厦门大学
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SCHOOL OF LIFE SCIENCES XIAMEN UNIVERSITY

MICROBIOLOGY

Lecture 3

1）Archaeal Cell Structure

2）Fungal Cell

（Chapter 4, 5, 26)

张连茹

Outline

- **A Typical Archaeal Cell**
- **Archaeal Cell Envelope(Membrane and wall)**
- **Archaeal Cell External Structures**
- **Compare and Discussion**
- **A Typical Fungal Cell (Yeast and Mold)**
- **Fungal Structure**
- **Fungal Reproduction**
- **Fungal Family (*Ascomycota*)**
- **What is an Archaea?**

Discussion

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

4.1 A Typical Archaeal Cell

- **Archaeal cells, like bacterial cells.**
- **Archaeal taxonomy is currently in a state of flux, but two phyla are well established:**
- ***Crenarchaeota* and *Euryarchaeota*.一个新的古菌类群——奇古菌门(*Thaumarchaeota*)**

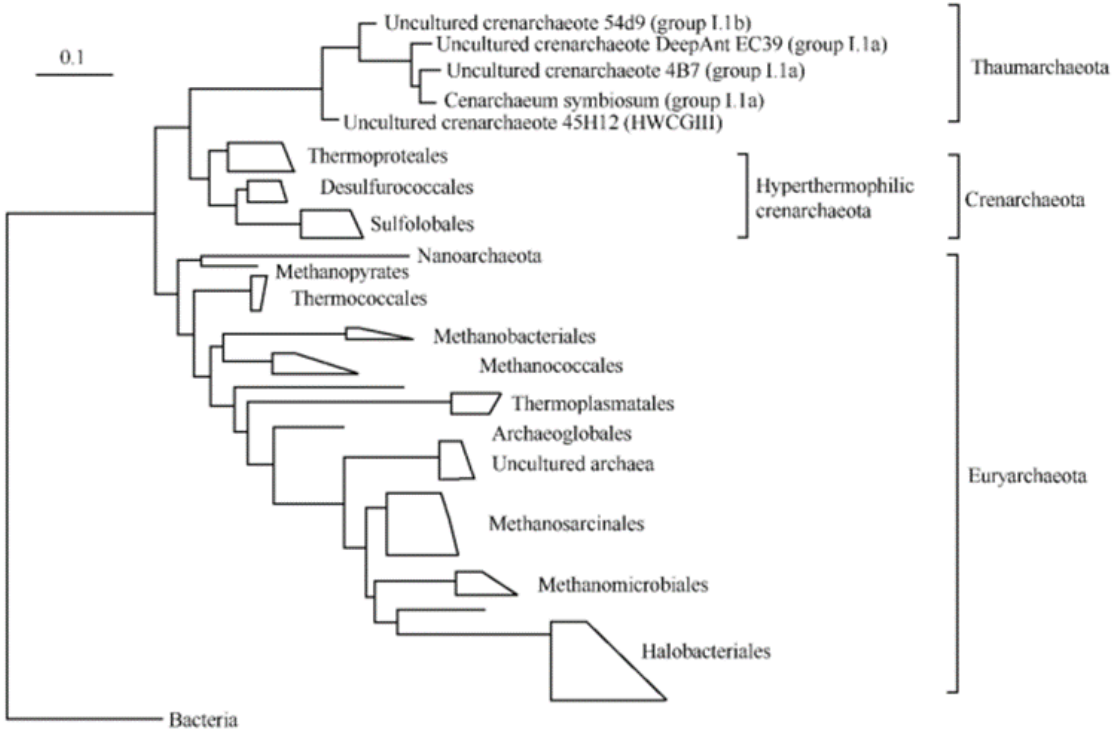
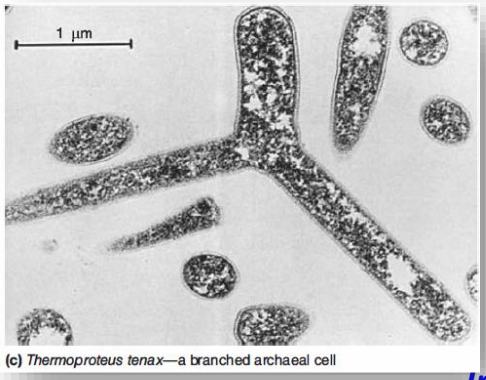


图 1　基于 226 个 SSU rRNA 和 LSU rRNA 基因的细菌和古菌系统发育关系示意图[4]

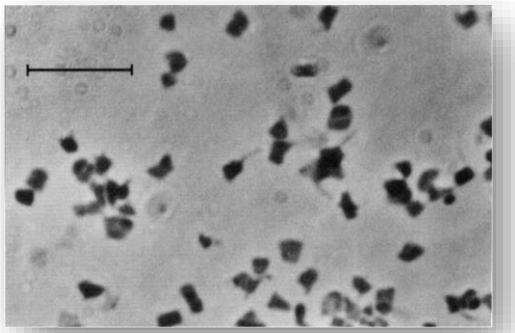
Fig. 1　Schematic phylogeny of archaea and bacteria based on the concatenation of 226 SSU and LSU rRNA gene sequences[4].

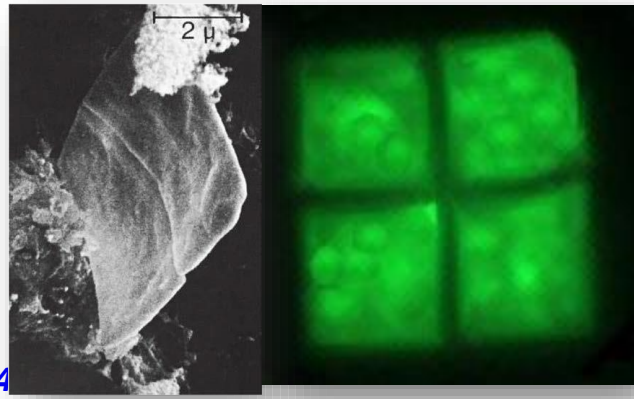
4.1.1 Shape, Arrangement, and Size

- **Archaeal cells, exhibit a variety of shapes. Cocci and rods are common.**
- **To date, no spirochete-like and mycelial archaea have been discovered (?) .**
- **However, some archaea exhibit unique shapes, such as the branched form of *Thermoproteus tenax* and the flat, postage-stamp-shaped *Haloquadratum walsbyi*, an archaeon that lives in salt ponds and measures about 2 µm by 2 to 4 µm and only 0.25 µm thick**



(c) *Thermoproteus tenax*—a branched archaeal cell





International Journal of Systematic Bacteriology4

4.1.2 Cell General Structure

- The unusual lipids were one of the first pieces of evidence to suggest that these microbes are phylogenetically distinct from bacteria.
- Most archaea have a cell wall, but their walls are considerably more diverse than bacterial walls.
- Notably, archaeal cell walls lack peptidoglycan.
- Capsules are not widespread among those archaea examined thus far.
- Within the archaeal cytoplasm, a nucleoid, ribosomes, and inclusions can be found.
- Finally, many archaea use flagella for locomotion.

4.1.3 Comparison of Archaeal and Bacterial Cell

Table 4.1 Comparison of Bacterial and Archaeal Cells

Property	Bacteria	Archaea
Plasma membrane lipids	Ester-linked phospholipids and hopanoids form a lipid bilayer; some have sterols	Glycerol diethers form lipid bilayers; glycerol tetraethers form lipid monolayers
Cell wall constituents	Peptidoglycan is present in nearly all; some lack cell walls	Very diverse but peptidoglycan is always absent: some consist of S-layer only, others combine S-layer with polysaccharides or proteins or both; some lack cell walls
Inclusions present	Yes, including gas vacuoles	Yes, including gas vacuoles
Ribosome size	70S	70S
Chromosome structure	Most are circular, double-stranded (ds) DNA; usually a single chromosome	All known are circular, dsDNA
Plasmids present	Yes; circular and linear dsDNA	Yes; circular dsDNA
External structures	Flagella, fimbriae (pili) common	Flagella, pili, and piluslike structures common
Capsules or slime layers	Common	Rare

We define the cell envelope as the plasma membrane and any layers external to it. One of the most distinctive features of archaeal cells is the nature of their cell envelopes.

Discussion

Identify three features that distinguish archaeal plasma membranes from those of bacteria.

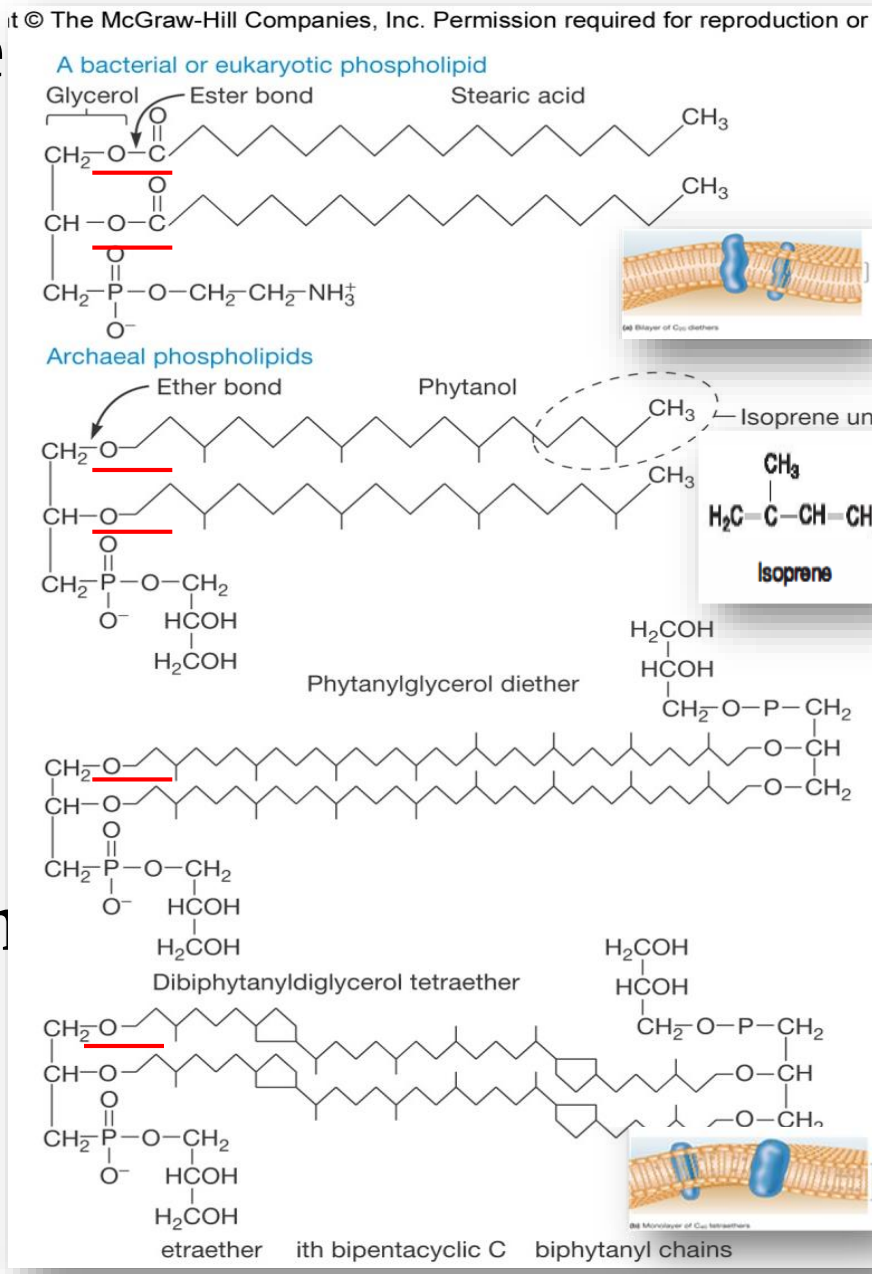
4.2. Archaeal cell envelopes(layers)

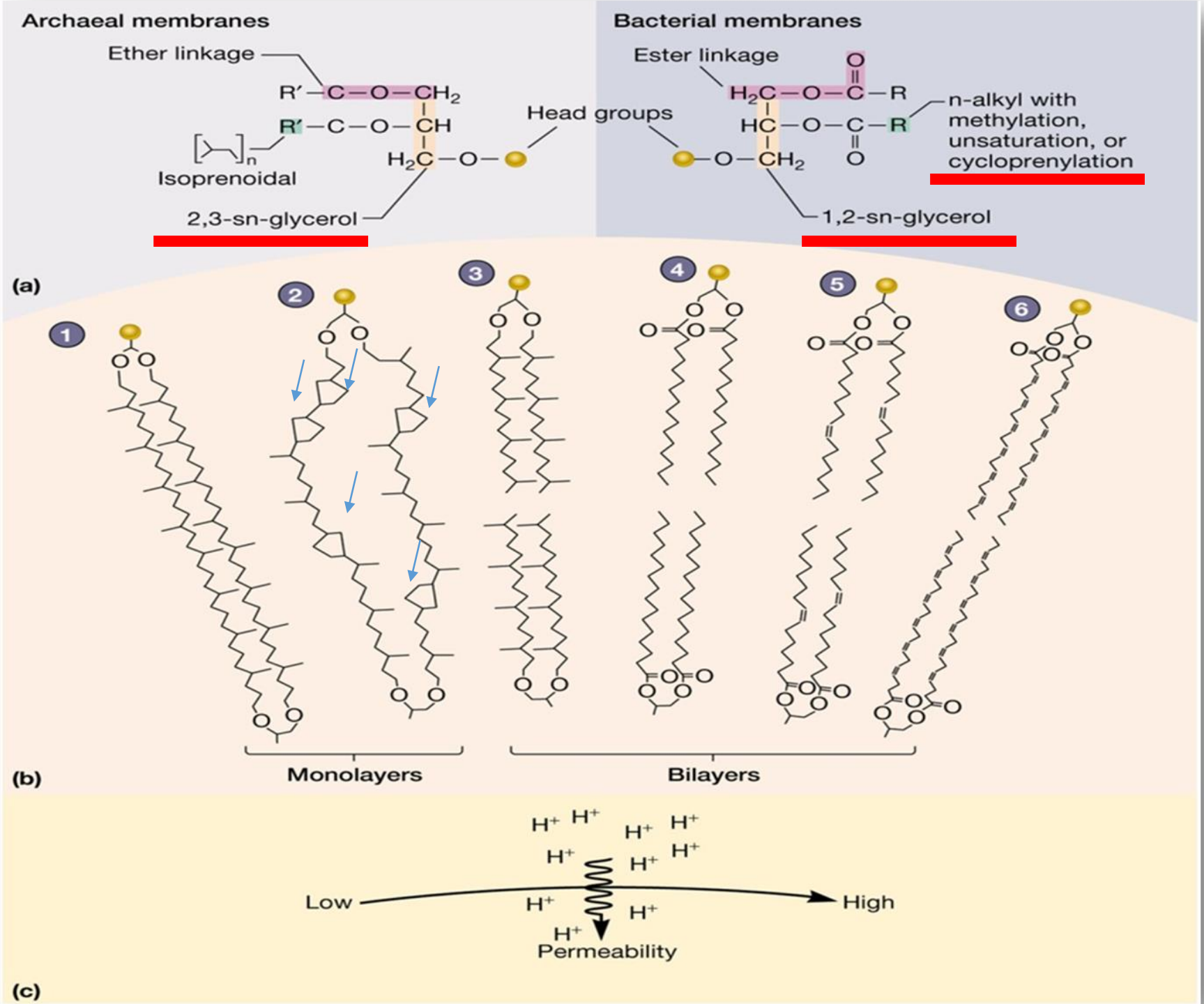
- **Cell envelope as the plasma membrane and any layers external to it. For bacteria, these include the plasma membrane, cell walls, S-layers, capsules, and slime layers.**

- **Differ from bacterial envelopes in the molecular makeup and organization**
  - **S layer may be only component outside plasma membrane(G^-)**
  - **Pseudomurein may be outermost layer(G^+)**
  - **Some lack cell wall**
  - **External layers are rare(capsules,slime layer)**

4.2.1 Archaeal Plasma Membranes and Nutrient Uptake

- First, the hydrocarbons are branched(?). This is especially important for extremophilic archaea for which membrane fluidity and permeability could be compromised by extreme conditions.
- Second, the hydrocarbons are attached to glycerol by ether links (?)rather than ester links.
- Some archaeal lipid form monolayers(?).




Archaeal membranes
Ether linkage
Isoprenoidal
Head groups
2,3-sn-glycerol
Bacterial membranes
Ester linkage
n-alkyl with methylation, unsaturation, or cycloprenylation
1,2-sn-glycerol
(a)
1
2
3
4
5
6
(b)
Monolayers
Bilayers
H+
Low
High
Permeability
(c)

4.2.1 Archaeal Plasma Membranes and Nutrient Uptake

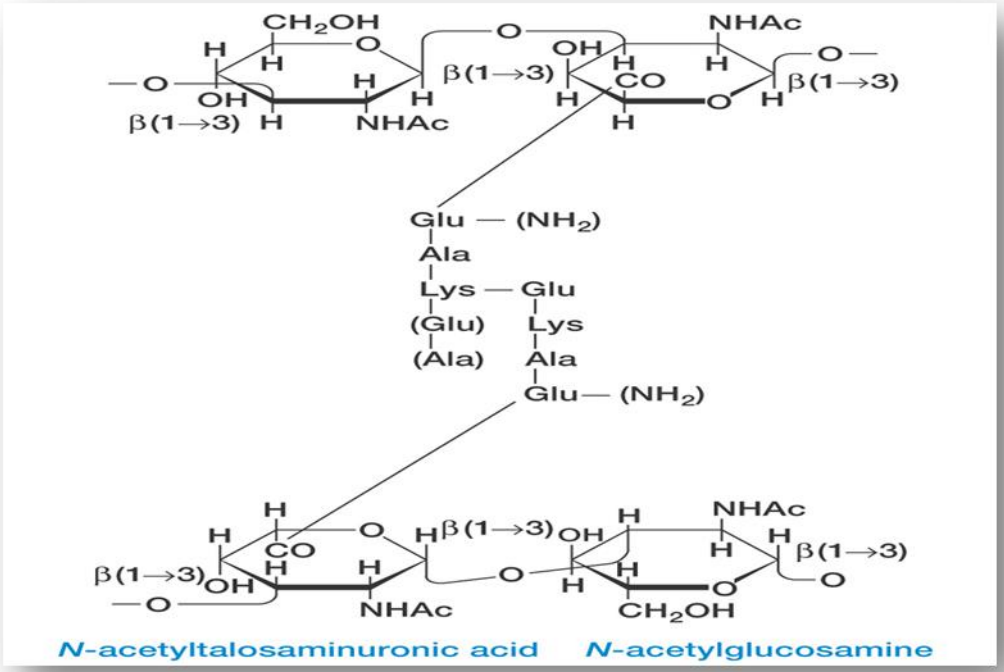
- **Archaea typically use primary and secondary active transport systems to obtain nutrients from their environment(often by searching an archaean's genome for the genes encoding components of these systems).**
- **Thus far, group translocation systems such as the phosphoenolpyruvate: sugar phosphotransferase system (PTS) have not been identified in any archaea.**
- **How about of the Gram stain in archaea?**

Discussion

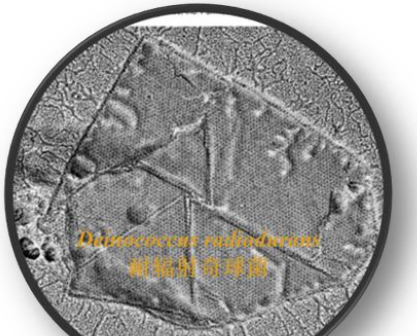
Both bacteria and archaea can have S-layers. How does their use as components of the cell envelope differ?

4.2.2 Archaeal cell walls(p84)

- **Lack peptidoglycan(G^-)**
- **Pseudomurein may be outermost layer – similar to G^+**
- **Most common cell wall is S layer**
- **May have protein sheath external to S layer**
- **S layer may be outside membrane and separated by pseudomurein(methan)**
- **Polysaccharides or Slime may be outside(*Ferroplasma)***



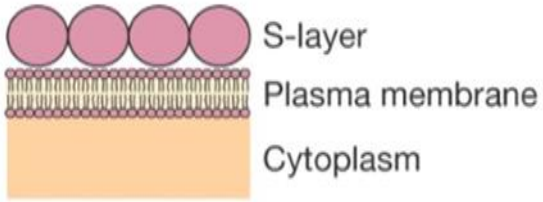
L-amino acids instead of D-amino acids in its cross-links, N-acetyltalosaminuronic acid instead of N-acetylmuramic acid, and (1-3) glycosidic bonds instead of (1-4) glycosidic bonds



4.2.2 Archaeal cell wall types

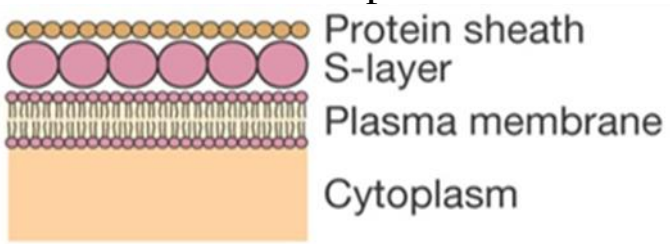
(1) S-layer as the cell wall

Methanococcus, Halobacterium, Pyrodictium, Sulfolobus, **and** ***Thermoproteus*** **cell envelopes.**



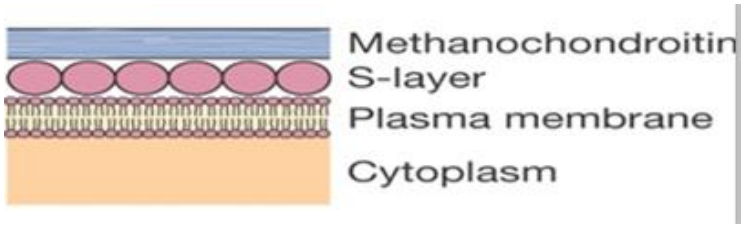
(2) S-layer+Protein sheath

Methanospirillum cell envelope



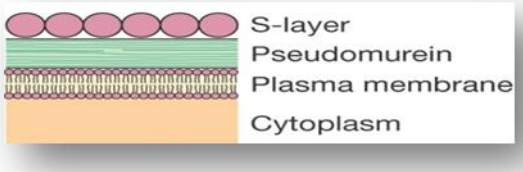
(3) Methanochondrotin+S-layer

Methanosarcina **cell envelope.**



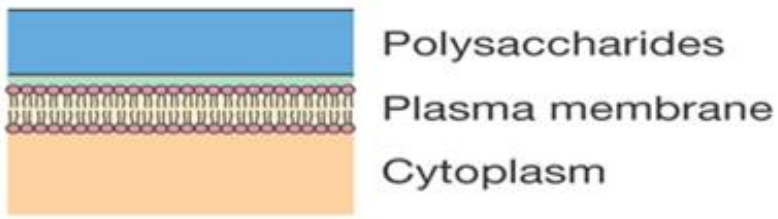
(4)Pseudmurein+S-layer

Methanothermus **and** ***Methanopyrus*** **cell envelopes.**

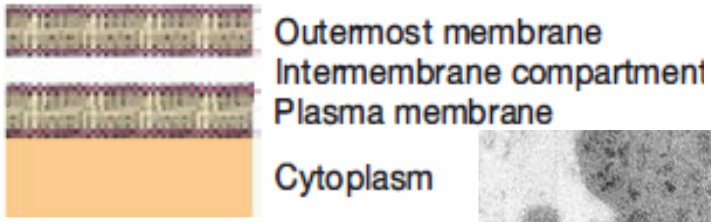


(5)Polysaccharides

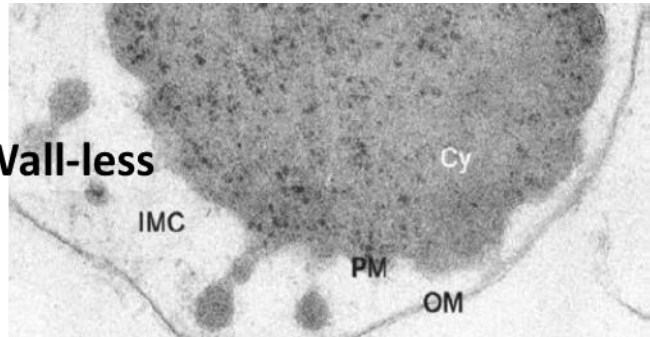
Methanobacterium, Methanosphaera, Methanobrevibacter, Halococcus, **and** ***Natronococcus*** **cell envelopes**



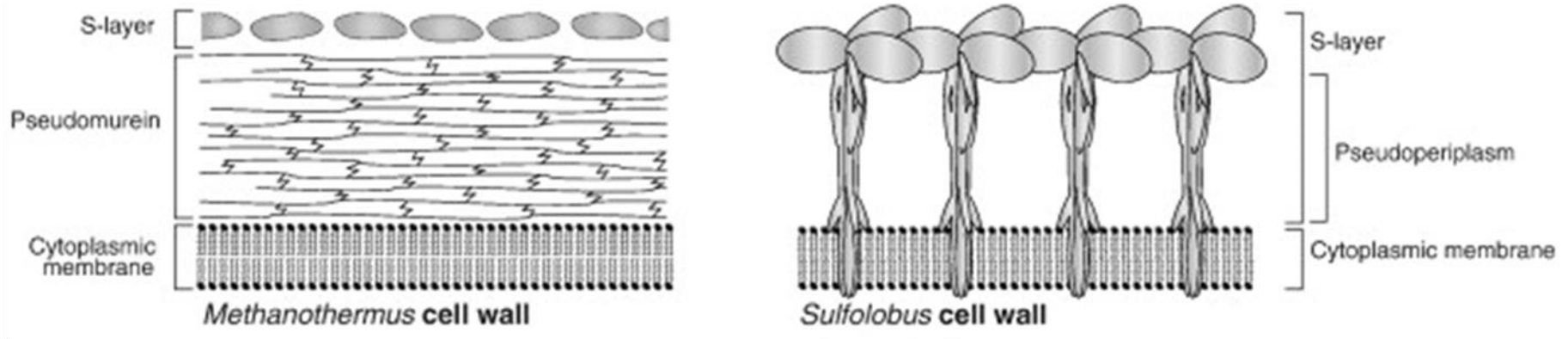
(6)OM+ ***Ianicoccus*** **cell envelope.**



Cell Envelope of the Wall-less



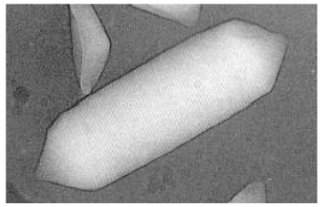
4.2.2 Surface layer (S layer)



Philippe M. Oger, Anaïs Cario, In Biophysical Chemistry, 183, 2013,42-56

- **Protect** from environment changes (e.g.ion and pH fluctuations, osmotic stress, enzymes, and predation)
- **Maintains** shape and rigidity
- **Promotes** adhesion to surfaces
- **Protects** from host defenses(virulence)
- Potential use in **nanotechnology**
  - S layer **spontaneously associates**

4.3 Archaeal Cytoplasm



Overall, the cytoplasm of archaeal cells is very similar to that of bacteria. Within it can be found inclusions-PHB, polyphosphate granules, glycogen granules, and gas vacuoles; ribosomes; a nucleoid; and, in some cases, plasmids.

Cytoskeletal proteins have also been identified, crenactin, an actin homologue unique to certain members of the phylum *Crenarchaeota*.

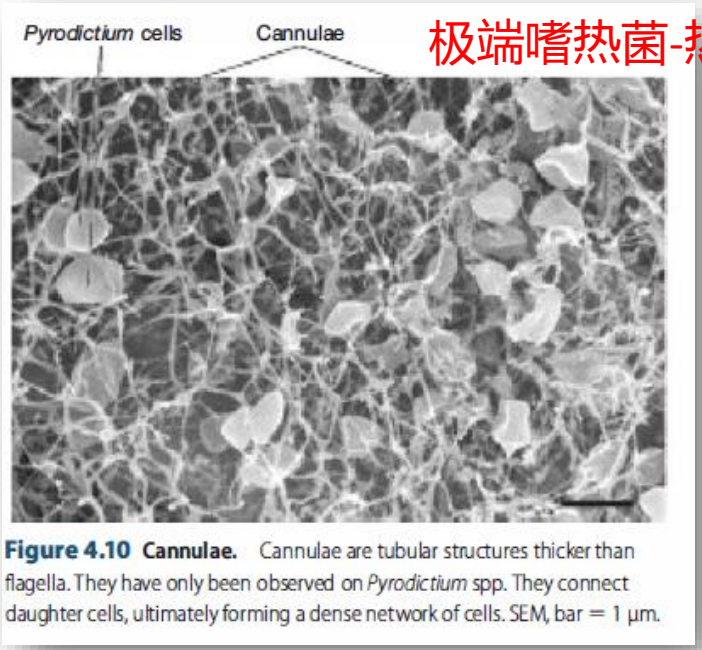
- **Ribsome:70S**
- **rRNA: 5.8S-Eukaryotic**
- **16S etc.-Prokaryotic**
- **Protein: both**

- **Nucleoid(polyploid)**
- **With Histone**

4.4 External Structures(pili,cannulae and Hami)

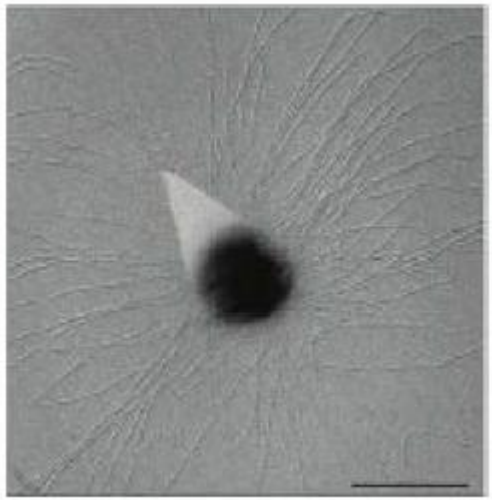
Many archaea have pili. However, the pilus formed from these proteins(IVpili) is unique in several ways, including the presence of a central lumen. Central lumens are observed in bacterial flagella but not in bacterial type IV pili.

- **Cannulae, and Hami(**unique to archaea)



极端嗜热菌-热网菌

Figure 4.10 Cannulae. Cannulae are tubular structures thicker than flagella. They have only been observed on *Pyrodictium* spp. They connect daughter cells, ultimately forming a dense network of cells. SEM, bar = 1 µm.



(a) Hami radiating from cell

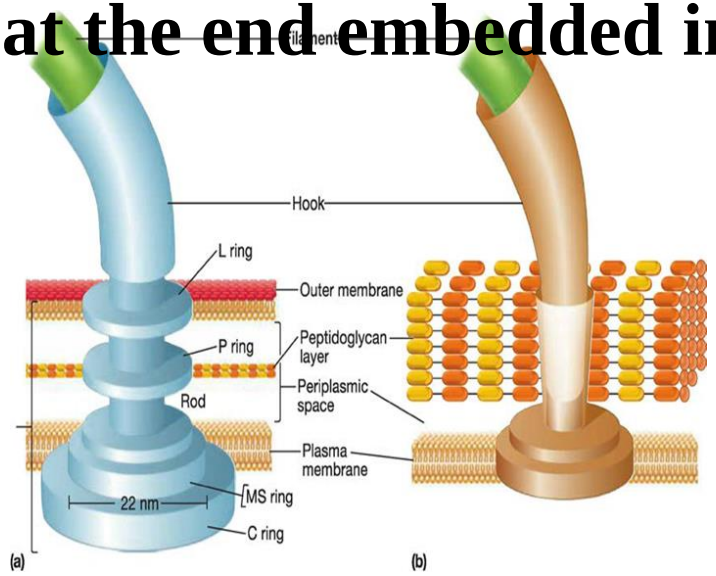
(b) "Grappling hooks" distal ends of hami

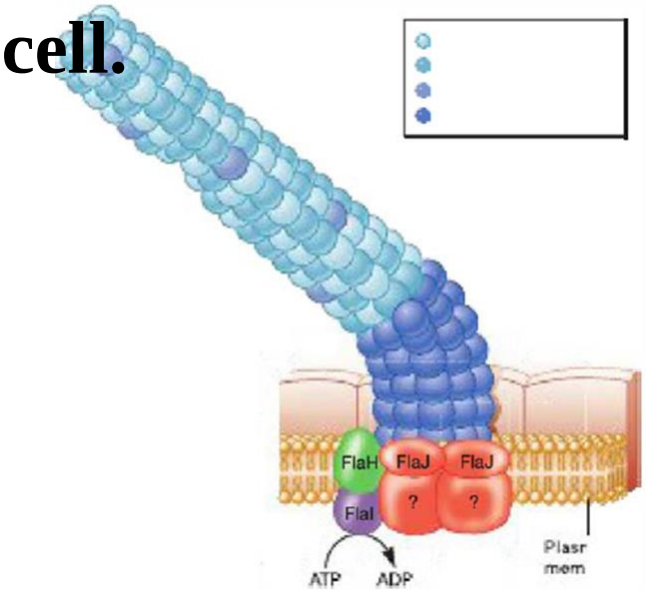
Cannulae are hollow, tubelike structures observed on the surface of thermophilic archaea belonging to the genus *Pyrodictium*. Function?

Archaeal cells that produce hami are members of biofilm communities generally consisting of a hami-producing archaean and a bacterium.

4.4 Archaeal Flagella And Motility

- **Archaeal flagellum is not hollow,**
- **Archaeal hooks are difficult to distinguish from the filament; they also tend to be longer than bacterial hooks.**
- **A basal body has not been identified, but some preparations of archaeal flagella have a knoblike structure at the end embedded in the cell.**





Surprisingly, the machinery controlling chemotaxis and phototaxis in *H. salinarum* is homologous to that found in bacterial systems.

Summary

- **One major difference between bacterial and archaeal cells is that they have distinctive cell envelopes. There are also important differences between bacterial and archaeal ribosomes, chromosomes, flagella, and pili.**

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External structures	Flagella, fimbriae (pili) common	Flagella, pili, and piluslike structures common
Capsules or slime layers	Common	Rare

- **How about of the Fungi?**

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MICROBIOLOGY

Lecture 3-2

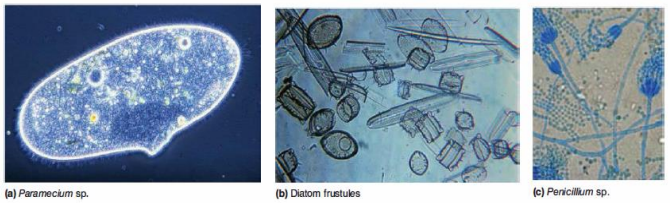
Fungal Cell Structure

What are eukaryotes?
What are fungi?
What are yeasts?
What are molds?

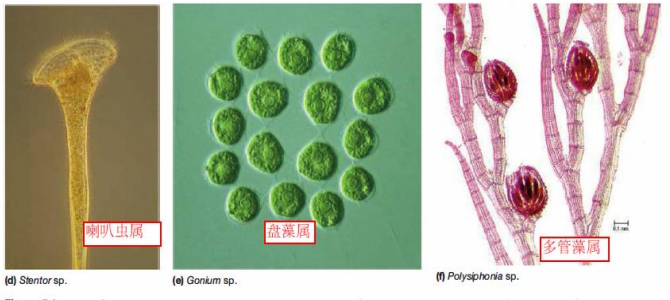
张连茹

What are eukaryote?

- Prominent member of ecosystem.
- They have membrane-delimited nuclei, and membranes play a prominent part in the structure of many other organelles. For adequate regulation, metabolic activity, and transport.
- Two group: Protists; Fungi
- Facilitated diffusion plays a more prominent, also use passive diffusion and active transport.
- In addition, eukaryotes have another materials into cells: endocytosis.



- Fungi May Be Key to Quelling Malar

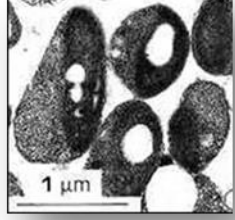


What is a fungus?

- **The term fungus (pl., fungi) describes eukaryotic organisms that are spore-bearing, have absorptive nutrition, lack chlorophyll, and reproduce both sexually and asexually.**

- **Single-cell microscopic fungi are referred to as yeasts, while multicellular masses are called molds.**
- **Fungi also include macroscopic puffballs and mushrooms.**

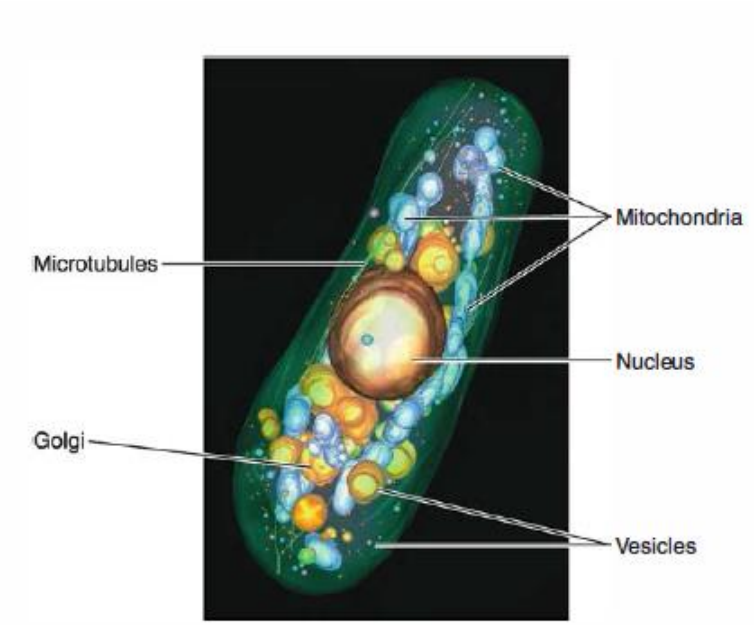
5.1 A Typical Fungal Cell

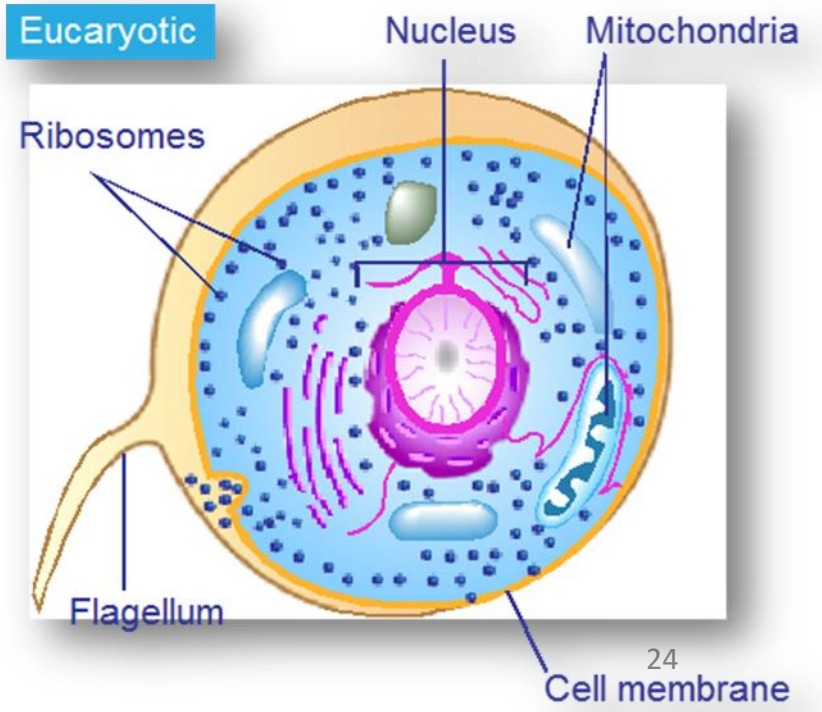


More structurally complex and generally larger than bacterial or archaeal cells. The smallest one is *Ostreococcus tauri*. (a unicellular green alga)

Eukaryotic cells are distinctive because of their use of membranes.

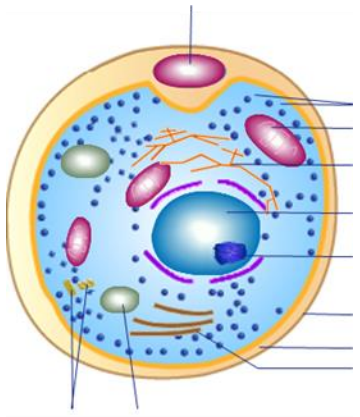
Organelles are intracellular structures that perform specific functions in cells.





5.2. Fungal distribution and importance

- **Fungi are primarily terrestrial organisms.**
- **They have a global distribution from polar to tropical regions.**
- **Fungi are important decomposers.**
- **Many fungi are pathogenic for plants and humans （5,000 species-plants，about 20/year new human fungal pathogens are documented).**
- **Conversely, fungi also form beneficial relationships with other organisms(mycorrhizae)菌根菌**
- **Industrial importance(drug)**
- **Research use(model)**



5.2. Fungal distribution and importance

- **Fungi, especially yeasts (single-celled fungi), are essential to many industrial processes involving fermentation.**
- **Examples include the making of bread, wine, beer, cheeses, and soy sauce.**
- **Industrial importance**
  - **Fermentation – yeast used in making bread, wine, beer, cheese, soy sauce**
  - **Organic acids – citric and gallic acid**
  - **Certain drugs – ergometrine麦角新碱, cortisone可的松,**
  - **Antibiotics – penicillin, griseofulvin 灰黄霉素**
  - **Immunosuppressive agents - cyclosporin**
- **In addition, fungi(*Saccharomyces cerevisiae)* are important research tools in the study of fundamental biological processes.**

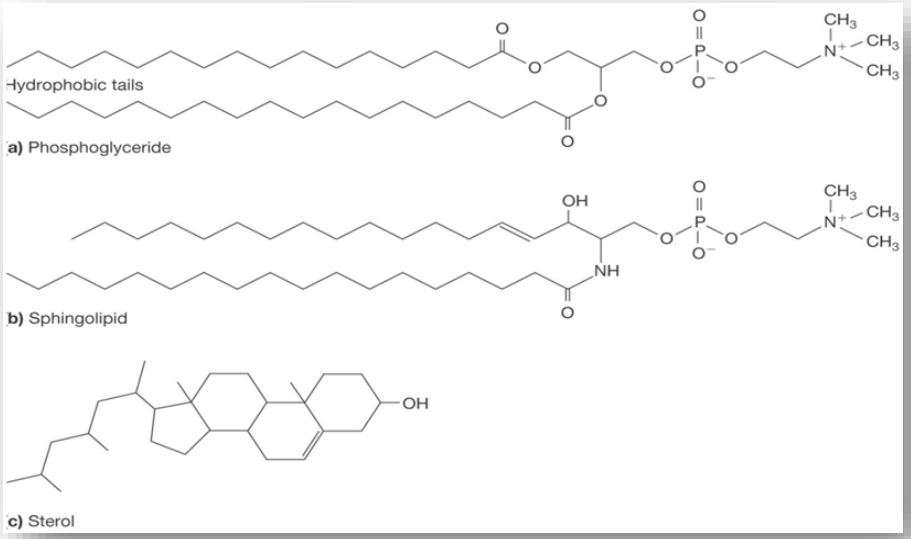
5.3 Fungal Structure-Cell Membrane

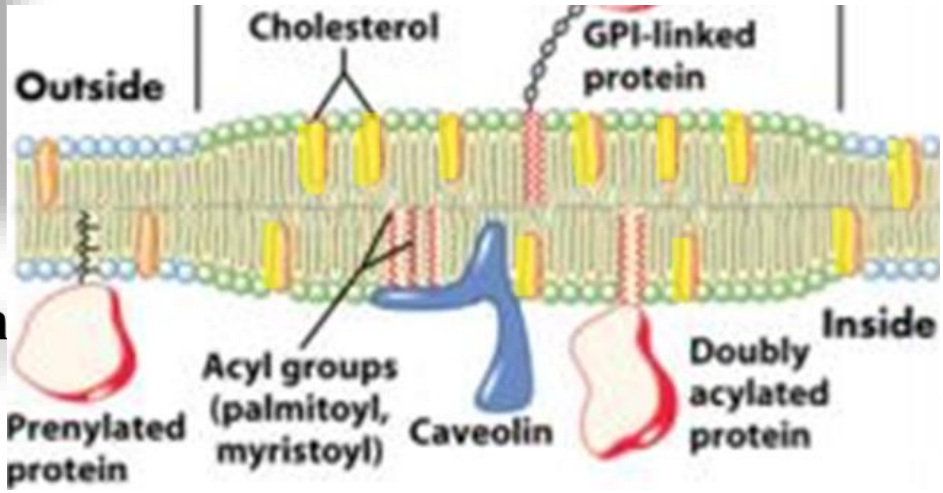
- **The plasma membrane of eukaryotes is a lipid bilayer composed of a high proportion of sphingolipids and sterols.**
- **The distribution of lipids in the plasma membrane is asymmetric. Lipids in the outer leaflet differ from those of the inner leaflet.**
- **There are microdomains that differ in lipid and protein composition. These microdomains are sometimes referred to as lipid rafts.**

5.3 Fungal Structure- Cell Membrane

lipid raft

A microdomain, which is enriched in cholesterol and lipids with many saturated fatty acids including some sphingolipids.

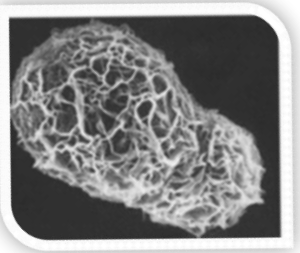




Cell movement and signal transduction

Virus entrance and assemble

5.3 Fungal Structure-Cell Wall



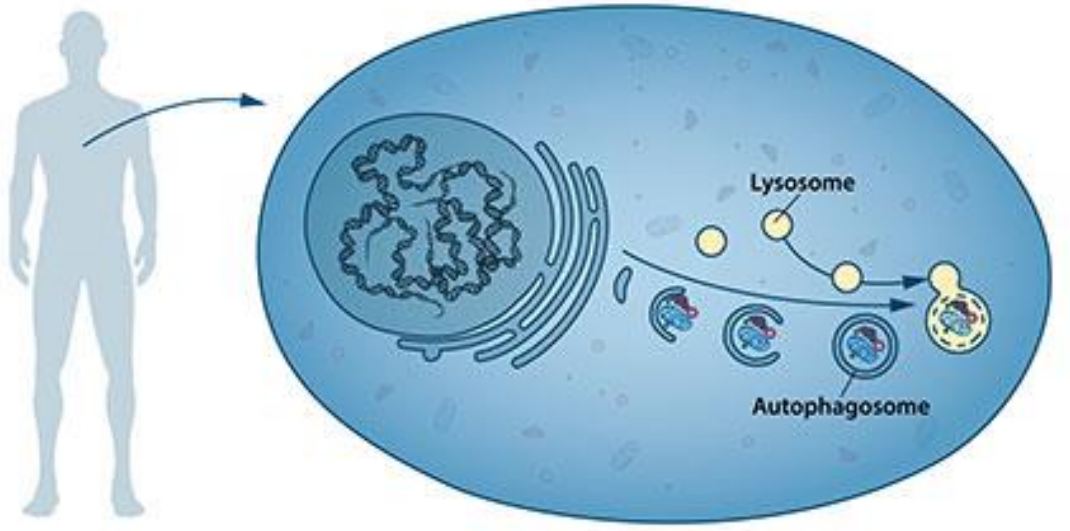
- **Fungal cell walls normally are rigid.**
- **Their exact composition varies with the organism; usually cellulose, chitin, or glucan is present.**
- **Chitin is a strong but flexible nitrogen containing polysaccharide consisting of N-acetylglucosamine residues.**

- **They lack flagella and cilia but have most other eukaryotic organelles**

What is a Yeast?

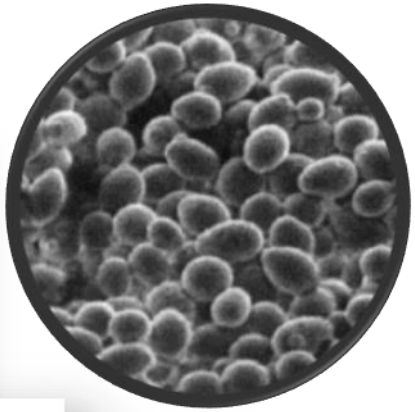
5.4. Typical Fungus-Yeast

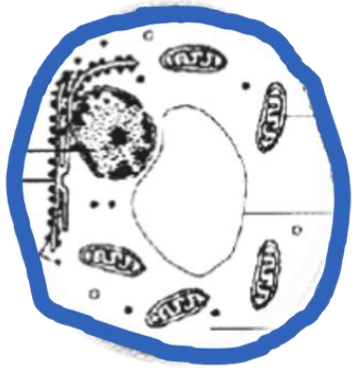
- **A yeast is a unicellular fungus with a single nucleus,**
- **Generally yeast cells are larger than bacteria and are commonly spherical to egg-shaped.**
- **They are often isolated from sugar-rich materials (such as on the skins of grapes, apples, or peaches).**



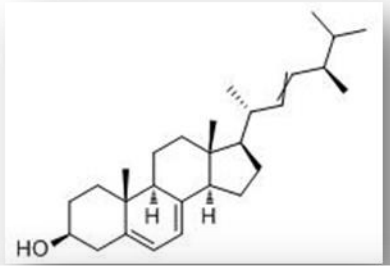
5.4 Typical Fungus-Yeast

- **Yeasts are unicellular, sizes vary greatly, typically measuring 3–4 μm in diameter, although some yeasts can grow to 40 μm in size.**
- **What is look like?**

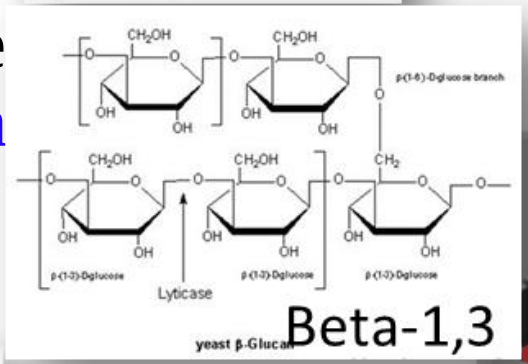


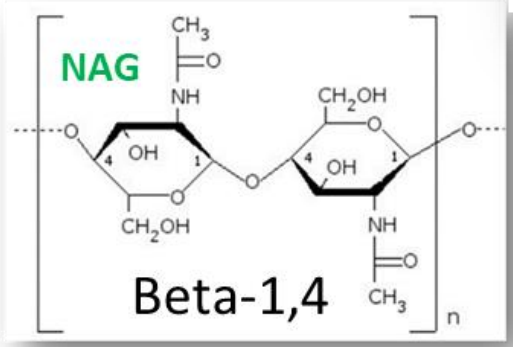


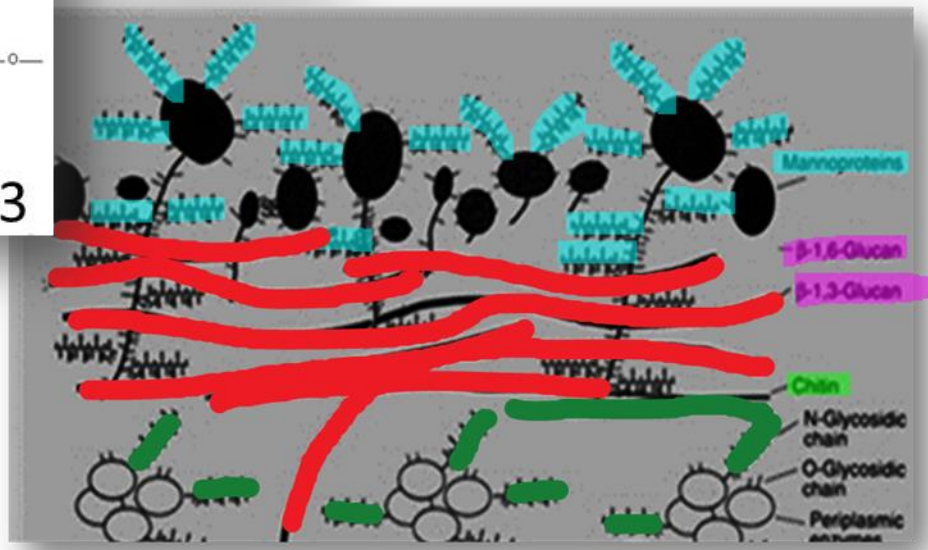
- **Membrane: rich in ergosterol** (麦角甾醇)



- **Cell wall: three layers, mannan glucan and chitin**

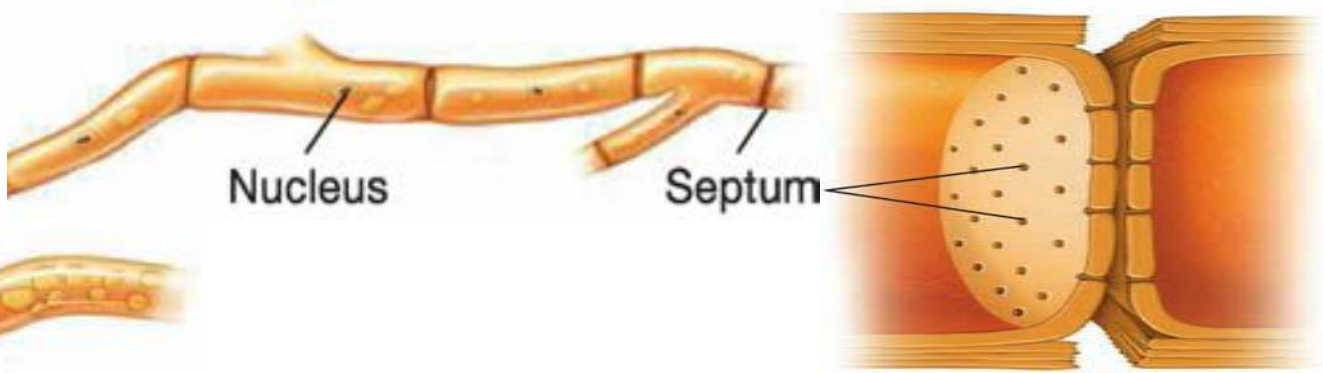






5.4. Typical Fungus -Mold

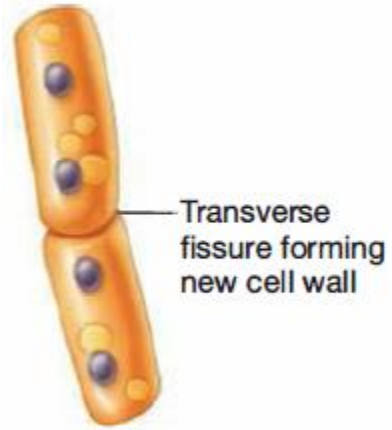
- **Molds are multinucleated fungi consists of long, branched, threadlike filaments of cells called hyphae(2-10 µm) that form a tangled mass called a mycelium.**
- **In some fungi, hyphae are called coenocytic or aseptate hyphae; the other`s hyphae are termed septate hyphae.**

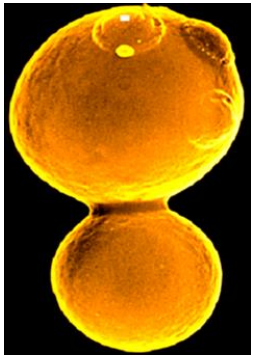


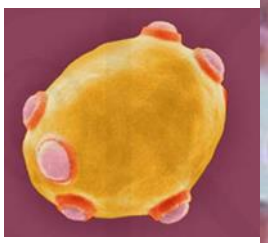
- **The filamentous nature of hyphae results in a large s/v.**
- **This makes adequate nutrient absorption possible.**

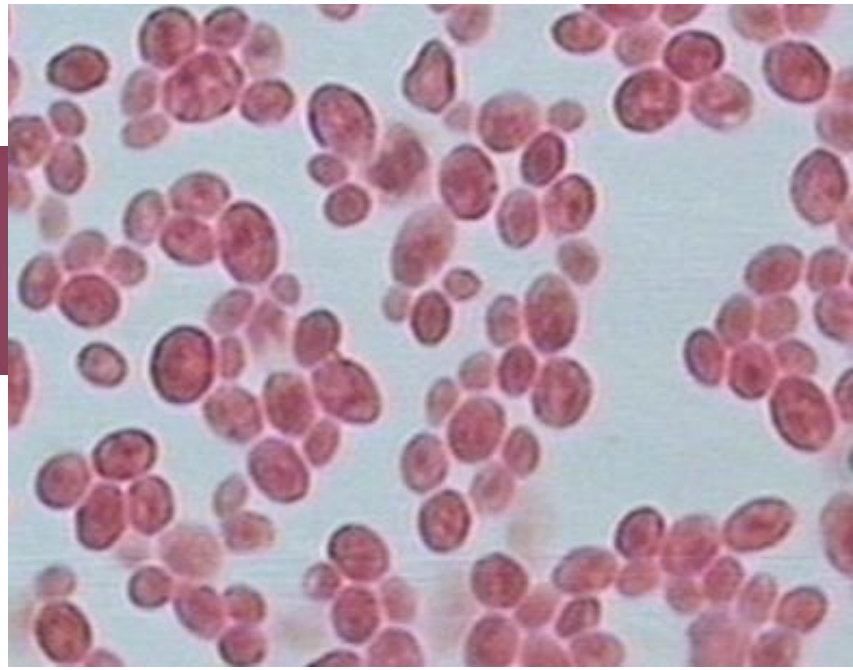
5.5 Fungal Reproduction

- **Reproduction in fungi can be either asexual or sexual.**
- **<u>Asexual</u>: (mitosis and asexual spores)**
- **1) A parent cell undergoes mitosis and divides into two, or with budding to produce a daughter cell (in yeasts).**





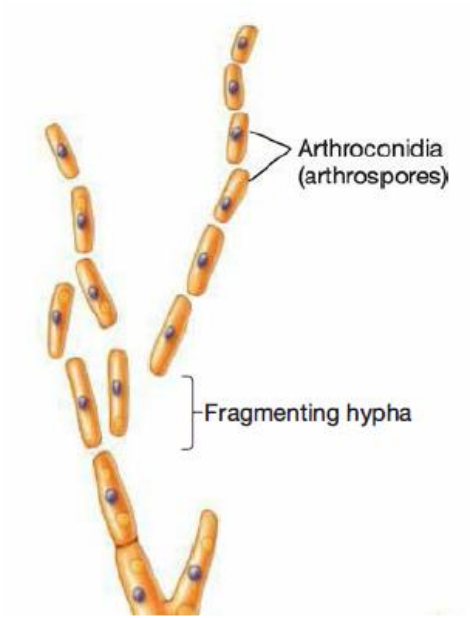


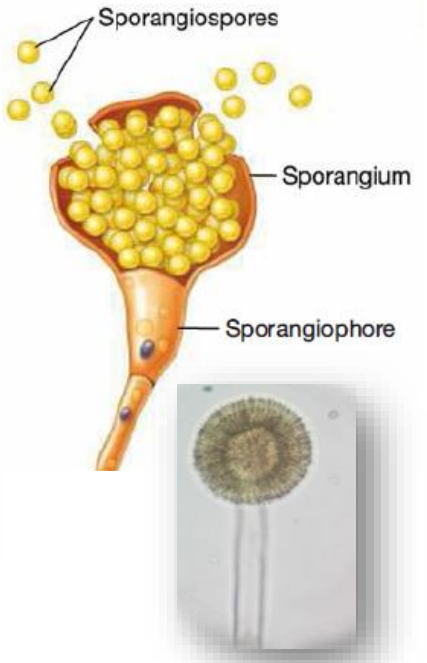


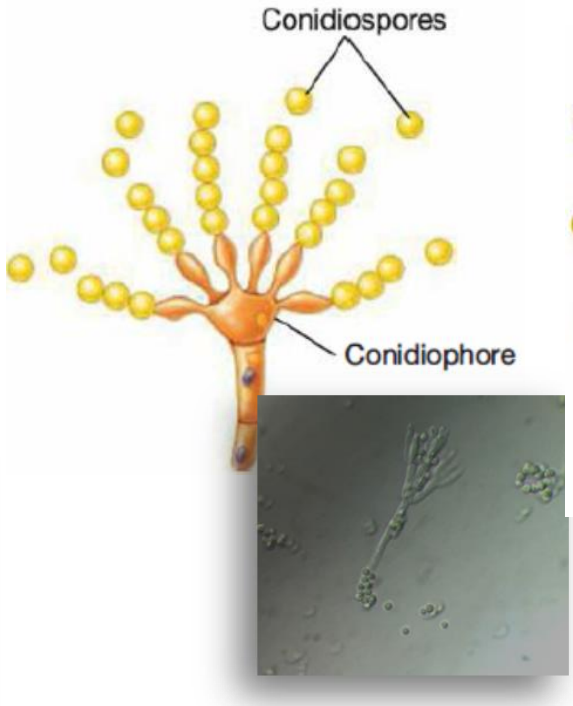
- **2)The formation of asexual spores is usually used as a means of dispersal.**

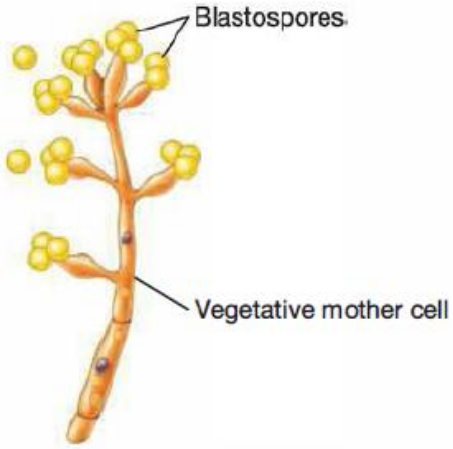
5.5. Fungal Reproduction-Axexual Spores

- **2)The formation of asexual spores is usually used as a means of dispersal.**
- **There are many types of asexual spores, Arthrospores, Sporangiospores, Conidiospores and Blastospores.**





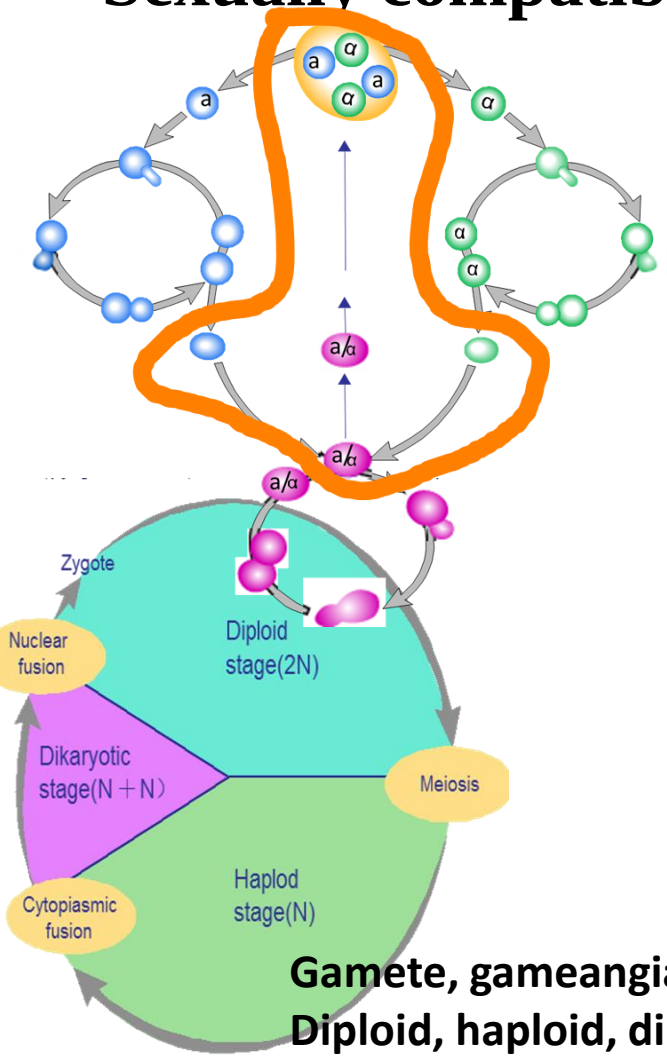


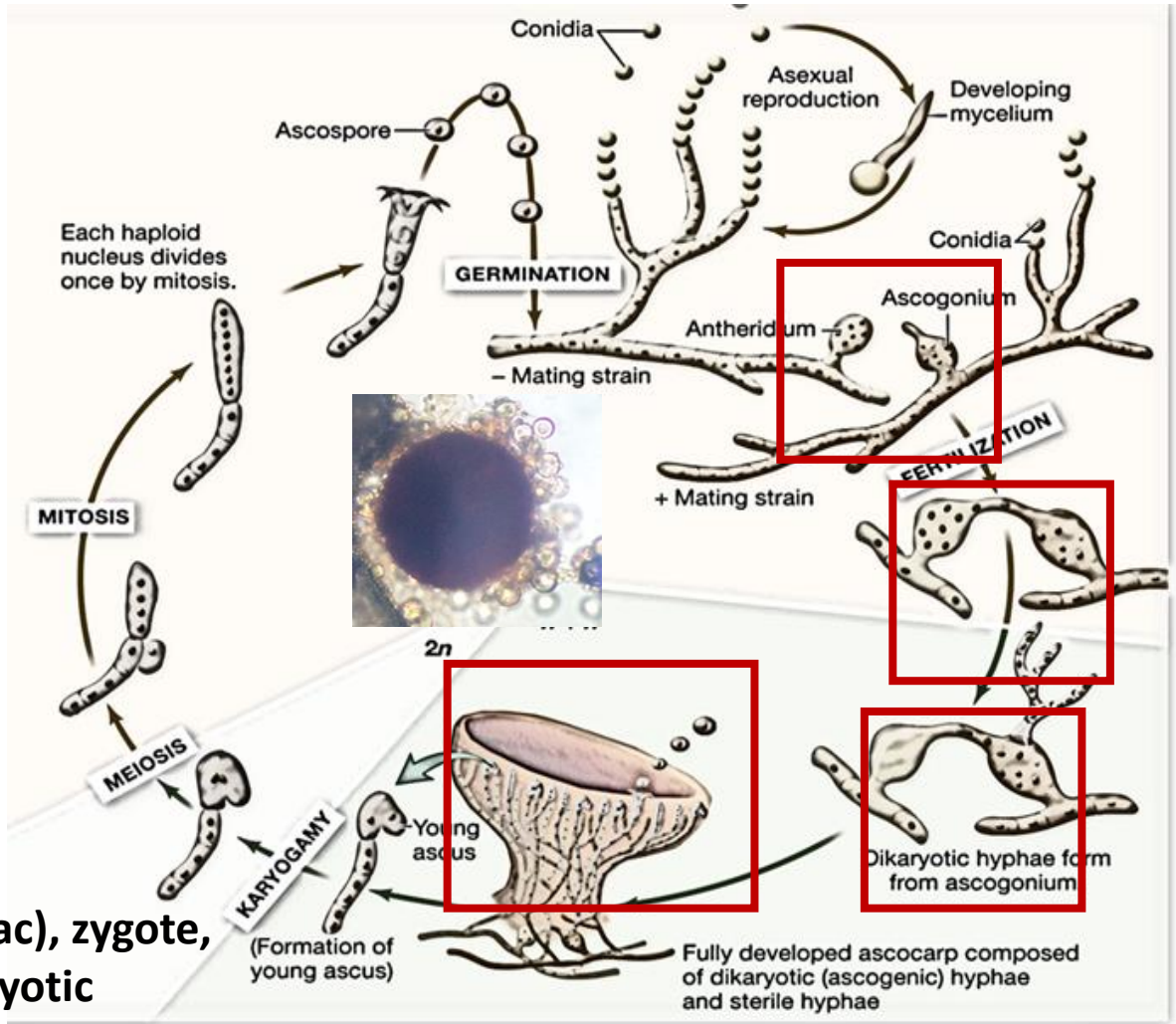


- **These spores are disseminated by air, water, animals or objects and upon landing on a suitable environment, germinate and <u>produce new hyphae</u>.**

5.5 Fungal Reproduction- Sexual spores

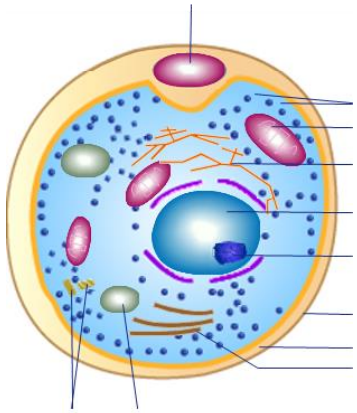
- **Sexual reproduction in fungi involves the fusion of compatible nuclei.**
- **Sexually compatible gametes on the mycelium or spores.**





Gamete, gameangia(sac), zygote, Diploid, haploid, dikaryotic

Summary and Discussion



- **Alternates between haploid and diploid**
  - **Asexual: in nutrient rich, 1）mitosis and budding occurs； 2）Asexual Spore**
  - **Sexual: nutrient poor, meiosis and haploid ascus containing ascospores formed**
    - **Haploid cells of opposite mating types fuse**
    - **Tightly regulated by pheromones外激素**

Why are so important for fungal spores, in both asexual and sexual?

They enable fungi to survive environmental stresses such as desiccation, nutrient limitation, and extreme temperatures, although they are not as stress resistant as bacterial endospores.

They aid in fungal dissemination, which helps explain their wide distribution.

Because spores are often small and light, they can remain suspended in air for long periods and are often spread by adhering to the bodies of insects and other animals.

Summary and Discussion

Provide two examples that illustrate the similarity of archaea to bacteria; list two examples of their similarity to eukaryotes.

厦门大学
生|命|科|学|学|院
SCHOOL OF LIFE SCIENCES XIAMEN UNIVERSITY

MICROBIOLOGY

Lecture 3-3

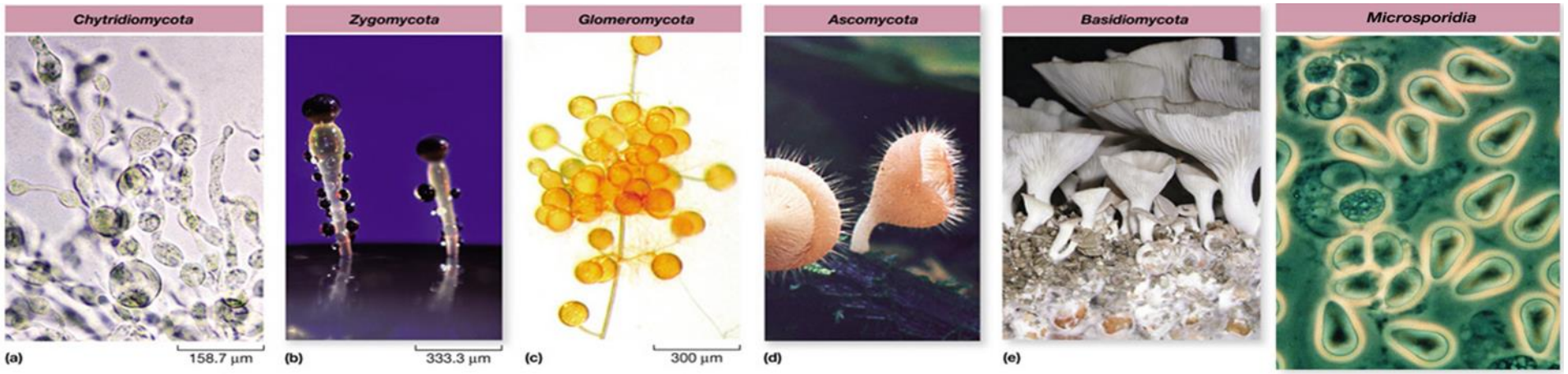
How many types of fungi?

张连茹

5.6 Overview of Fungal Family

- **A fungus is any member of a large group of eukaryotic organisms that includes microorganisms such as yeasts and molds (moulds), as well as the more familiar mushrooms.**
- **90,000 fungal species have been described, possible 1.5 million**
- **Six major fungal groups(phylum)**
  - ***Chytridiomycota*壶菌; *Zygomycota*接合菌*Glomeromycota*球囊菌;**
  - ***Ascomycota*子囊菌 *Basidiomycota*担子菌*Microsporidia*微孢子门**

壶菌 接合菌 球囊菌 子囊菌 担子菌 微孢子菌 门

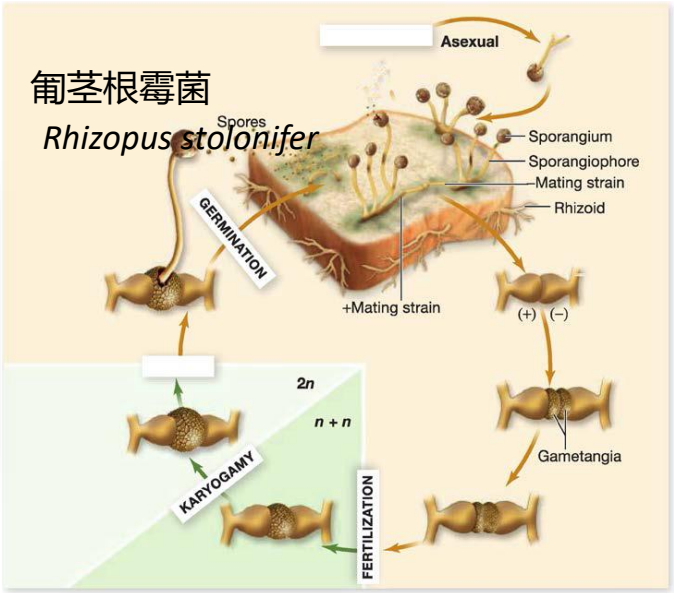


5.6.1 *Chytridiomycota*

- **Most are saprophytic; some reside in the rumen of herbivores.**
- **Chytrids are unique among fungi in the production of a zoospore with a single, posterior, whiplash flagellum.**
- **These fungi are microscopic and display both sexual and asexual reproduction.**
- **Many are capable of degrading cellulose and even keratin, which enables the degradation of crustacean exoskeletons.**
- **The model chytrid *Allomyces macrogynus* has a complex life cycle that includes four types of sporangia and five developmentally distinct spore types.**

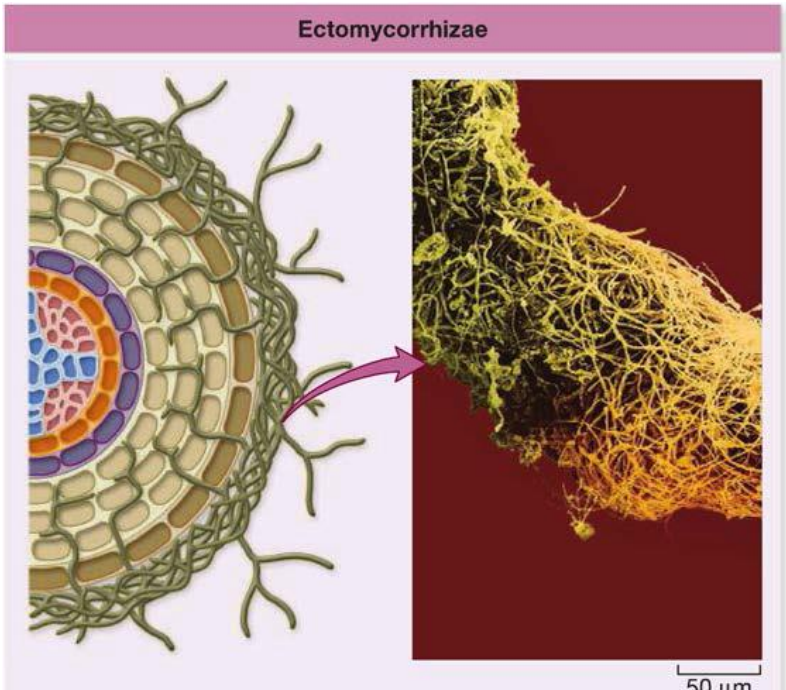
5.6.2 *Zygomycota*（*Rhizopus* species）

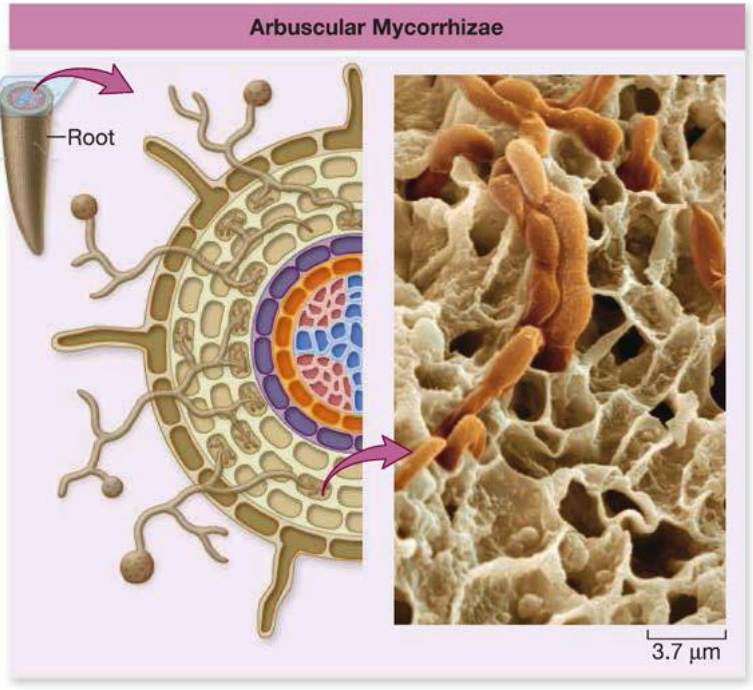
- **One member of the genus *Rhizopus* is important because it is involved in the rice disease known as seedling blight.**
- **Much to everyone‘s surprise, an a-proteobacterium, *Burkholderia* sp.伯克氏菌found growing within the fungus produces the toxin.**
- ***Zygomycetes* also contribute to human welfare. For example, one species of *Rhizopus* is used in Indonesia to produce a food called tempeh from boiled, skinless soybeans. Another *zygomycete* (*Mucor* spp.) is used with soybeans in Asia to make a curd called sufu.**



5.6.3 *Glomeromycota*球囊菌（菌根菌）

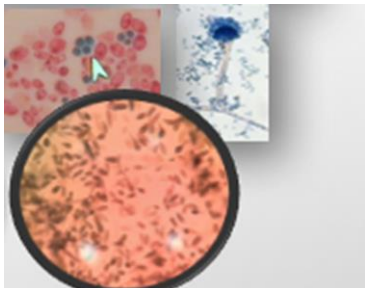
- ***Glomeromycetes*** **are of critical ecological importance because they are *mycorrhizal* symbionts of vascular plants.**
- ***Mycorrhizal*** **fungi form important associations with the roots of almost all herbaceous plants and tropical trees.**
- **Only asexual reproduction is known to occur in *glomero-mycetes*.**





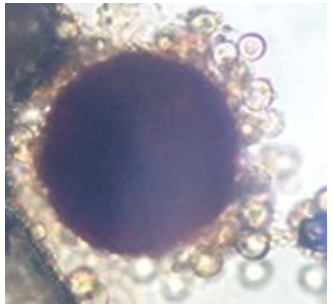
5.6.4 *Ascomycota*

- **Ascomycetes or sac fungi.**
- **Ascomycetes can have either a yeast morphology or a mold morphology.**
- **Important ascomycetes include the yeast *Saccharomyces cerevisiae*, *Aspergillus* spp., *Claviceps purpurea* (the cause of ergotism), and the indoor mold *Stachybotrys chartarum*.**
  - **Red, brown, and blue-green molds cause food spoilage**
  - **Some are human and plant pathogens**
  - **Some yeasts and truffles 块菌 are edible**
  - **Some used as research tools**



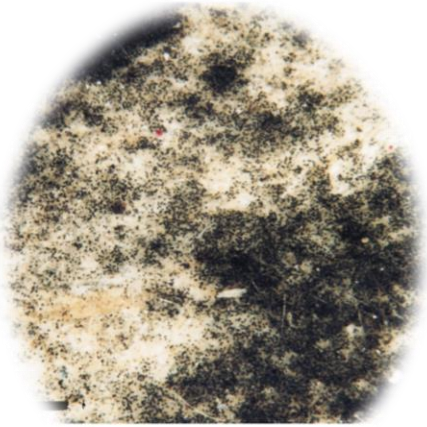
5.6.4 *Ascomycota* -filamentous form life cycle

- ***Ascomycetes*** **are ecologically important in freshwater, marine, and terrestrial habitats because they degrade many chemically stable organic compounds, including lignin, cellulose, and collagen.**
- **Many species are quite familiar and economically important**
- **Asexual reproduction - conidia**
- **Sexual reproduction**
  - **Ascus formation with ascospores**
  - **Opposite mating types form zygote**
  - **Ascospores forcefully released from ascocarp子囊果, germinate**
- **Sclerotia菌核masses of hyphae survive the winter then germinate**



5.6.4 Genus *Aspergillus*

- ***A. fumigatus*烟曲霉**
  - **Ubiquitous environmental**
  - **Allergies过敏and significant pathogen**
- ***A. oryzae* 米曲霉**
  - **Production of fermented foods**
  - **Important in biotechnology**
- ***Aspergillus* aflatoxins and cancer**
  - **37 Mb genome, model system**



麦角菌

5.6.5 *Basidiomycota*

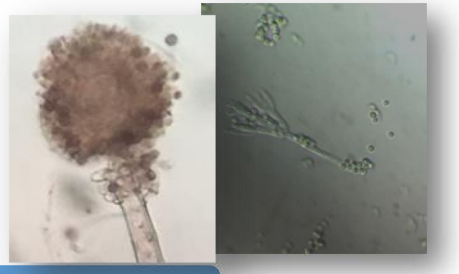
- ***Basidiomycota*** **are commonly known as club fungi珊瑚菌. Examples include jelly fungi, rusts, shelf fungi, stinkhorns, puffballs马勃菌, toadstools蕈类, mushrooms, and bird's nest fungi.**
- **Most are saprophytes that decompose plant debris, especially cellulose and lignin.**
- **Genera from *urediniomycetes* and *ustilaginomycetes*(锈菌纲和黑粉菌纲)include important plant pathogens(rusts) (dimorphic)**
- **Many mushrooms are used as food, and the cultivation of the mushroom *Agaricus campestris* is a multimillion-dollar business.**

5.6.6 *Microsporidia*

- **Members of *Microsporidia* have a unique morphology and are still sometimes considered protists.**
- **They include virulent human pathogens; some infect other vertebrates and insects.**

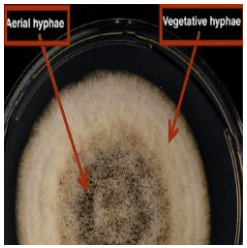
Summary

- **Fungal structure and function**
- Yeast
- Mold



Mycelium

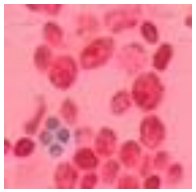
Aerial hyphae



Vegetative hyphae

- Uptake-nutrient
- Adhesion-branch
- Creeping stem
- Dormant-
- Predator-

- Asexual
  - **Conidiospores**
  - **Sporangiospores**



- Sexual
  - Zygospores
  - Cleistothecium ascospores

The differences of bacteria and fungi

Thanks!

Next, we will talk about of virus!

1. Discuss whether you think viruses evolved before the first cell or whether they have coevolved and are perhaps still coevolving with their hosts.

2. Discuss the ways that viruses can be cultivated.

3. What advantages might a phage gain by being capable of lysogeny?

4. Explain why the receptors that viruses have evolved to use are host surface proteins that serve very important, and sometimes essential, functions for the host cell?

5. Consider the origin of viral envelopes and suggest why enveloped viruses that infect plants and bacteria are rare.

6. Compare and contrast in general terms viruses, viroids, satellites, and prions

作业和练习

- 1.请用任意一种文体，介绍细菌的相关知识（形态特征、结构及其功能等）。引力波会对细菌的结构有影响吗？
- 2.您认为细菌、古菌和真菌最主要的差别是什么？它们的细胞膜的组成或结构有什么异同？您能否举例说明2017年诺贝尔化学奖中的技术用于细胞膜蛋白质的研究，有何显著的特点？
- 3.根据病毒的组成及结构以及繁殖特点，设想病毒病的几种治疗策略。
- 同学间互评的翻译练习（不需要交）：第3章（星期二班）；第4章（星期五班）；第6章（星期三班）
- 说明：请在期中考试的前2周前提交作业；请在期中考试前完成翻译练习。