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# MICROBIOLOGY

WITH DISEASES BY TAXONOMY, THIRD EDITION

## Chapter 12

## Characterizing and Classifying Eukaryotes

## 真核生物的特性與分類

- Understand the general characteristics of eukaryotes.
- Understand eukaryotic classification
  - Protozoa
  - Fungi
  - Algae
  - Water molds
- Understand the general characteristics of parasitic helminths and vectors

- Five major groups
  - Protozoa
  - Fungi
  - Algae
  - Water molds
  - Slime molds
- Include both human pathogens and organisms vital for human life

- **Reproduction in Eukaryotes**

- More complicated than that in prokaryotes
  - Eukaryotic DNA packaged as chromosomes in the nucleus
  - Have variety of methods of asexual reproduction
  - Many reproduce sexually by forming gametes and zygotes
  - Algae, fungi, and some protozoa reproduce both sexually and asexually

- **Reproduction in Eukaryotes**

- Nuclear division

- Nucleus has one or two complete copies of genome

- Single copy (haploid)

- Most fungi, many algae, some protozoa

- Two copies (diploid)

- Remaining fungi, algae, and protozoa

- Two types

- Mitosis

- Meiosis

- **Reproduction in Eukaryotes**

- Nuclear division

- **Mitosis**

- Cell partitions replicated DNA equally between two nuclei

- **Maintains ploidy of parent nucleus**

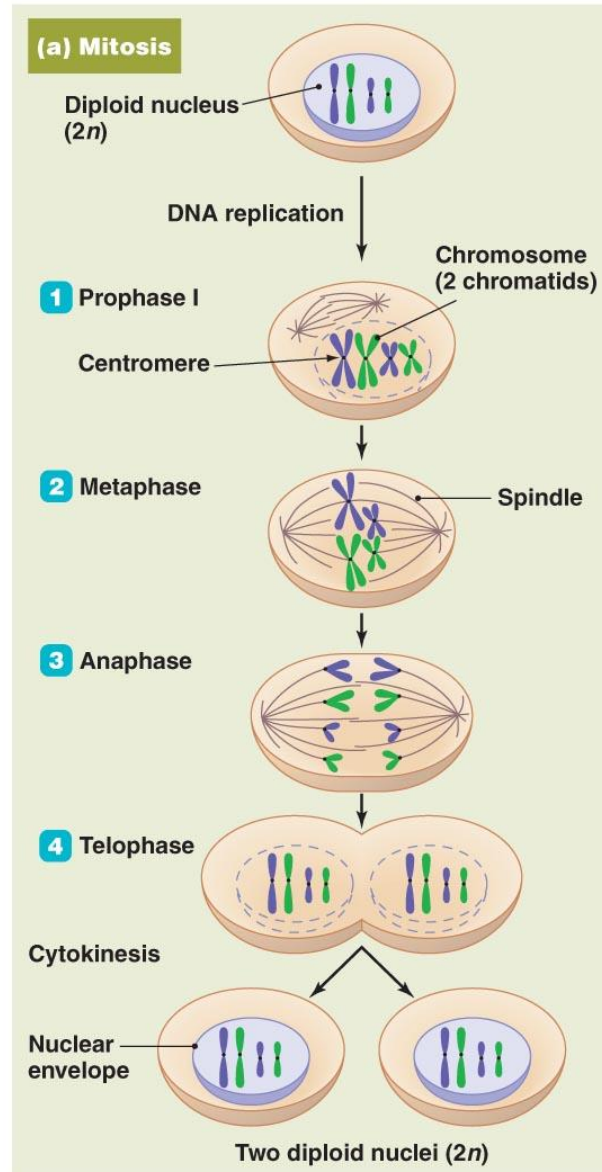
- Four phases

- Prophase

- Metaphase

- Anaphase

- Telophase



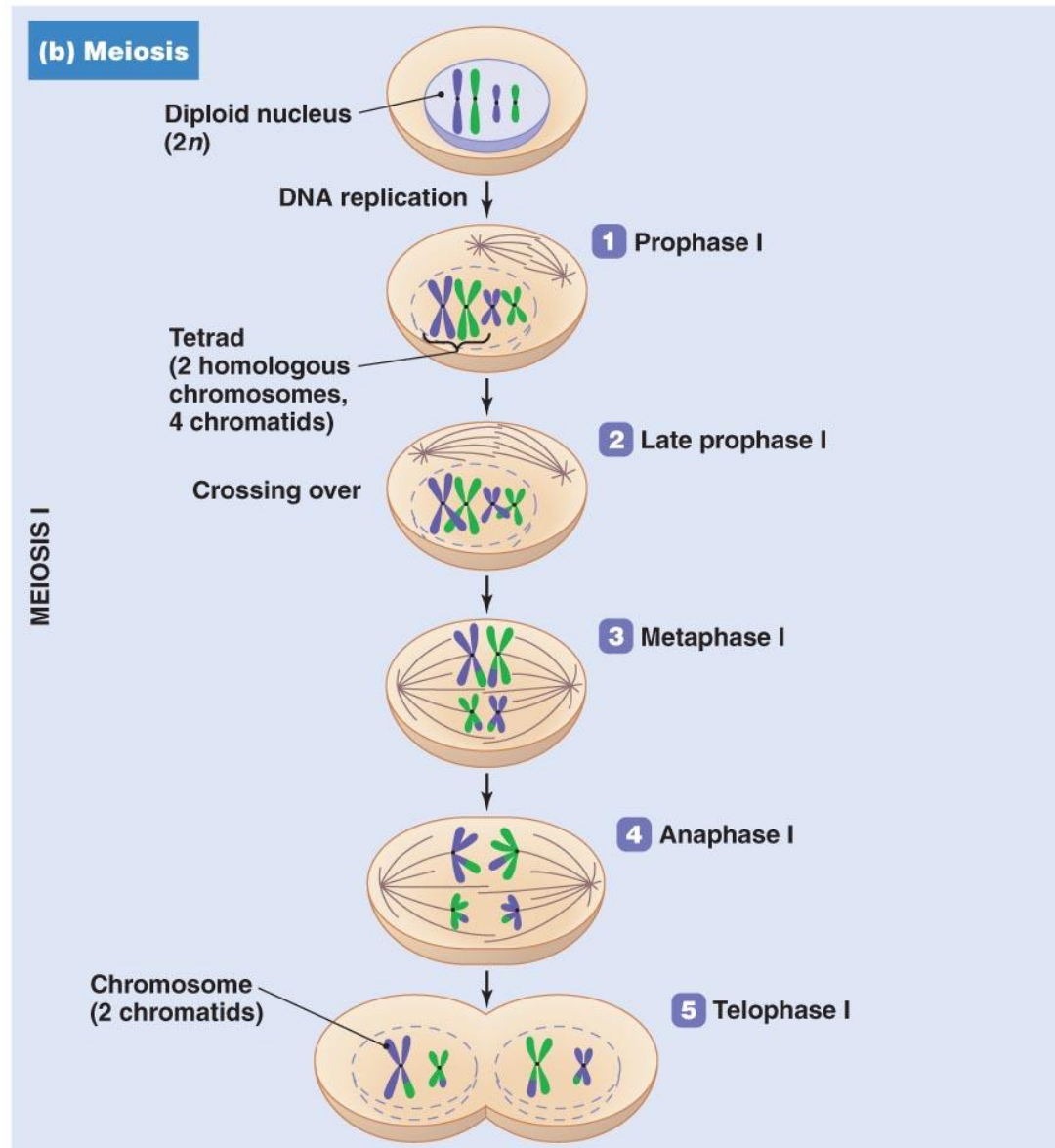
- **Reproduction in Eukaryotes**

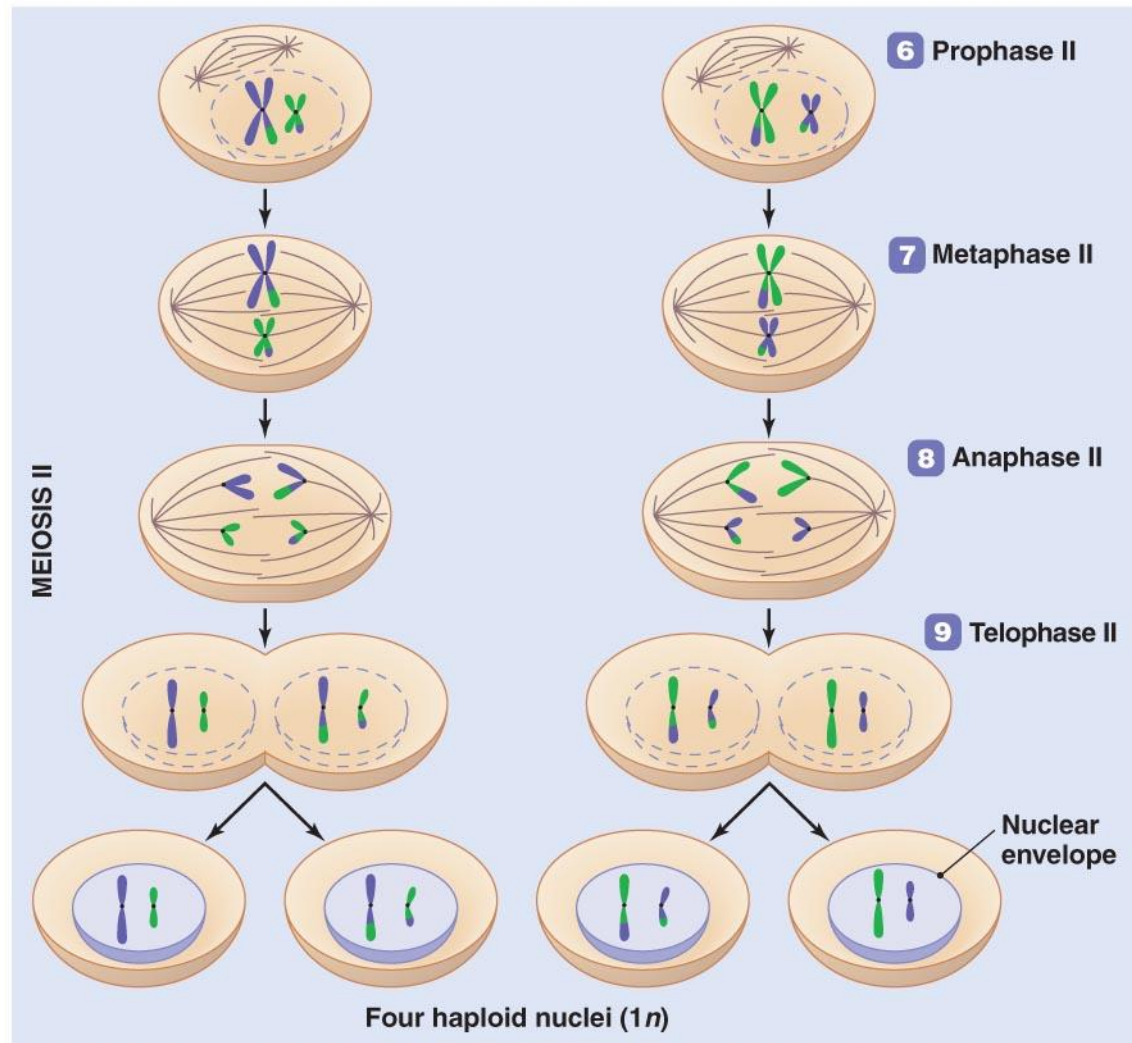
- Nuclear division

- **Meiosis**

- Nuclear division that partitions chromatids into four nuclei
      - Diploid nuclei produce haploid daughter nuclei
      - Two stages – meiosis I and meiosis II
      - Each stage has four phases
        - Prophase
        - Metaphase
        - Anaphase
        - Telophase







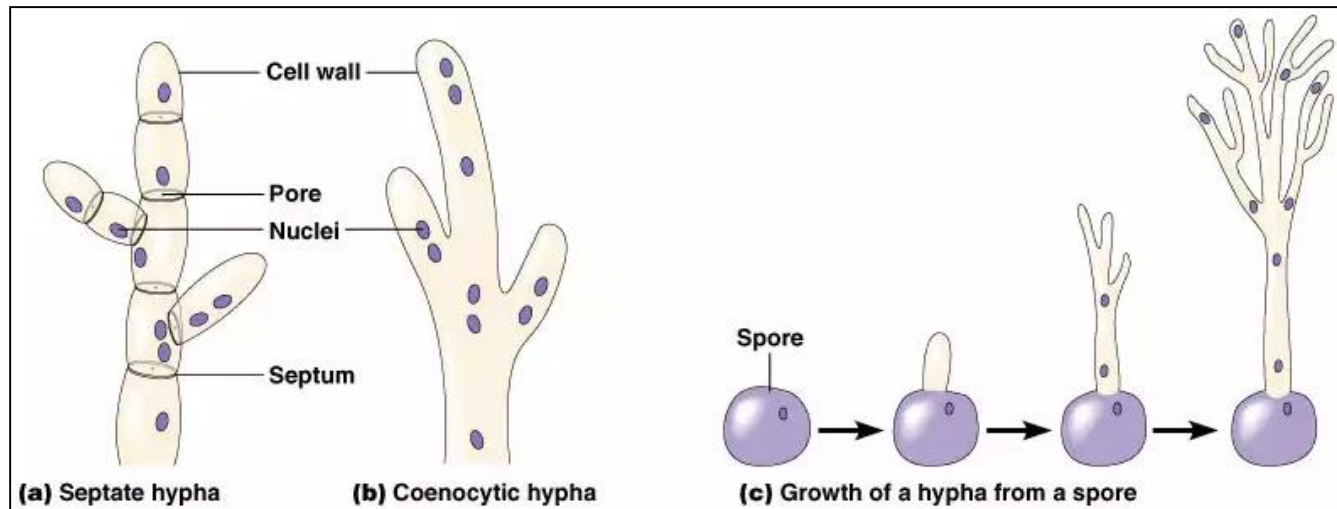
- **Reproduction in Eukaryotes**

- **Cytokinesis** (cytoplasmic division)

- Typically occurs simultaneously with telophase of mitosis

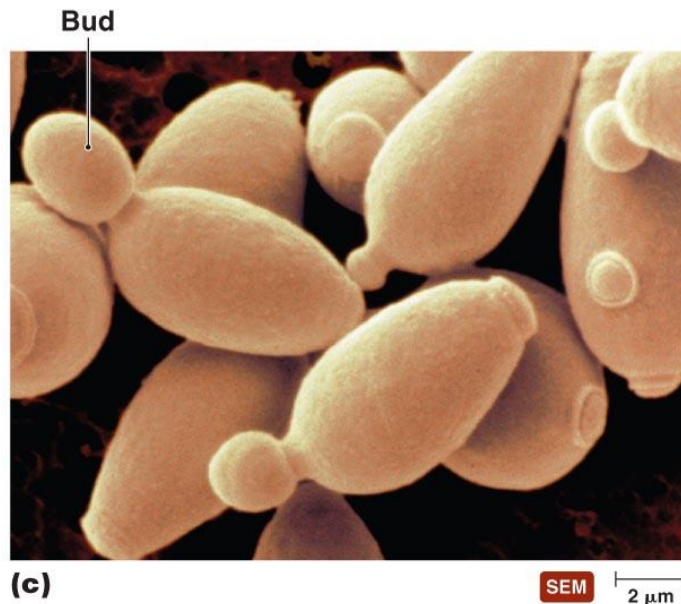
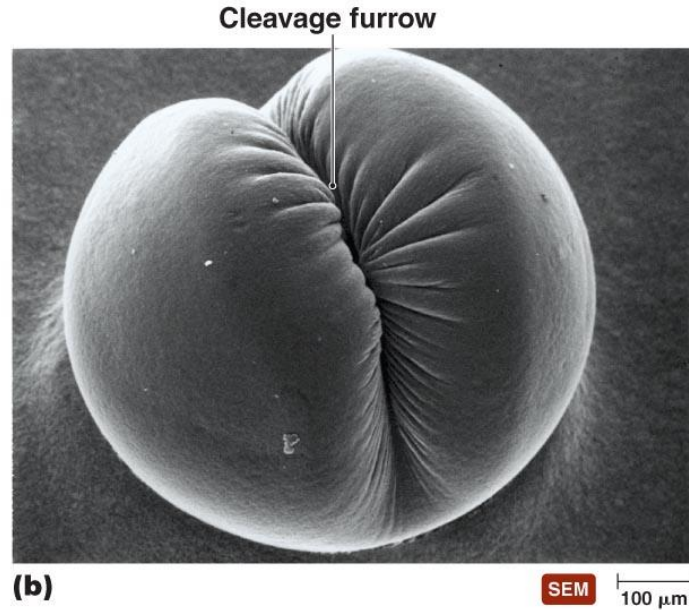
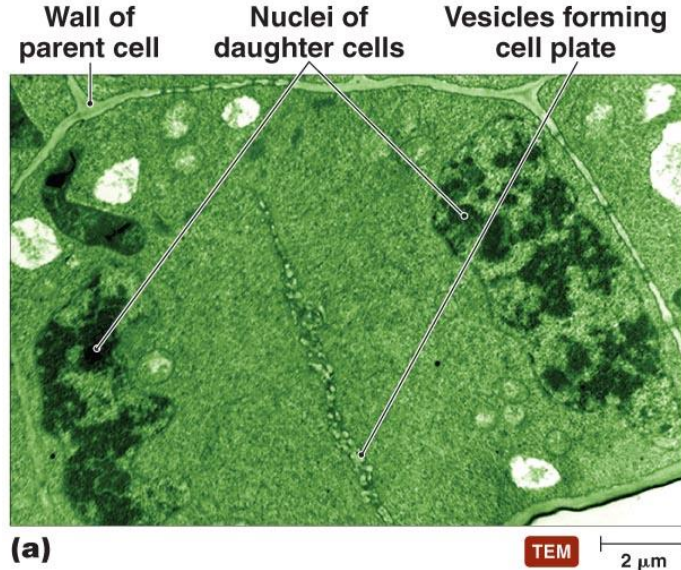
- In some **algae** and **fungi**, postponed or does not occur at all

- Results in **multinucleated cells** called **coenocytes**



# Different types of cytoplasmic division

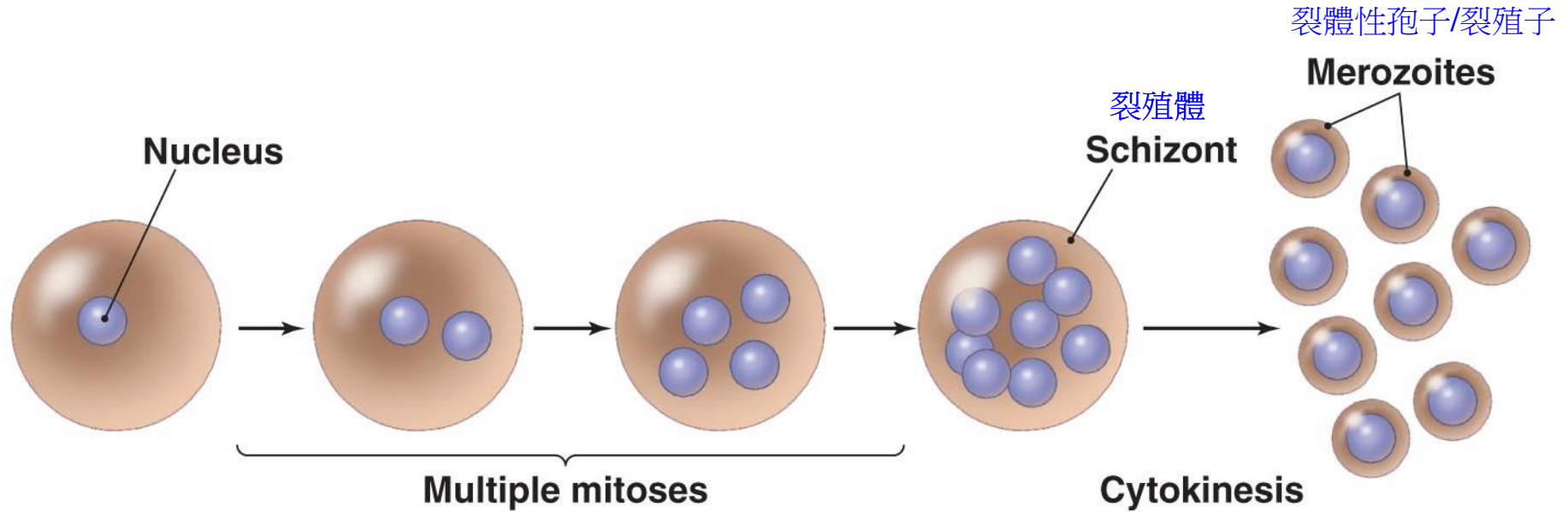
12



# Schizogony (胞內裂體生殖)

13

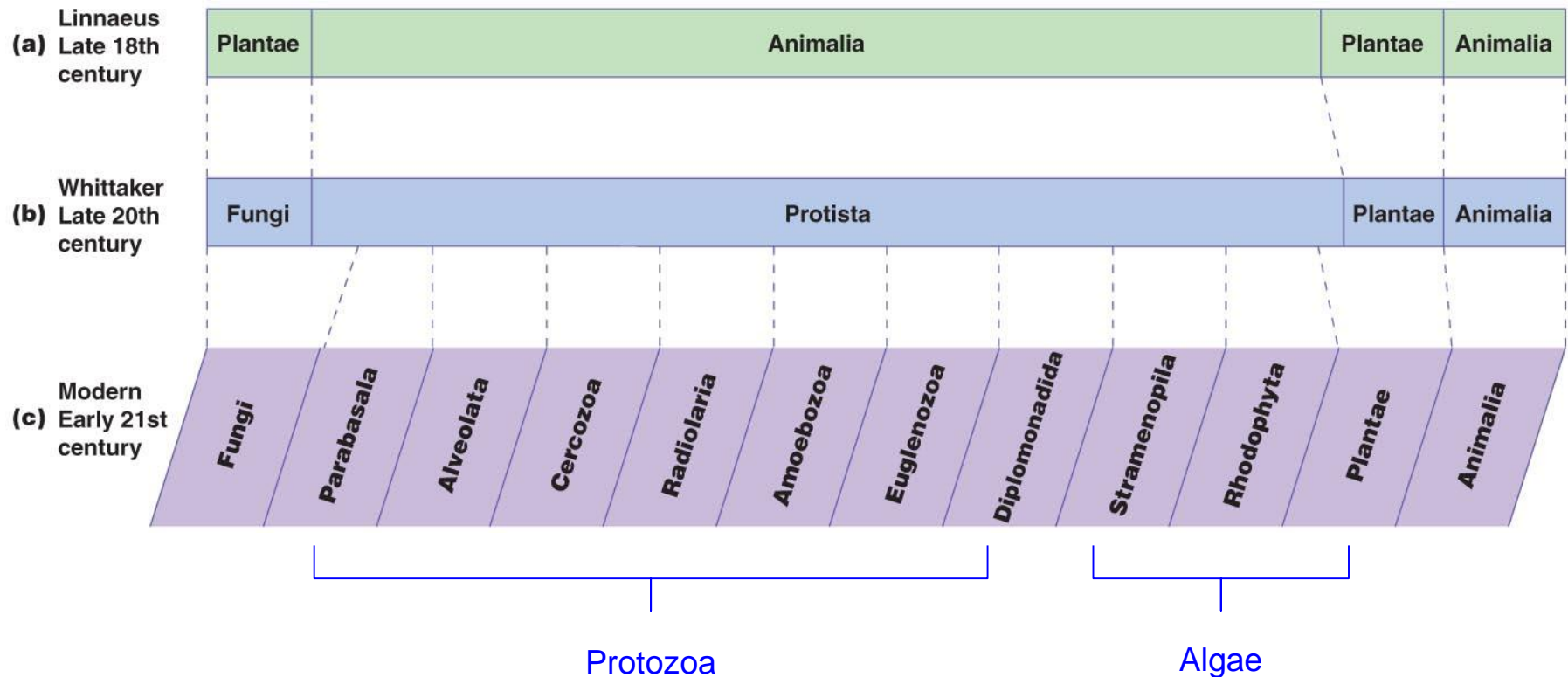
By some protozoa (e.g. *Plasmodium spp.*)





# The changing classification of eukaryotes

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- Diverse group defined by **three** characteristics
  - **Eukaryotic**
  - **Unicellular**
  - **Lack a cell wall**
- Motile by means of cilia, flagella, and/or pseudopodia
  - Except subgroup, **apicomplexans** 頂複門

- **Distribution of Protozoa**

- Require moist environments
- Most live in ponds, streams, lakes, and oceans
  - Critical members of plankton
- Others live in moist soil, beach sand, and decaying organic matter
- Very few are pathogens



- **Morphology of Protozoa**

- Great morphologic diversity
- Some have **two nuclei**
  - **Macronucleus**
    - Contains many copies of the genome
  - **Micronucleus**
- Variety in number and kinds of mitochondria
- Some have **contractile vacuoles**
- All produce **trophozoites**; some produce **cysts**

# A contractile vacuole

18



Vacuole

**(a)**



Vacuole

**(b)**

LM

18  $\mu$ m

- Nutrition of **Protozoa**

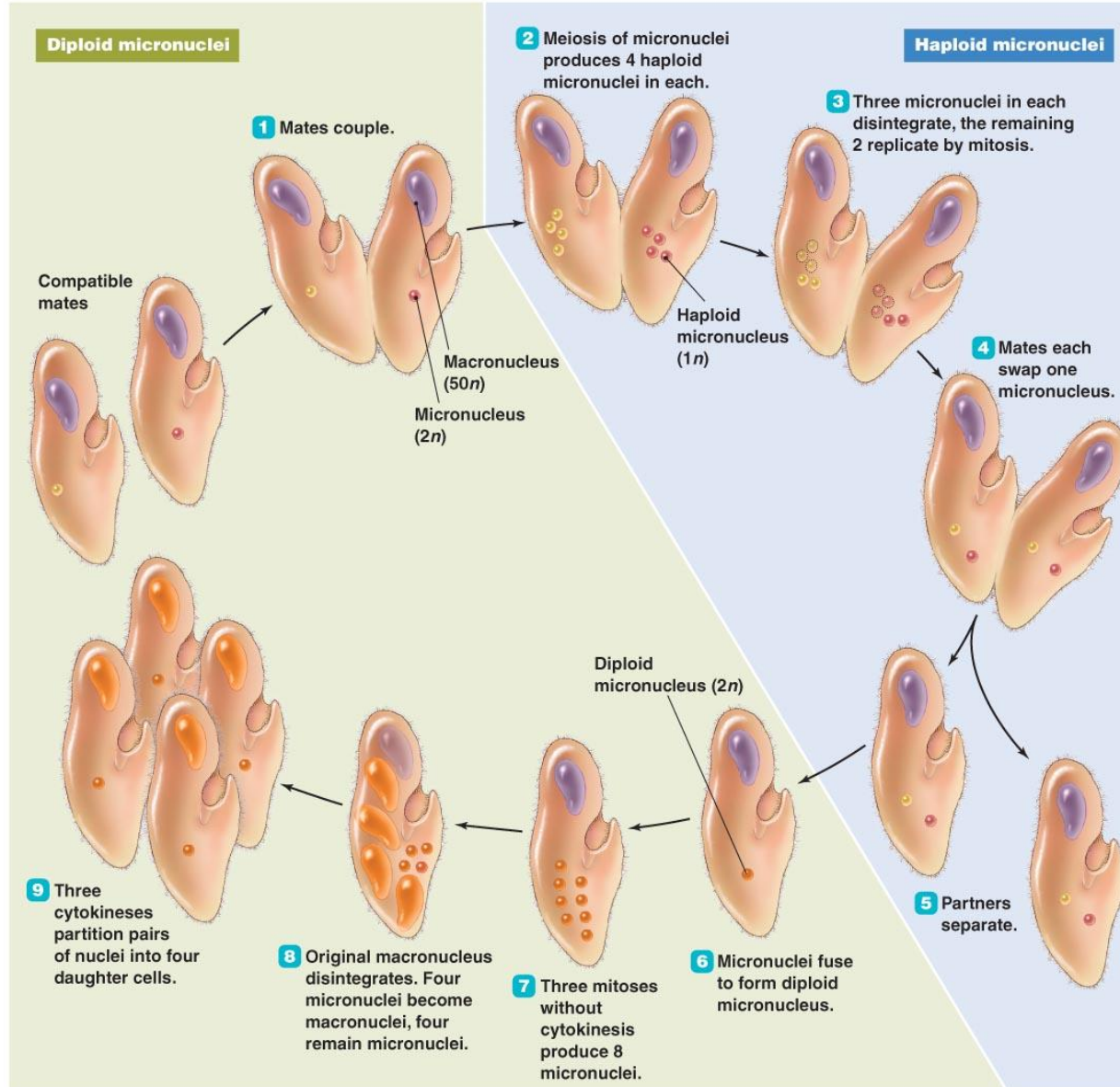
- Most are **chemoheterotrophic**
- Obtain nutrients by phagocytizing bacteria, decaying organic matter, other protozoa, or the tissues of host
- Few absorb nutrients from surrounding water
- **Dinoflagellates** and **euglenoids** are **photoautrophic**  
(甲藻，腰鞭毛藻，渦鞭藻)      (眼蟲藻，眼蟲，裸藻)

- **Reproduction in Protozoa**

- Most reproduce **asexually** only
  - **Binary fission** or **schizogony**
- Few also have sexual reproduction
  - Some become **gametocytes** that fuse with one another to form **diploid zygotes**
  - Some utilize a process called **conjugation**

# Sexual reproduction via conjugation in ciliates

分類屬 Alveolates 囊泡蟲

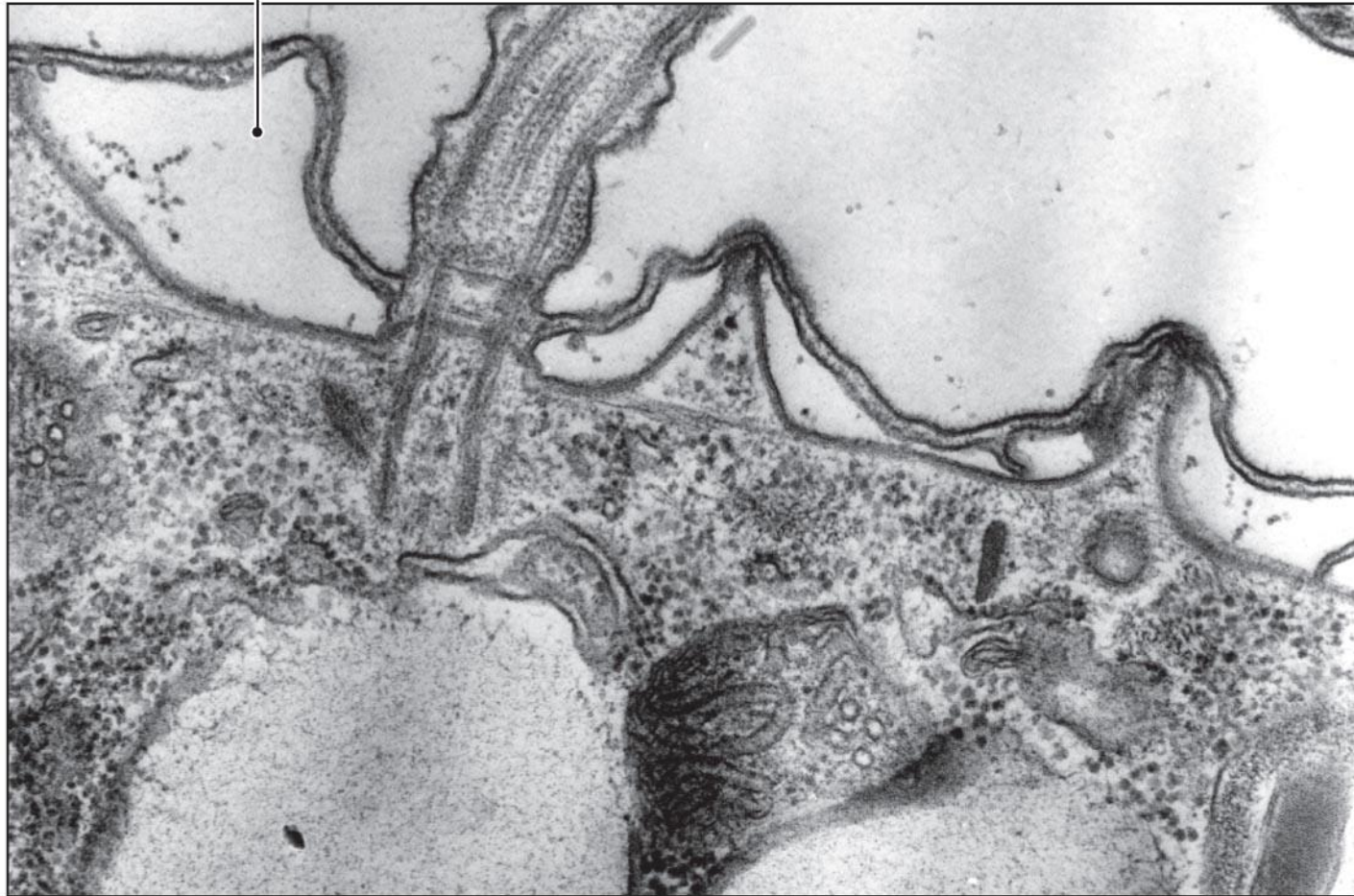


# Alveoli membrane-bound structures found in protozoa

22

Alveolus

分類屬 Alveolates 囊泡蟲



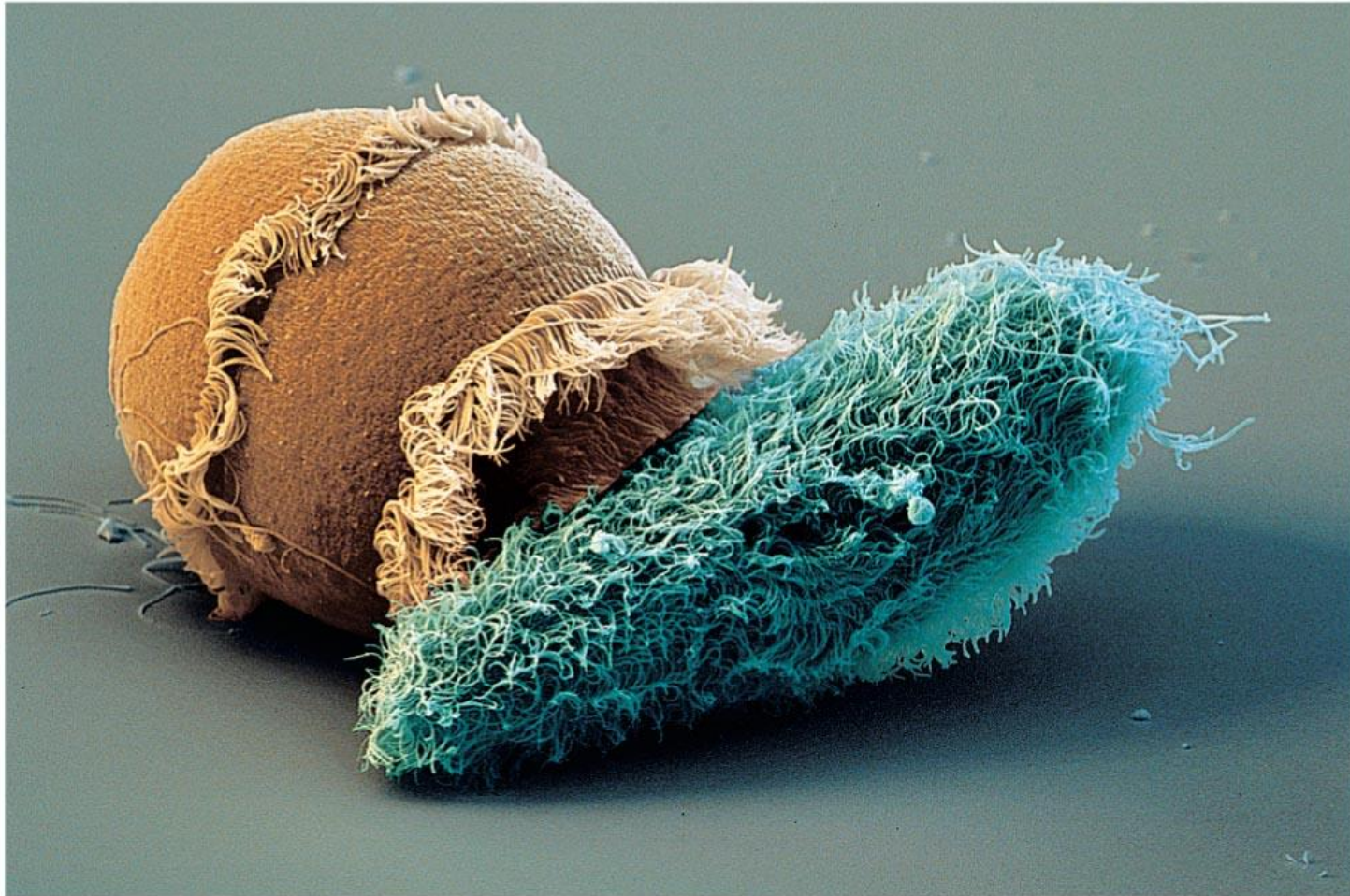
TEM

0.2  $\mu\text{m}$



# A predatory ciliate devouring another ciliate

23

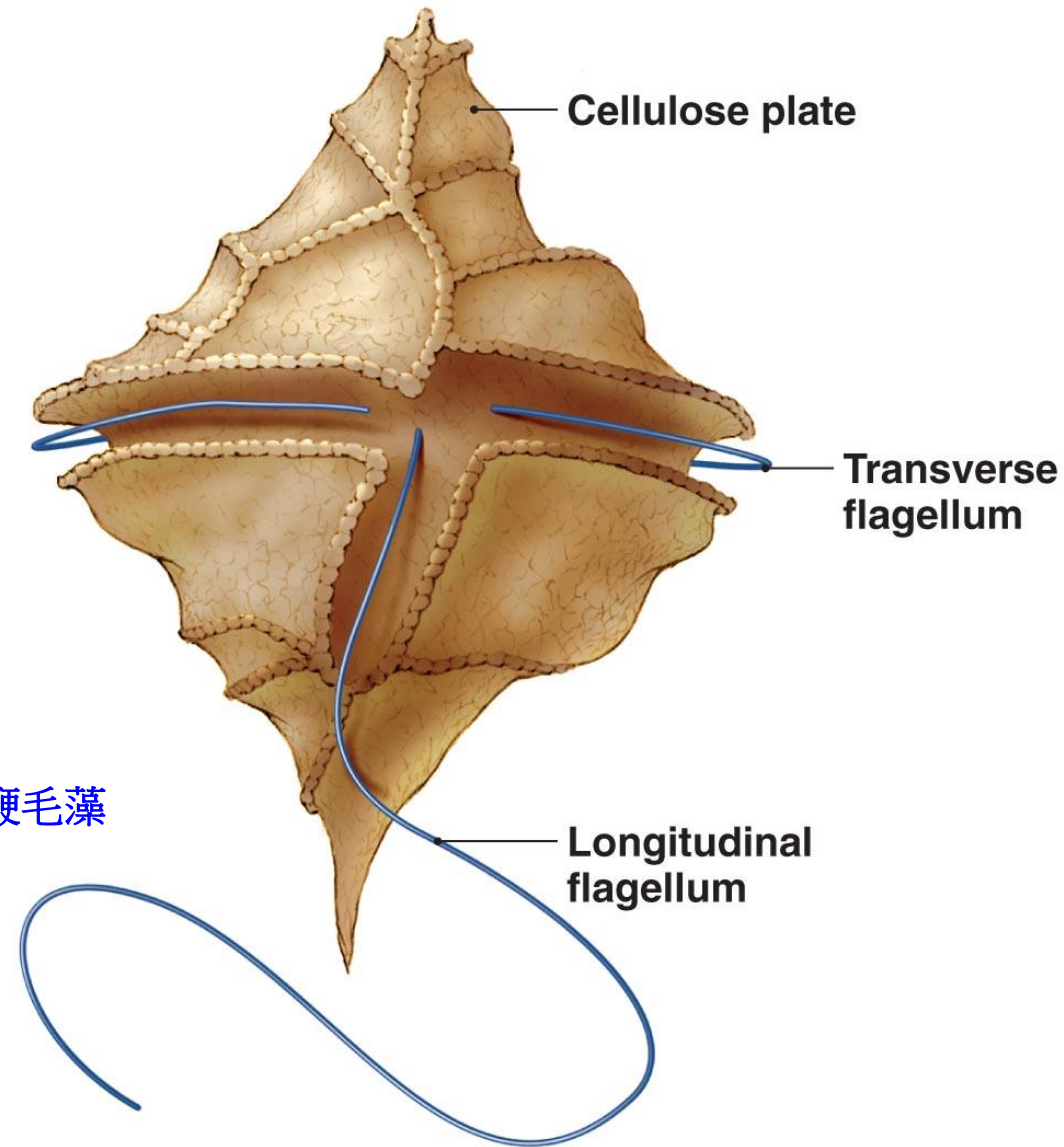


SEM

25  $\mu\text{m}$

# *Peridinium*, a motile armored dinoflagellate

24



分類屬 **Dinoflagellates** 腰鞭毛藻



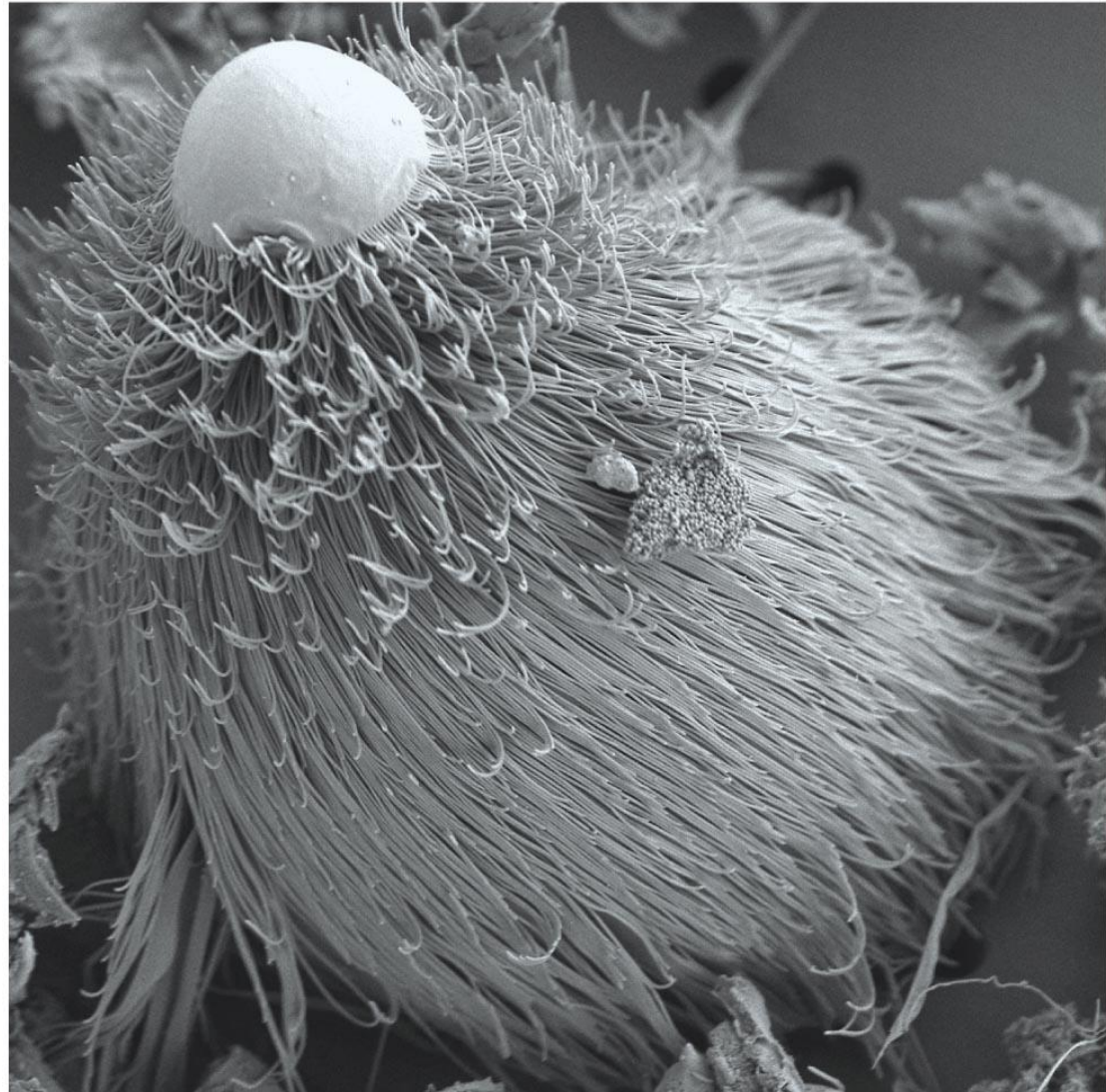
# A parabasalid with prodigious flagella

## Parabasalids (群體性鞭毛蟲)

- Single nucleus
- Lack mitochondria
- Parabasal body (Golgi-like structure)
- Resides in termites' gut → assisting the digestion of wood

## *Trichomonas* (陰道滴蟲)

- Human pathogens (female vagina)
- Proliferates when pH is raised
  - Inflammation
  - Sterility
- Sexually transmitted
  - Infected males are asymptomatic

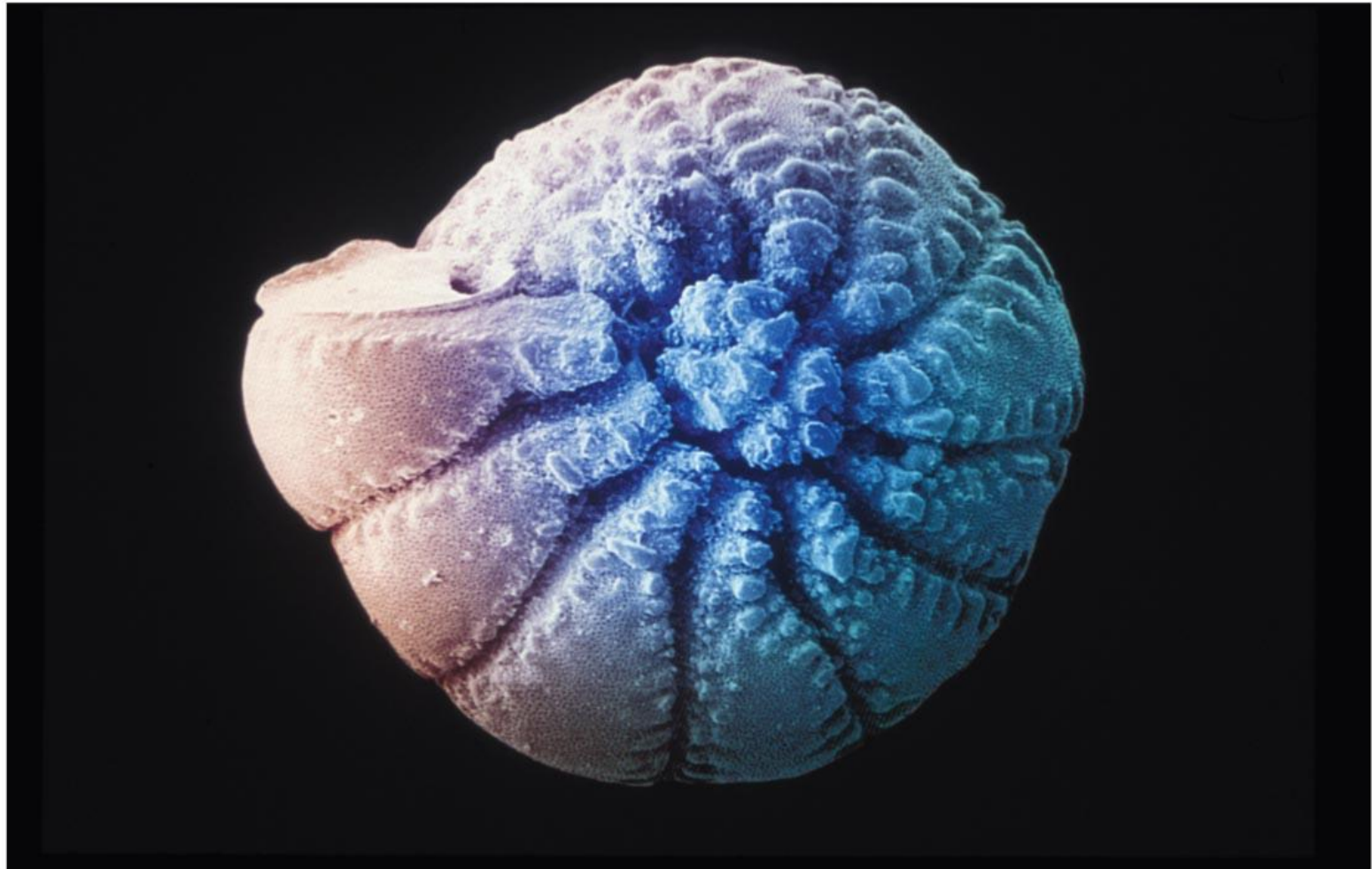


SEM

6.5  $\mu$ m

# Foraminifera have multichambered, snail-like shells

26

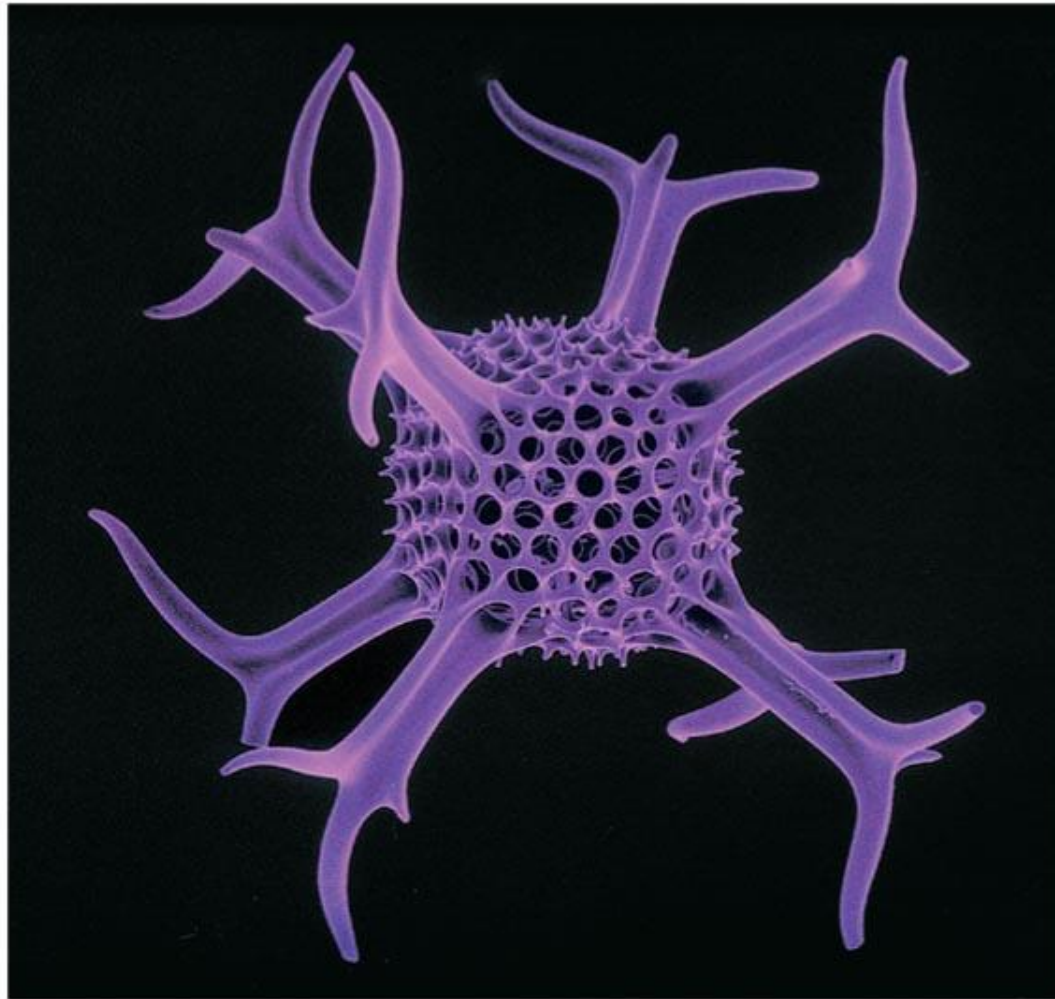


SEM

5  $\mu$ m

# Radiolaria have ornate shells of silica

27



SEM

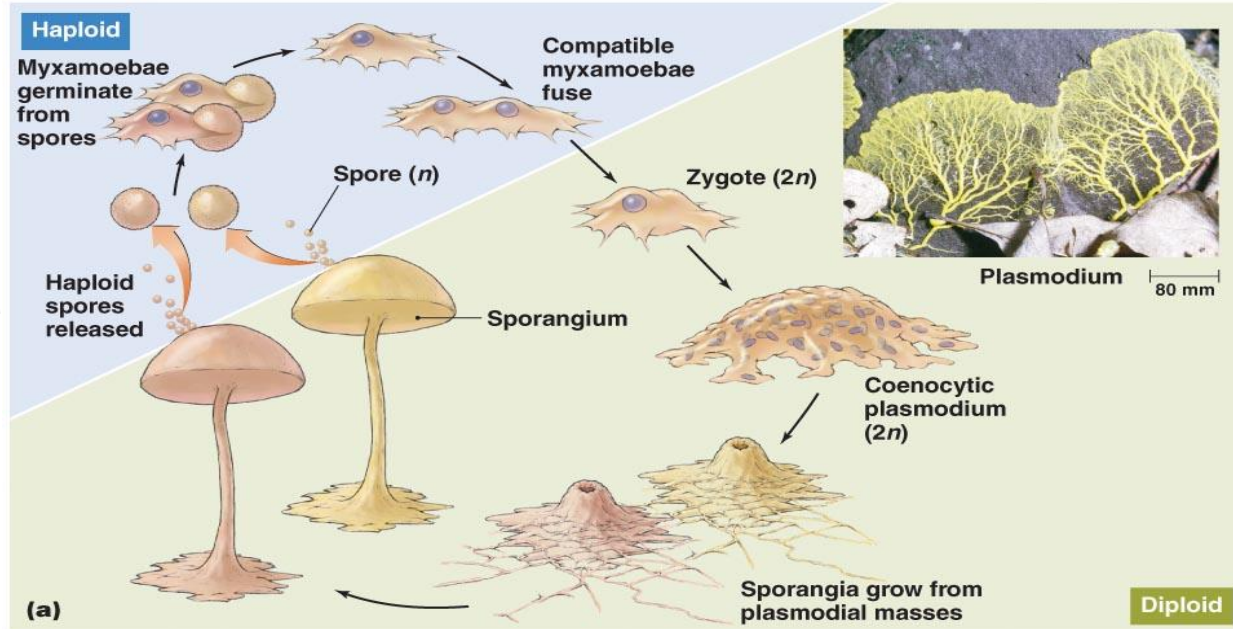
0.25 mm



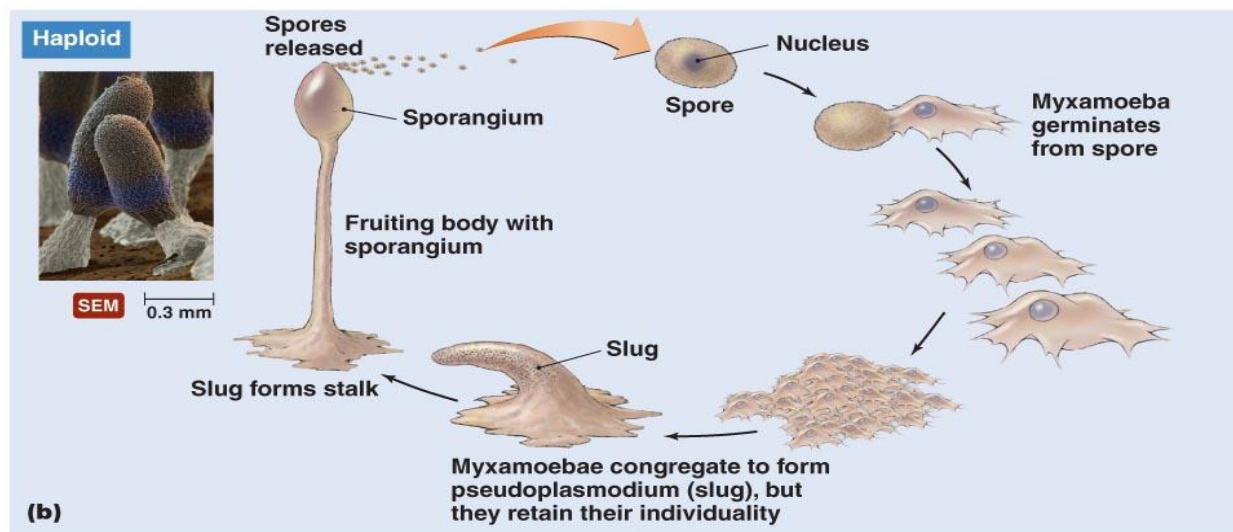
# Life cycles of slime molds

28

Acellular phase

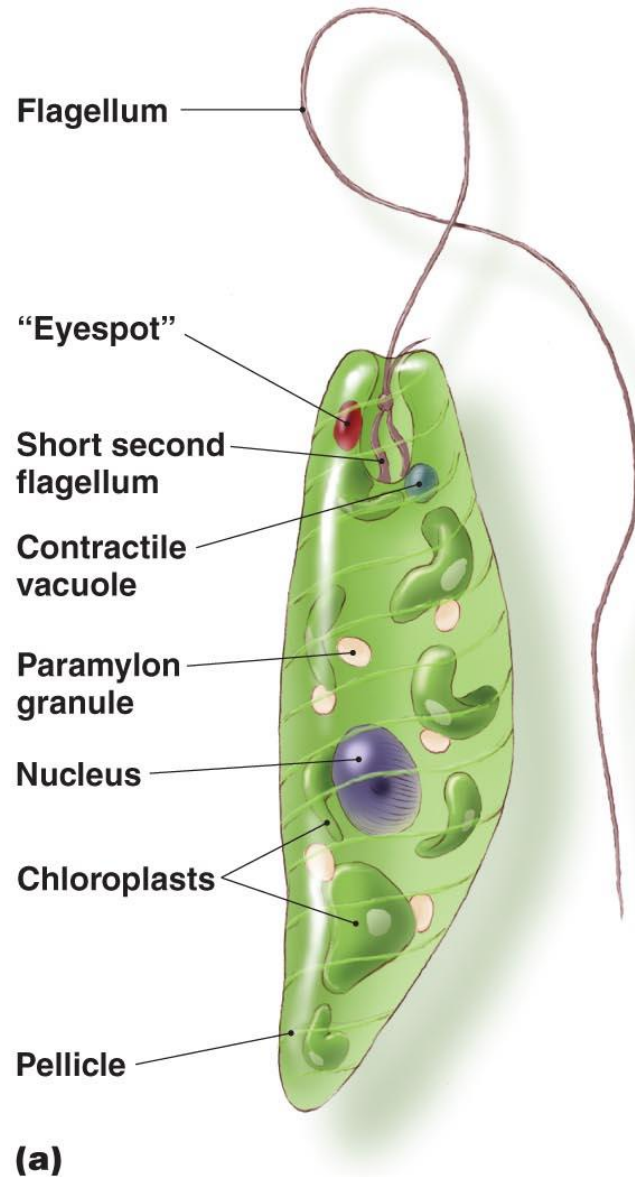


Cellular phase



# Two representatives of the kingdom **Euglenozoa** 眼蟲門

29



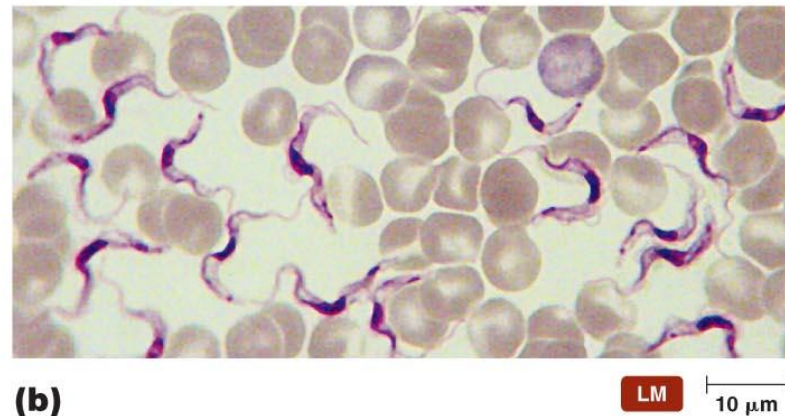
Two groups:

## (a) Euglenids 眼蟲

- unicellular, lack cell wall
- Photoautotrophic
- Food storage → **paramylon**

## (b) Kinetoplastids 動基體

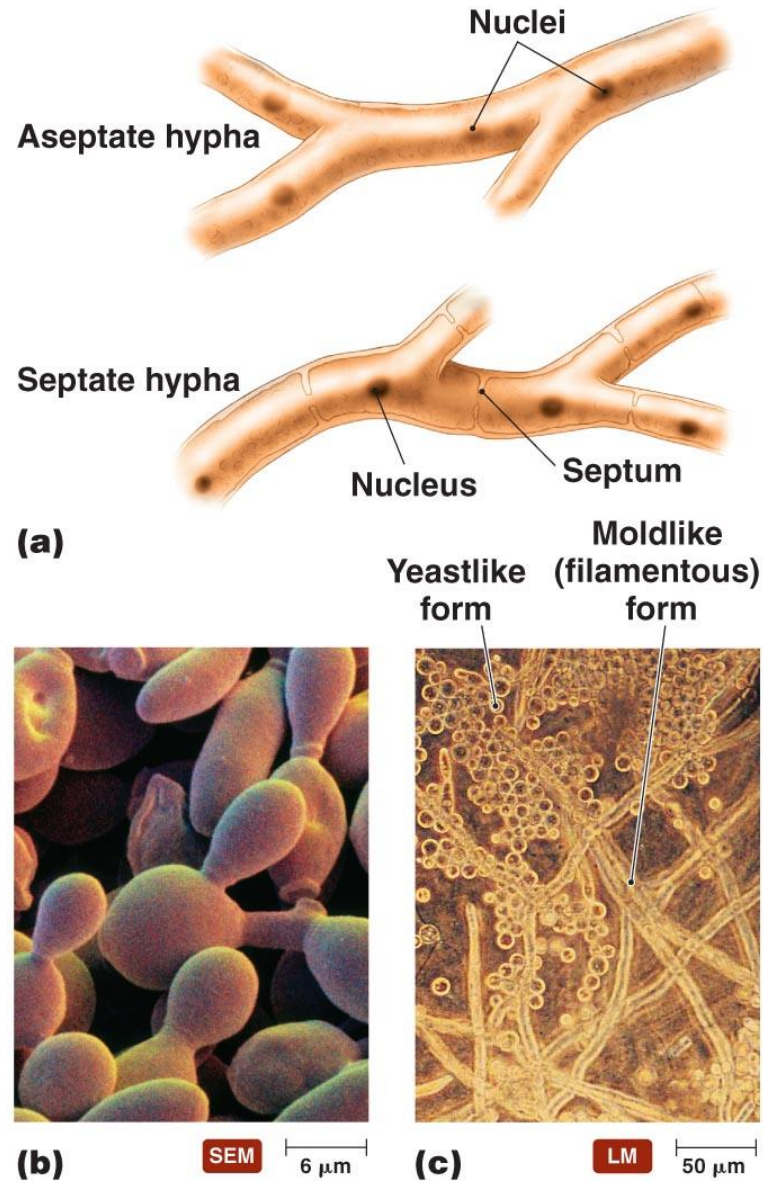
- Single large mito. → kinetoplast
- Intracellular pathogen for humans
  - ***Trypanosoma***
  - ***Leishmania***



- Chemoheterotrophic
- Have cell walls typically composed of chitin
- Do not perform photosynthesis
  - Lack chlorophyll
- Related to animals

- **The Significance of Fungi**

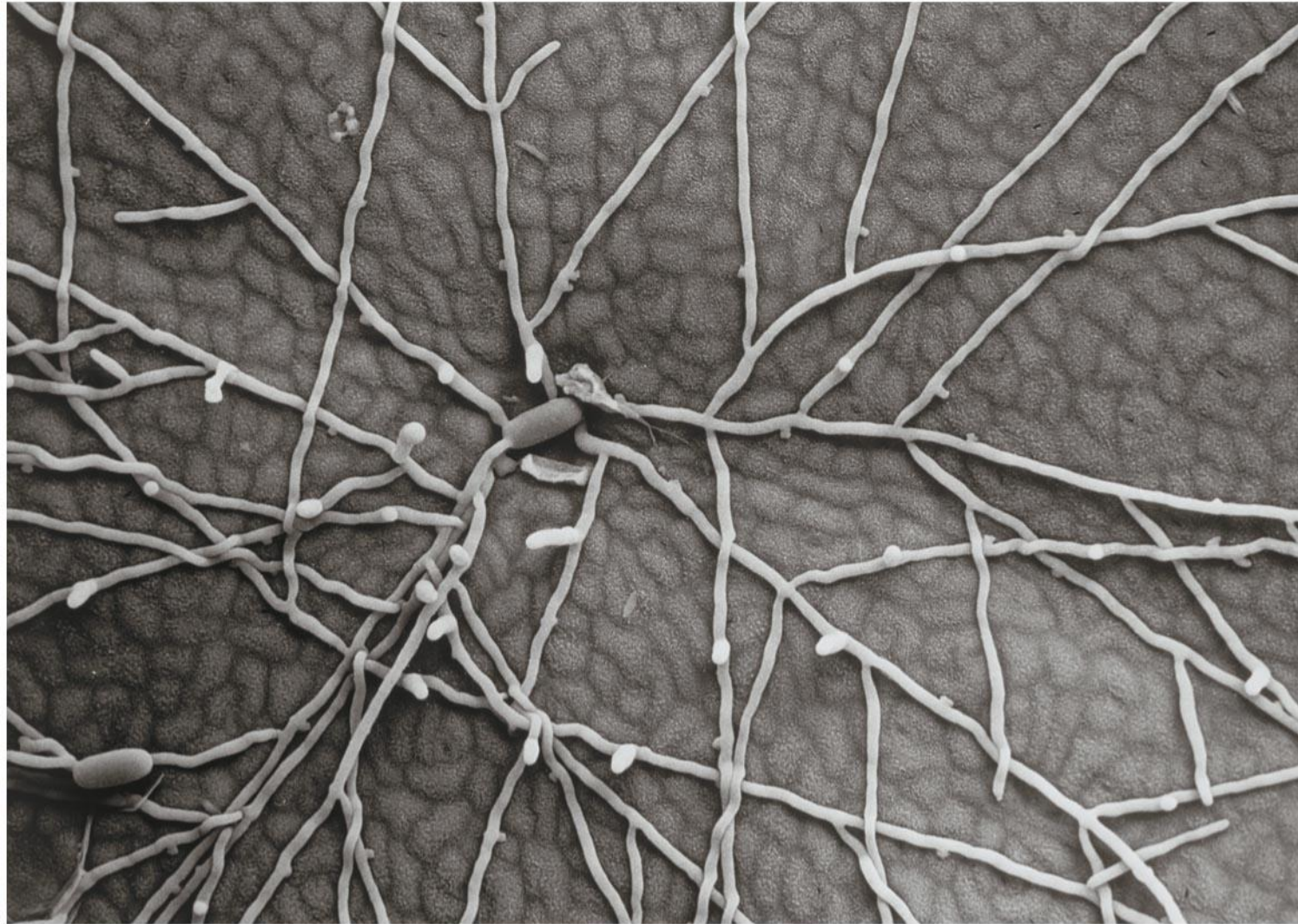
- Decompose dead organisms and recycle their nutrients
- Help plants absorb water and minerals
- Used for food, in religious ceremonies, and in manufacture of foods and beverages
- Produce antibiotics
- Serve as important research tools
- 30% cause diseases of plants, animals, and humans
- Can spoil fruit, pickles, jams, and jellies





# A fungal **mycelium** growing on wood

33



SEM

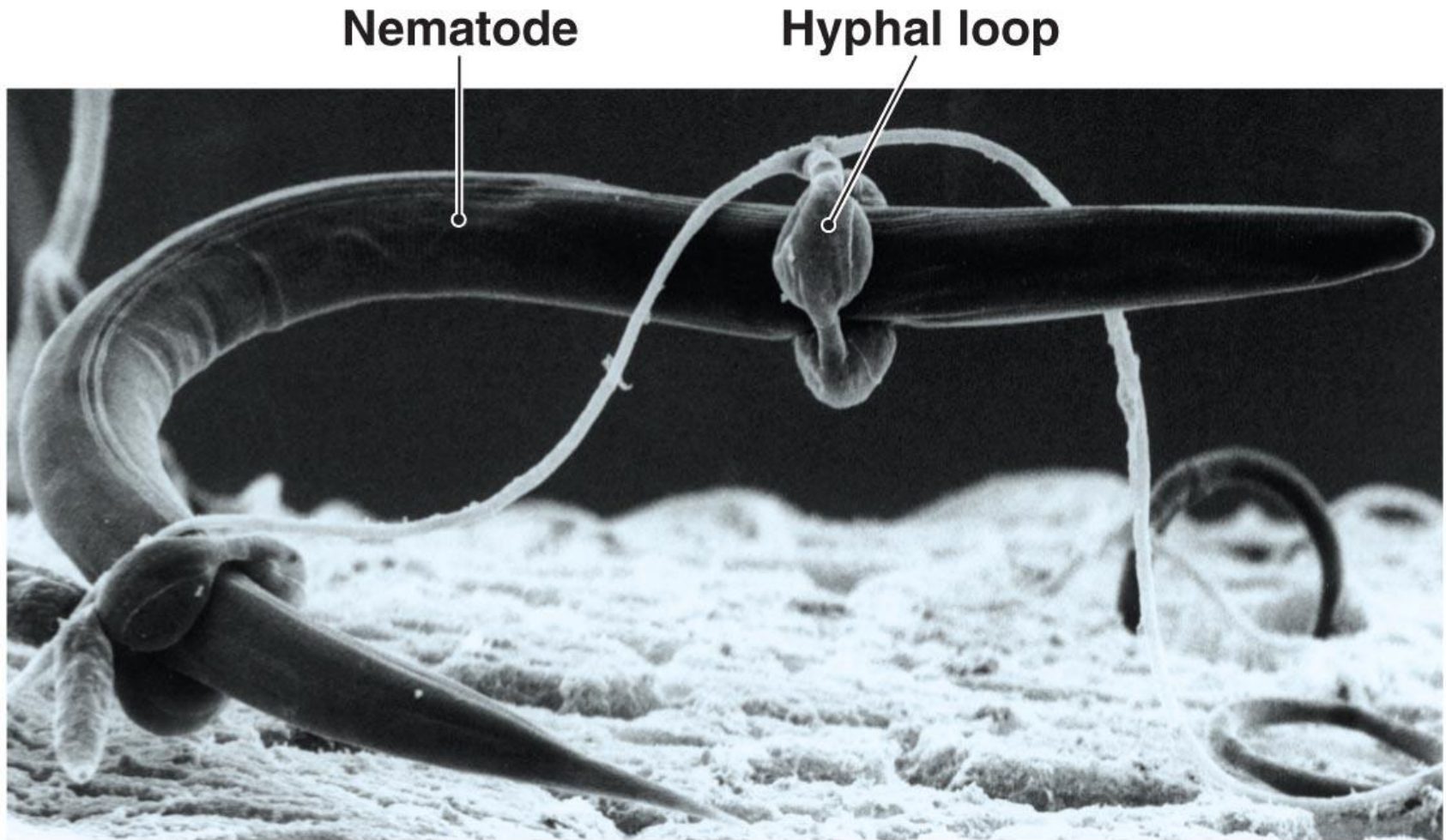
35  $\mu\text{m}$

- **Nutrition of Fungi**

- Acquire nutrients by **absorption**
- Most are **saprobies**
- Some trap and kill microscopic soil-dwelling nematodes
- **Hauatoria** allow some to derive nutrients from living plants and animals
- Most **fungi** are **aerobic**
- Many **yeasts** are **facultative anaerobes**

# Predation of a nematode by the fungus *Arthrobotrys*

35



SEM

75  $\mu\text{m}$

- **Reproduction in Fungi**

- All have some means of asexual reproduction involving mitosis and cytokinesis
- Most also reproduce sexually

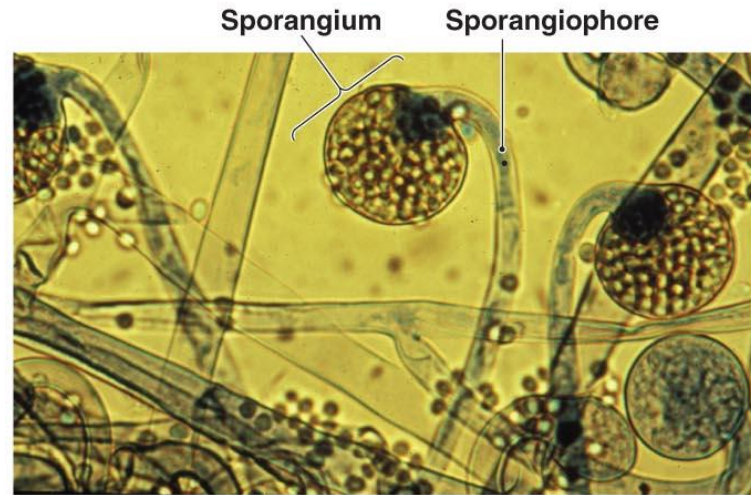
- **Reproduction in Fungi**

- Budding and asexual spore formation
  - Yeasts bud in manner similar to prokaryotic budding
  - Pseudohypha
    - Series of buds that remain attached to one another and to parent cell
  - Filamentous fungi produce lightweight spores that disperse over large distances



# Representative asexual spores of molds

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(a)

LM

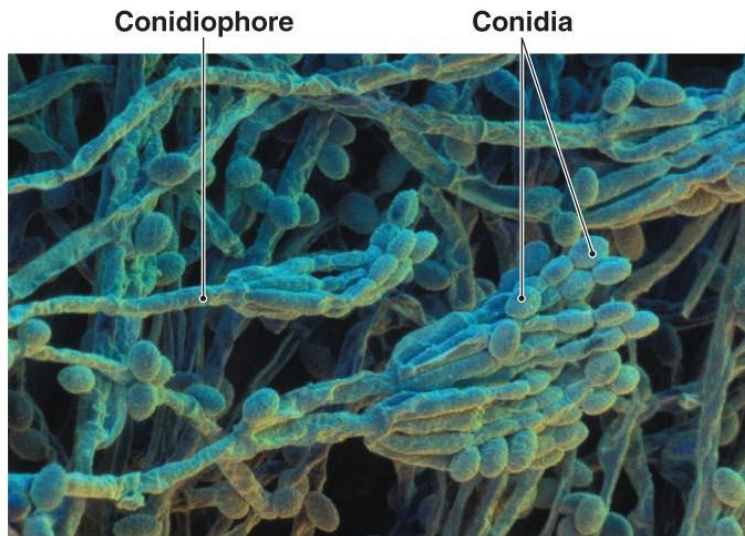
13  $\mu\text{m}$



(b)

LM

10  $\mu\text{m}$



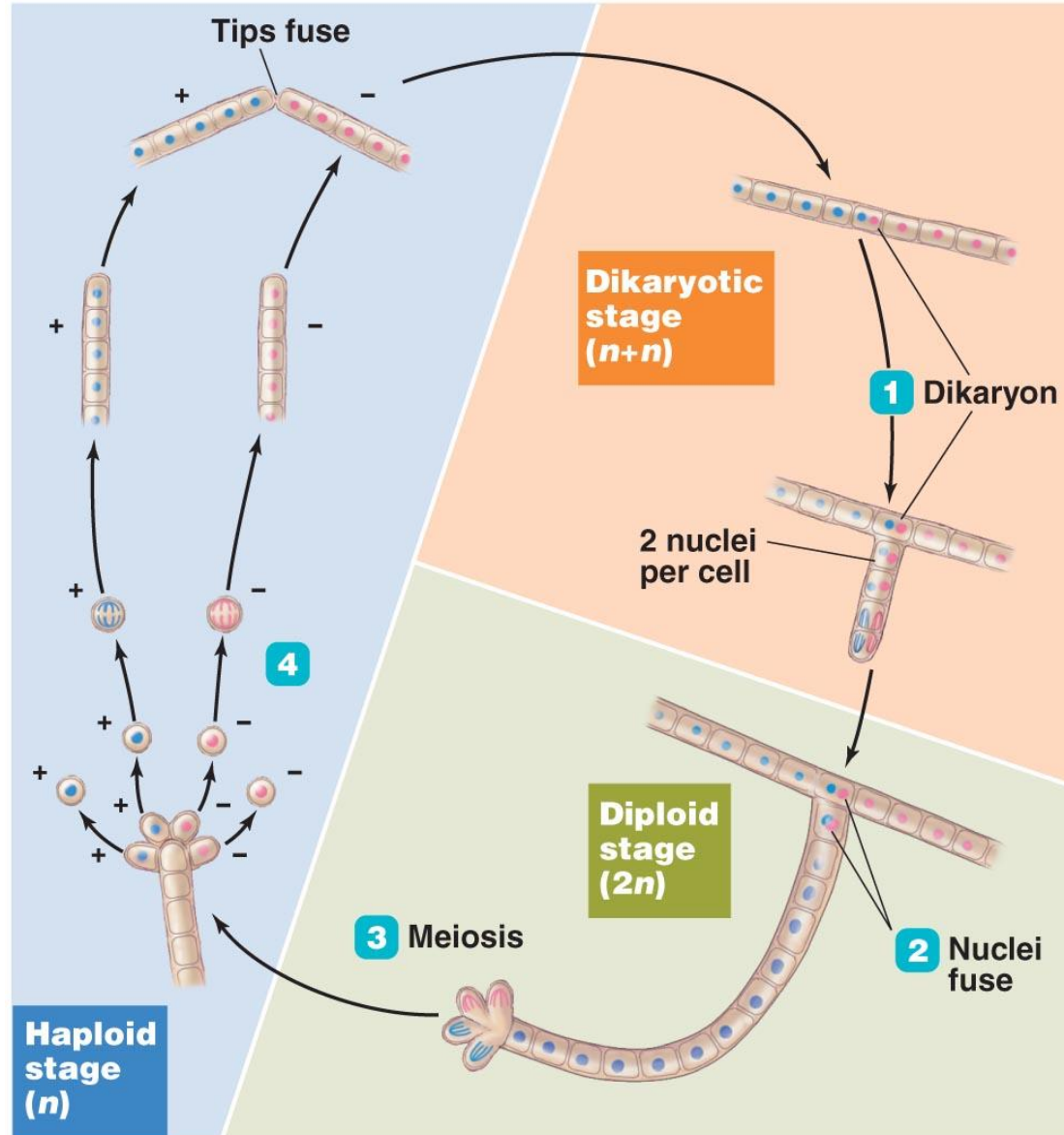
(c)

SEM

15  $\mu\text{m}$

# The process of sexual reproduction in fungi

39



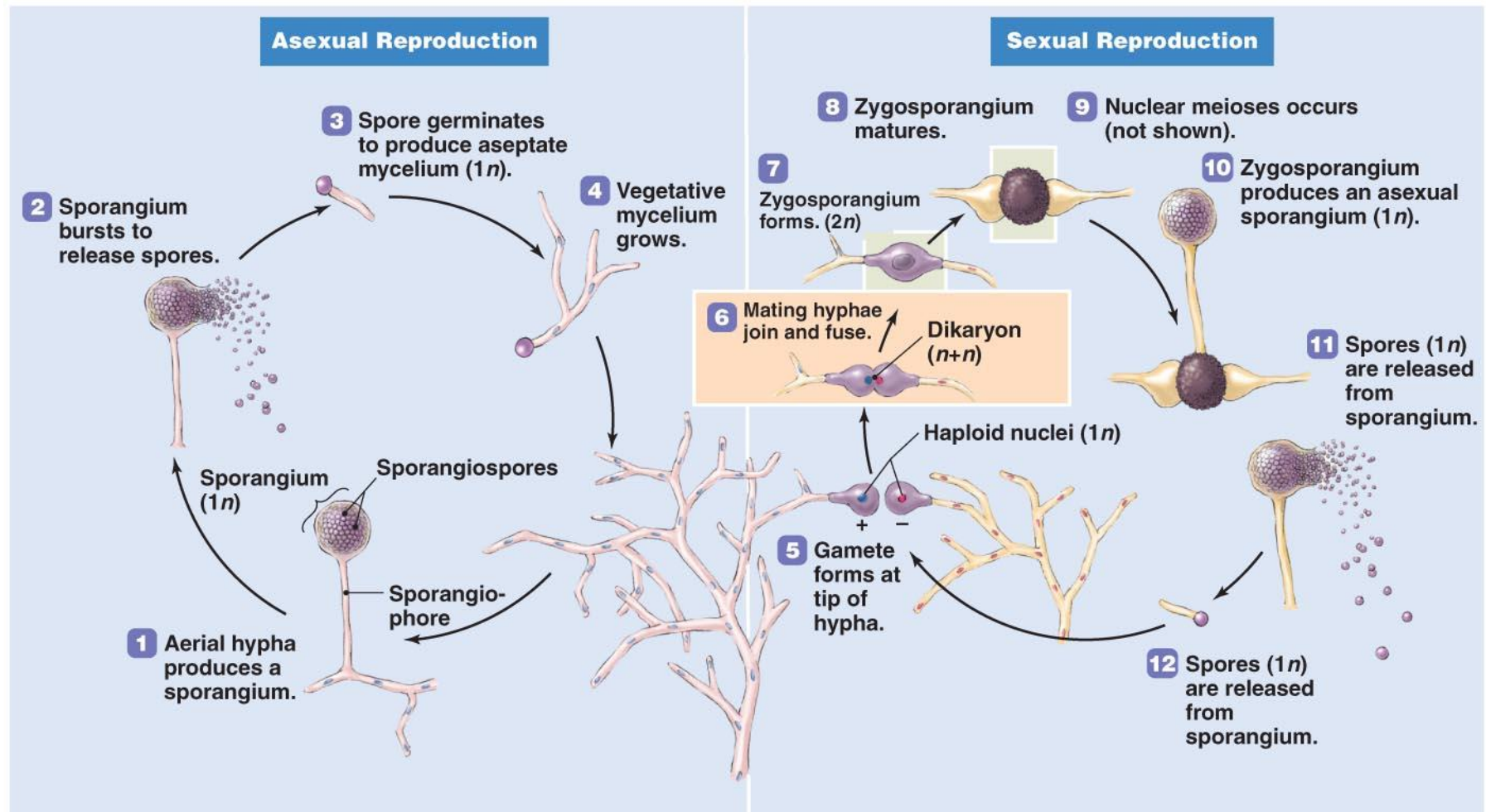
- **Classification of Fungi**

- Division **Zygomycota** 接合菌門
- Division **Ascomycota** 子囊菌門
- Division **Basidiomycota** 擔子菌門
- **Deuteromycetes** 不完全菌綱



# Life cycle of the zygomycete *Rhizopus*

41



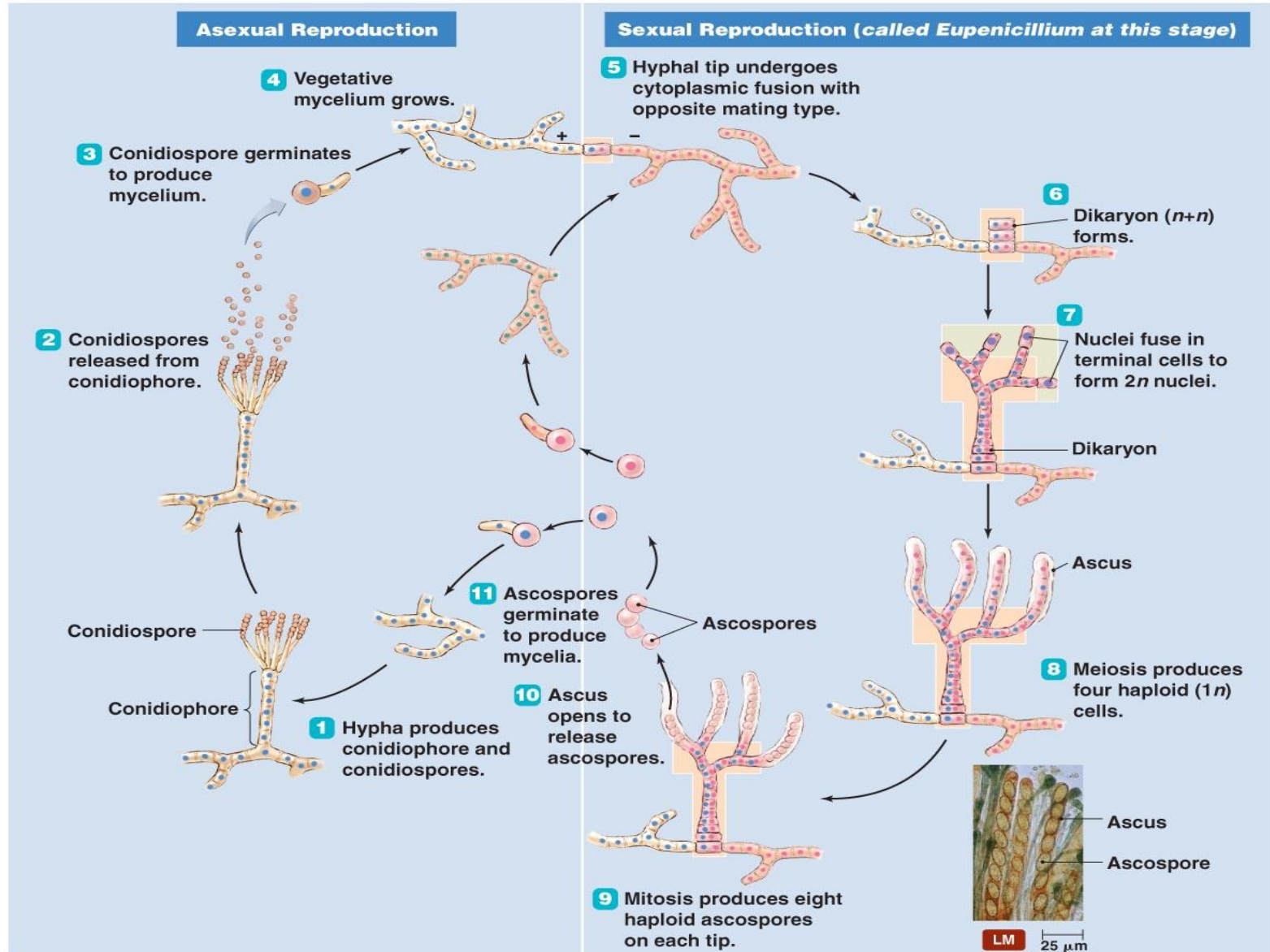
羊肚菌, 羊肚菜  
- 無毒，可食



1 cm

# The life cycle of an ascomycete, *Penicillium*

43





# Basidiocarps of the bird's nest fungus, *Crucibulum*

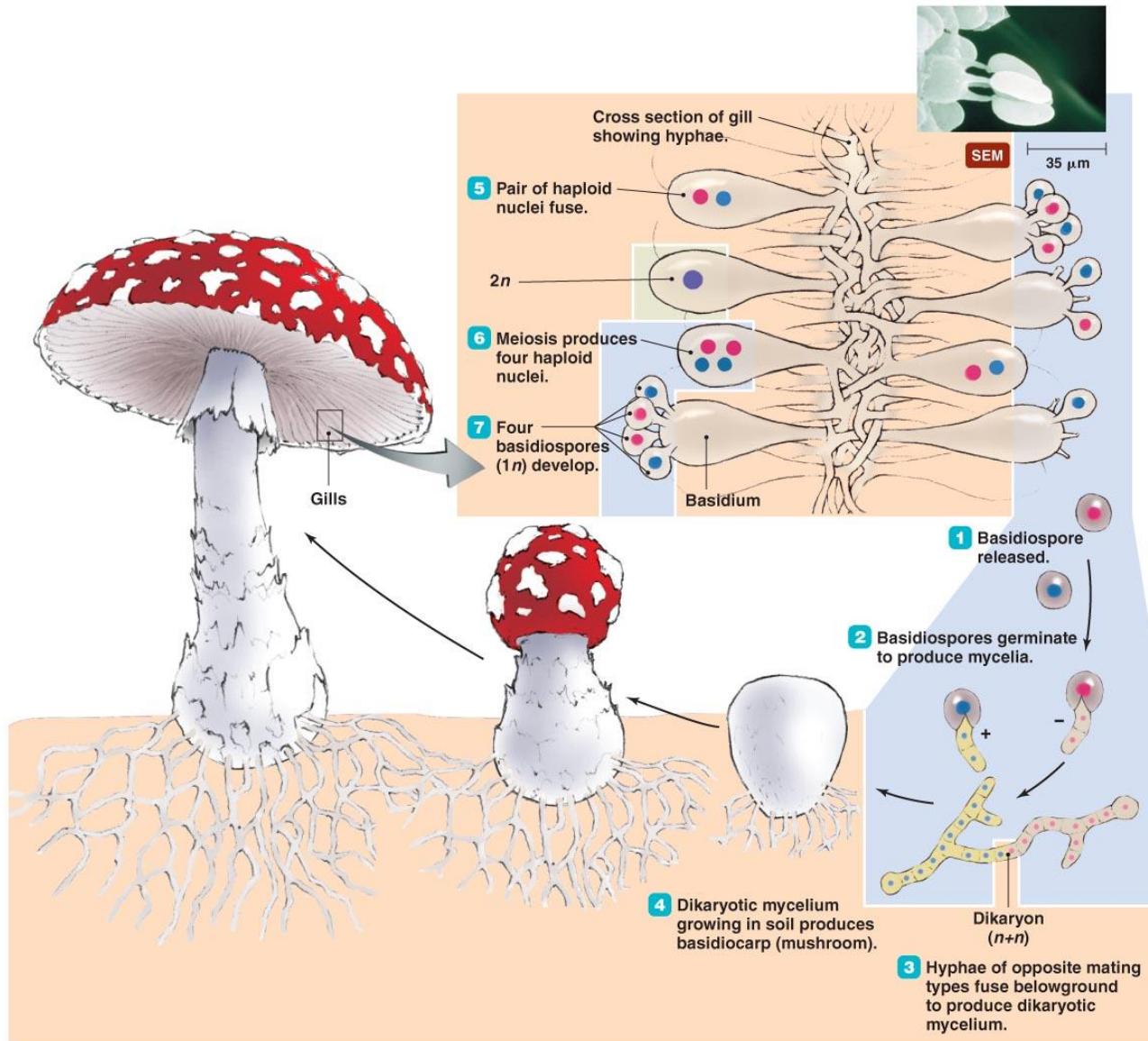
44



1 mm

# Sexual life cycle of a poisonous basidiomycete

45



- **Classification of Fungi**

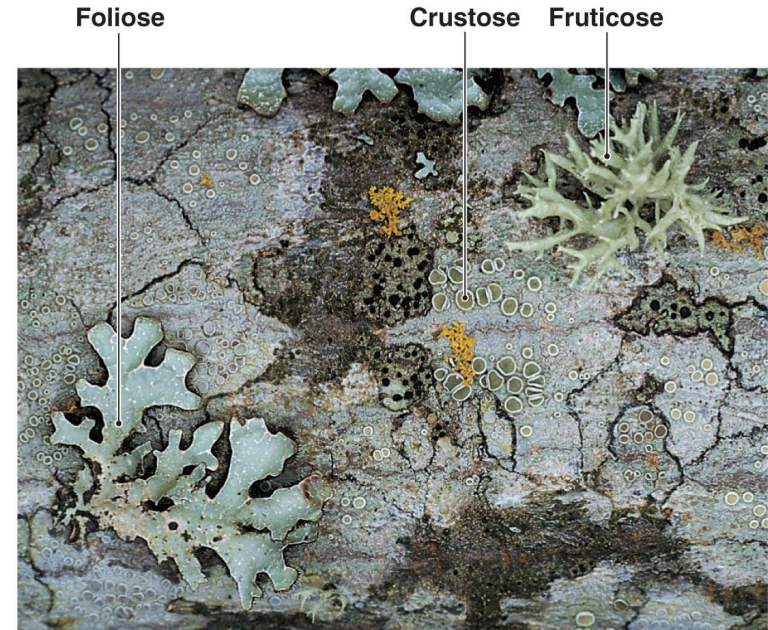
- Deuteromycetes

- Heterogeneous collection of fungi with unknown sexual stages
    - rRNA analysis revealed that most deuteromycetes belong in the division *Ascomycota*



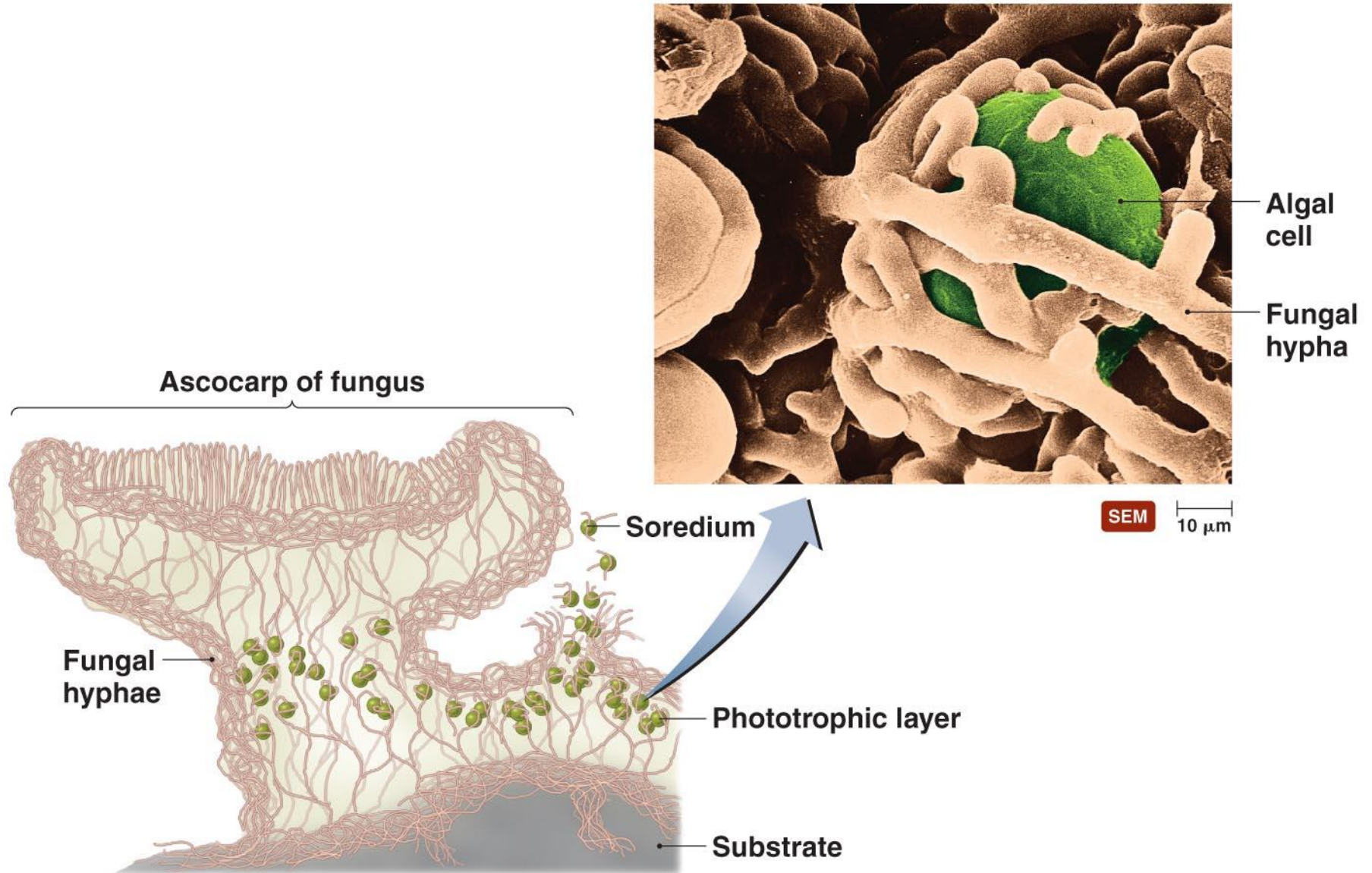
- **Lichens**

- Partnerships between **fungi** and **photosynthetic microbes**
- Abundant throughout the world, particularly in pristine habitats
- Grow in almost every habitat
  - On soil, rocks, leaves, tree bark, other lichens, even backs of tortoises
- Occur in three basic shapes
  - **Fruticose**, **crustose**, **foliose**
- Create soil from weathered rocks
- Eaten by many animals



# Makeup of a lichen

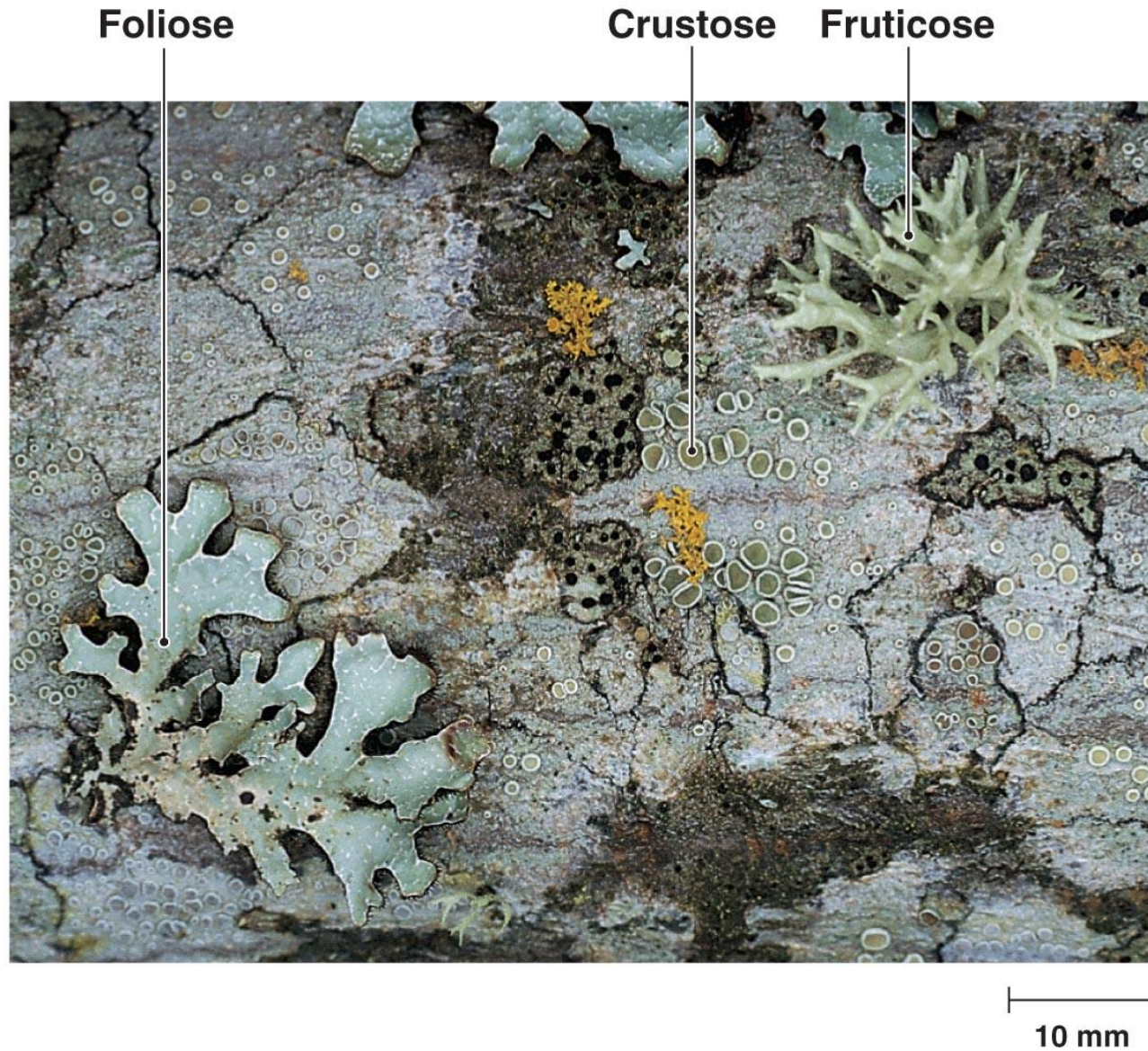
48





# Gross morphology of lichens

49



- Simple, eukaryotic phototrophs that carry out **oxygenic photosynthesis** using **chlorophyll a**
- Have **sexual reproductive structures**
  - Every cell becomes a gamete
- Differ widely in distribution, morphology, reproduction, and biochemical traits

- **Distribution of Algae**

- Most are aquatic
  - Live in the *photic zone* of fresh, brackish, and saltwater
- Have accessory **photosynthetic pigments** that trap energy of light and pass it to **chlorophyll a**

- **Morphology of Algae**

- Unicellular, colonial, or have simple multicellular bodies (thalli)

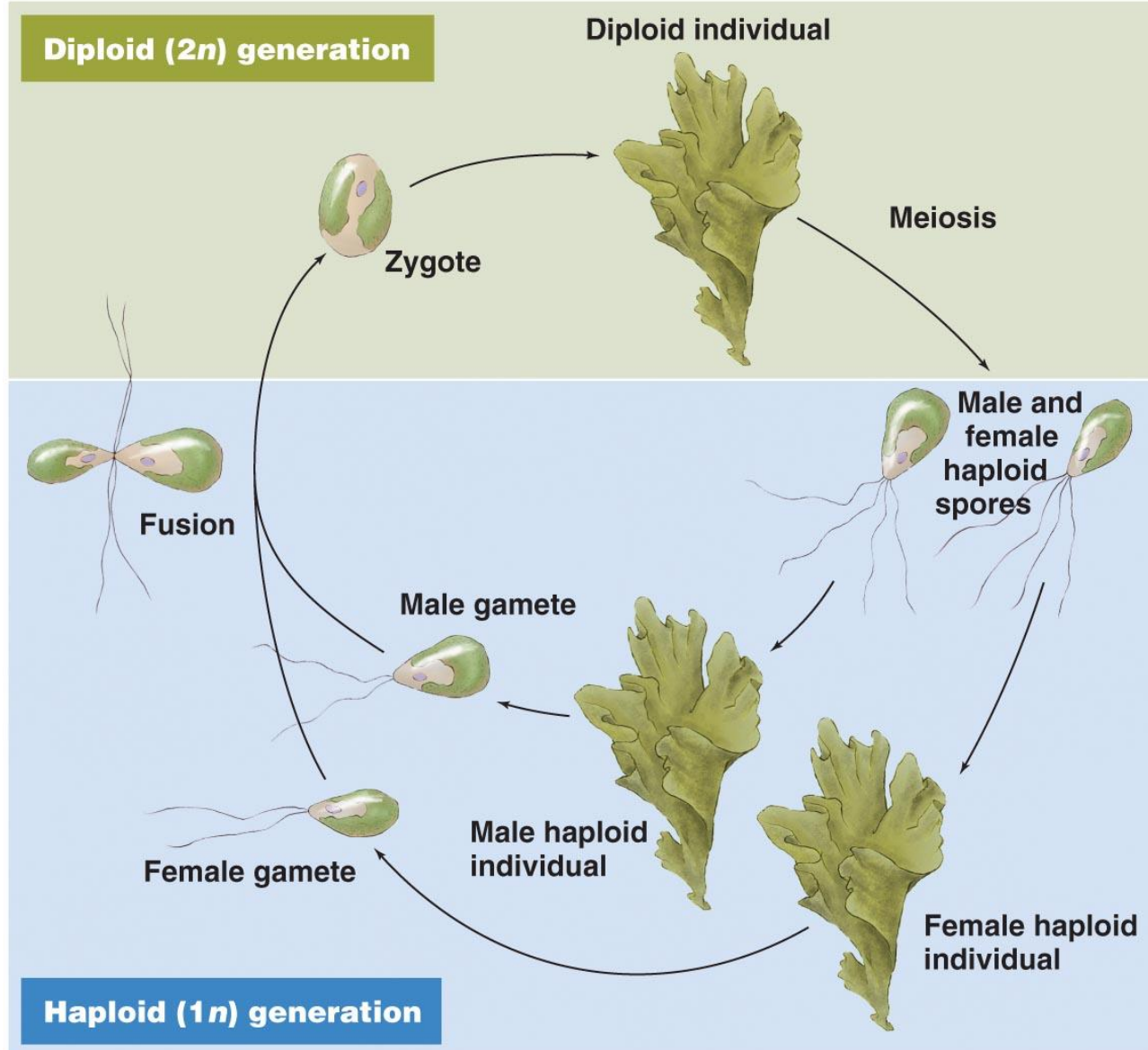


- **Reproduction in Algae**

- Asexual reproduction in unicellular algae involves mitosis followed by cytokinesis
- Unicellular algae that reproduce sexually form zygotes from individual gametes
  - Zygote undergoes meiosis
- Multicellular algae may reproduce asexually by fragmentation
- Many multicellular algae reproduce sexually with alternation of generations

# Alternation of generations in algae

54



# *Antithamnion*, a red alga

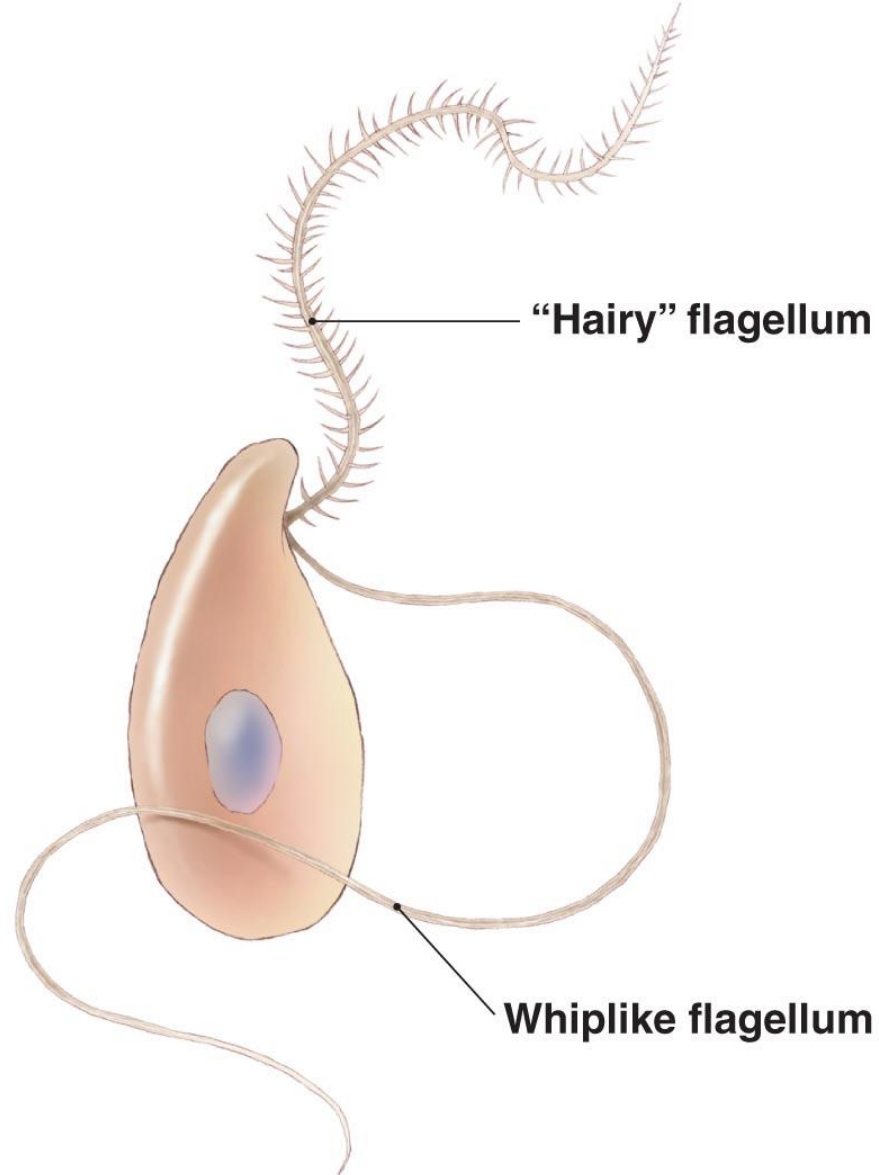
55



LM

5  $\mu$ m

# Two types of flagella of the sperm of the brown alga *Fucus* 56





# The giant kelp *Macrocystis*, a brown alga

57

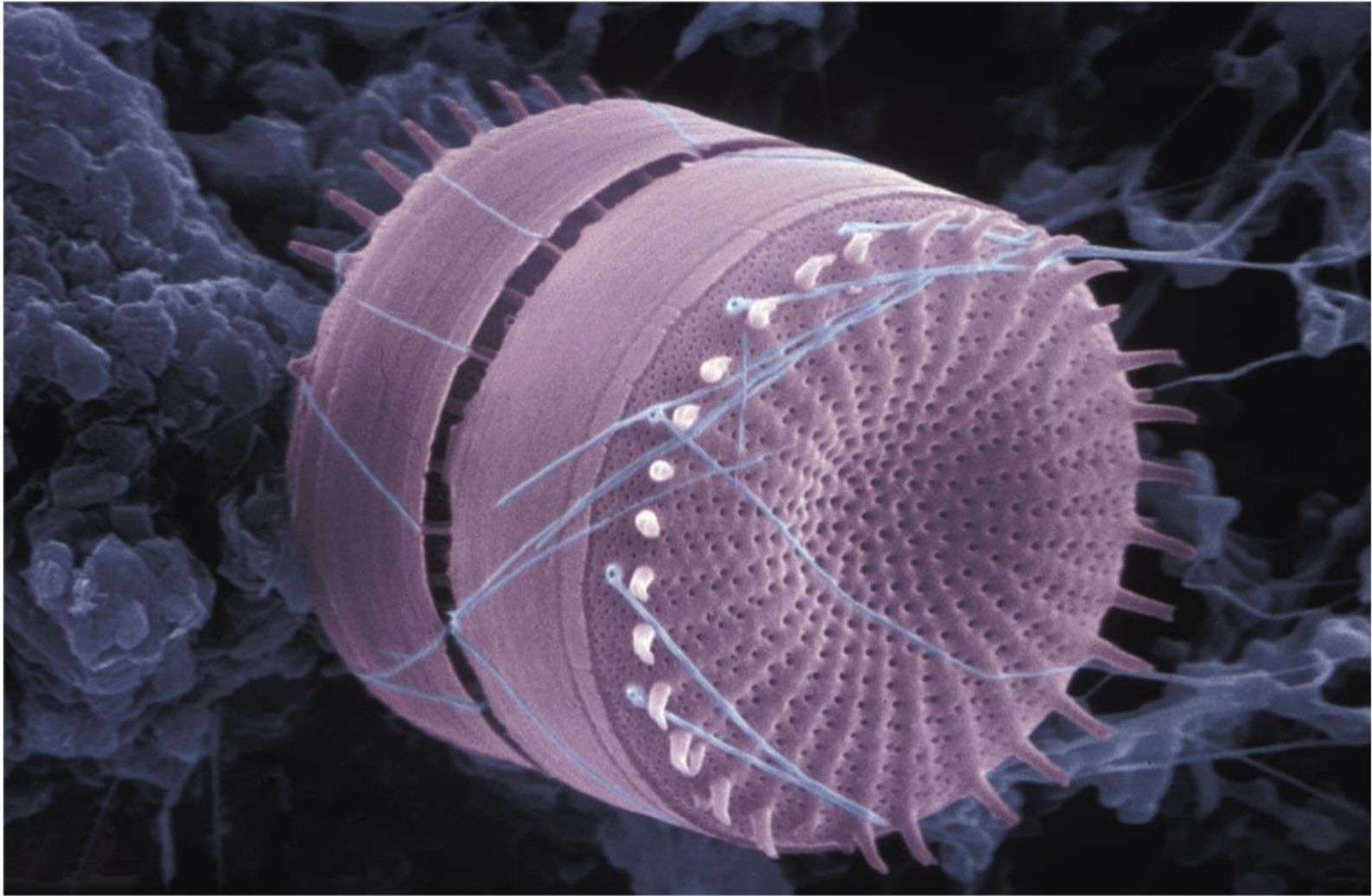
Pneumocyst



20 mm

# *Stephanodiscus*, a diatom

58



SEM

30  $\mu\text{m}$



- Differ from fungi in the following ways
  - Have **tubular cristae** in their **mitochondria**
  - Cell walls are of **cellulose** instead of chitin
  - Spores have **two flagella**
    - One whiplike and one tinsel-like
  - Have true **diploid thalli**

# Water molds recycle organic nutrients in aquatic habitats

60



# Other Eukaryotes of Microbiological Interest: Parasitic Helminths and Vectors<sub>61</sub>

- **Parasitic worms** have microscopic infective and diagnostic stages – usually **eggs** or **larvae**
- **Arthropod vectors** are animals that carry pathogens
  - Mechanical vectors
  - Biological vectors
- **Disease vectors** belong to two classes of arthropod
  - *Arachnida* 蛛形綱
  - *Insecta* 昆蟲綱

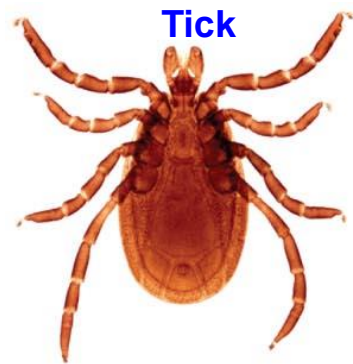
- **Arachnids**

- Adult arachnids have **four pairs of legs**
- **Ticks** are the most important arachnid vectors
  - Hard ticks are most prominent tick vectors
- A few **mite** species transmit **rickettsial diseases**

- **Insects**

- Adult insects have three pairs of legs and three body regions
- Include
  - Fleas
  - Lice
  - Flies
  - Mosquitoes
  - Kissing bugs





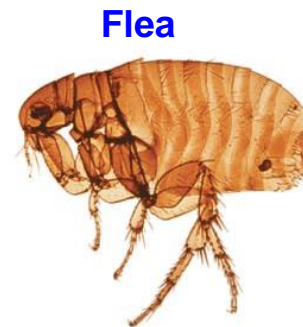
Actual size

(a)



Actual size

(b)



Actual size

(c)



Actual size

(d)

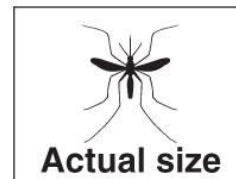
**True fly**



Actual size

(e)

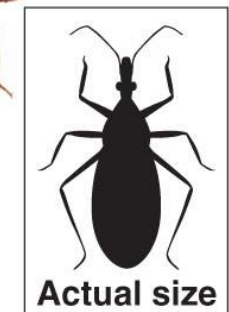
**Mosquito**



Actual size

(f)

**True bug (Kissing bug)**



Actual size

(g)

# End of Chapter

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