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MICROBIOLOGY

Lecture 2

Bacterial Cell Structure (Chapter 3)

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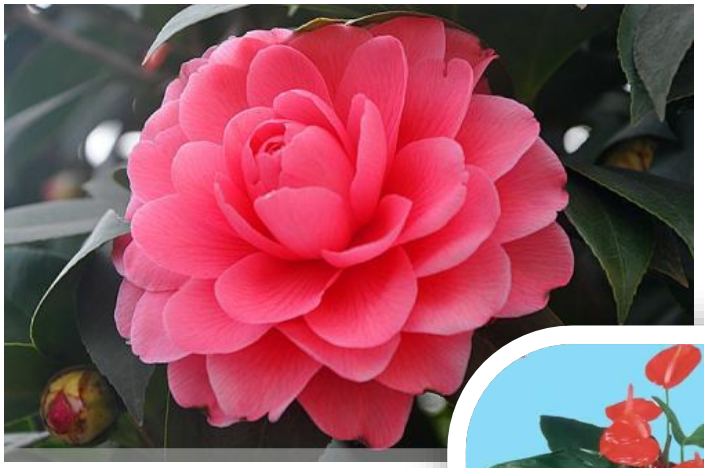
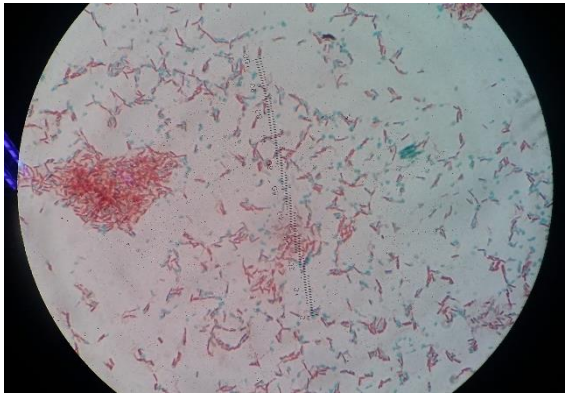
Animals

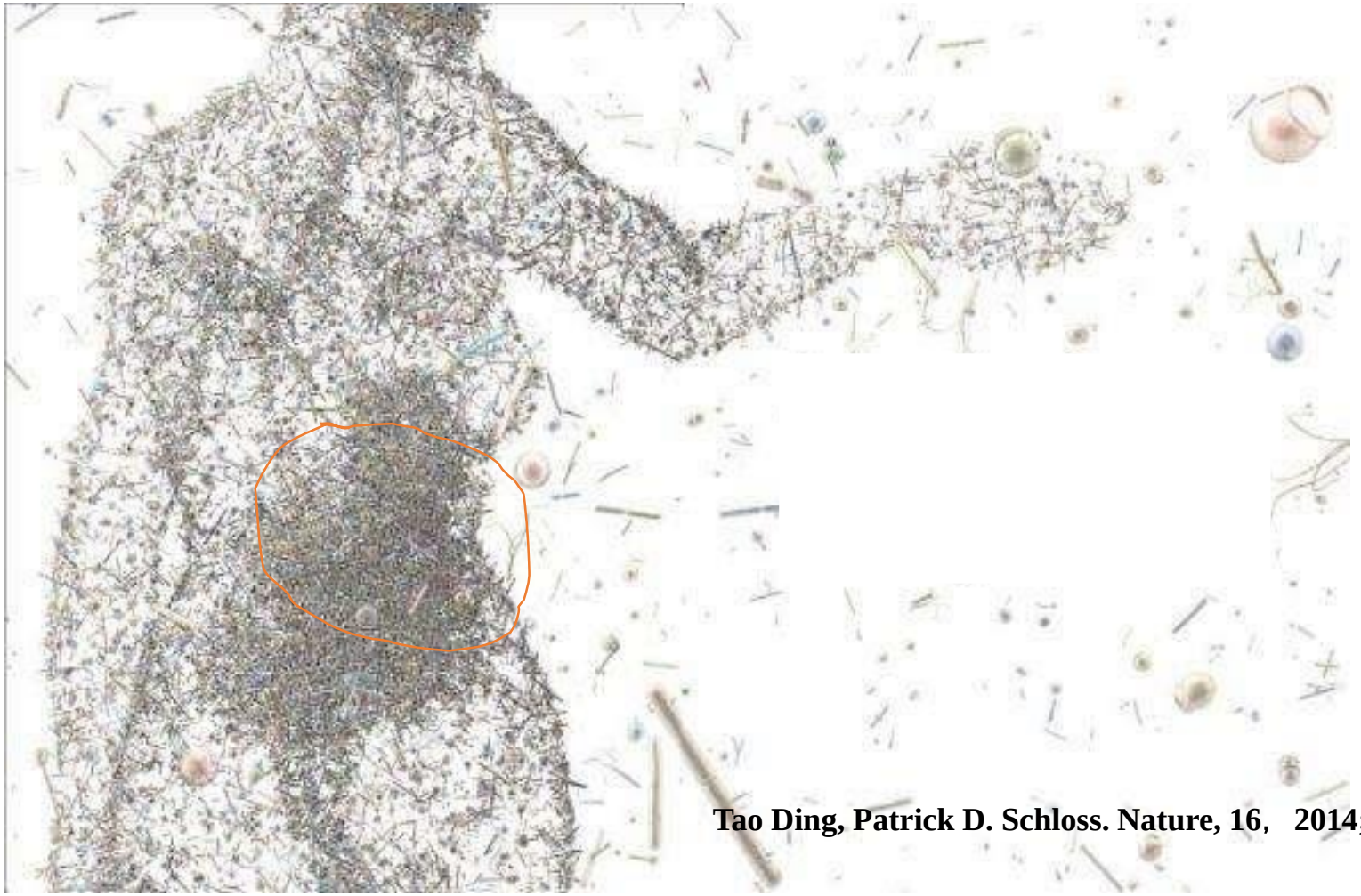
Plants



Microorganisms



People are indulged in the ocean of microorganisms



Tao Ding, Patrick D. Schloss. Nature, 16, 2014;

How to prove the bacterial such as *HP* exist in stomach?

What is a bacterium?

Episode 1

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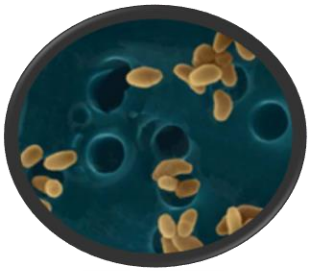
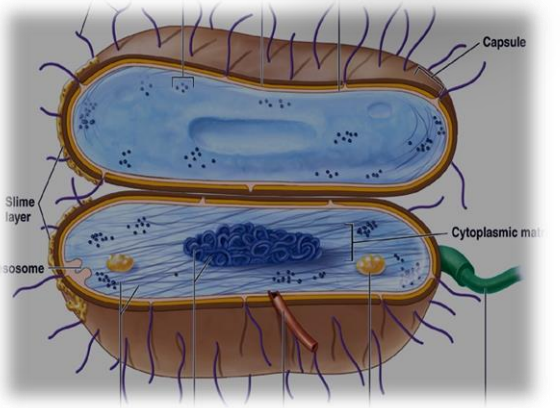
Features of bacteria

- **The morphology of bacteria**
- **Size-**
- **Shape and arrangement-**
- **Survive strategies-S/V**

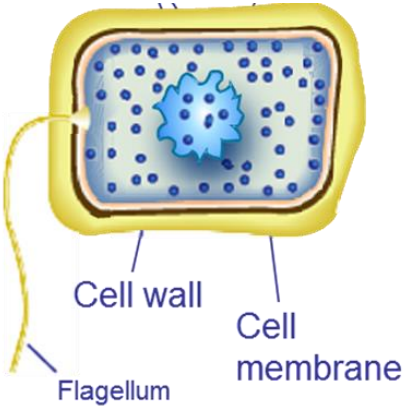


- **Only 1% microbes are culturable**



- **What are bacteria?**
- **Structure Simple-Prokaryote**

R. Stanier and C. B. van Niel
described prokaryotes in terms of what they lacked in comparison to eukaryotic cells.
Prokaryote –unicellular organisms, lack nuclei and membrane-bound organelles.



3.1 The "Prokaryote" Controversy

What is your opinion about of The "Prokaryote" Controversy?
Please use three or more evidences to support your opinion.

3.2 A Typical Bacterial Cell

3.2.1. Size of Bacterial-Small

- **Bacteria are measured in micrometers(μm).**

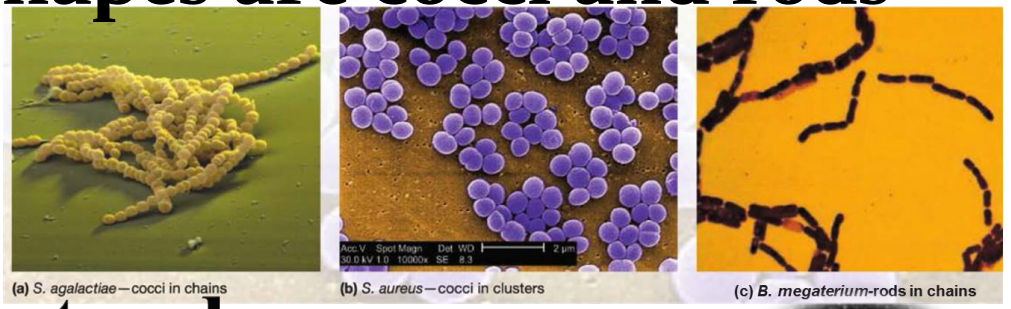
- **Average rod – 1.1 - 1.5 x 2 – 6 μm (*E. coli*)**
- **Smallest – 0.1x0.3 μm (*Mycoplasma*)**

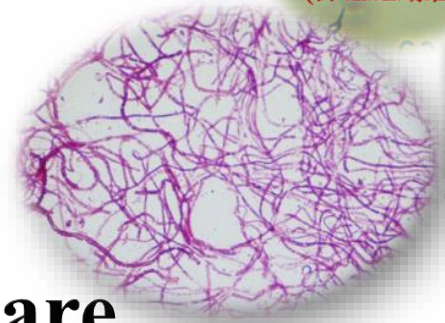
- **Largest-80x600 μm**
- **Filter pore size:0.22 μm**

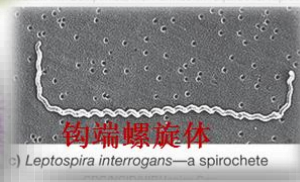
3.2.2 Shape and Arrangement

The two most common shapes are cocci and rods

- **Cocci-balls**
- **Bacilli – rods**
- **Coccobacilli – very short rods**
- **Vibrios – resemble rods, comma shaped**
- **Spirilla (s., spirillum) – rigid helices**
- **Spirochetes – flexible helices**
- **Mycelium-hyphae**
- **Pleomorphic – organisms that are variable in shape.**



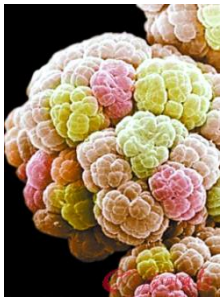




3.2.2 Shape and Arrangement

1.They can exist singly or can be associated in characteristic-arrangements.

Why ?



2.Determined by plane of division(1,2,3)

3.Determined by separation or not

Such as the genus *Sarcina*, cocci divide in three planes,

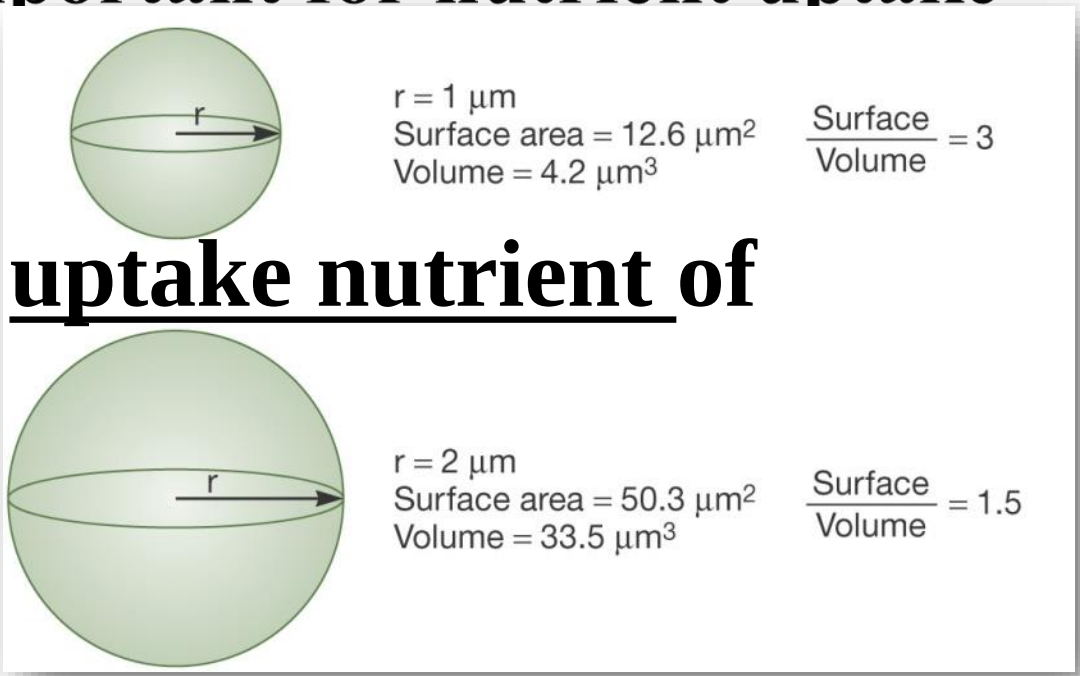
Long chains of cocci result when cells adhere after repeated divisions in one plane (*Streptococcus, Enterococcus, and Lactococcus*)

- **What causes a bacterial species to have a particular size and shape?**

3.2.3 Size – Shape Relationship(S/V)

- Microbe has a small volume but a large surface (S/V: surface to volume ratio)
- Small size may be protective mechanism from predation
- A large surface is important for nutrient uptake efficiently.

How and where to uptake nutrient of microbe?



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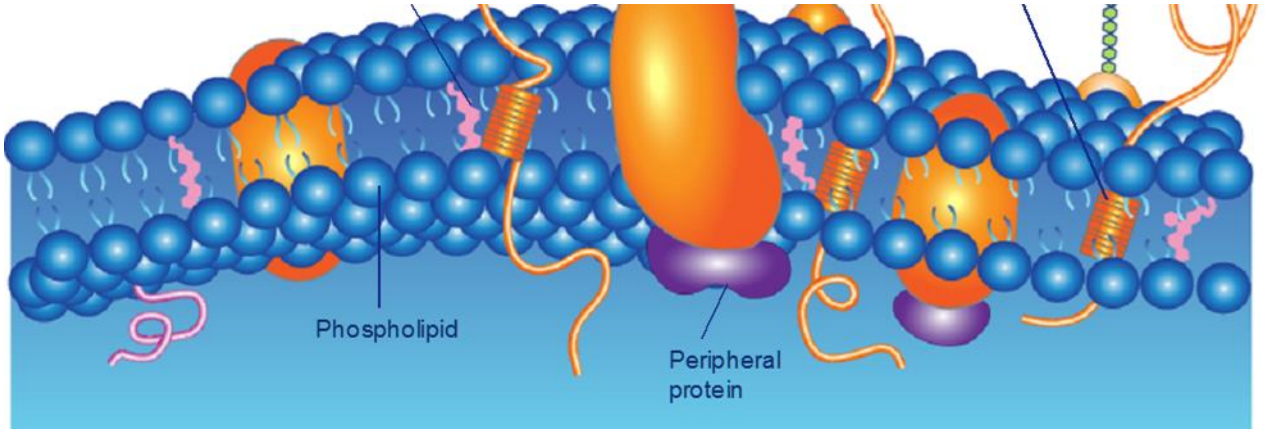
Episode 2

- **Uptake of Nutrients with <u>Plasma Membrane</u>**

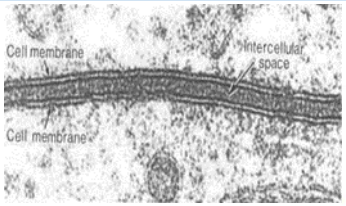


3.3 Bacterial Plasma Membranes

The most widely accepted model for membrane structure is the: **fluid mosaic model of membrane structure**

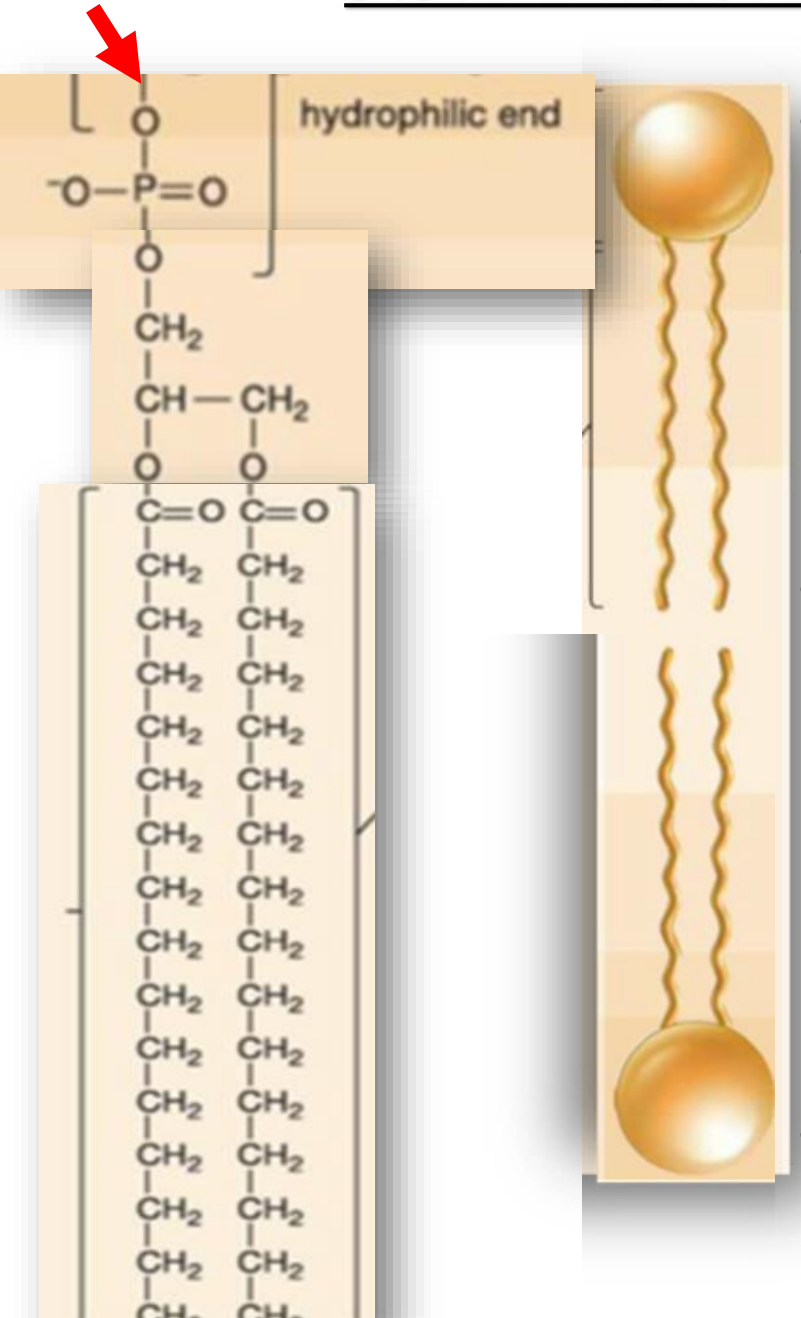
Singer and Nicholson

The model was established using a variety of experimental approaches, including TEM and AFM.



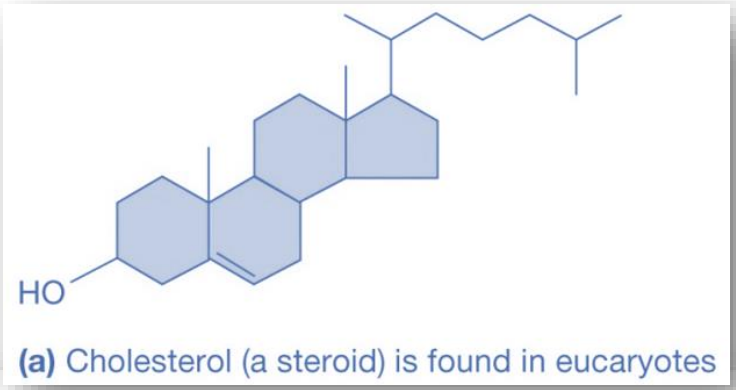
- **Lipid bilayers with floating(25%) and integral-mosaic(75%) proteins**

3.3.1 Bacterial Lipids

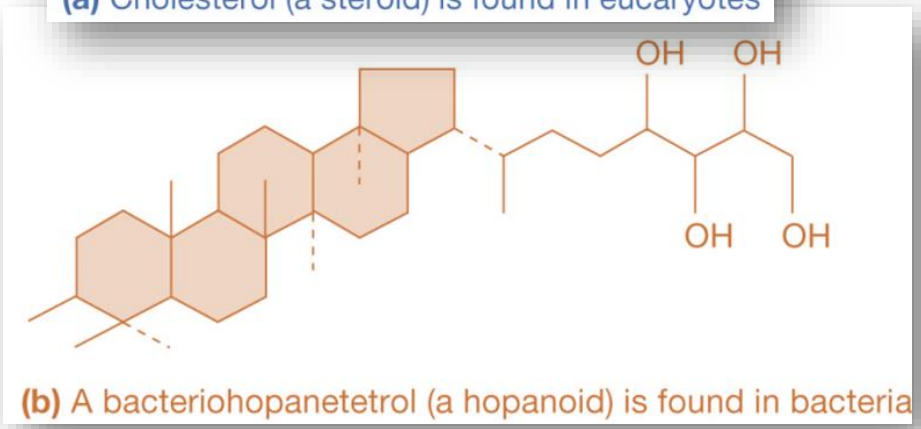


- Component:**phospholipid**
- **The lipid composition varies with environmental temperature.**
- **Bacteria growing at lower temperatures have more unsaturated fatty acids in their membrane phospholipids;**
- **Why? To remain fluid.**

3.3.1 Bacterial Lipids



(a) Cholesterol (a steroid) is found in eucaryotes



(b) A bacteriohopanetetrol (a hopanoid) is found in bacteria

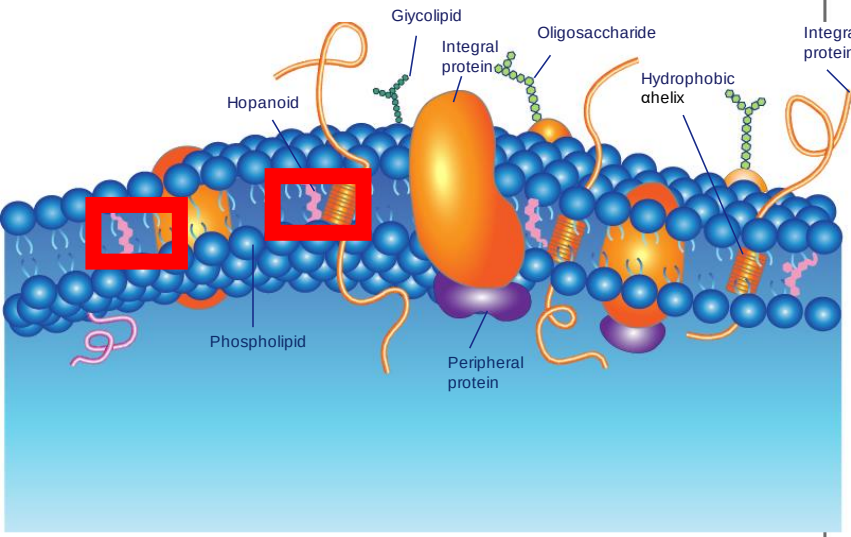
- Bacterial membranes lack sterols but do contain sterol-like molecules, hopanoids
  - Synthesis from the same precursors as steroids
  - Stabilize membrane
  - Found in petroleum(in sediment)

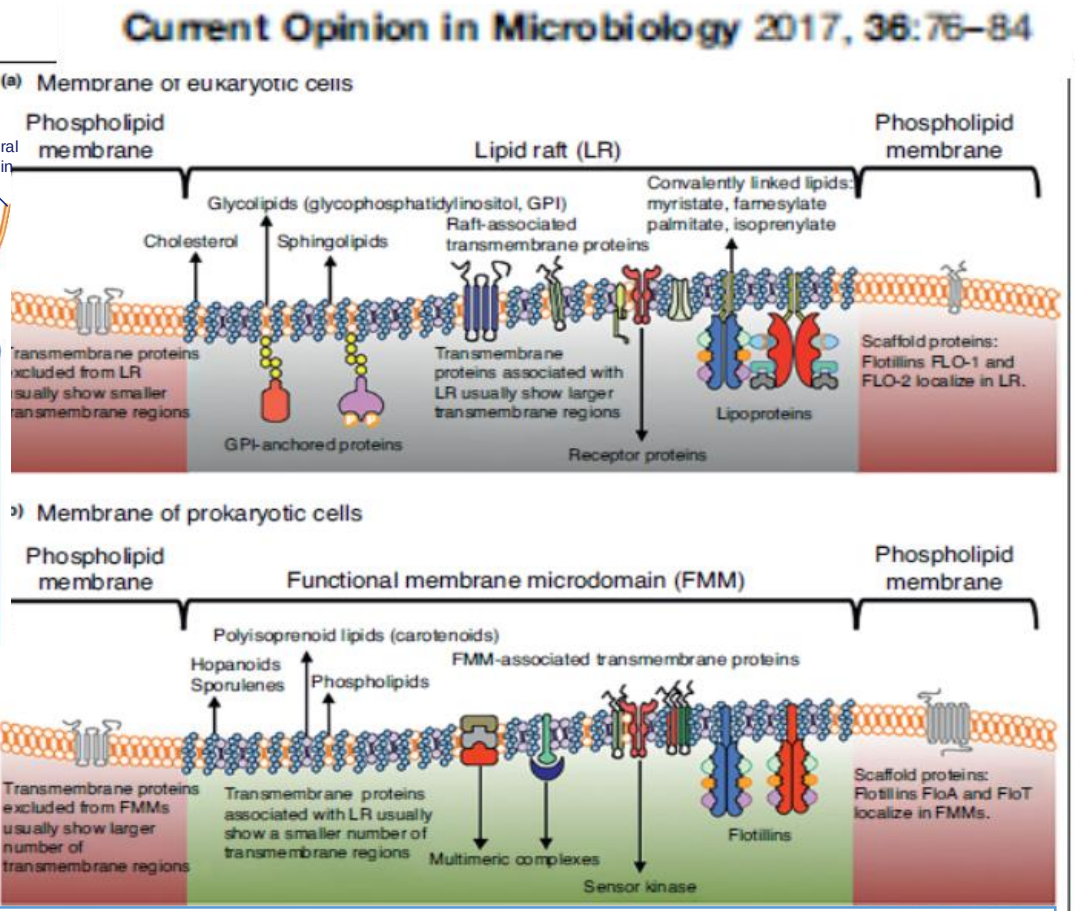
Summary

- Lipid bilayers: phospholipid(hopanoids)
- Floating proteins: soluble(E?)
- Integral-mosaic proteins: insoluble, amphipathic (ETC, transport protein, etc)

• 3.3.2 Model of Plasma Membranes(PM)

Is it perfect? What is the flaw of this model?





However, the presence of <u>microdomains</u> enriched for <u>certain lipids</u> and the observation that some <u>integral proteins</u> are present at <u>only certain sites</u> do not support this view.

3.3.3 Bacterial Plasma Membrane Function

- **Encompasses the cytoplasm**
- **Selectively permeable barrier(e.g. uptake nutrient)**
- **Interacts with external environment**
  - **Receptors for detection of and response to chemicals in surroundings**
  - **Transport systems**
  - **Metabolic processes**
  - **Mesosome(中介体)-like a mitochondria**

3.3.3. Uptake of Nutrients

- **What are nutrients?**
- **Elements(macro-; micro-;trace-)**
- **C,O,H,N,S,P,K,Ca,Mg,Fe;**
- **Mn,Zn,Co,Mo,Ni,Cu**
- **Growth factor (AA, Base, Vitamin is essential for some bacteria)**
- **How to uptake? (mechanisms)**
  - **Passive diffusion- concentration gradient**
  - **Facilitated diffusion – all microorganisms**
  - **Active transport – all microorganisms(energy)**
  - **Group translocation(energy) –**
- **Bacteria can uptake soluble nutrients**

3.3.3.1. Passive Diffusion

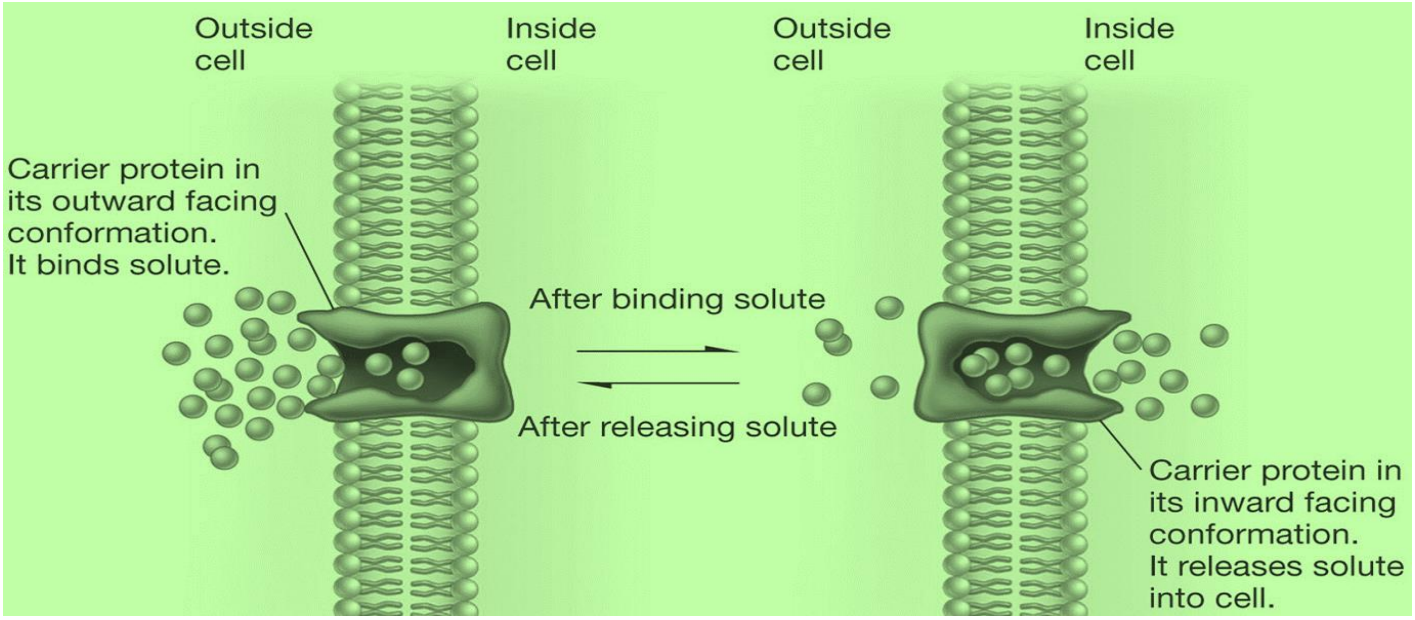
被动扩散

- Molecules move from region of higher concentration to one of lower concentration between the cell's interior and the exterior
- Movement of molecules is not energy dependent
- H_2O, O_2, and CO_2 often move across membranes

3.3.3.2. Facilitated Diffusion

促进扩散

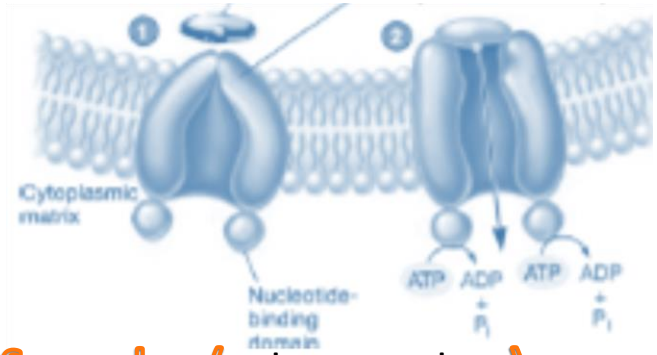
- Similar to passive diffusion
- Differs from passive diffusion
  - Uses membrane bound carrier molecules (permeases)(glycerol, sugars, and amino acids)



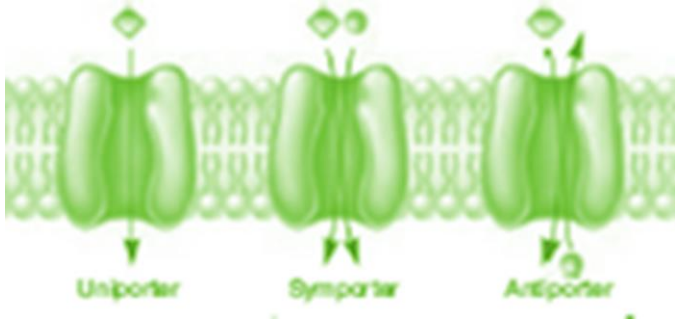
3.3.3.3 Active Transport

主动运输

Primary(ATP)



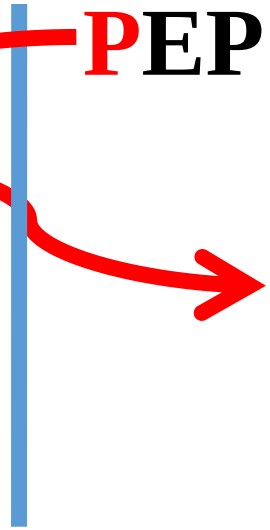
Secondary(cotransporters)



- Energy-dependent process
  - ATP(primary) or proton(secondary) motive force used
- Move molecules against the gradient
- Involves carrier proteins (permeases)
- AA(glu, leu) (K^+)

3.3.3.4. Group Translocation

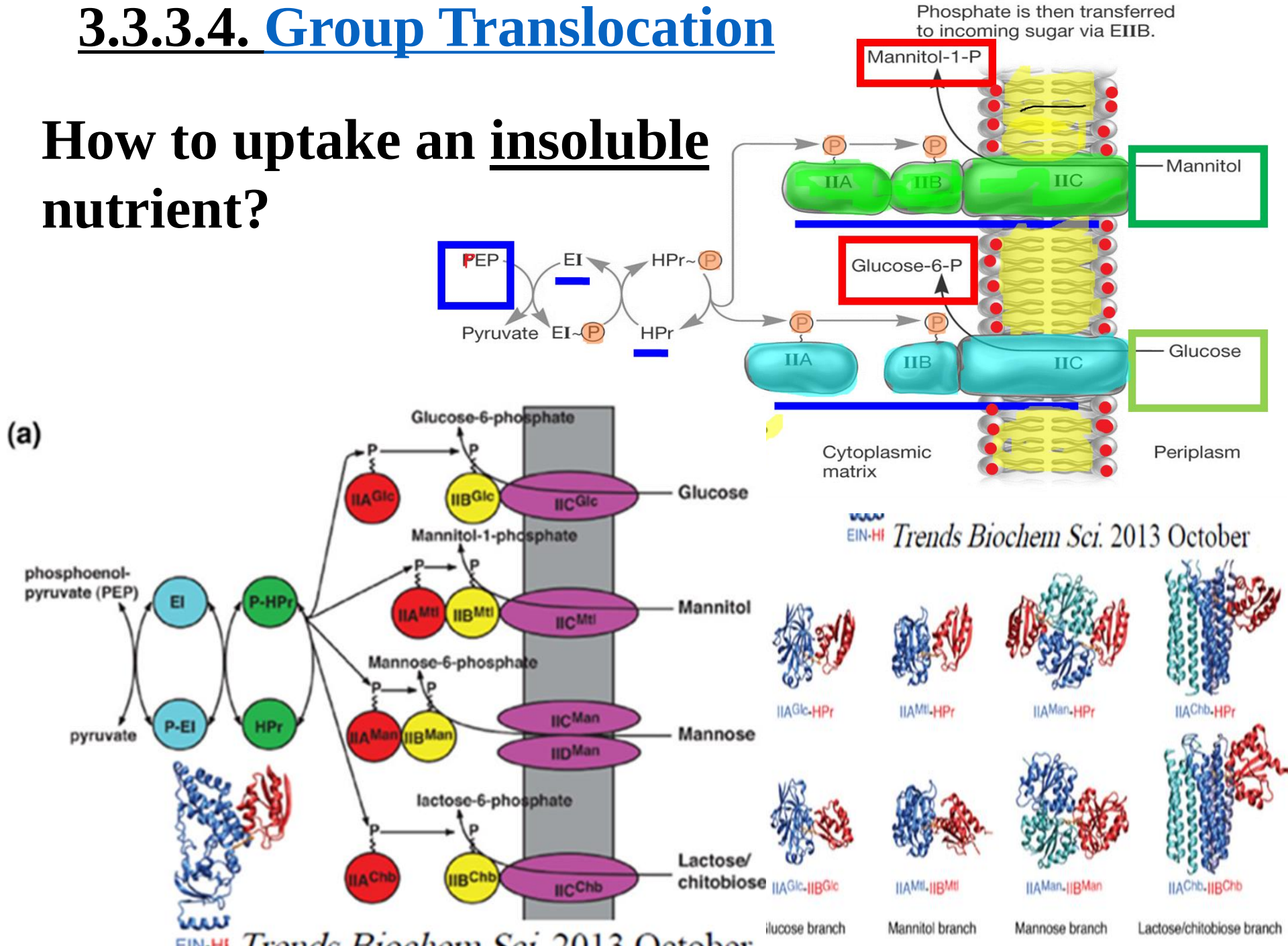
- **Energy dependent transport that chemically modifies molecule as it is brought into cell**
- **Best known translocation system is phosphoenolpyruvate(PEP): sugar phosphotransferase system (PTS)**
  - **sugar**
  - **PEP (metabolite, high energy)**
  - **P-sugar(in)**
  - **?**



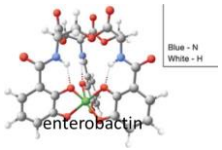
out **in**

3.3.3.4. Group Translocation

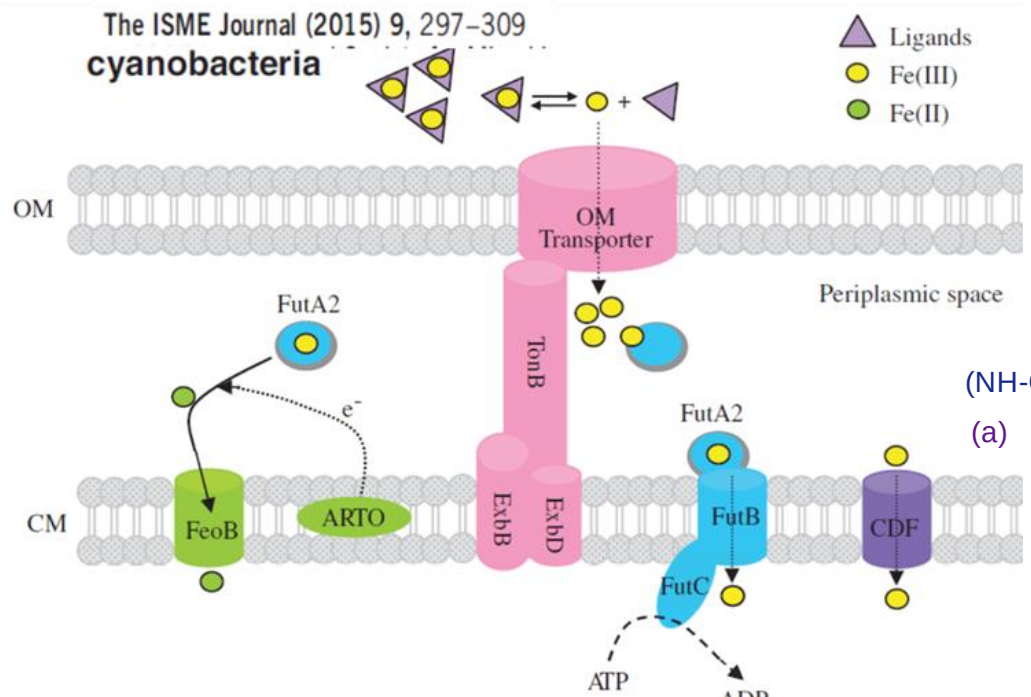
How to uptake an insoluble nutrient?



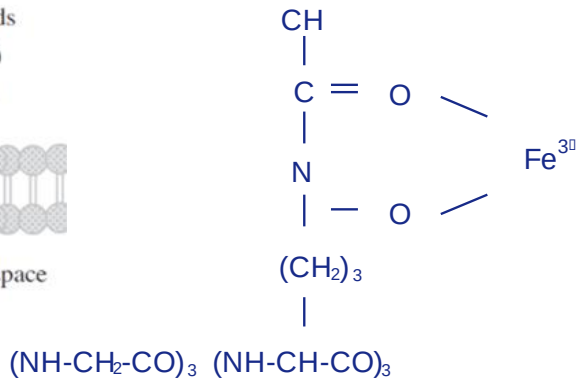
3.3.3.5. Iron Uptake



- Fe $^{3+}$ is very insoluble so uptake is difficult
- Microorganisms secrete siderophores to aid uptake
- Siderophore complexes with Fe $^{3+}$ then transported into cell

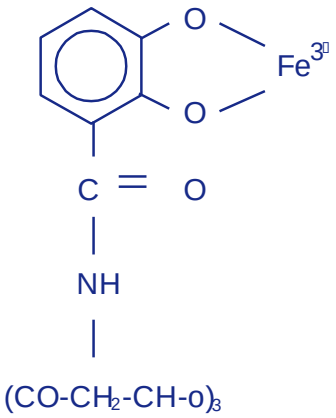


Ferrichrome



(a)

Enterobactin



(b)

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Summary

- **Size- 0.1-10 um**
- **Shape-simple coccus/rods**
  - **Shape was determined by plane of division and separation or not**
- **S/V is a survive strategy.**
- **The nutrients uptake**
- **PTS uptake system and iron uptake mechanism**

Comments

- **Passive diffusion- concentration gradient**
- **Facilitated diffusion**
- **Active transport (energy)**
- **Group translocation(energy)**

Above four mechanisms, which one is the best for bacteria?

For human cells, the plasma membrane is enough, but microorganism cells need more……Why?

Next we will talk about of the outside structure of membrane ……

Thanks!

Please try to discuss the mechanism of Gram stain.

Mechanism of Gram Staining

- **What is the procedure of Gram stain?**
- **How to prove cell wall is the main factor for Gram stain?**
- **What is the main difference of G+ and G- in cell wall?**
- **Try to explain the mechanism of Gram stain.**