



# Marine Phytoplankton

Department of Oceanography  
Xiamen University



# 1 海洋浮游植物重要意义

- 浮游植物（**phytoplankton**）是海洋中的**初级生产者**，是海洋动物直接或间接的饵料，在海洋渔业方面有着重要的意义。
- 浮游植物是海流和水团的**指示生物**（**Biological indicator**），在生物海洋学研究中意义重大。
- 浮游植物能**富集污染物质**，在海洋环境保护研究中有重要意义。



## 2 海洋浮游植物的主要类别

原核细胞型生物:

- 1.细菌 (Bacteria)
- 2.蓝藻门(Cyanophyta)

真核细胞型生物:

- 1.硅藻门(Bacillariophyta): 是最重要的浮游植物, 将重点介绍。
- 2.甲藻门(Pyrrophyta): 是很重要的类别, 大多种类是赤潮生物。
- 3.绿藻门(Chlorophyta): 是海水养殖中的重要饵料, 如盐藻、扁藻、小球藻。
- 4.金藻门(Chrysophyta): 在海水养殖中也有重要地位, 有些种类是良好的饵料。
- 5.黄藻门(Xanthophyta): 大多生活于淡水。
- 6.隐藻门(Cryptophyta): 主要生活于淡水。
- 7.眼藻门(Euglenophyta): 淡水中多, 且个体极小, 不易采到。





# Chapter 1 Bacillariophyta

known as diatom, the most important  
group of phytoplankton, regarded as  
"Marine Pasture"



# 1.1 Morphological Features

## 1.1.1 Exterior morphology of the cell

**a.form:** spherical, ellipsoid, triangular, poyangular etc.

**b.frustule:** epitheca, hypotheca, valve, girdle band, connecting band, valve mantle

**c.axis:** transapical axis, apical axis, pervalval axis



**1.1.2 areolae, puncta, pore**

**1.1.3 raphe:** central nodule, polar nodule,  
stauros

**1.1.4 canal-raphe**

**1.1.5 intercalary band**

**1.1.6 processes on the cell surface:**

process, spine, hairs, membranaceous,  
gelatinous process

**1.1.7 cell inclusion:** nucleus, chromatoplasts





## 1.2 Classification

### 一、分类系统的建立与发展

#### 1、硅藻的分类依据：

- a) 按地质史上出现的早晚
- b) 形态上的相似性
- c) 特征的产生缘由

#### 2、硅藻系统分类的主要研究过程

- a) 1824~1871年，为硅藻分类的草创时期
- b) 1872~1976年是近代硅藻分类的奠基时期





**1872**，美国藻类学家H.L.Smith，根据硅藻的形态和行  
为，将其划分成三大类：

一是不能行动的硅藻

二是能动壳缝在中线上的硅藻

三是能动壳缝在壳缘的硅藻

**1896**，德国学者F.Schiitt把上述三类合并为二类：  
即现在的中心硅藻纲和羽纹硅藻纲。

**1974**，英国学者Hendey提出一系列硅藻的科名，并指  
出系统方面，尚未接近自然分类。

**1978~1990年**，

**金德祥教授**多次在国际藻类学术会上宣读有关硅藻系统  
分类的研究论文，得到同行专家的认可和赞誉。



金德祥学术观点：中心硅藻比羽纹硅藻原始

长形、无壳缝(退化的结果)



长形、部分壳缝消失



长形、能行动有壳缝的硅藻



圆形、能行动有壳缝的硅藻(羽纹硅藻初始类型)



圆形、不能行动的硅藻(中心硅藻)



## 二、硅藻门的分类

根据壳面花纹排列的情况，硅藻门分为2个纲：  
(共包括9个目，20个科，44个属，约1万多个种类)

- 壳面花纹辐射对称的为**中心硅藻纲** (**Centriales**)
- 壳面花纹左右对称的为**羽纹硅藻纲** (**Pennatales**)



# 硅藻门Bacillariophyta分科检索表



1. 壳面花纹辐射对称。中心硅藻纲 **Centricae**
2. 壳面圆形、个别呈半圆形、椭圆形或三角形-----圆筛藻目 **Coscinodiscales**
3. 壳面花纹无无花纹眼或无“明显地分成小块”.....1. 圆筛藻科**Coscinodiscaceae**
4. 细胞球形或圆柱形，偶有壳面呈椭圆形的，常相连成长链。壳外套发达.....1a. 直链藻亚科**Melosiroideae**
4. 细胞短柱形或长柱形、靠硅质刺、硅质小突起，胶质丝或胶质块相连成链，胞壁硅质很少.....1b. 骨条藻亚科**Skeletonemoideae**
4. 细胞盘形、鼓形，大多单独生活，表面略有凸起，有时扁平或略有凹入。壳环带花纹不明显。壳套不特别发达..... 1c. 圆筛藻亚科**Coscinodisoideae**
3. 壳面有明显的无纹眼，有乳状突或粗短的大突起...2. 眼纹藻科**Eupodiscaceae**
3. 壳面分成小块，表面常凹凸不平
5. 壳面中央不分块.....3. 辐盘藻科**Actinodiscaceae**
5. 分块达壳的中央.....4. 星纹藻科**Asterolampraceae**
2. 壳面长椭圆形、多角形或长形，偶有椭圆形-----盒形藻目**Biddulphiales**
6. 壳面非长形
7. 刺毛短于细胞（唇状突），如长于细胞则有爪或没有刺毛，有突起.....5. 盒形藻科**Biddulphiaceae**
7. 刺毛长于细胞，毛端无爪。细胞借角毛相连...6. 角毛藻科**Chaetoceraceae**
6. 壳面长形.....7. 舟辅藻科**Rutilariaceae**
2. 壳面宽椭圆形，偶有圆形-----根管藻目**Rhizosoleniales**.....8. 根管藻科**Rhizosoleniaceae**



# 硅藻门Bacillariophyta分科检索表

- 1. 壳面花纹左右对称, 羽纹硅藻纲Penntae
  - 8. 两壳均具壳缝, 舟形藻目Naviculales
    - 9. 壳面左右对称.....9. 舟形藻科Naviculaceae
    - 9. 壳面左右不对称.....10. 桥弯藻科Cymbellaceae
    - 9. 壳面上下端不对称.....11. 异极藻科Gomphonemaceae
    - 9. 壳面很不对称, 弯转似人耳或肾形。两壳的龙骨突向同一方向转弯.....12. 耳形藻科Auriculaceae
  - 8. 壳缝多少退化
    - 10. 全部壳缝退化。等片藻目Diatomales.....13. 等片藻科Diatomaceae
    - 10. 单条壳缝或部分壳缝退化。曲壳藻目Achnanthales
      - 11. 壳的横轴弯曲.....14. 卵形藻科Cocconeiaceae
      - 11. 壳的纵轴弯曲.....15. 曲壳藻科Achnanthaceae
    - 10. 中部壳缝退化, 短缝藻目Eunotiales.....17. 短缝藻科Eunotiaceae
  - 8. 壳环带和一个壳面退化, 有时全部硅质壁退化。褐指藻目Phaeodactylales.....16. 褐指藻科Phaeodactylaceae
  - 8. 壳缝成为管壳缝者。双菱藻目Surirellales
    - 12. 管壳缝在壳面中央, 成人字型.....18. 窗纹藻科Epithemiaceae
    - 12. 管壳缝在壳的一侧.....19. 菱形藻科Nitzschiaceae
    - 12. 管壳缝在壳的两侧.....20. 双菱藻科Surirellaceae



# 1.2.1 Class Centriac

## 1 Order Coscinodiscales

本目分科的依据：

- ※ 壳面花纹有否“无纹区”；
- ※ 壳面有否分块；
- ※ 壳面有否乳突



## (1) Family Coscinodiscaceae

### Subfamily Coscinodisoideae

- *Planktoniella* *P. sol*
- *Coscinodiscas*

全世界有450多种，我国约30种，常见代表有：

*Cos. radiatus*

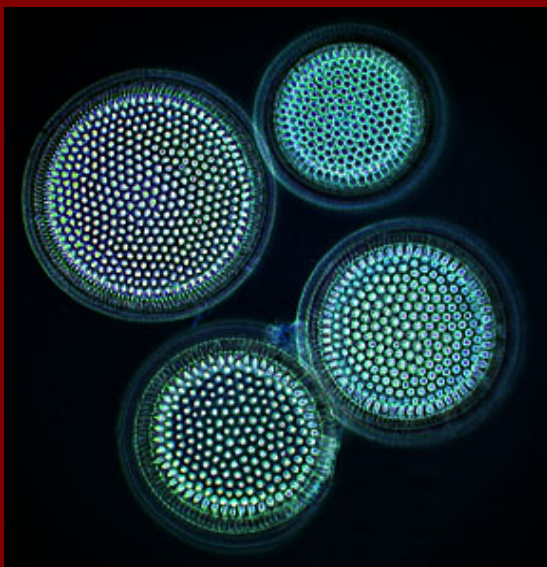
*Cos. lineatus*

*Cos. excentricus*

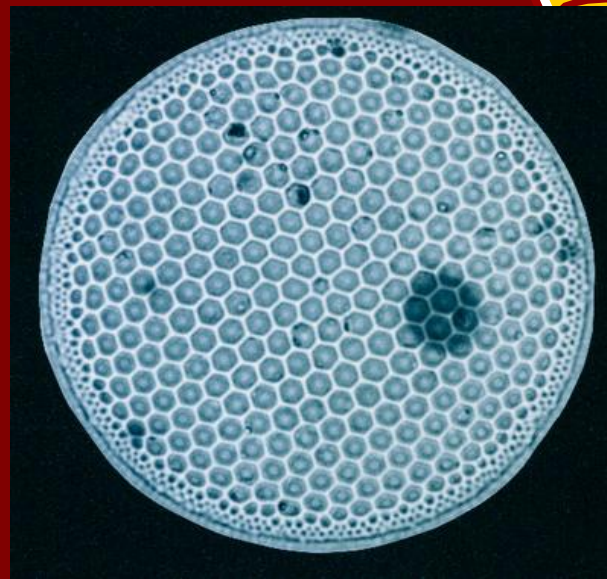
*Cos. asteromphalus*

- *Cyclotella*
- 

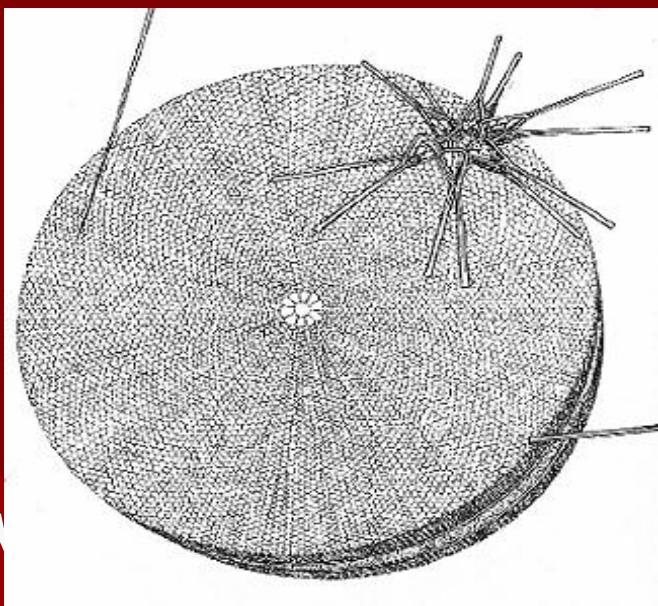




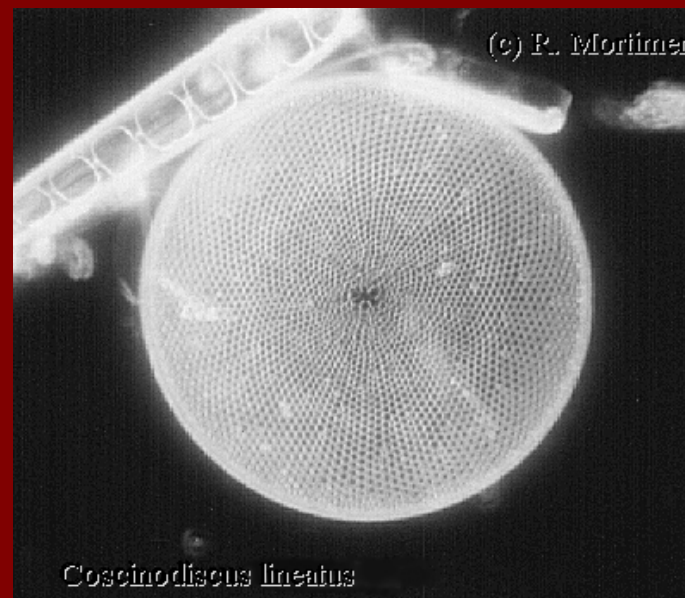
偏心圆筛藻 *Coscinodiscus*



线形圆筛藻 (*Coscinodiscus lineatus*)



星脐圆筛藻 (*Coscinodiscus asteromphalus*)



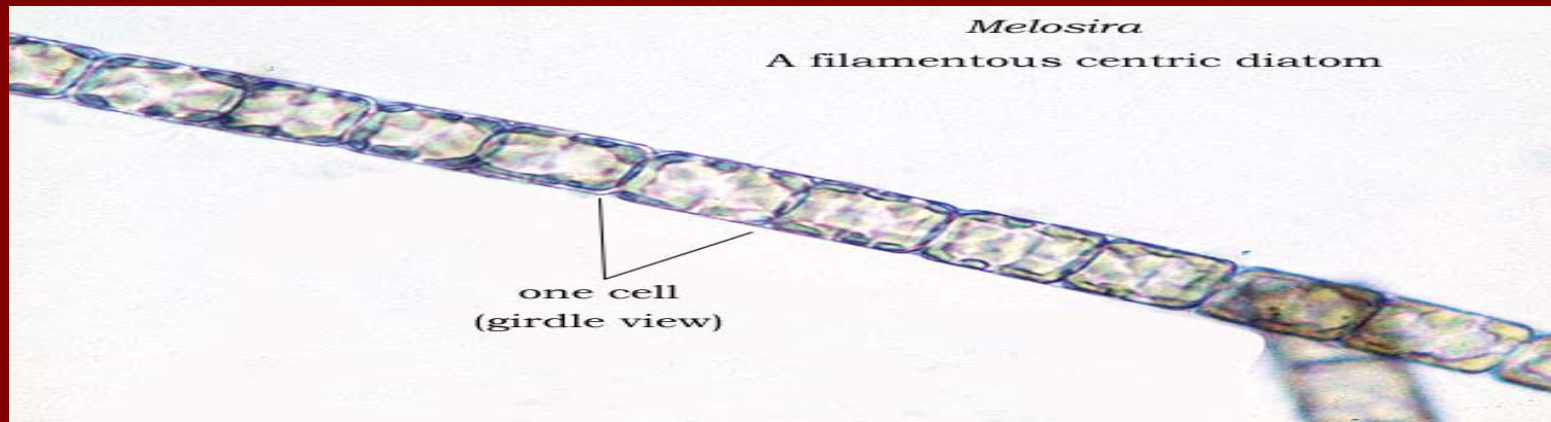
辐射圆筛藻 (*Coscinodiscus radiatus*)



## Subfamily Melosiroideae

- *Melosira*  
*M. sulcata.*
- *Stephanopyxis*  
*S. palmeriana.*
- *Corethron*  
*C. hystrix.*





具槽直链藻 (*Melosira sulcata*)

## Subfamily Skeletonemoideae

- *Skeletonema*

  - S. costatum*

- *Bacteriastrum*

  - B. hyalinum*

  - B. delicatulum*

- *Thalassiosira*

  - Th. rotula*

  - Th. subtilis*





中肋骨条藻 (*Skeletonema costatum*)



# 2. Order Biddulphiales

## (1) Family Biddulphiaceae

- *Ditylum*
- *D. brightwellii*
- *Hemiaulus*
- *Triceratium*
- *Biddulphia*
- *B. sinensis*



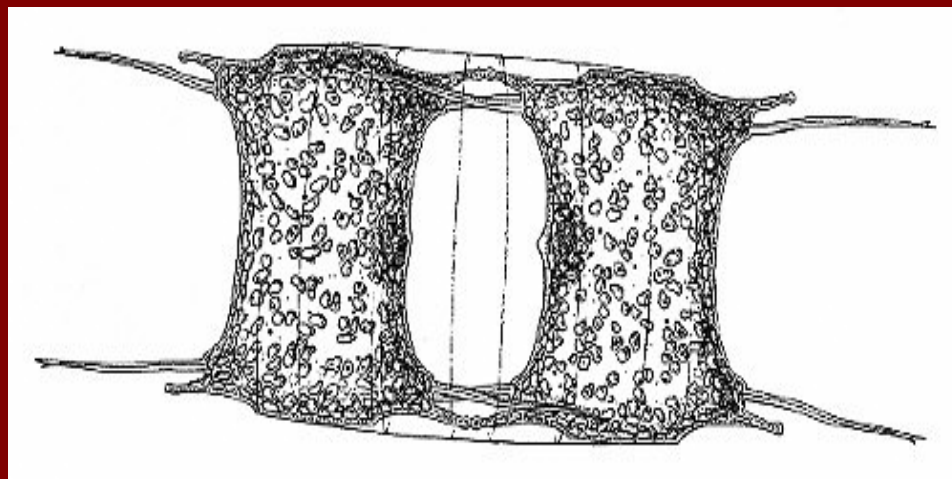


*Biddulphia.pulchella*



布氏双尾藻(*Dytillum brightwellii*)





中华盒形藻 (*Biddulphia sinensis*)



## (2) Family Chaetoceraceae

### *Chaetoceros*

- 多色暗角毛亚属：色素体分布于细胞内和角毛内
- 多色明角毛亚属：细胞内的色素体4个以上
- 寡色体亚属：细胞内的色素体2个以下

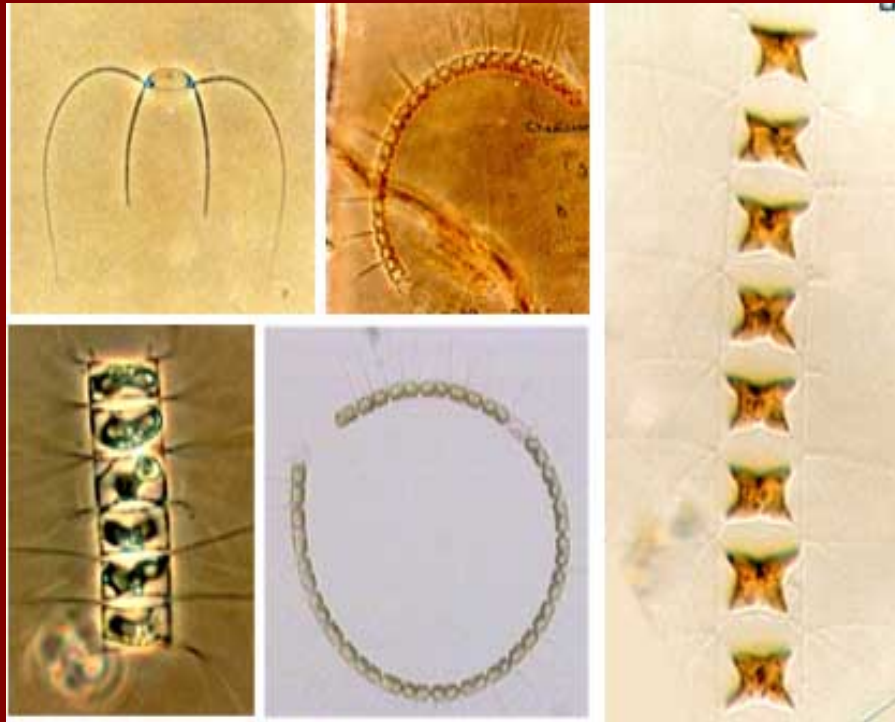
寡色体亚属是角毛藻中最重要的，生活在近岸水域。常见代表有：

*Ch. muelleri*

*Ch. didymus*







旋链角毛藻  
(*Ch. curvisetus*)



假弯角毛藻  
(*Ch. pseudocrinitus*)



# 3 Order Rhizosoleniales

## Family Rhizosoleniaceae

根管藻属(*Rhizosolenia*) 根据细胞壳面的突起；细胞形状；节间带情况分如下几个组：

- 无刺组：突起的末端无刺。
- 多鳞组：节间带的鳞片状，而且很多。
- 窄隙组：壳面平或略成圆形，有短刺。
- 粗壮组：壳面近圆锥形，单独生活。
- 复瓦组：壳环纹（节间带）分为左右两列。
- 模式组：壳环纹（节间带）为背腹两列。



# **Chapter I Bacillariophyta**

## **Part 2**

**Department of Oceanography**

**Xiamen University**

# References

- Round F.E. et al. , 1990. The diatoms (Biology & morphology of the genera). Cambridge University Press.747p
- Tomas C. R., 1997. Identifying marine phytoplankton. Academic Press. 858p
- Botes L., 2003. Phytoplankton identification catalogue – Saldanha Bay, South Africa, April 2001. GloBallast Monograph Series, 7. IMO London. 87p
- Jin De-xiang et al., 1965. Marine Planktonic Diatoms of China. Shanghai Science & Technology Press. (in Chinese)
- Jin De-xiang, 1991. Marine Diatom. Xiamen University Press. (in Chinese)

# Contents

- **1.1 Morphological Features**
- **1.2 Classification**
  - 1.2.1 Class Centricae
  - 1.2.2 Class Pennatae
- **1.3 Reproduction**
- **1.4 Significance**

# 1.2 Classification

- ✚ Valves of cell radially symmetrical, without raphe and pseudoraphe Centricae
  - ✚ Valves of cell pennatrical with raphe and pseudoraphe Pennatae
- 
- 1.2.1 Class Centricae
  - 1.2.2 Class Pennatae

# 1.2.2 Class Pennatae

## 6 orders, 12 families

两壳均具壳缝

壳面左右对称

壳面左右不对称

壳面上下端不对称

壳面很不对称，弯转似人耳或肾形；两壳的龙骨突向同一方向转弯

舟形藻科 **Naviculaceae**

桥弯藻科 **Cymbellaceae**

异极藻科 **Gomphonemaceae**

耳形藻科 **Auriculaceae**

壳缝多少退化

全部壳缝退化

单条壳缝或部分壳缝退化

壳的横轴弯曲

壳的纵轴弯曲

中部壳缝退化

壳环带和一个壳面退化，有时全部硅质壁退化

等片藻科 **Diatomaceae**

卵形藻科 **Cocconeaceae**

曲壳藻科 **Achnanthaceae**

短缝藻科 **Eunotiaceae**

褐指藻科 **Phaeodactylaceae**

壳缝成为管壳缝者

管壳缝在壳面中央，成人字型

管壳缝在壳的一侧

管壳缝在壳的两侧

窗纹藻科 **Epithemiaceae**

菱形藻科 **Nitzschiaceae**

双菱藻科 **Surirellaceae**

## 1.2.2.1 Order Naviculales

### Family Naviculaceae

*Navicula*

*Diploneis*

*Gyrosigma*

*Pleurosigma*

## 1.2.2.2 Order Diatomales

### Family Diatomaceae

*Asterionella*

*Synedra*

*Thalassiothrix*

*Thalassionema*

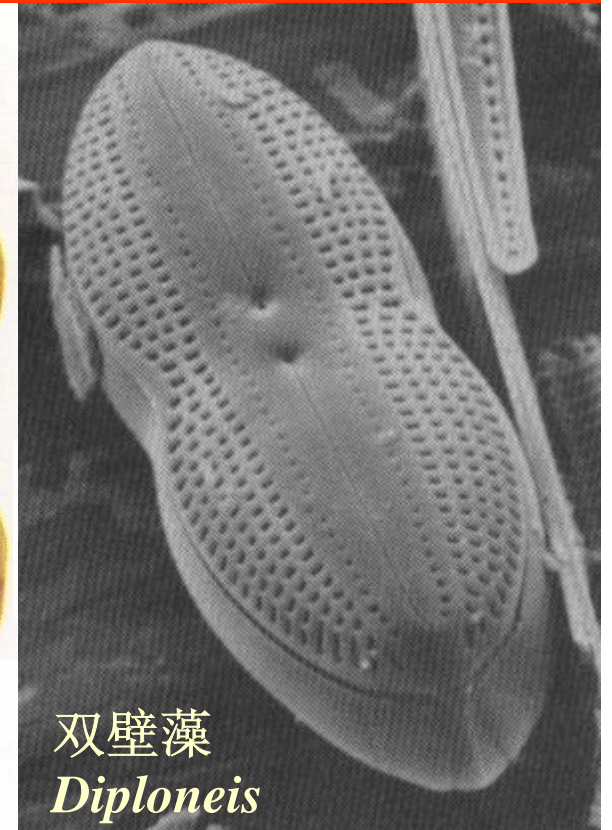
*Licmophora*



## Family Naviculaceae

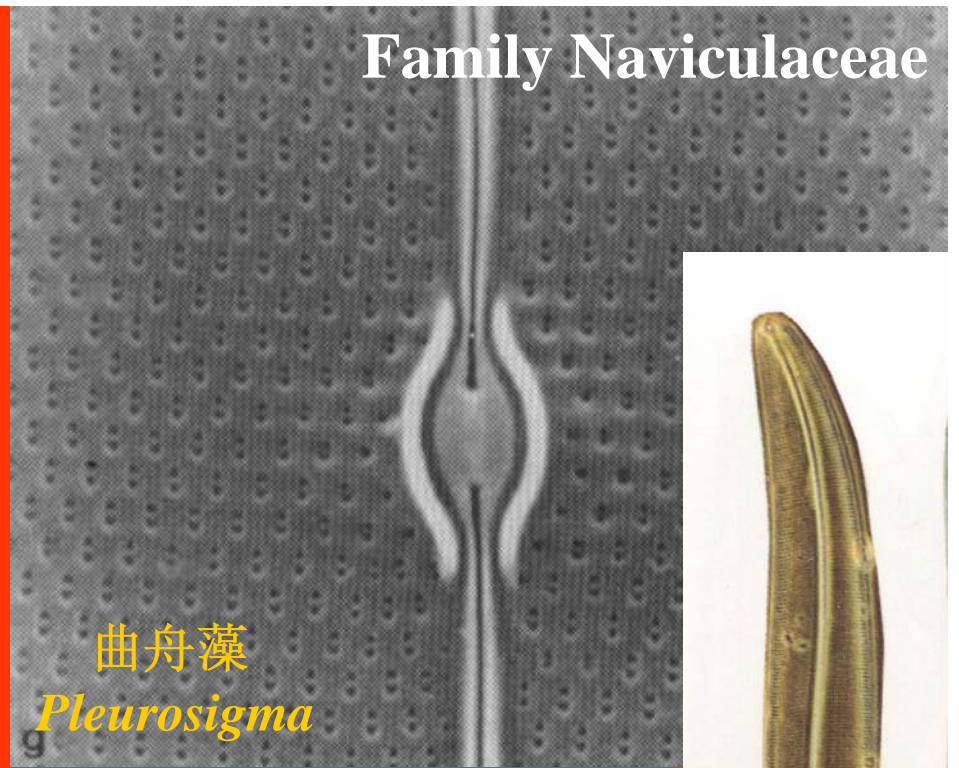


舟形藻 *Navicula*

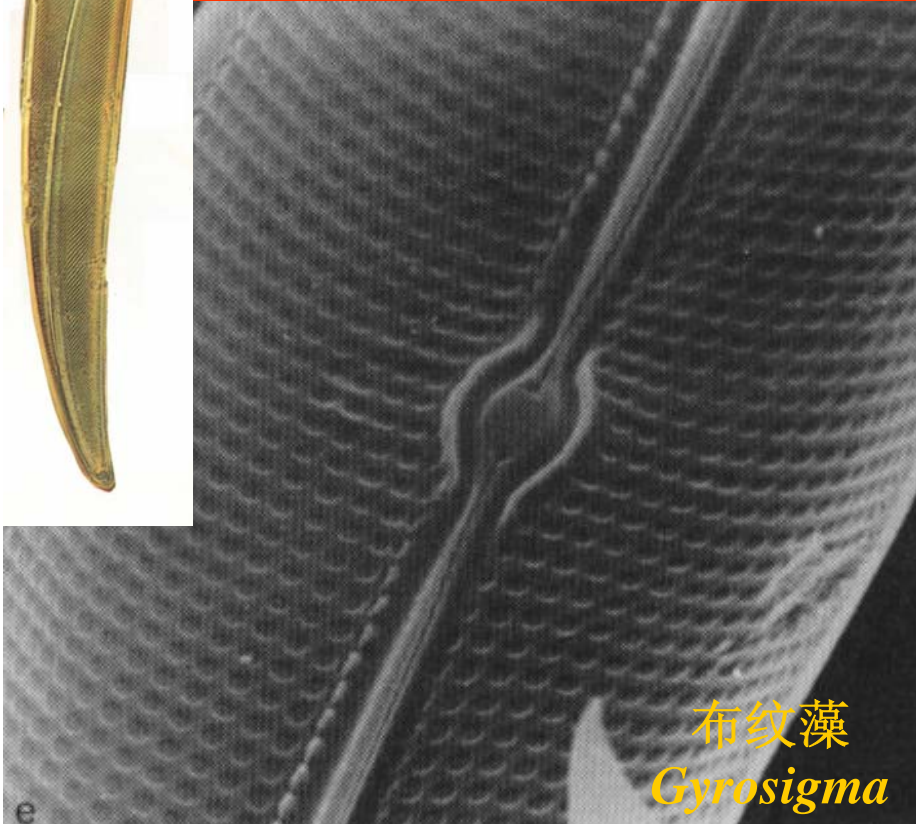


双壁藻  
*Diploneis*

Family Naviculaceae



曲舟藻  
*Pleurosigma*

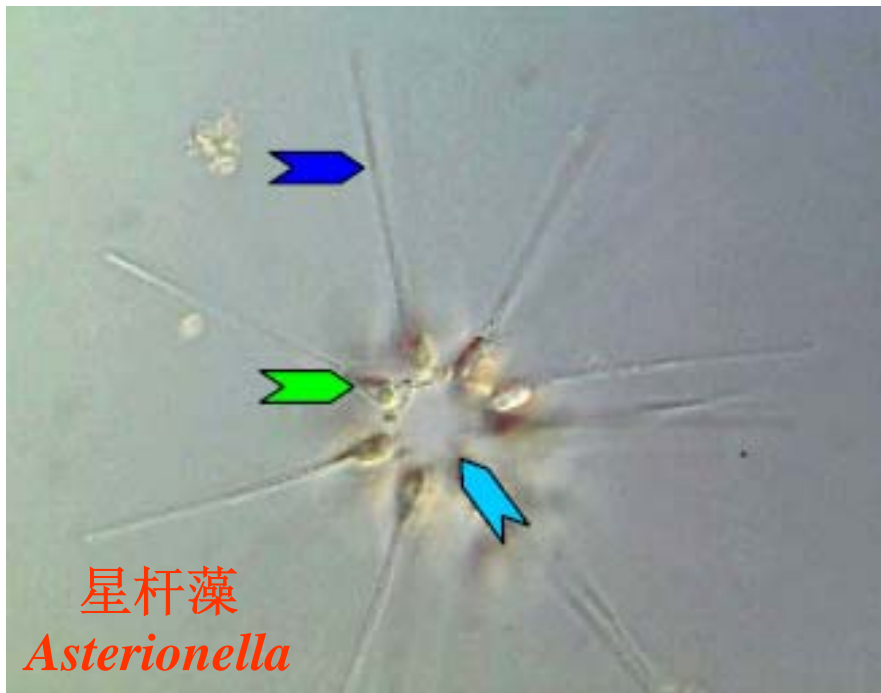


布纹藻  
*Gyrosigma*




e

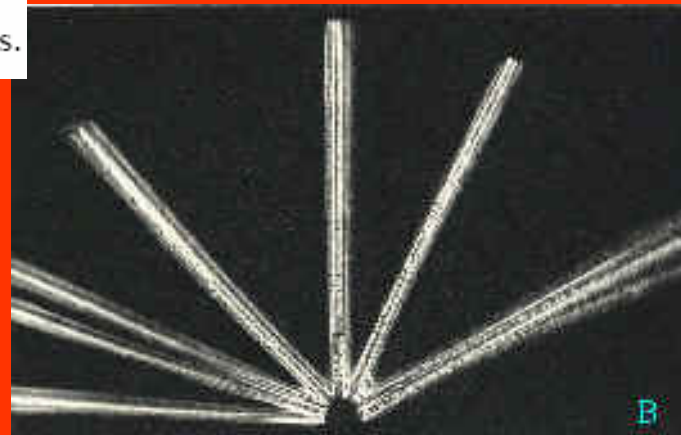
g

# Family Diatomaceae

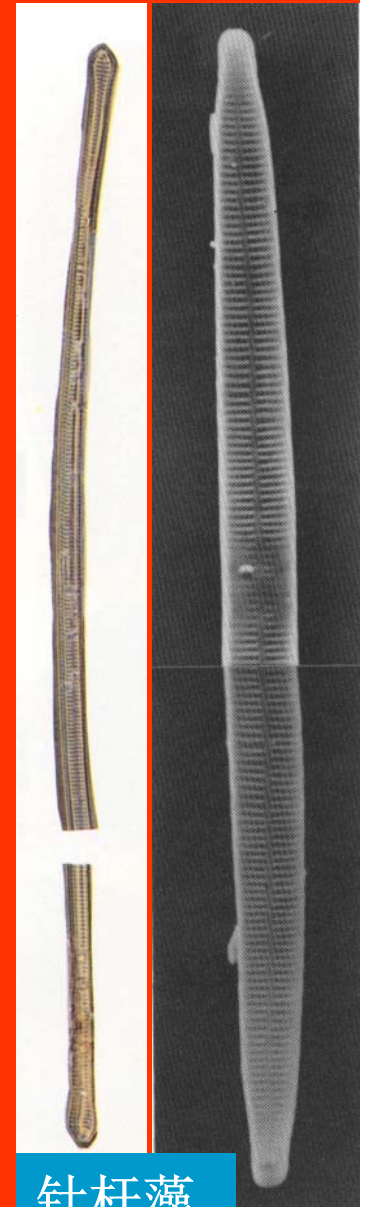


星杆藻  
*Asterionella*

-  Cells rod-like with distinctly dissimilar ends,
-  one end enlarged.
-  Larger ends united into star-like spiral colonies.

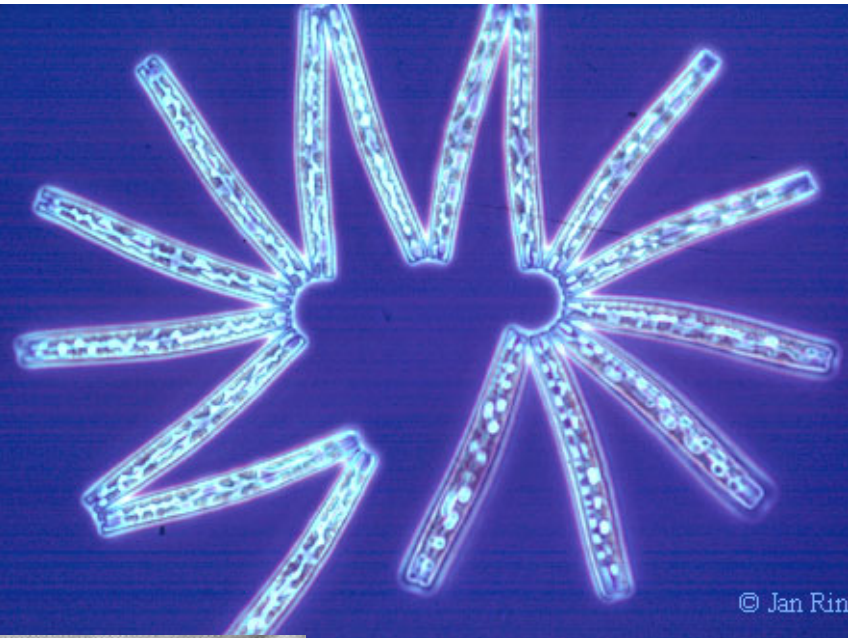
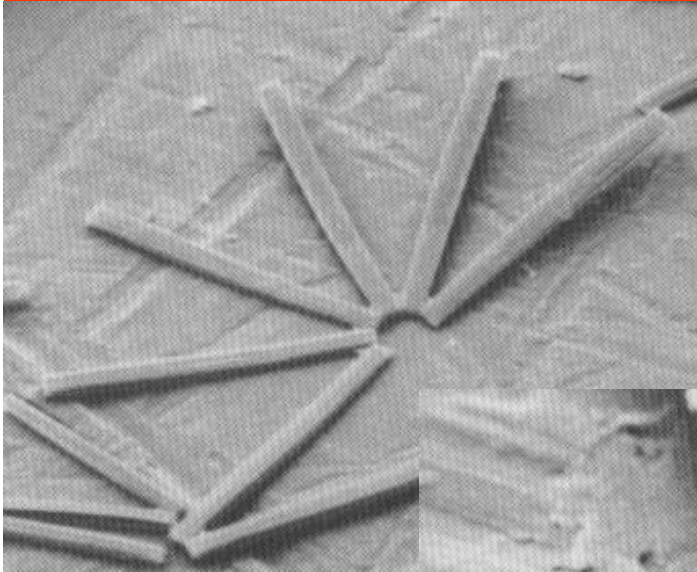


海毛藻 *Thalassiothrix*

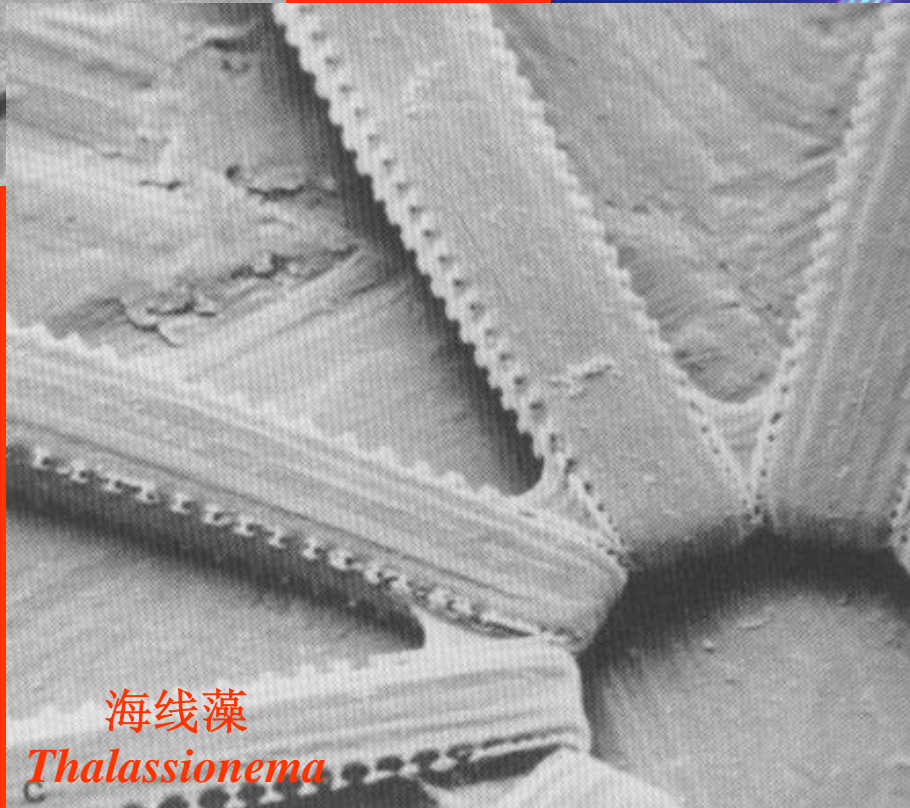


针杆藻  
*Synedra*

# Family Diatomaceae

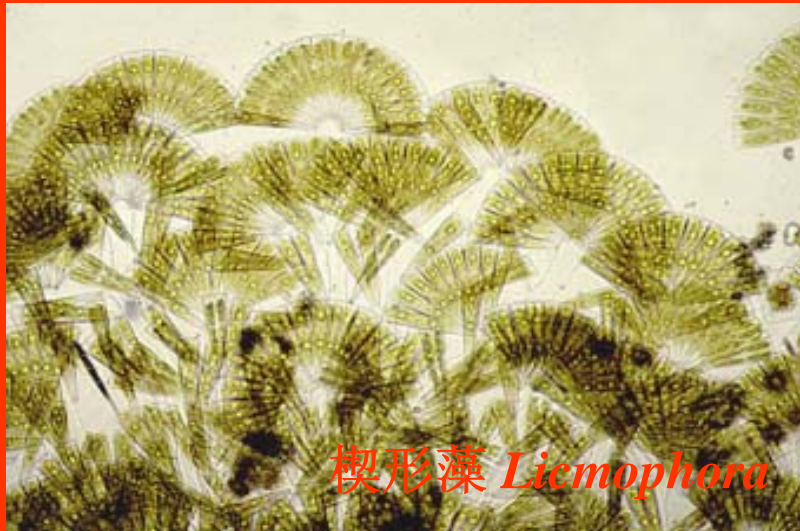


© Jan Rines

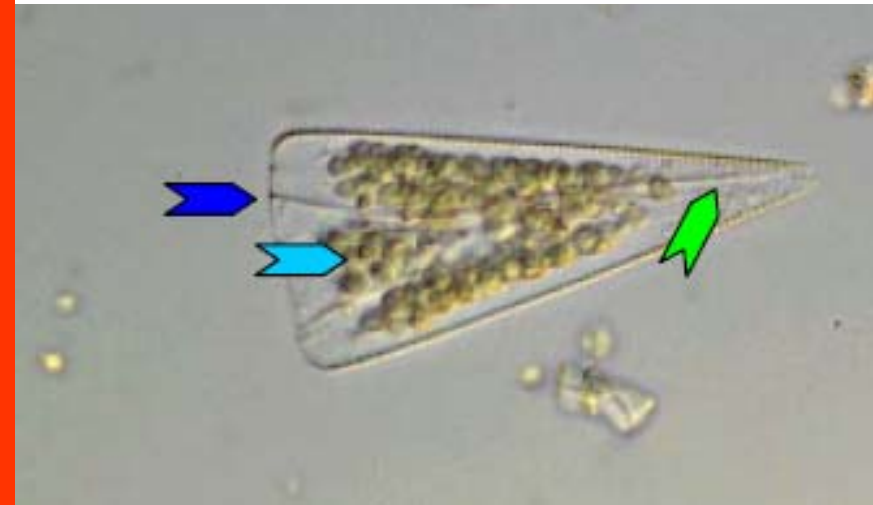


海线藻  
*Thalassionema*

## Family Diatomaceae



- ▶ Cells in girdle view are wedge-shaped with rounded corners.
- ▶ Strong clear striations.
- ▶ Chromatophores are granular.



### 1.2.2.3 Order Phaeodactyloales

#### Family Phaeodactylaceae

*Phaeodactylum tyicornutum*



# 1.2.2.4 Order Surirellales

## Family Nitzschiaceae

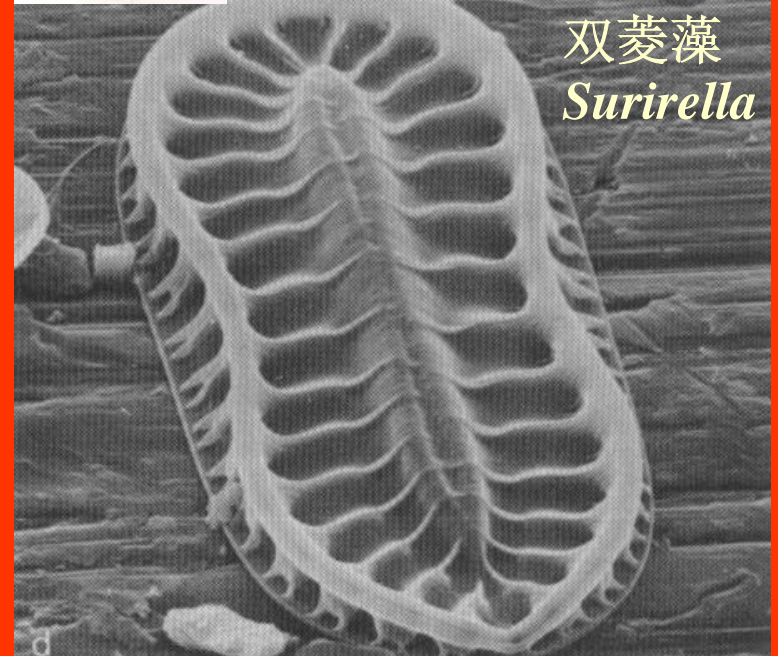
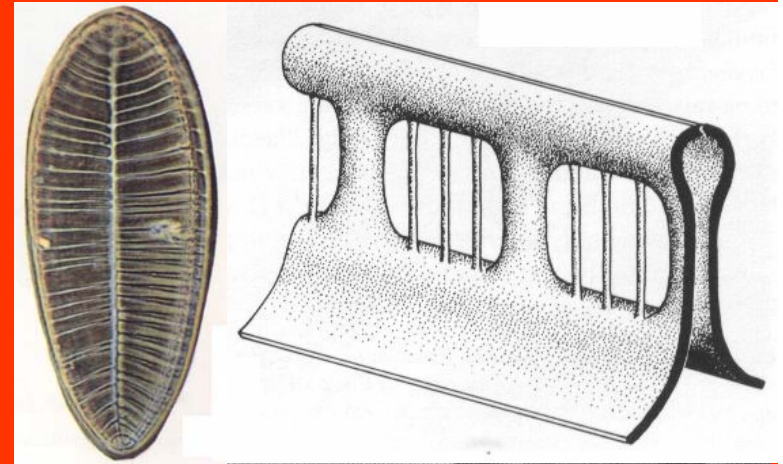
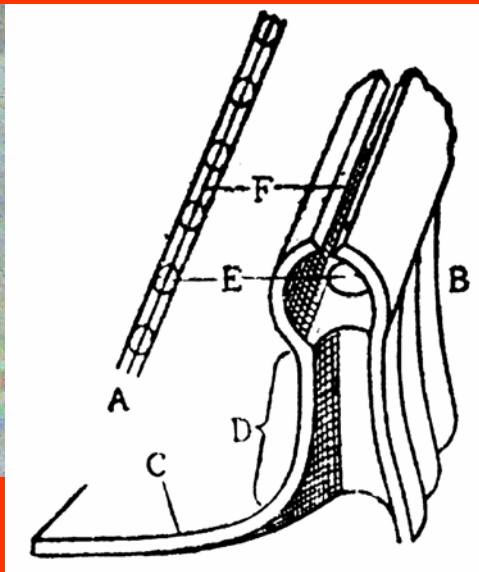
*Nitzschia*

## Family Surirellaceae

*Suirella*



菱形藻 *Nitzschia*



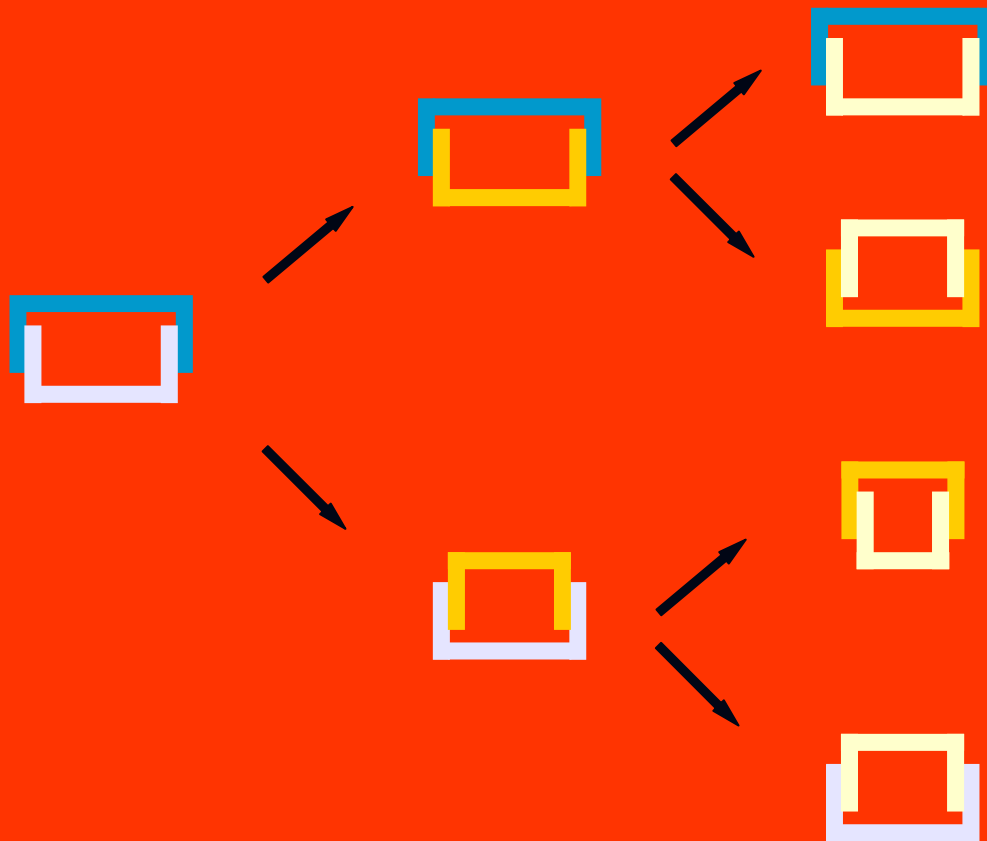
双菱藻  
*Suirella*

# Contents

- **1.1 Morphological Features**
- **1.2 Classification**
- **1.3 Reproduction**
  - 1.3.1 Vegetative reproduction
  - 1.3.2 Sexual reproduction (auxospore)
  - 1.3.3 Resting spore
- **1.4 Significance**

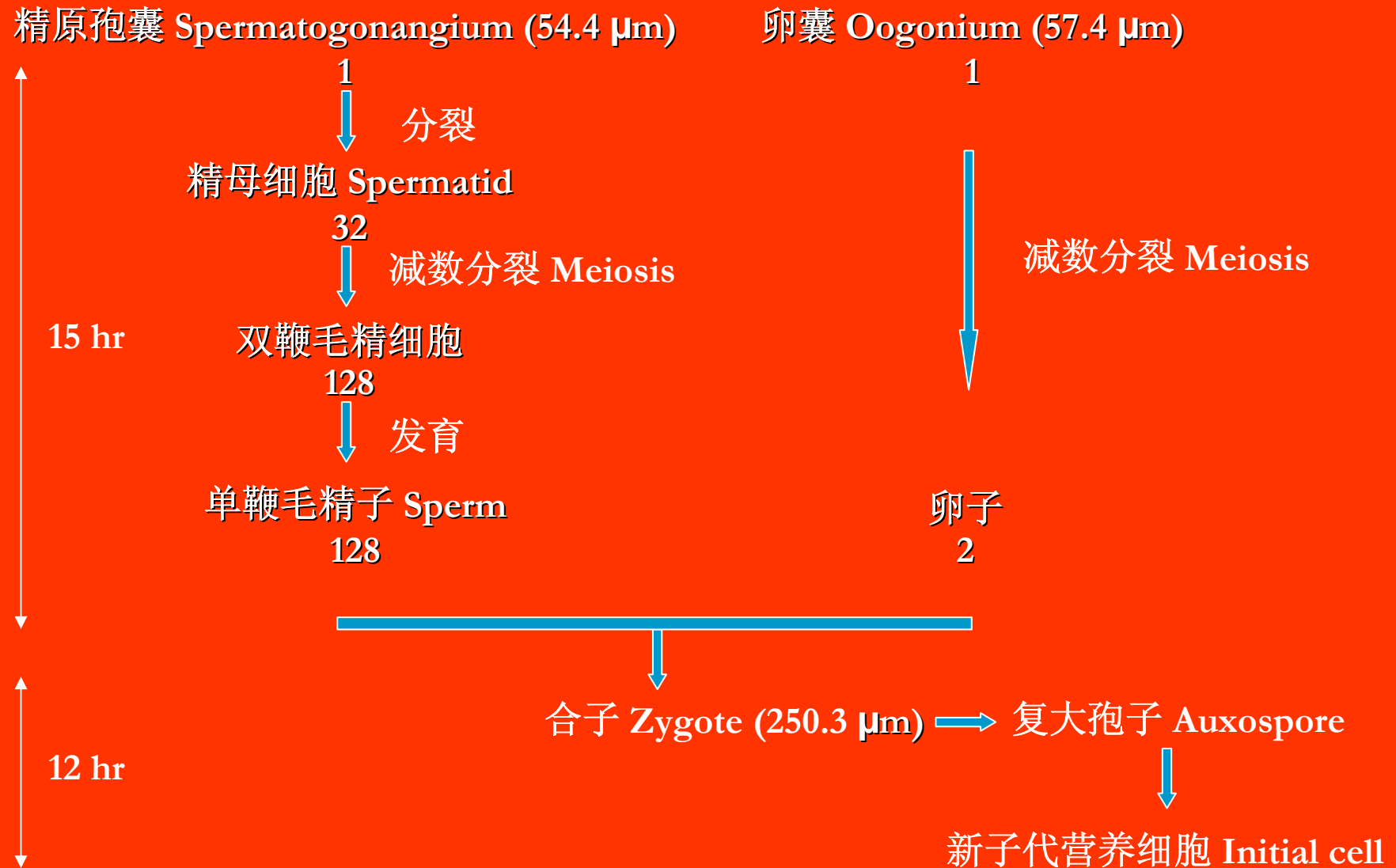
# 1.3 Reproduction

- 1.3.1 Vegetative reproduction (Cell division)

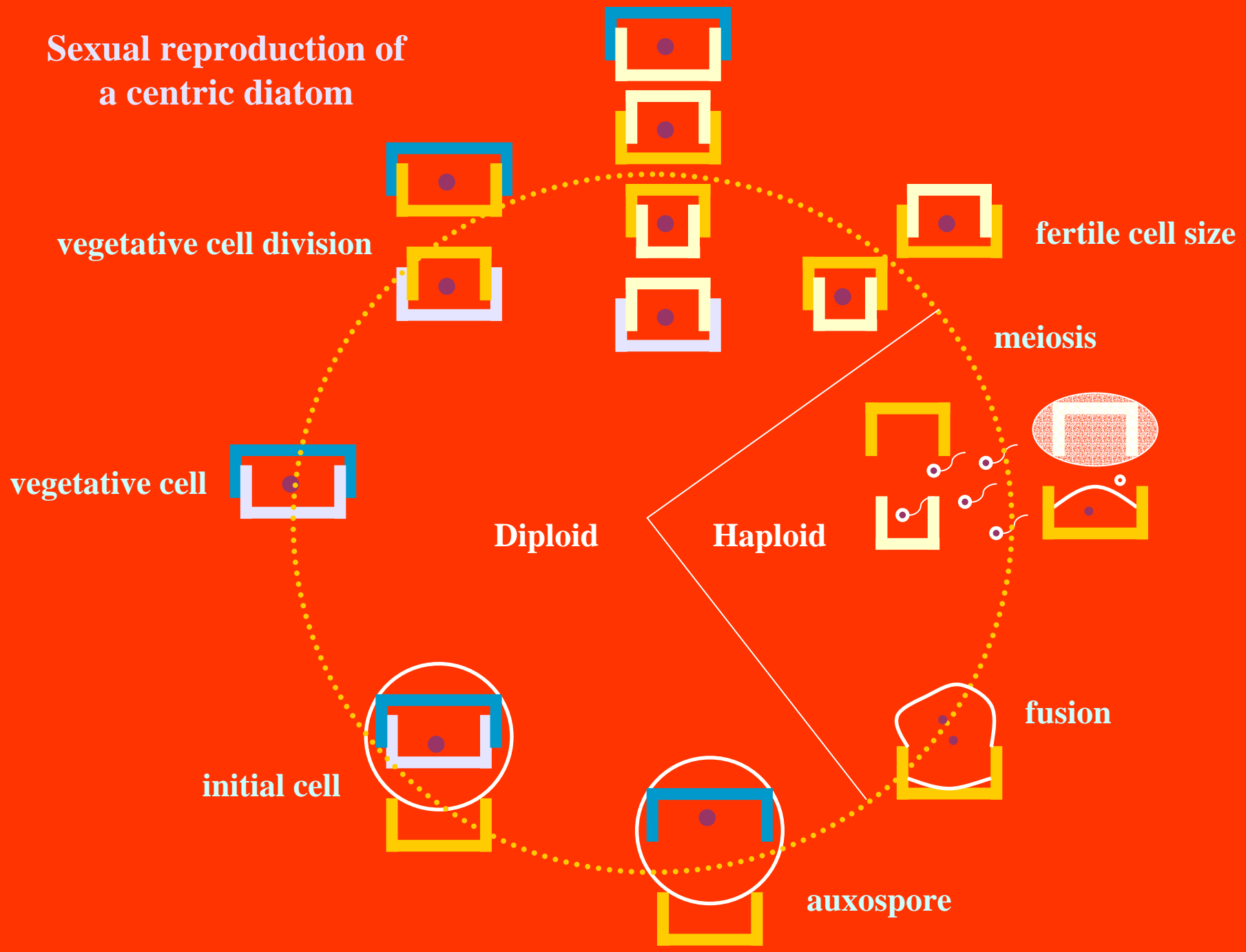




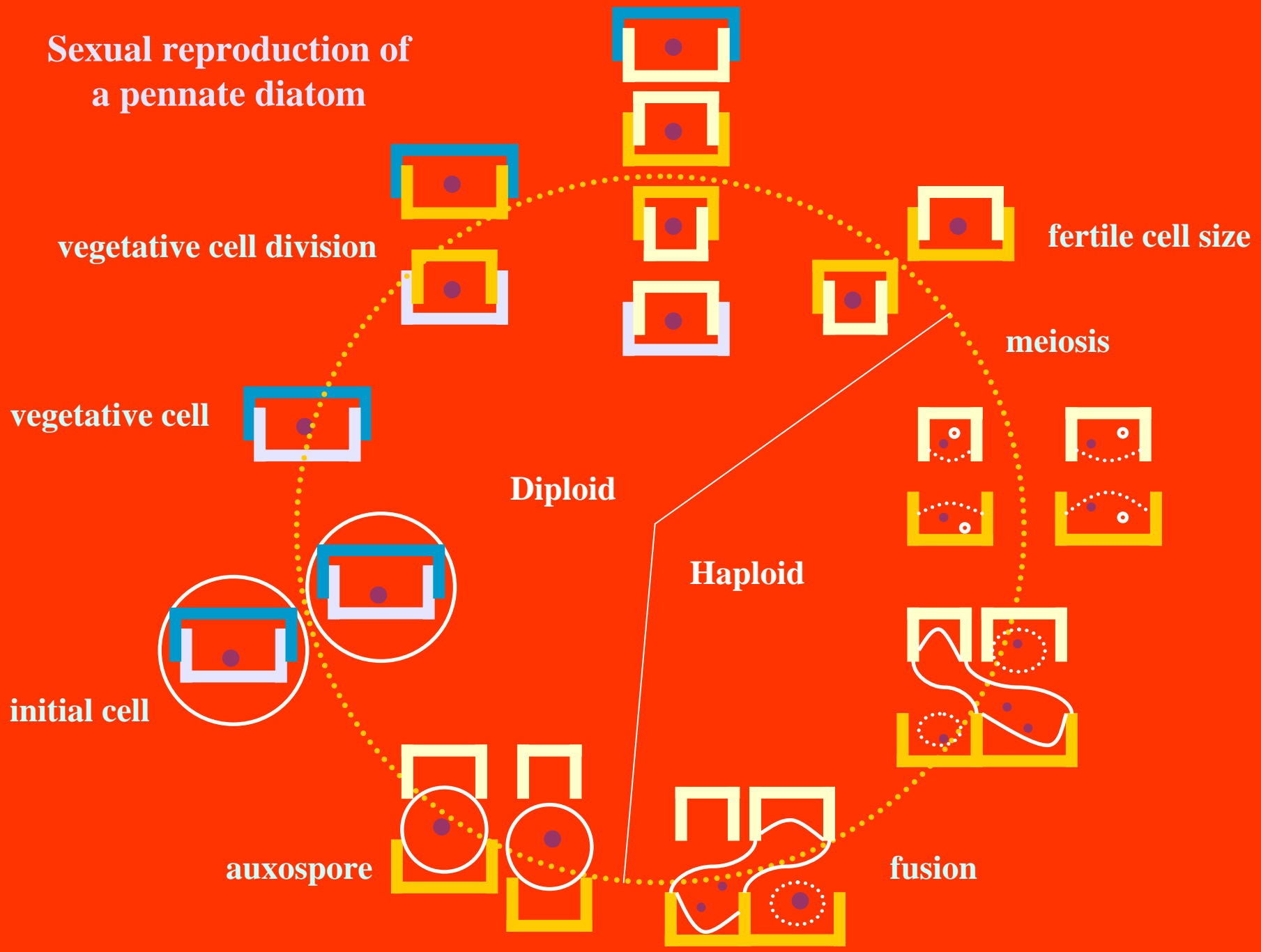
## ■ 1.3.2 Sexual reproduction (auxospore)



# Sexual reproduction of a centric diatom



# Sexual reproduction of a pennate diatom



### ■ 1.3.3 Resting spore

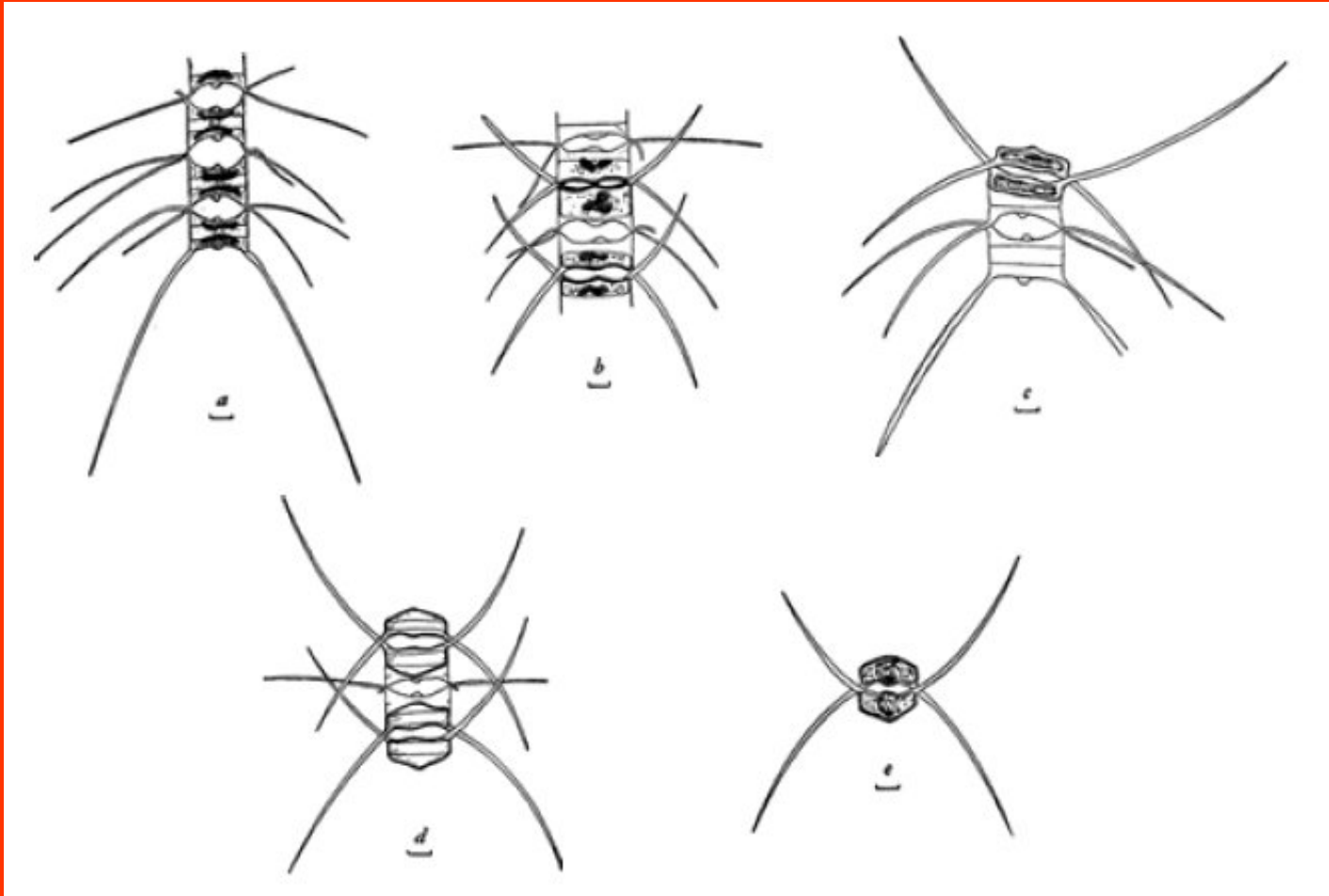


Fig. *Chaetoceros didymus* Ehr. a, typical chain, broad girdle view; width, 24 $\mu$ . b, section of chain showing beginning of formation of resting spores; width, 32 $\mu$ . c and d, resting spores almost completely formed, still within parent cells. e, typical resting spores free from parent cells.

# Contents

- **1.1 Morphological Features**
- **1.2 Classification**
- **1.3 Reproduction**
- **1.4 Significance**
  - 1.4.1 Usefulness**
  - 1.4.2 Harmfulness**

# 1.4 Significance

## 1.4.1 Usefulness

**A major food for fishes, molluscs and shrimps**

**B indicators of marine fisheries**

**C a major proportion of biogenic sediments**

**D forensic medicine**

## 1.4.2 Harmfulness

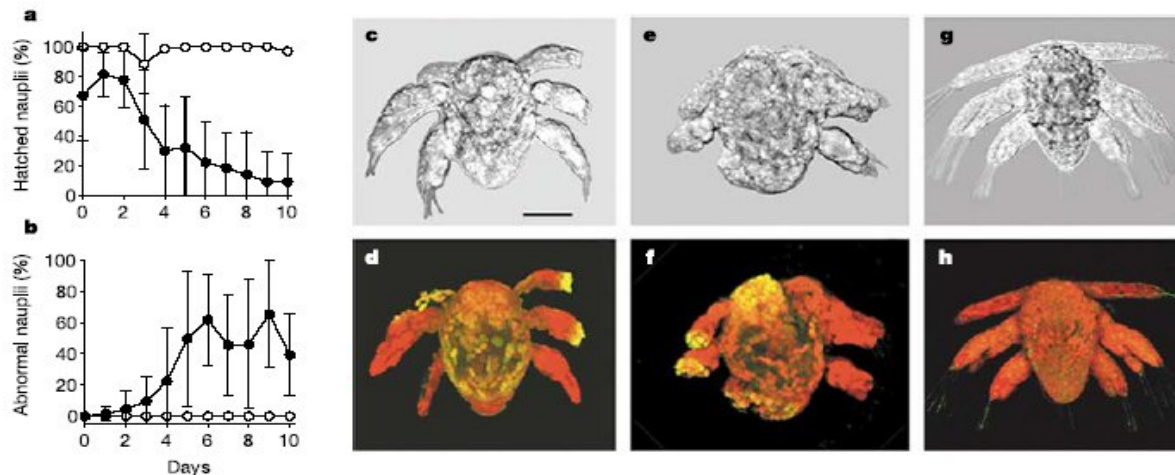
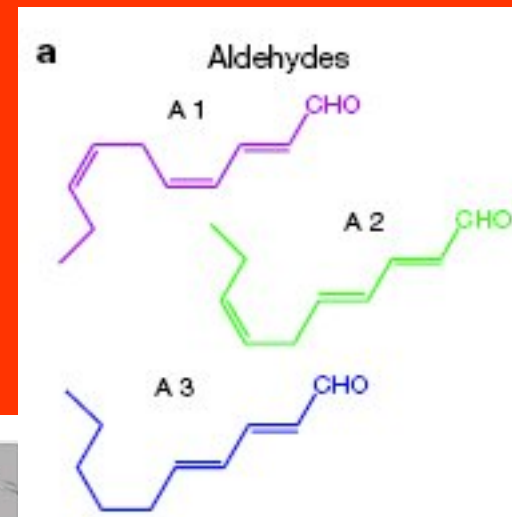
**A red tide**

**B absorption, uptake and accumulation of marine pollutants**

# Are diatoms good or toxic for copepod?

## ----the paradox of diatom-copepod interactions

- Nutritional deficient hypothesis
- Chemical defence hypothesis



**Figure 3** Effects of diet on *C. helgolandicus* offspring fitness. **a**, After ten days of feeding, the viability of eggs spawned by *C. helgolandicus* females fed the diatom *S. costatum* SKE (filled circles) dropped to <20% compared with >95% with the control dinoflagellate *P. minimum* PRO (open circles). **b**, After five days of feeding on SKE, 45–65% of the hatched nauplii were abnormal. **c, d**, Such nauplii had deformed limbs that were positive

for TUNEL staining (yellow, **d**) specific for apoptosis. **e, f**, After nine days of feeding on SKE, the degree of teratogenesis increased and nauplii were strongly deformed. **g, h**, Nauplii generated from females fed the control PRO diet appeared normal and stained negatively with TUNEL (**h**), indicating that nuclei were not apoptotic. Scale bar, 90  $\mu\text{m}$ .