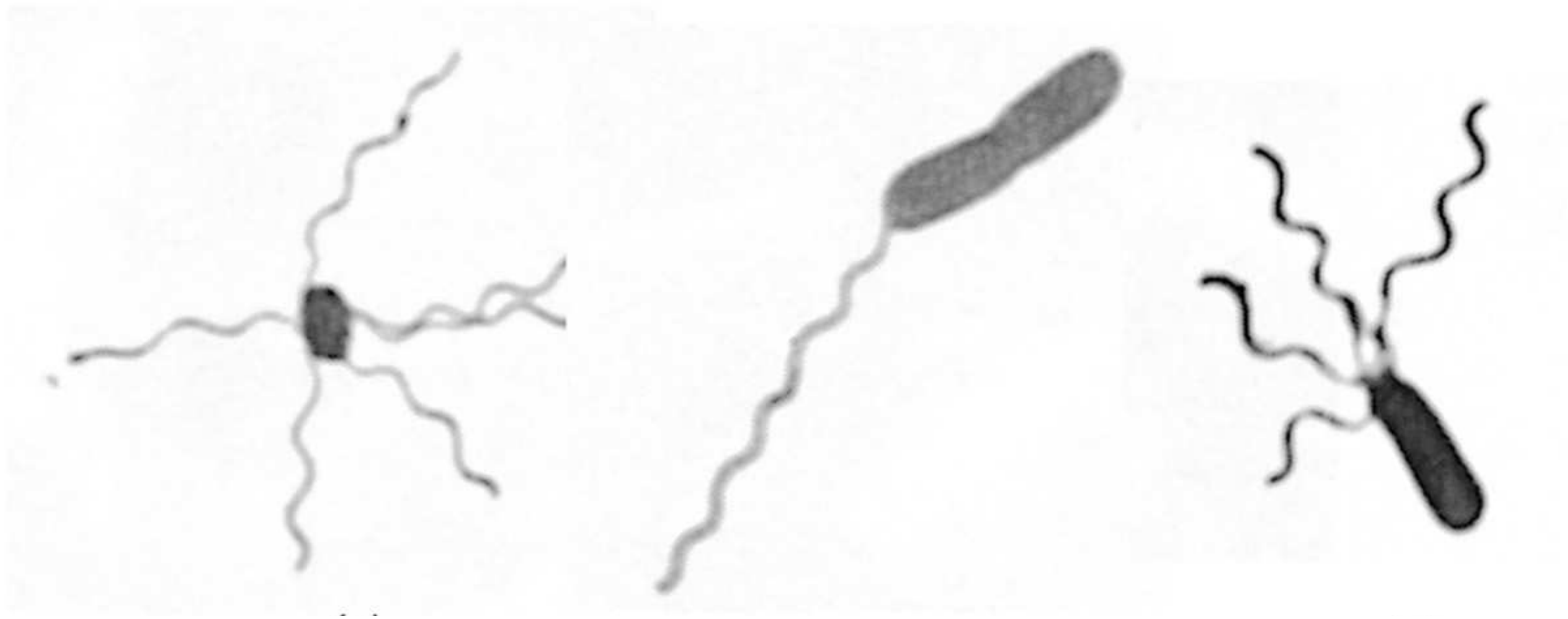
Dark-field



(b)

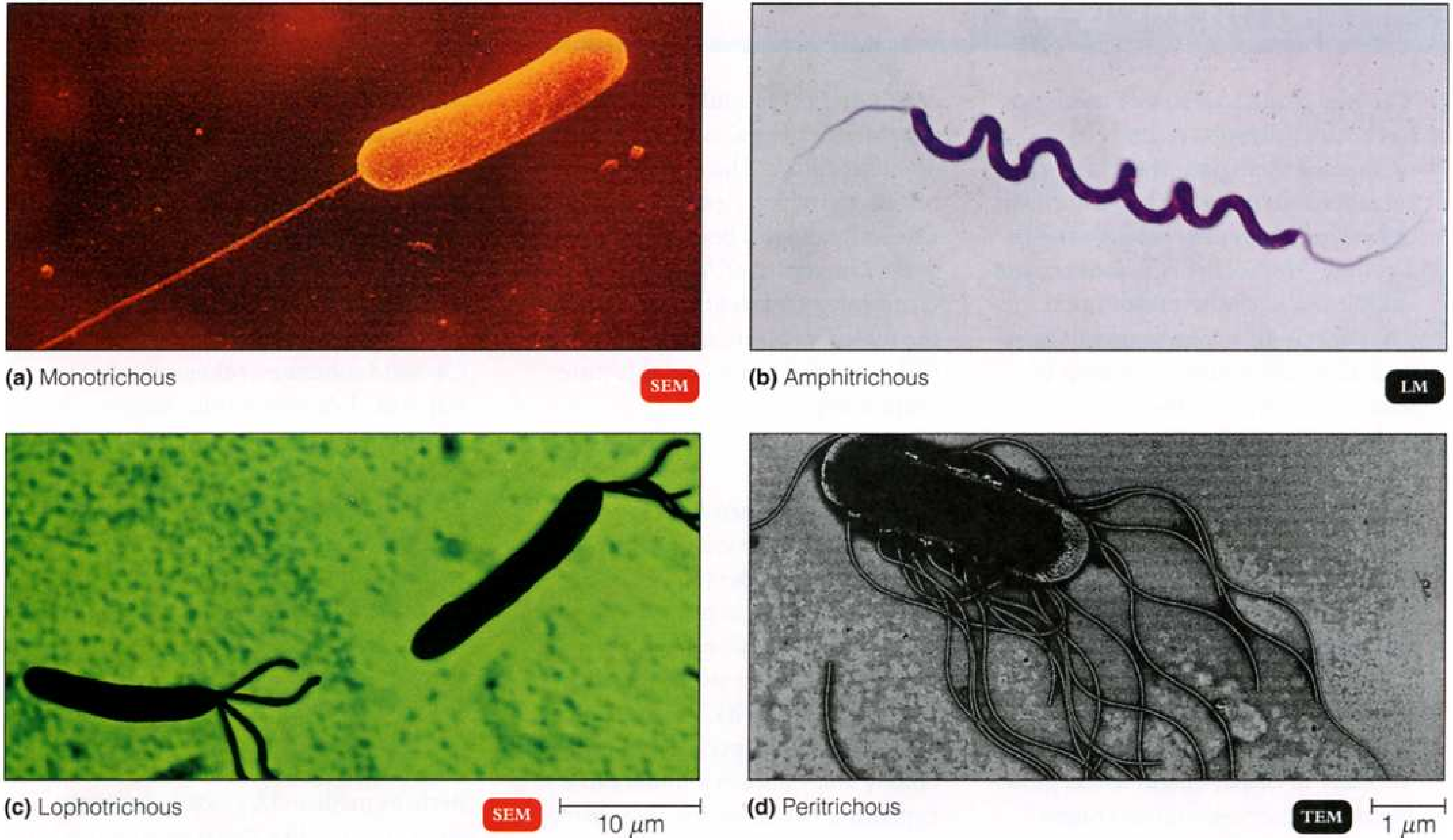
Phase contrast

Different flagellar arrangements



Peritrichous Polar Lophotrichous

Different flagellar arrangements



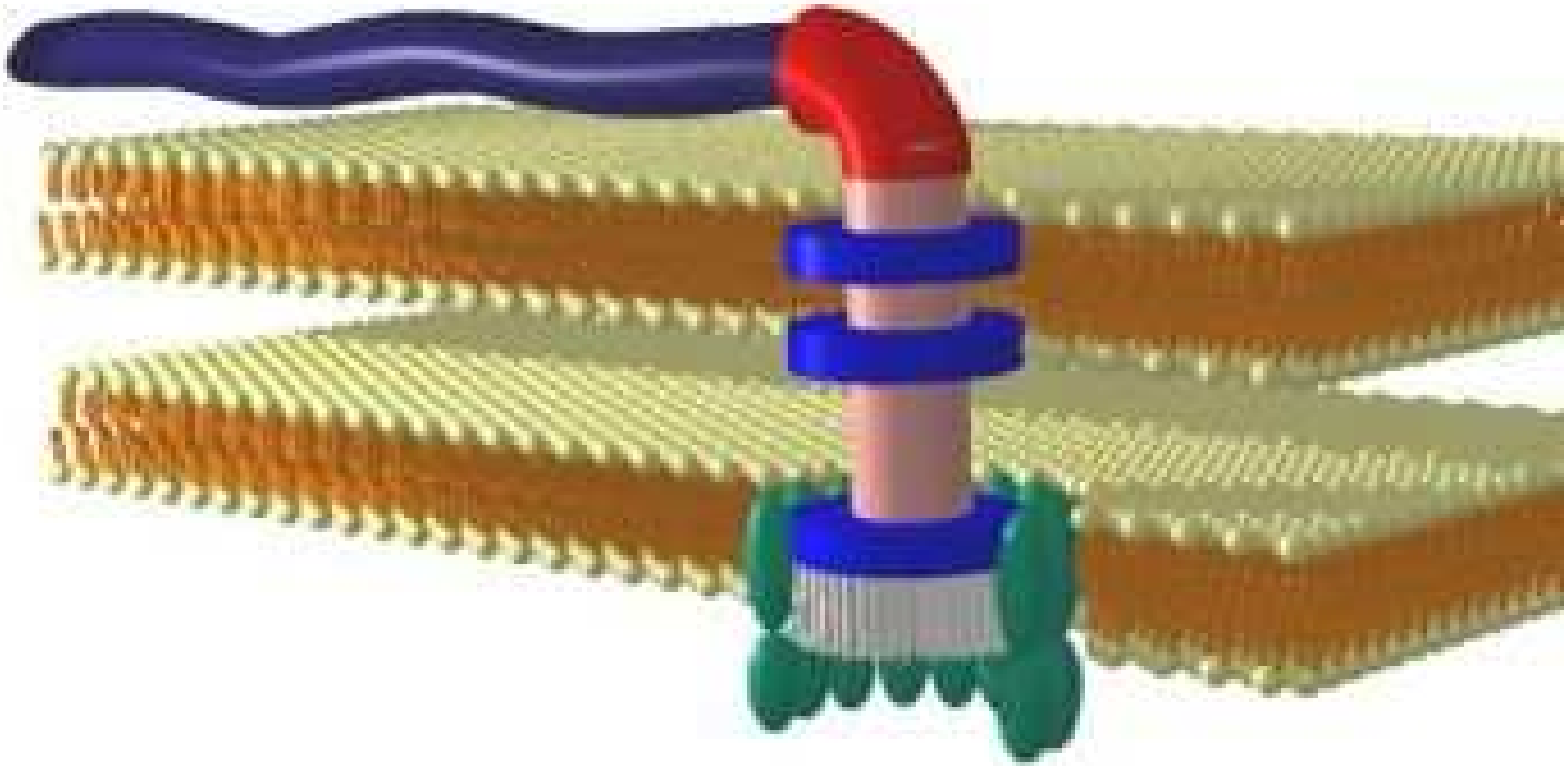
(a) Monotrichous

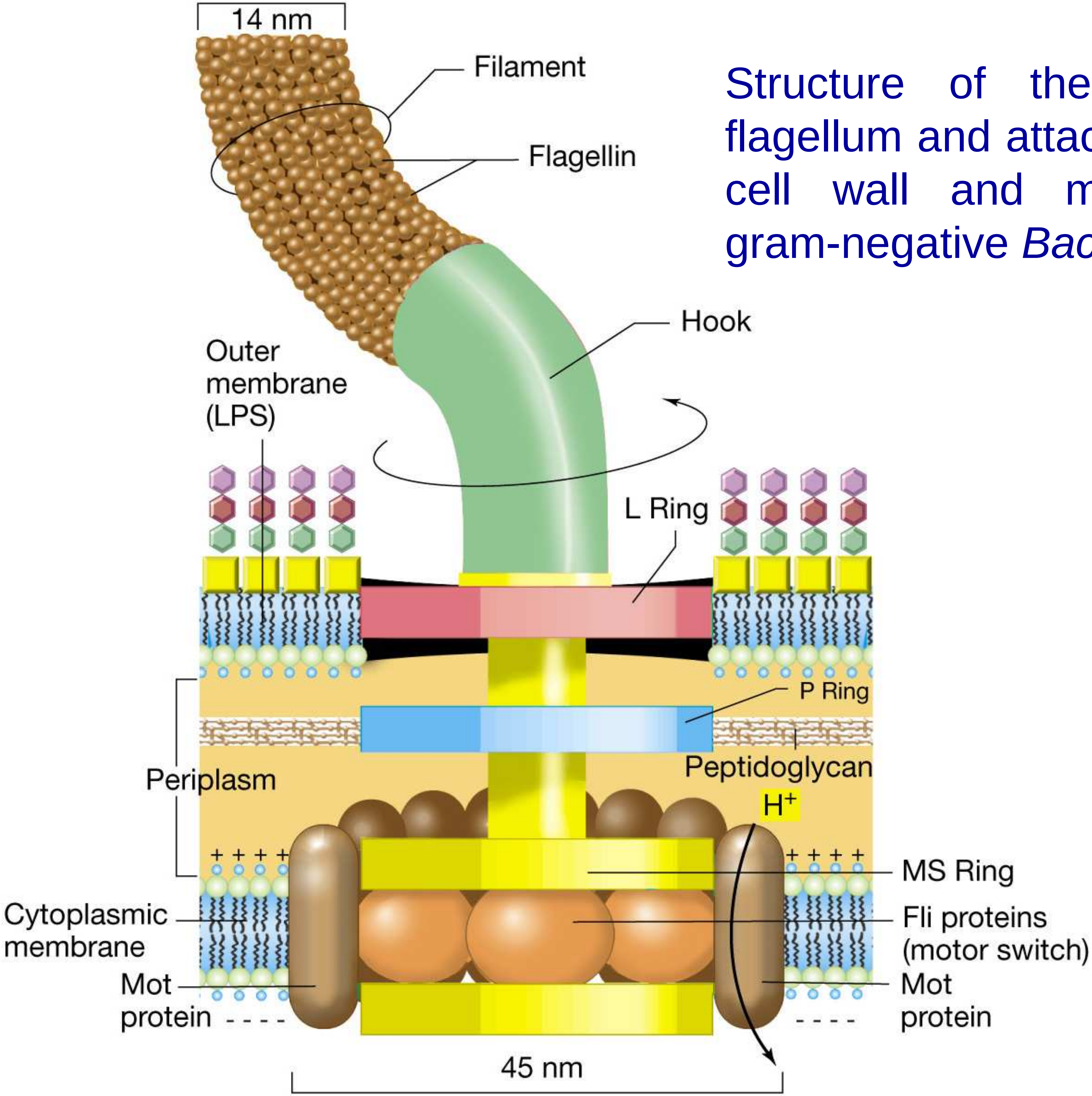
(b) Amphitrichous

(c) Lophotrichous

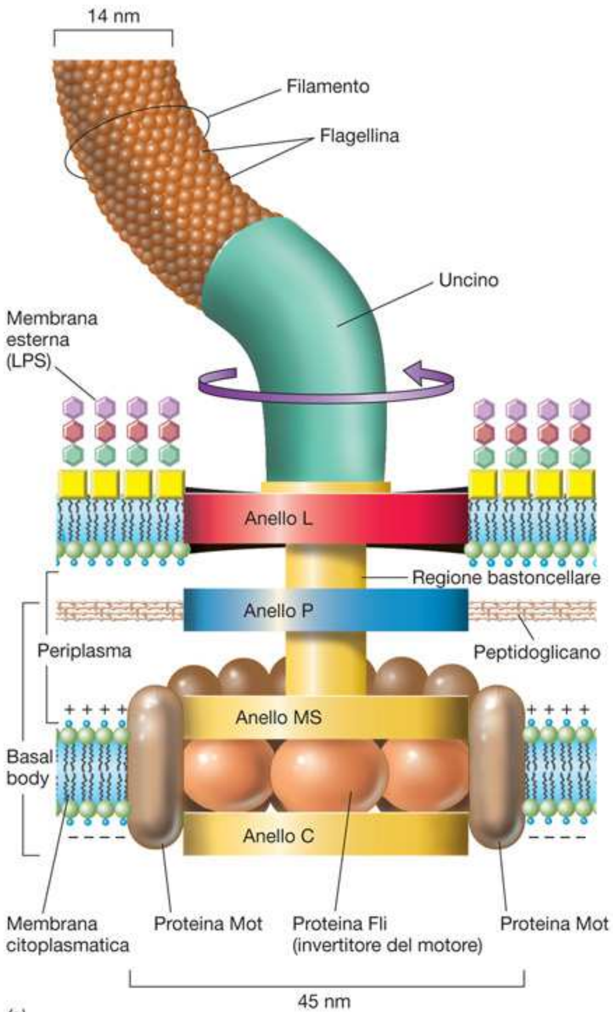
(d) Peritrichous

Flagellum structure



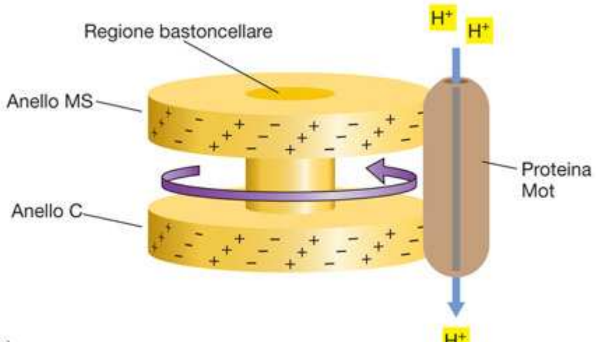


Structure of the prokaryotic flagellum and attachment to the cell wall and membrane in gram-negative *Bacteria*.



14 nm
Filamento
Flagellina
Uncino
Membrana
esterna
(LPS)
Anello L
Regione bastoncellare
Anello P
Periplasma
Peptidoglicano
Anello MS
Basal
body
Anello C
Membrana
citoplasmatica
Proteina Mot
Proteina Fli
(invertitore del motore)
Proteina Mot
45 nm

(a)

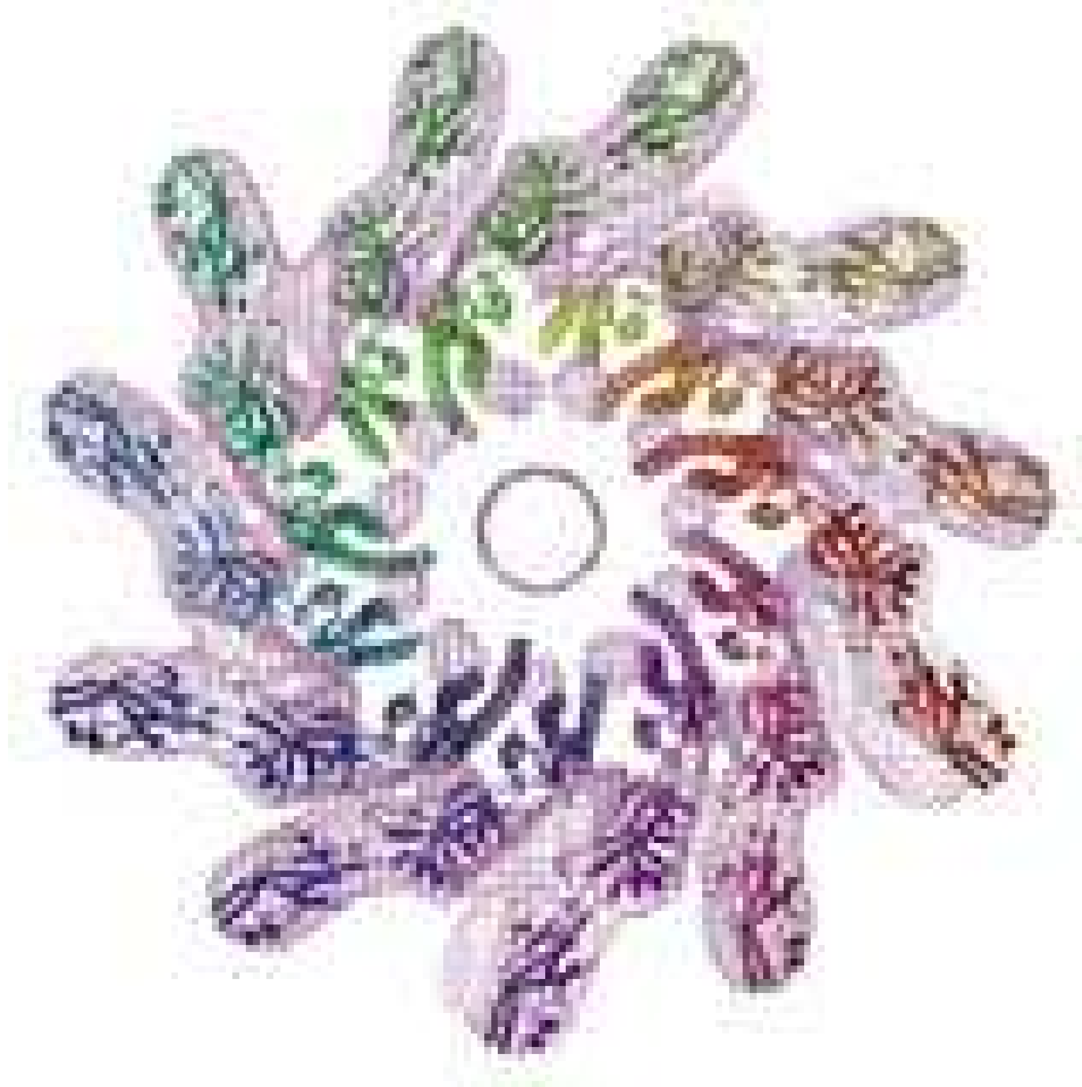


Regione bastoncellare
Anello MS
Anello C
Proteina
Mot
H+
H+
H+

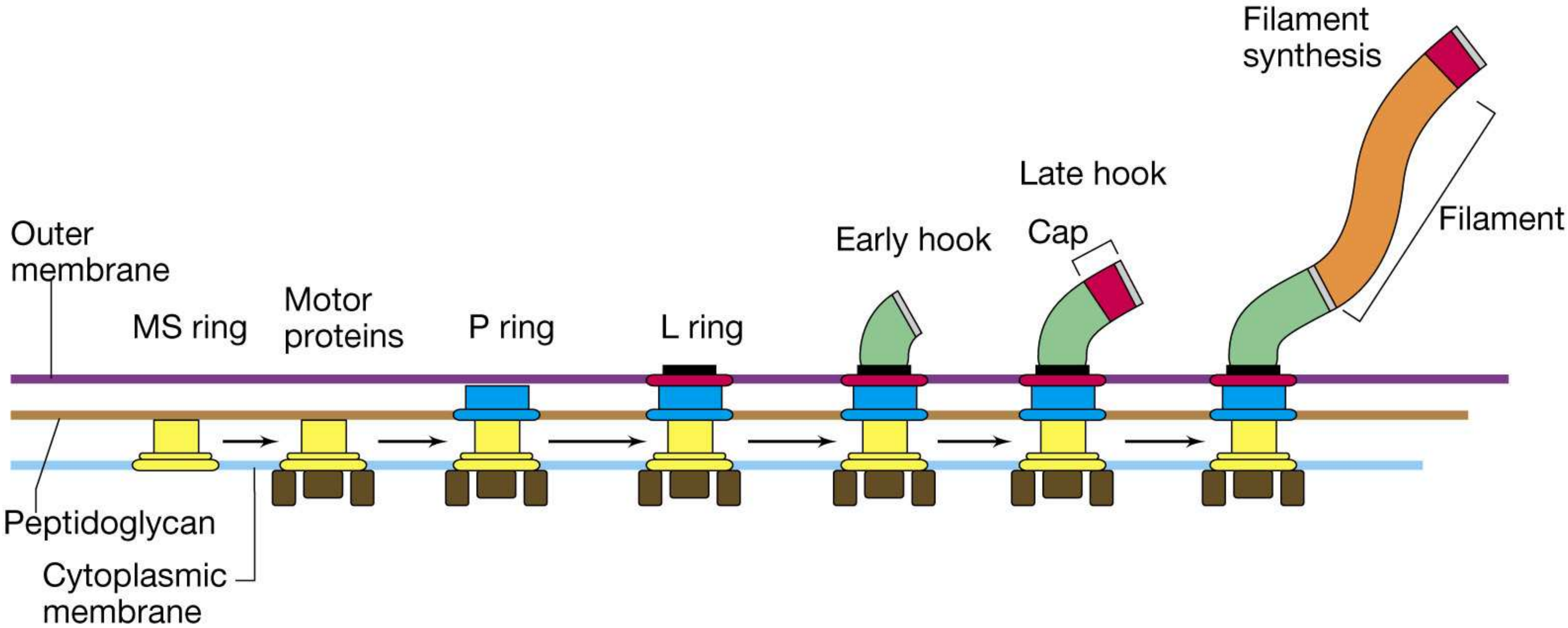
(b)

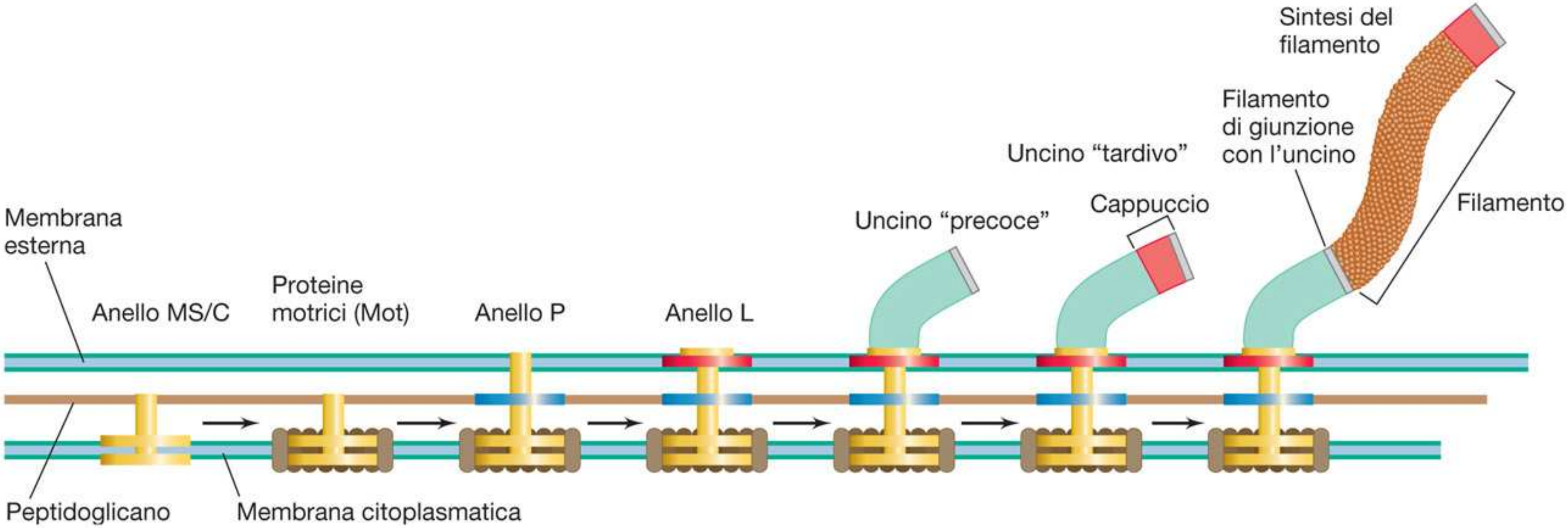
• The bacterial flagellum consists over almost all of its length of a single protein, **flagellin**.

• Thousands of flagellin molecules form a hollow tube composed of 11 simple polymer threads, known as protofilaments.



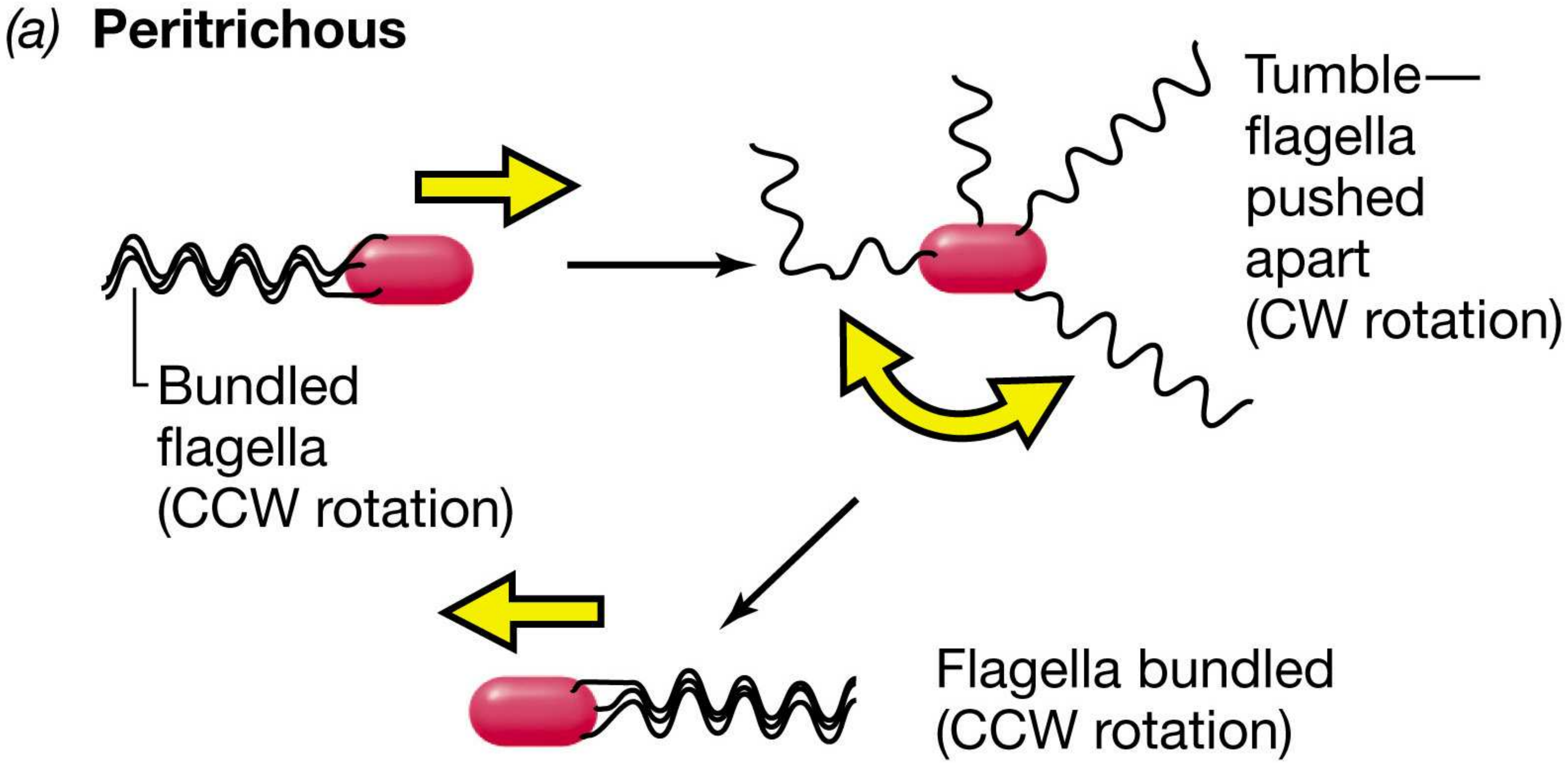
Summary of steps in flagella biosynthesis.



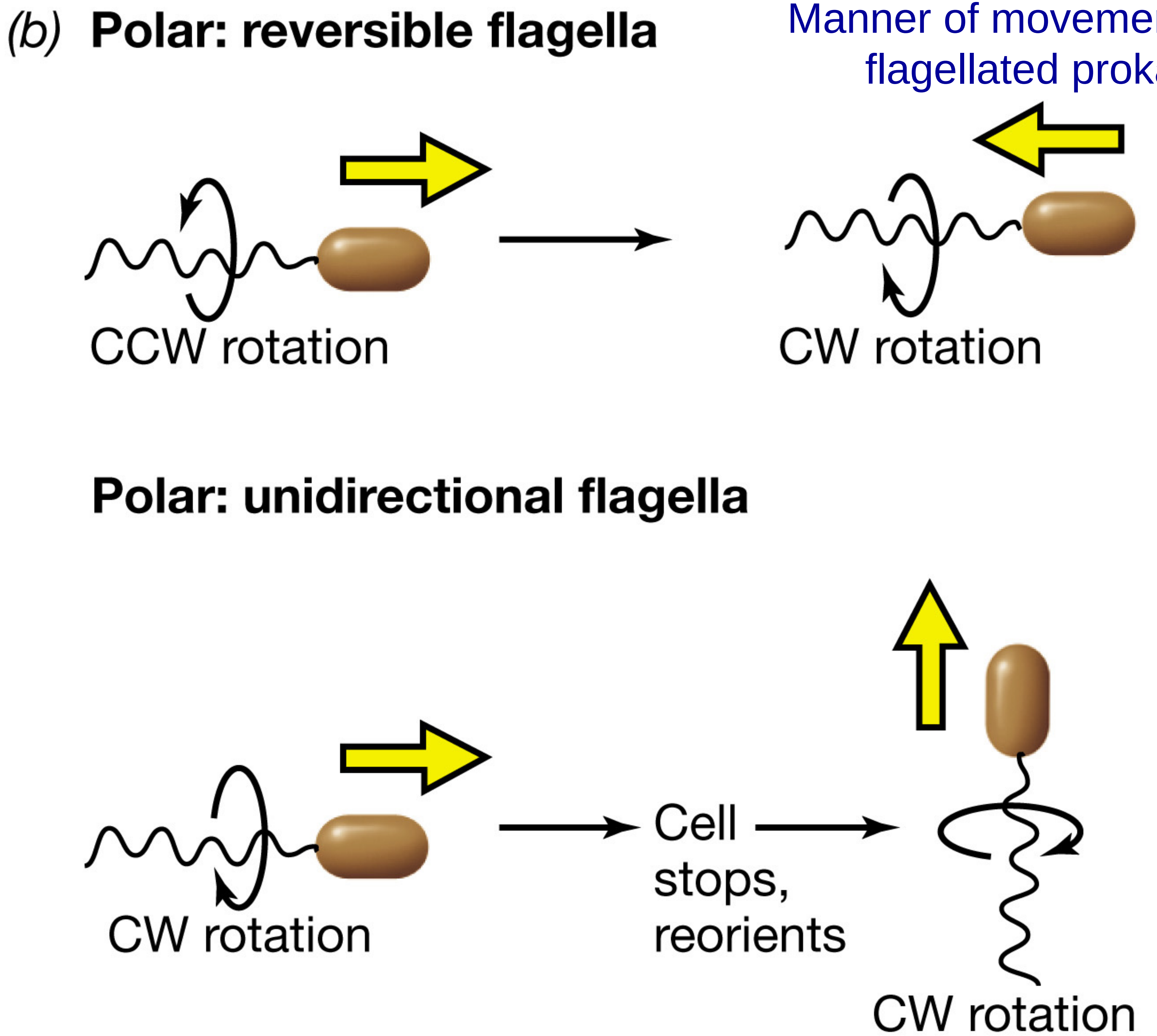


Sintesi del filamento
Filamento di giunzione con l'uncino
Uncino "tardivo"
Cappuccio
Filamento
Uncino "precoce"
Membrana esterna
Anello MS/C
Proteine motrici (Mot)
Anello P
Anello L
Peptidoglicano
Membrana citoplasmatica

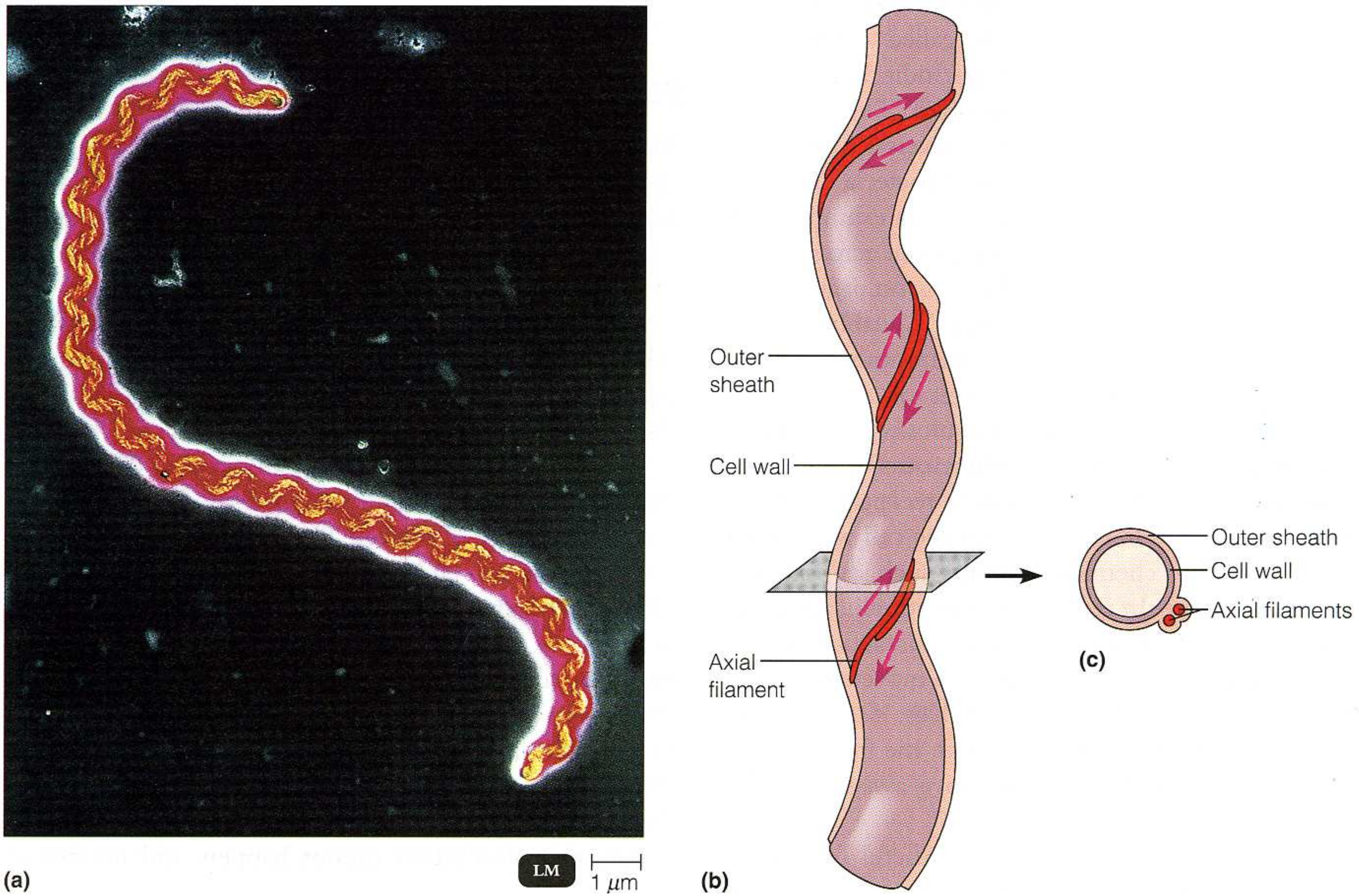
Manner of movement in peritrichously flagellated prokaryotes

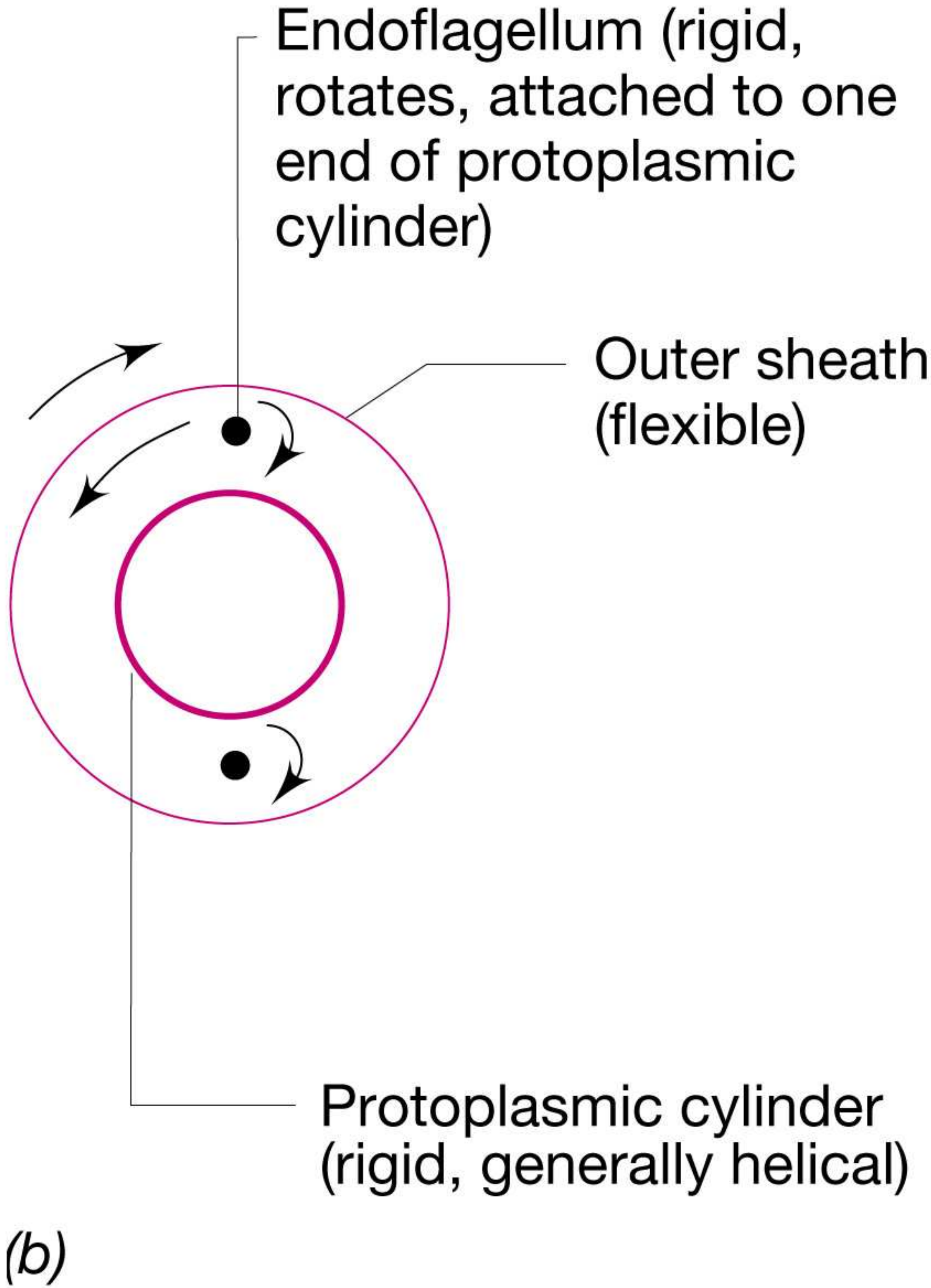


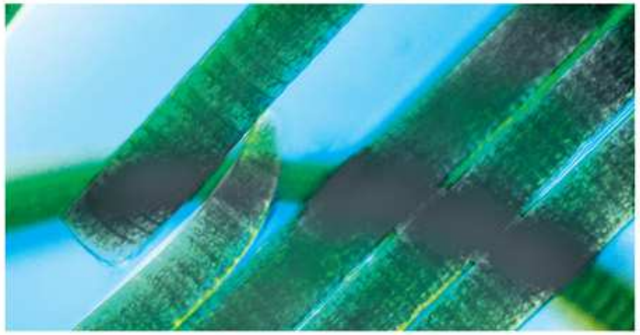
Manner of movement in polarly flagellated prokaryotes



Axial filaments of spirochetes




Endoflagellum (rigid, rotates, attached to one end of protoplasmic cylinder)
Outer sheath (flexible)
Protoplasmic cylinder (rigid, generally helical)
(b)



Richard W. Castenholz

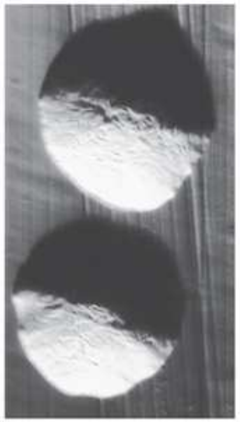
(a)

Richard W. Castenholz

(b)

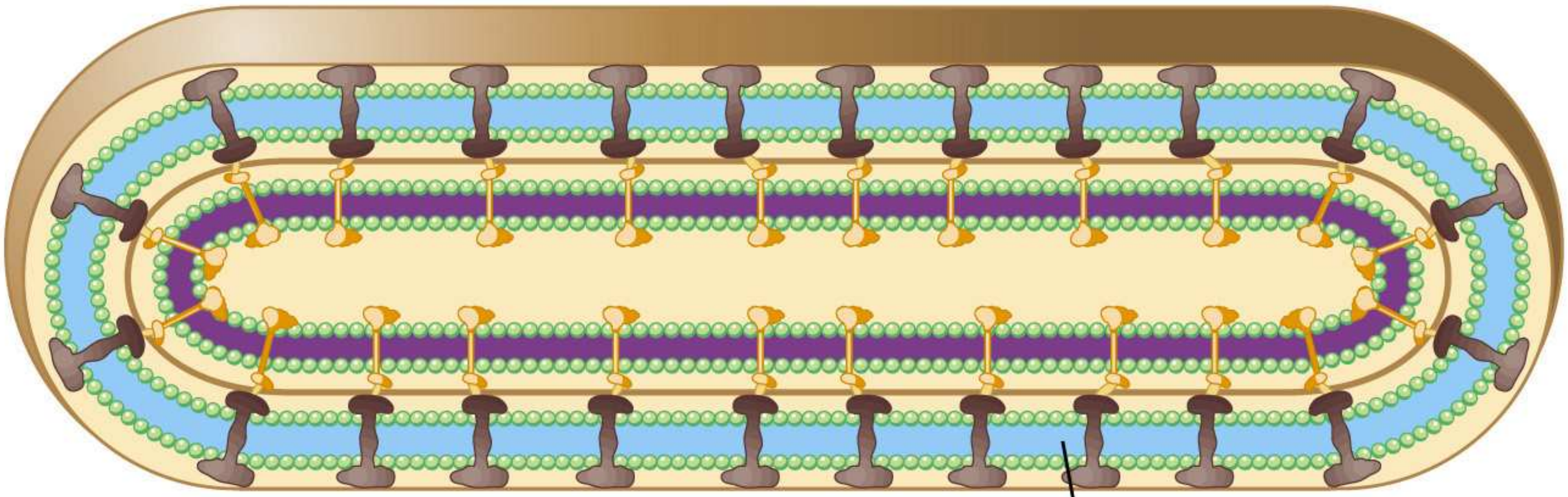
Mark J. McBride

(c)

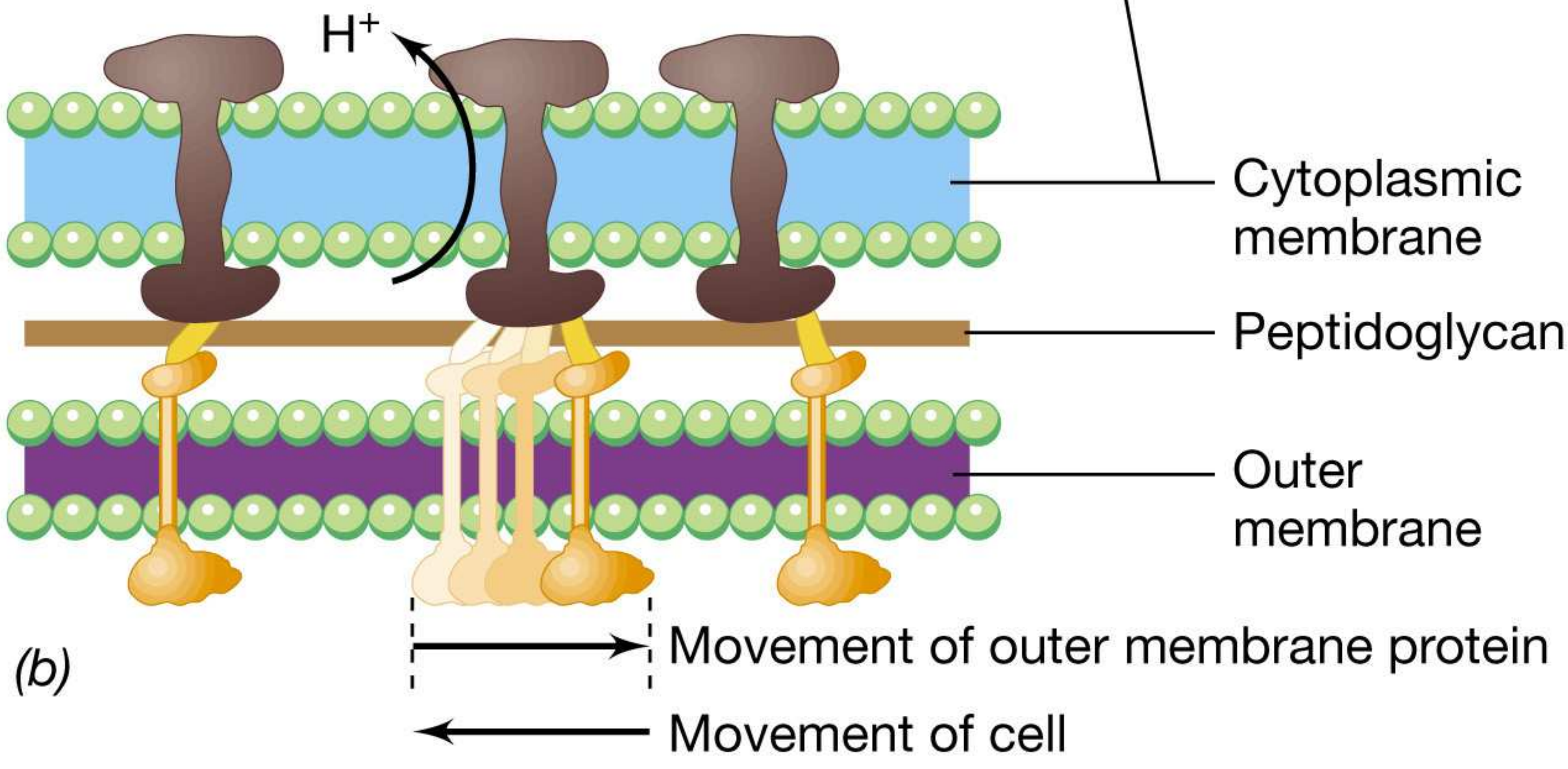


Mark J. McBride

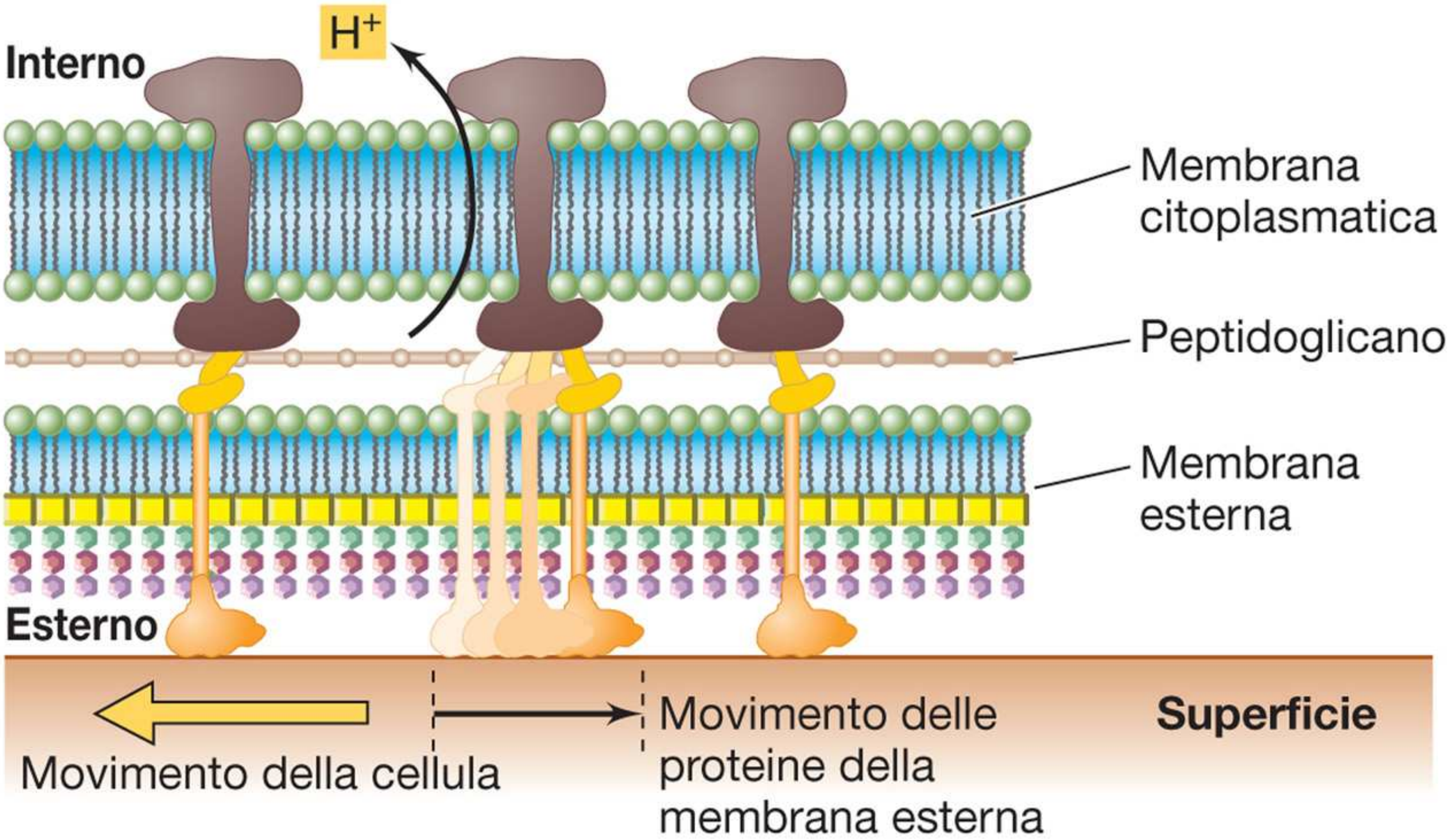
(d)



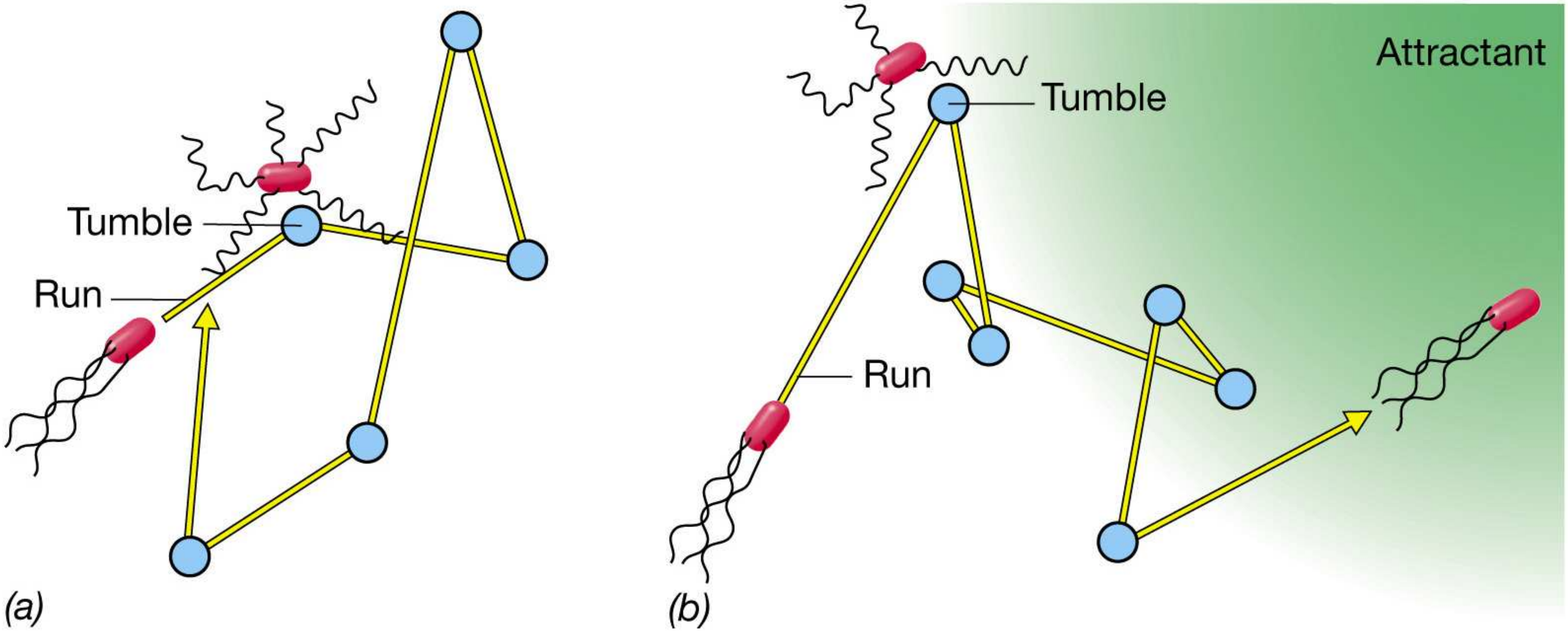
Proposed model for gliding motility



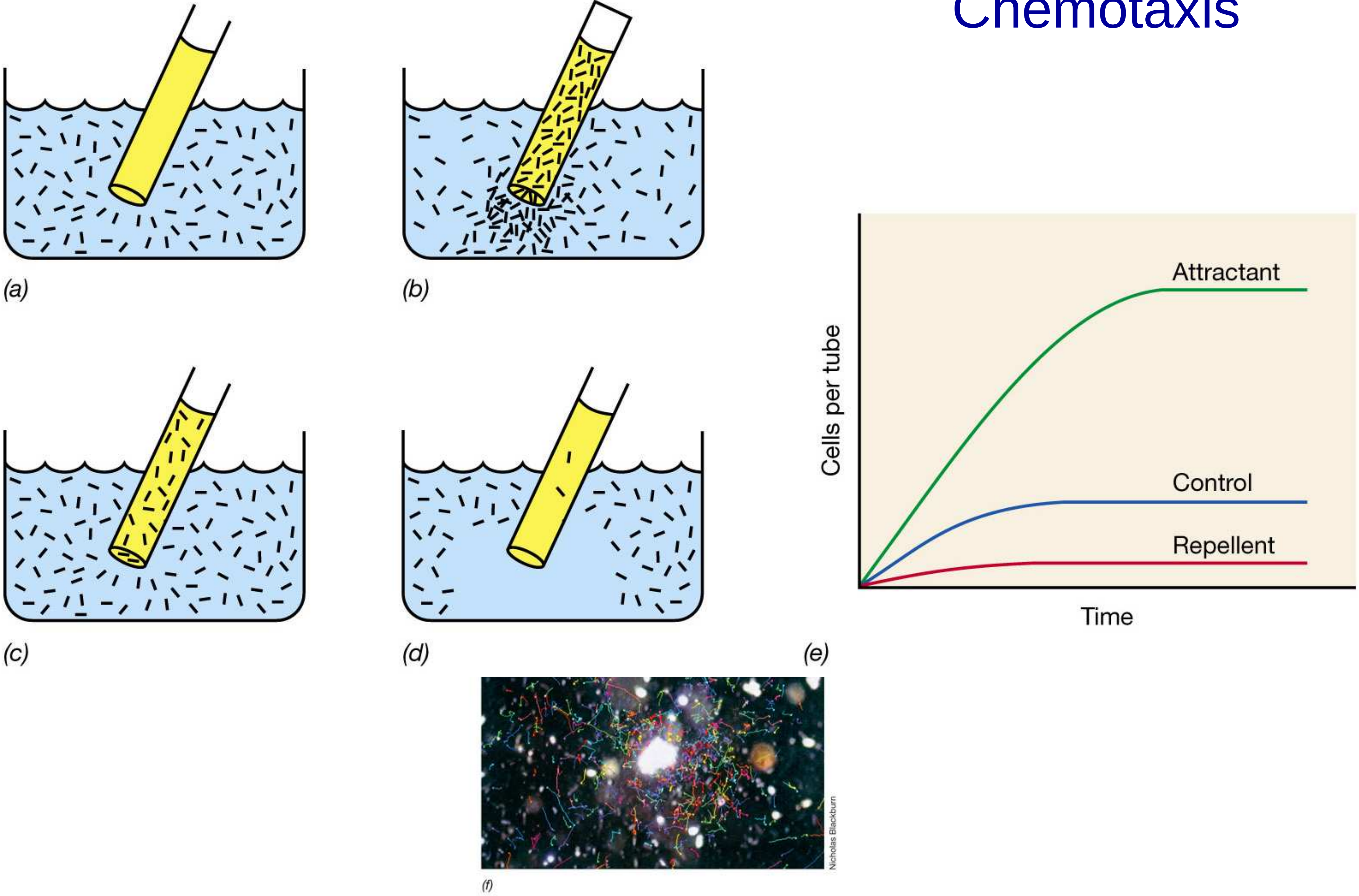
Proposed model for gliding motility



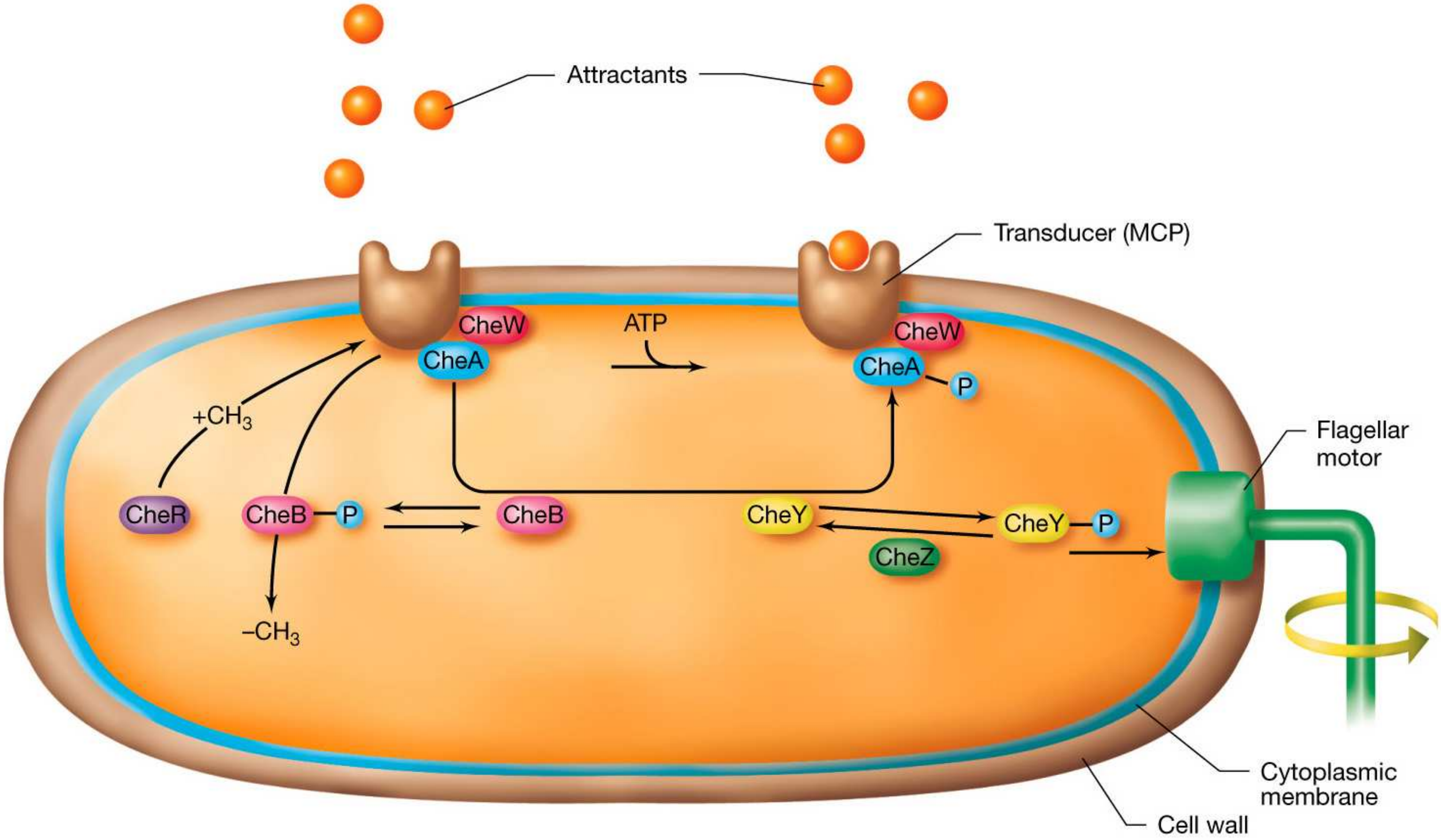
Chemotaxis in a peritrichously flagellated bacterium like *Escherichia coli*.



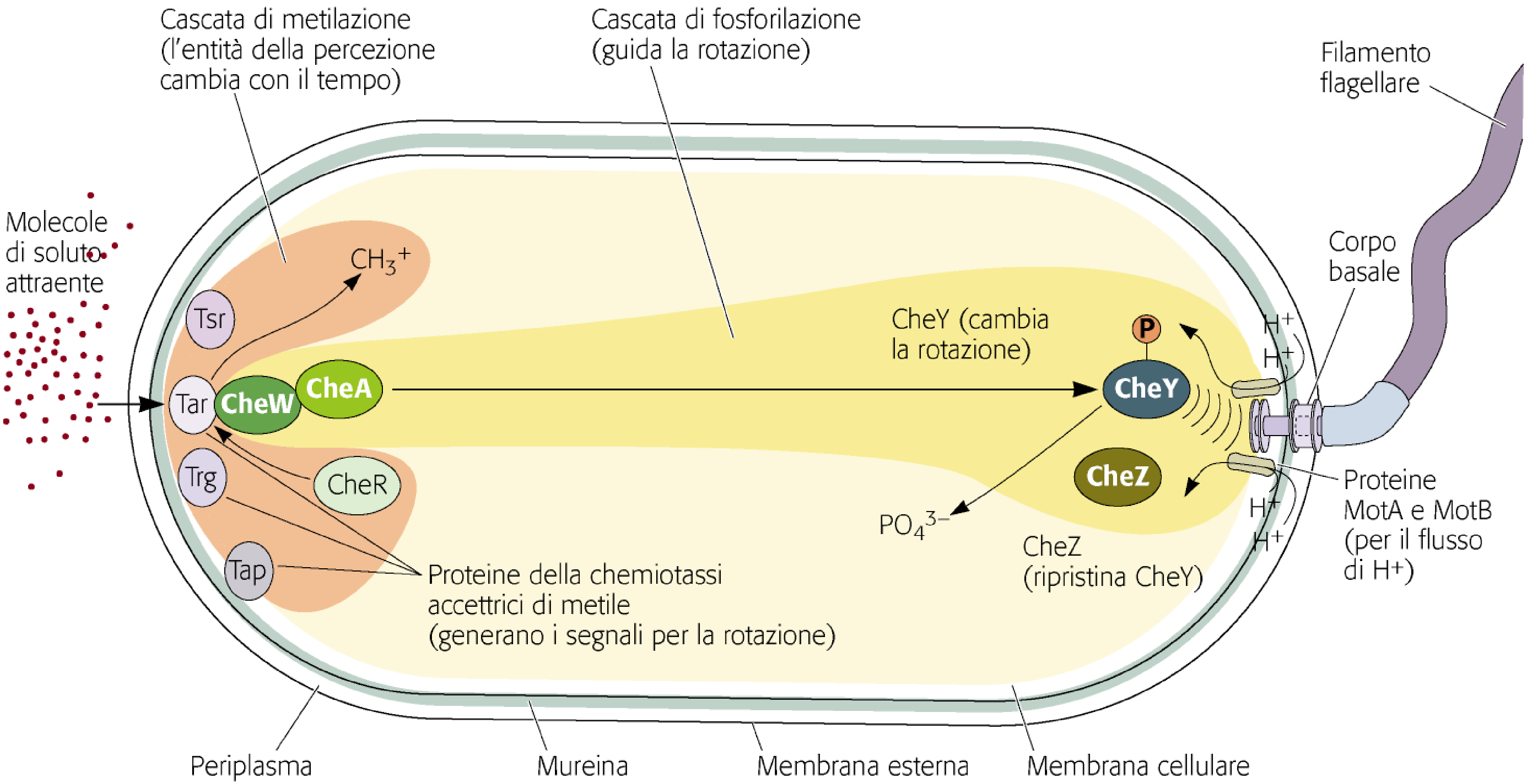
Chemotaxis


(a)
(b)
(c)
(d)
Cells per tube
Attractant
Control
Repellent
Time
(e)
Nicholas Blackburn
(f)

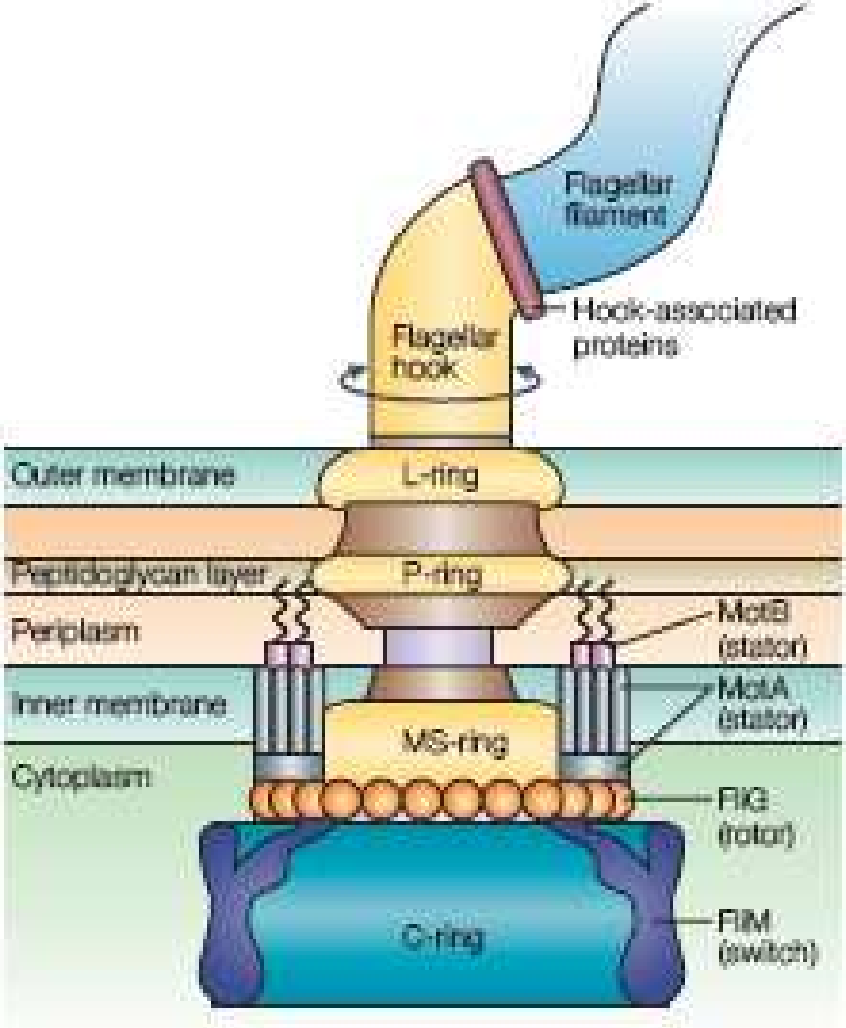
Interactions of transducers(MCP), chemotaxis (Che) proteins, and the flagellar motor in bacterial chemotaxis

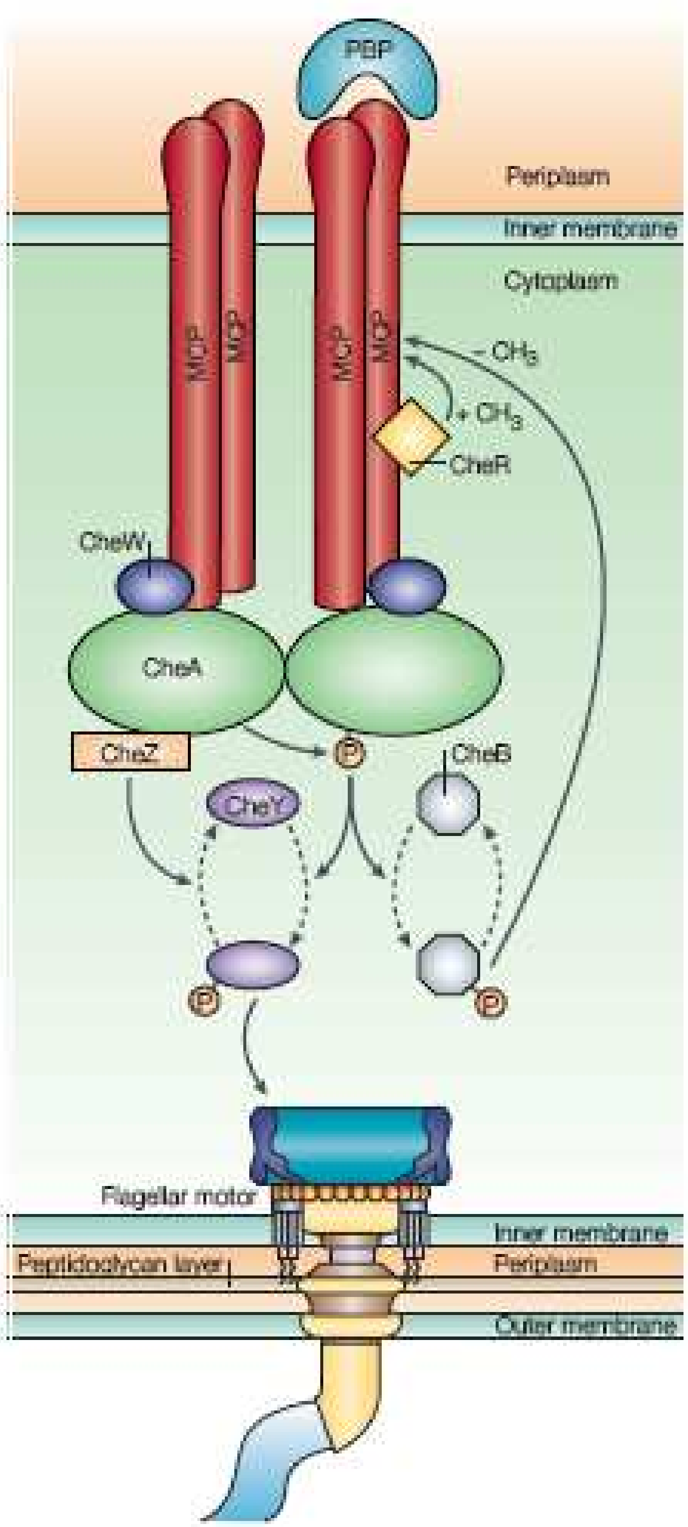


Interactions of transducers(MCP), chemotaxis (Che) proteins, and the flagellar motor in bacterial chemotaxis

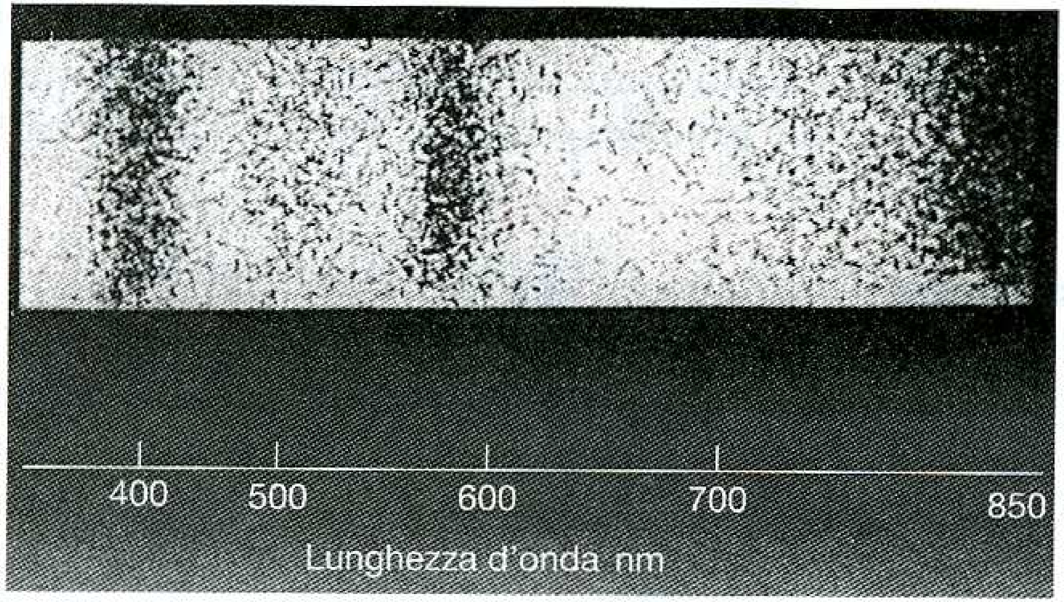


Schematic diagram of the chemosensory system of *Escherichia coli*



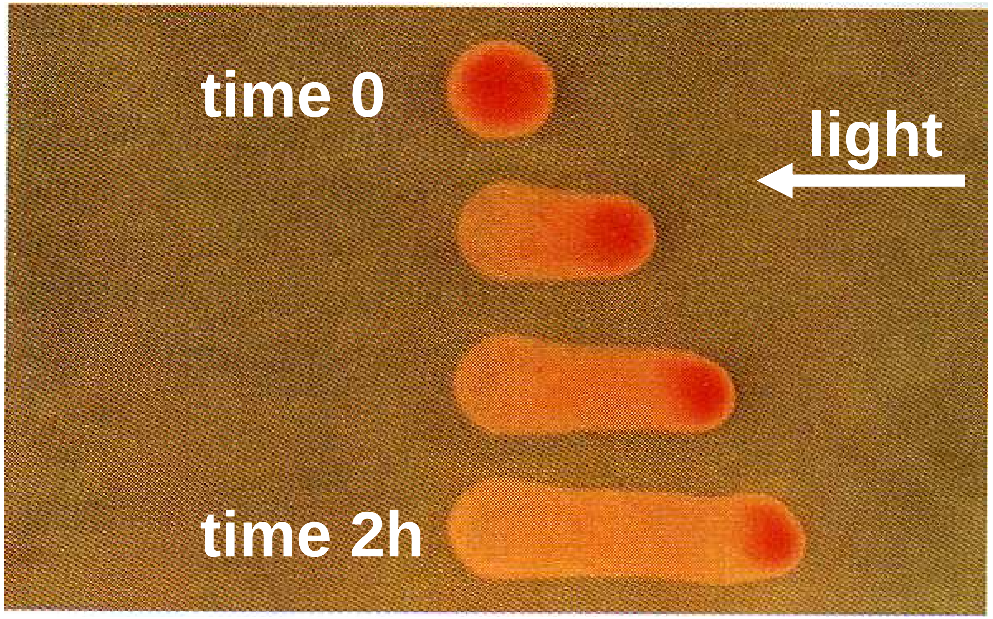


Bacterial phototaxis



Thiospirillum jenense
(scotophobotaxis)

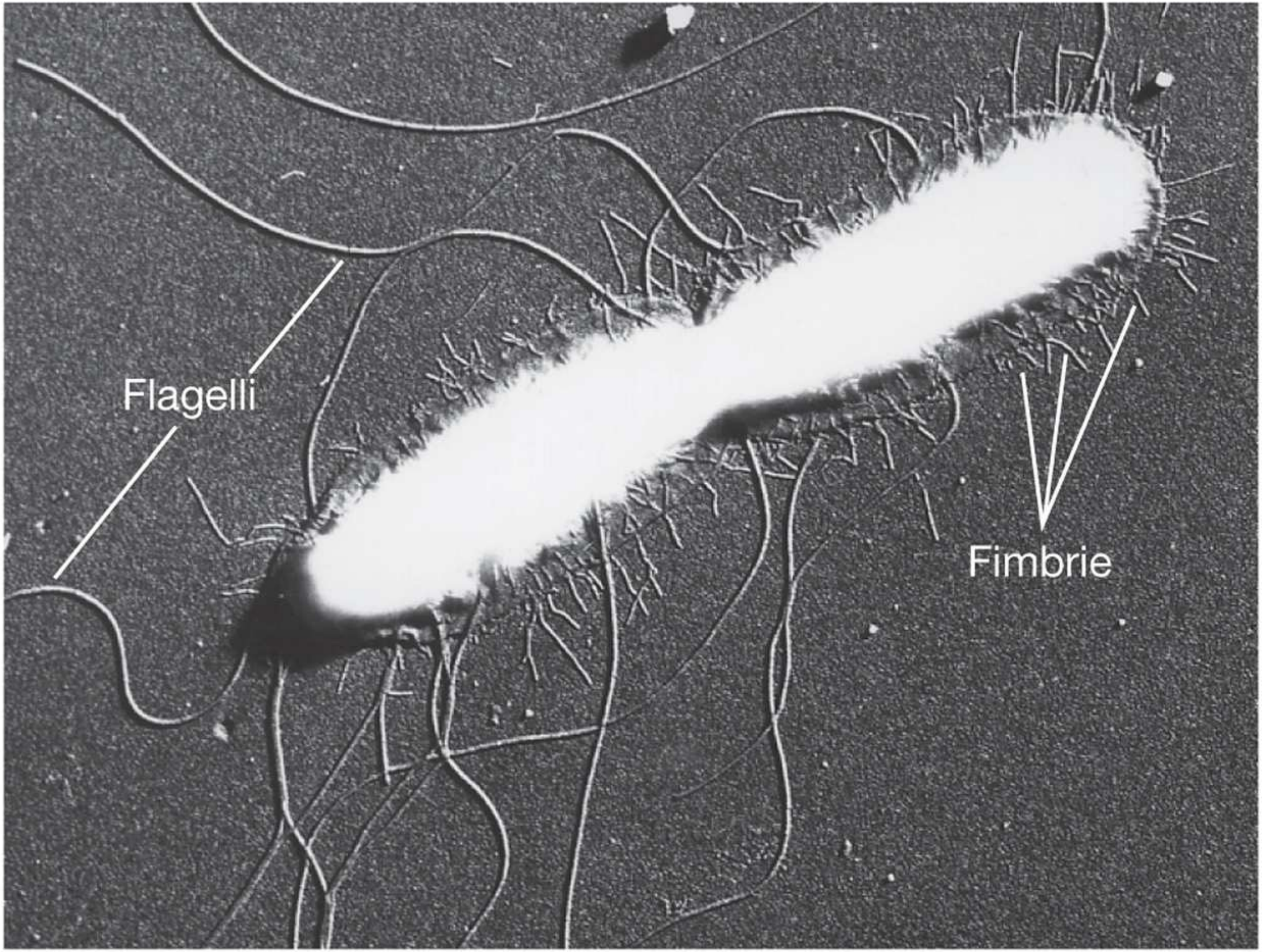
Rhodospirillum centenum
(true phototaxis)



Structure and function of prokaryotic cells:

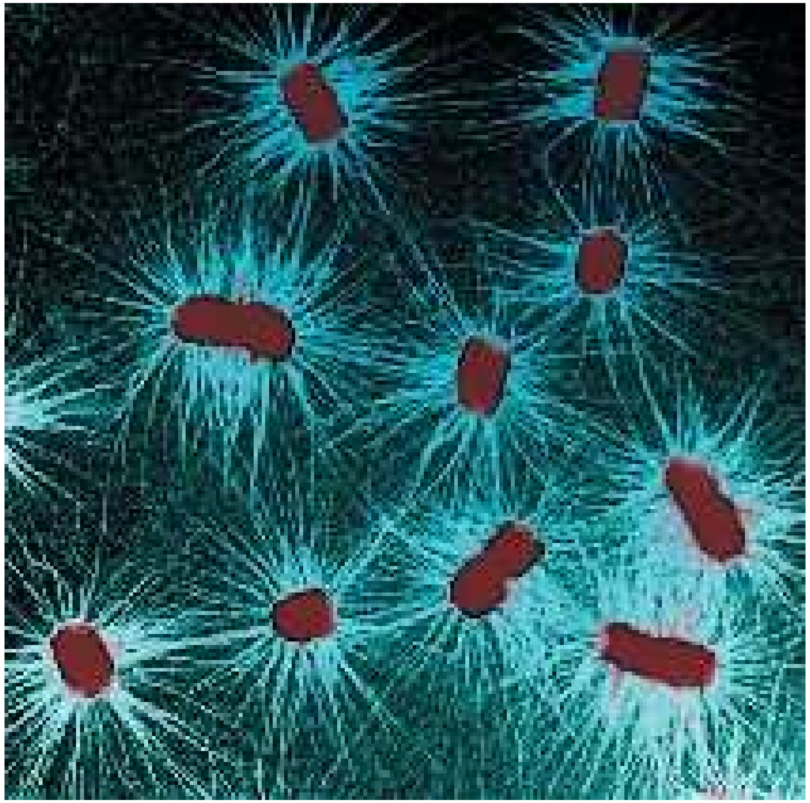
the fimbriae

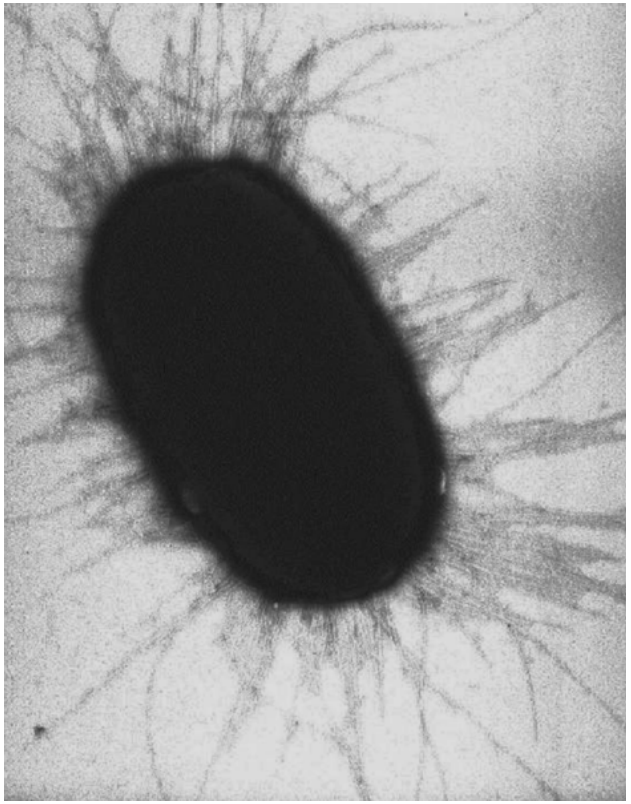
EM of a dividing *Salmonella typhi* showing flagella and fimbriae



J. P. Duguid and J. F. Wilkinson

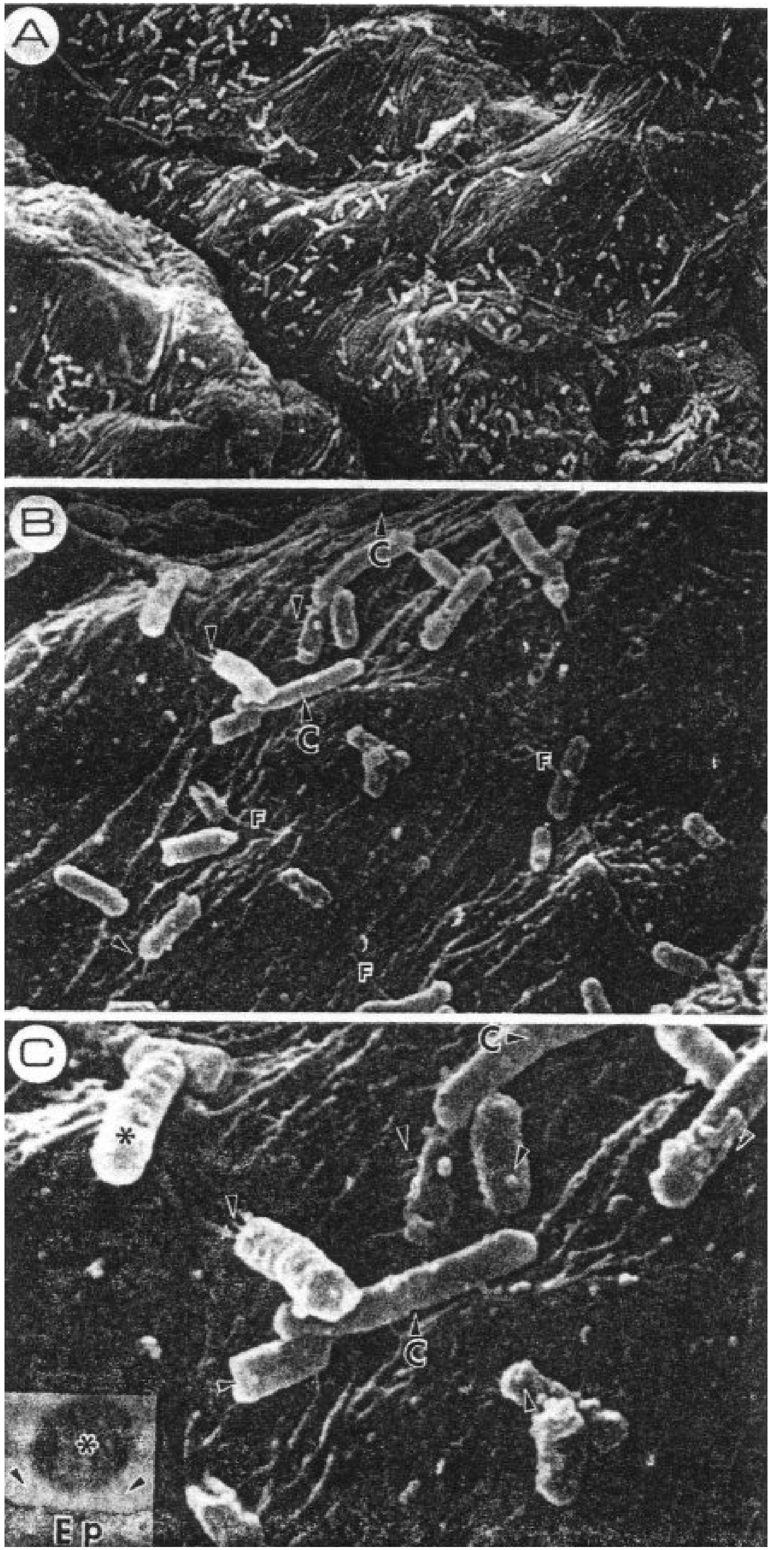
The fimbriae functions





• Common **pili (fimbriae)** are usually involved in specific adherence of prokaryotes to surfaces in nature.

• They are the major determinants of bacterial virulence because they allow pathogens to attach to (colonize) tissues and/or resist attack by phagocytes

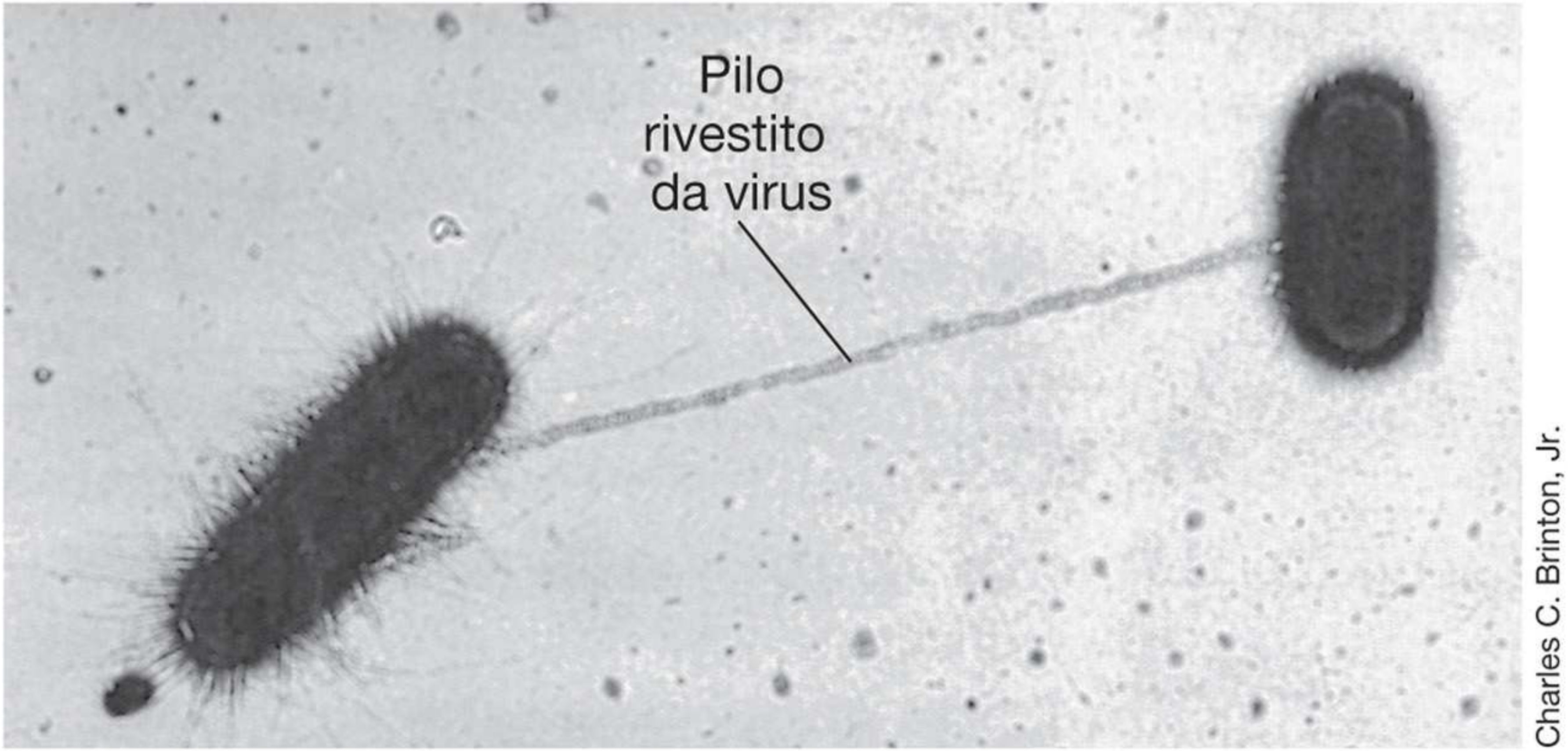


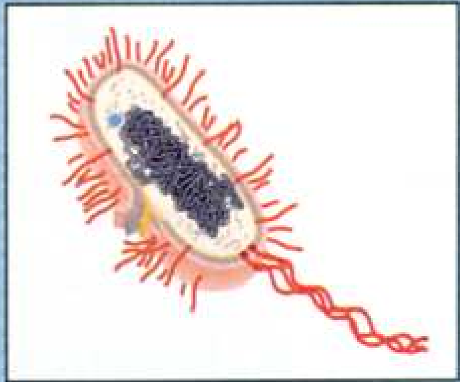
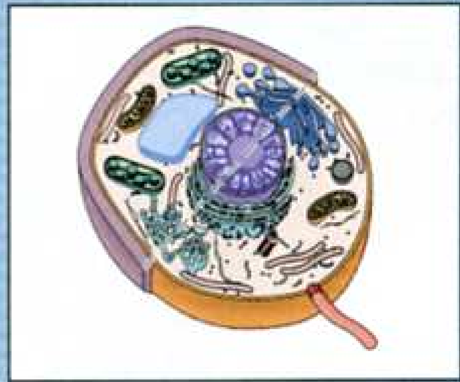
A) Transmission electron micrograph of adherence of *E. coli* JR1 strain to mucosal surface of human foreskin.

B) Enlargement of A with attachment of *E. coli* to mucosal surface by fimbriae (arrowheads).

C) Enlargement of B with attachment of *E. coli* by fimbriae (arrowheads).

Pili of *E .coli*



Characteristic	Procaryotic	Eucaryotic
		
Size of cell	Typically 0.2–2.0 μm in diameter	Typically 10–100 μm in diameter
Nucleus	No nuclear membrane or nucleoli	True nucleus, consisting of nuclear membrane and nucleoli
Membrane-enclosed organelles	Absent	Present; examples include lysosomes, Golgi complex, endoplasmic reticulum, mitochondria, and chloroplasts
Flagella	Consist of two protein building blocks	Complex; consist of multiple microtubules
Glycocalyx	Present as a capsule or slime layer	Present in some cells that lack a cell wall
Cell wall	Usually present; chemically complex (typical bacterial cell wall includes peptidoglycan)	When present, chemically simple
Plasma membrane	No carbohydrates and generally lacks sterols	Sterols and carbohydrates that serve as receptors present
Cytoplasm	No cytoskeleton or cytoplasmic streaming	Cytoskeleton; cytoplasmic streaming
Ribosomes	Smaller size (70S)	Larger size (80S); smaller size (70S) in organelles
Chromosome (DNA) arrangement	Single circular chromosome; lacks histones	Multiple linear chromosomes with histones
Cell division	Binary fission	Mitosis
Sexual reproduction	No meiosis; transfer of DNA fragments only	Involves meiosis