Introduction to the

Biology of Marine Life

Ninth Edition

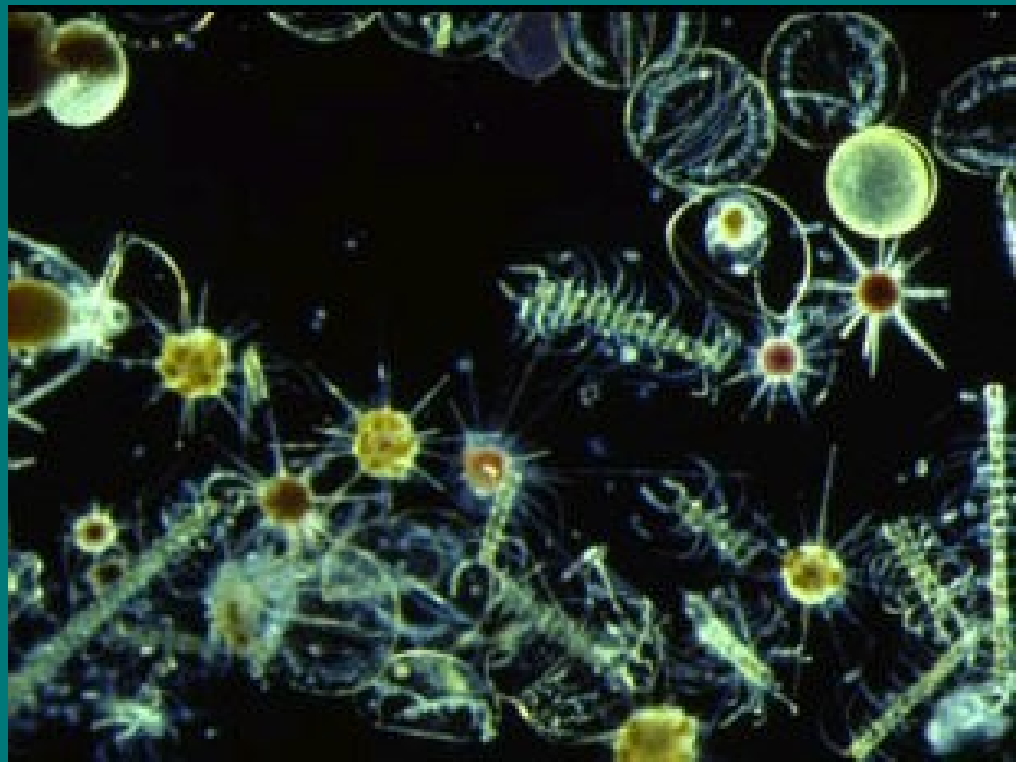
James L. Sumich | John F. Morrissey

Chapter 3

Phytoplankton

Phyto = Plant

How do you think they get their energy?



Plankton can be classified by size!!!

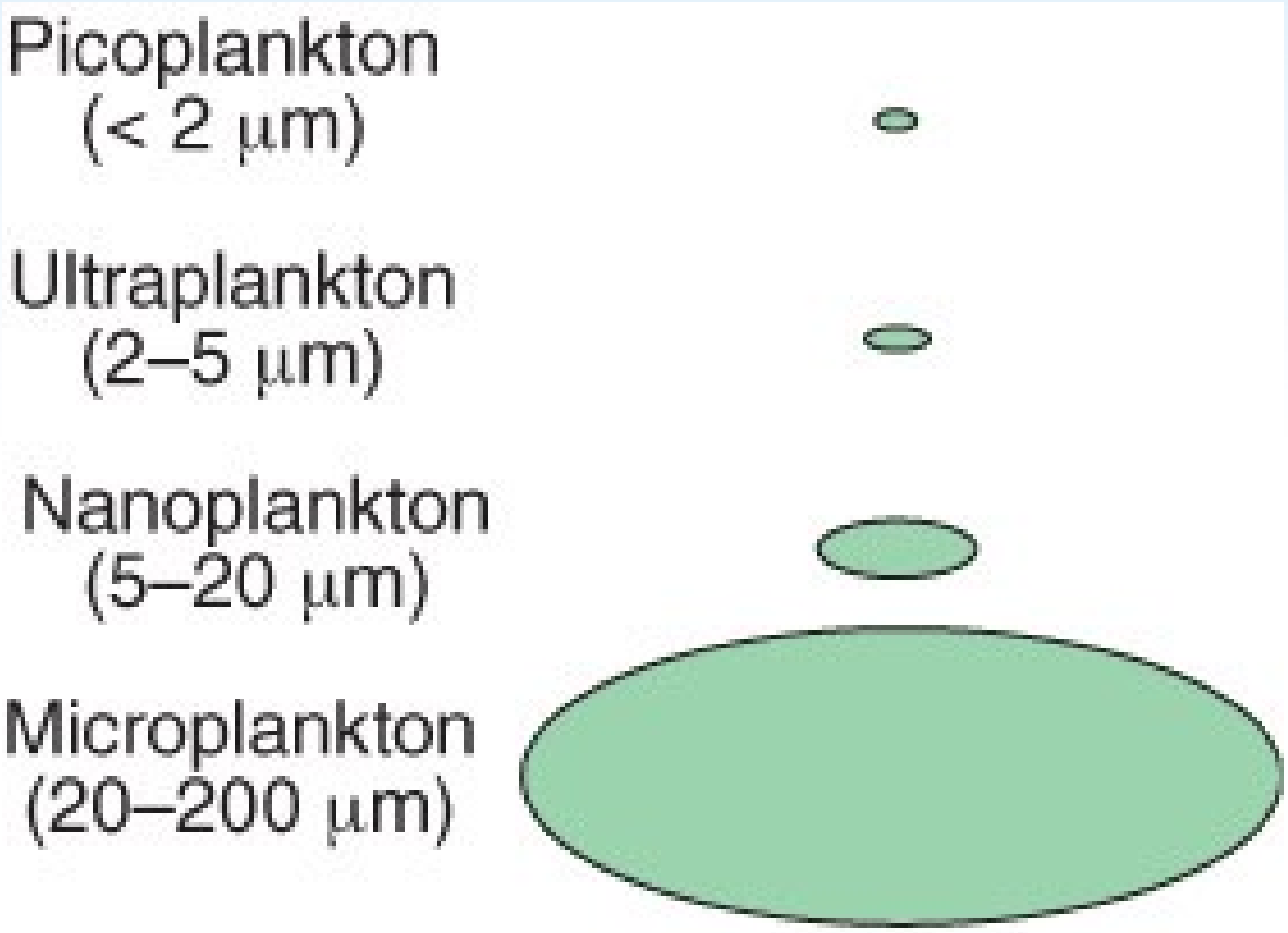


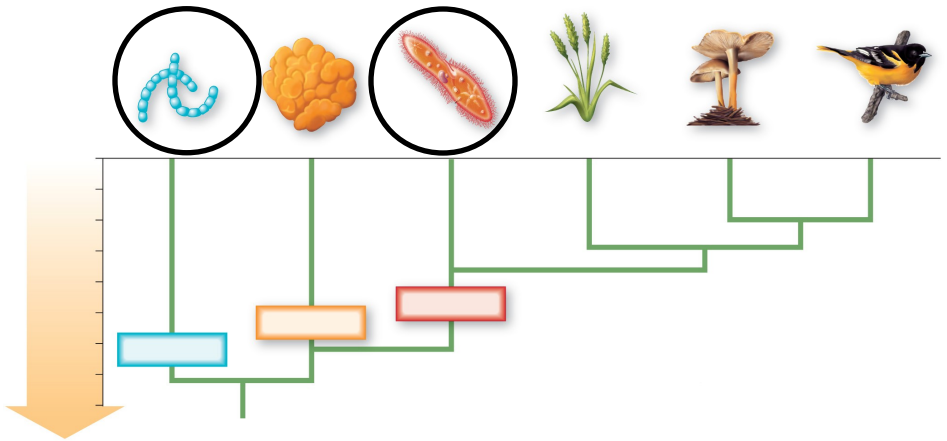
Fig. 3.2 Relative sizes of phytoplankton groups.

Phytoplankton Groups

Most common phytoplankton are from two kingdoms:

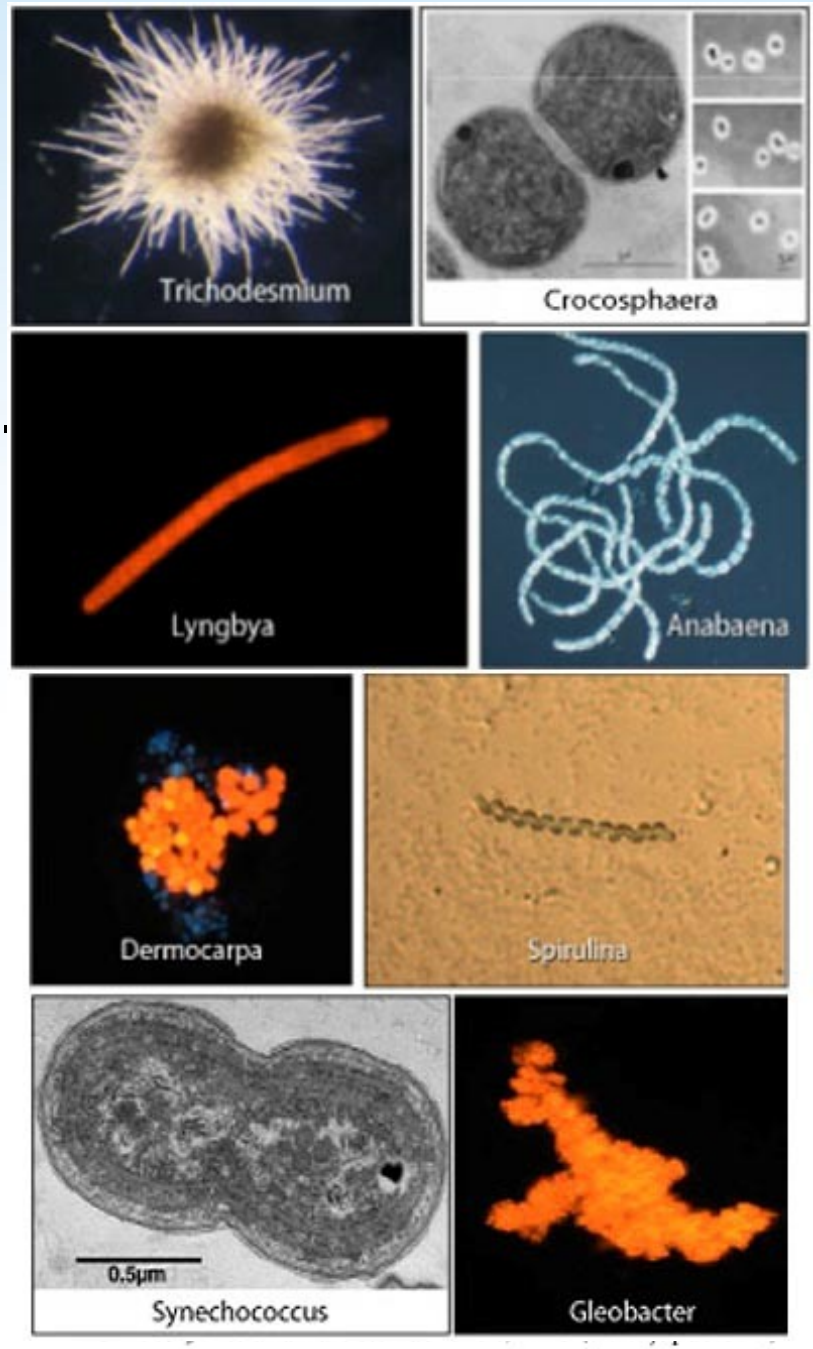
- **Bacteria**
  - **Phylum Cyanobacteria**
- Protista
  - Phylum Crysophyta
  - Phylum Dinophyta

Also found in Kingdom Archaea, but not as prominent



Cyanobacteria

- Around for three billion years.
- Are everywhere
- Some can fix nitrogen, others are symbionts, most are photosynthetic



Phytoplankton Groups - Cyanobacteria

Fig. 3.3 A transmission electron micrograph of a marine cyanobacterium, *Synechoccus*.

Phytoplankton Groups - Cyanobacteria

Fig. 3.4 Stromatolites, resembling mushrooms 1 m high, grow on a shallow sandy bottom of Shark Bay, Australia.

Phytoplankton Groups - Cyanobacteria

Fig. 3.5 Micrograph of the colonial cyanobacterium *Anabaena*, which contain spores (akinetes) and nitrogen-fixing **heterocysts** along its chain of vegetative cells.

Phytoplankton Groups - Chrysophyta

Chrysophyta

- coccolithophores, silicoflagellates and diatoms.
- How do they get their nutrition again???

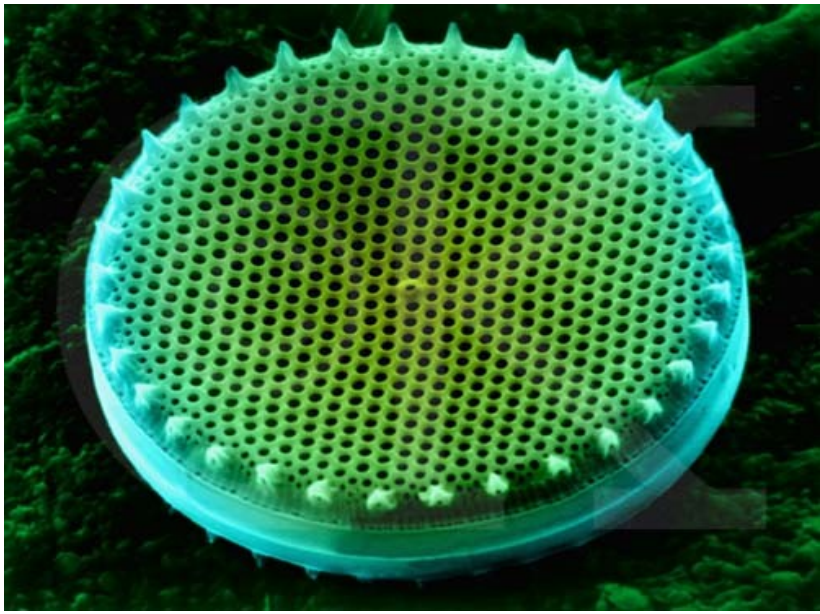
Kingdom Bacteria

Phylum Cyanobacteria

Kingdom Protista

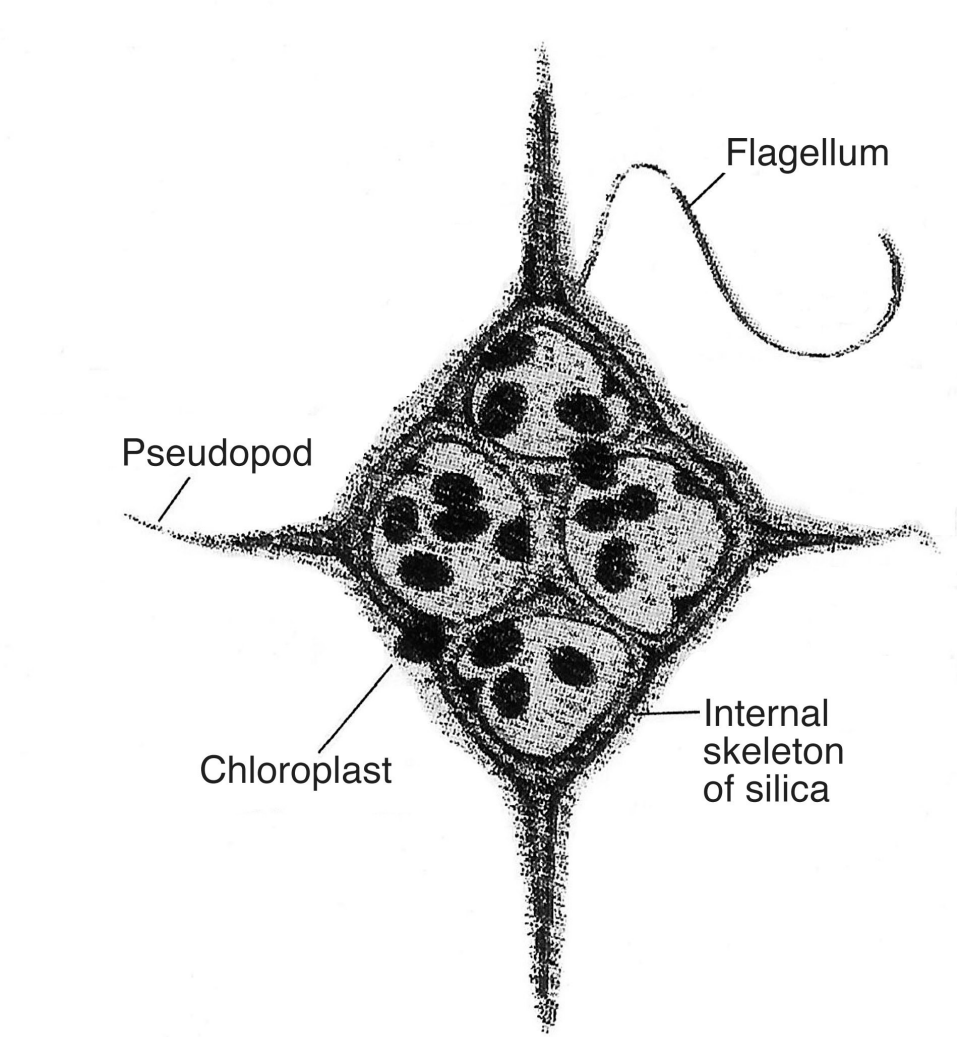
Phylum Crysophyta

Phylum Dinophyta

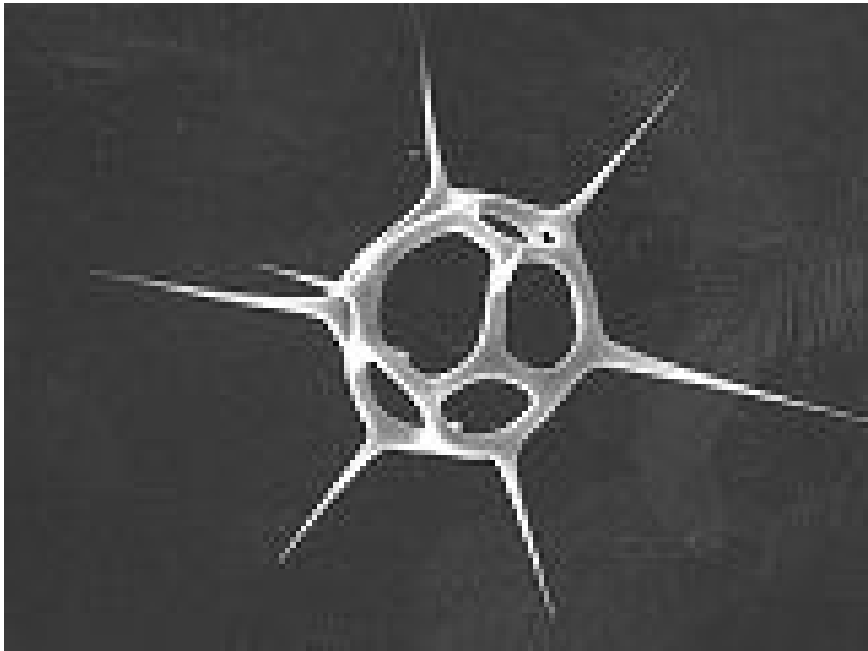



http://www.bbc.co.uk/nature/life/Coccolithophore#p00bxk9c
Calcium carbonate coccoliths!
Sunscreen???
2 microns

Phytoplankton Groups - Chrysophyta



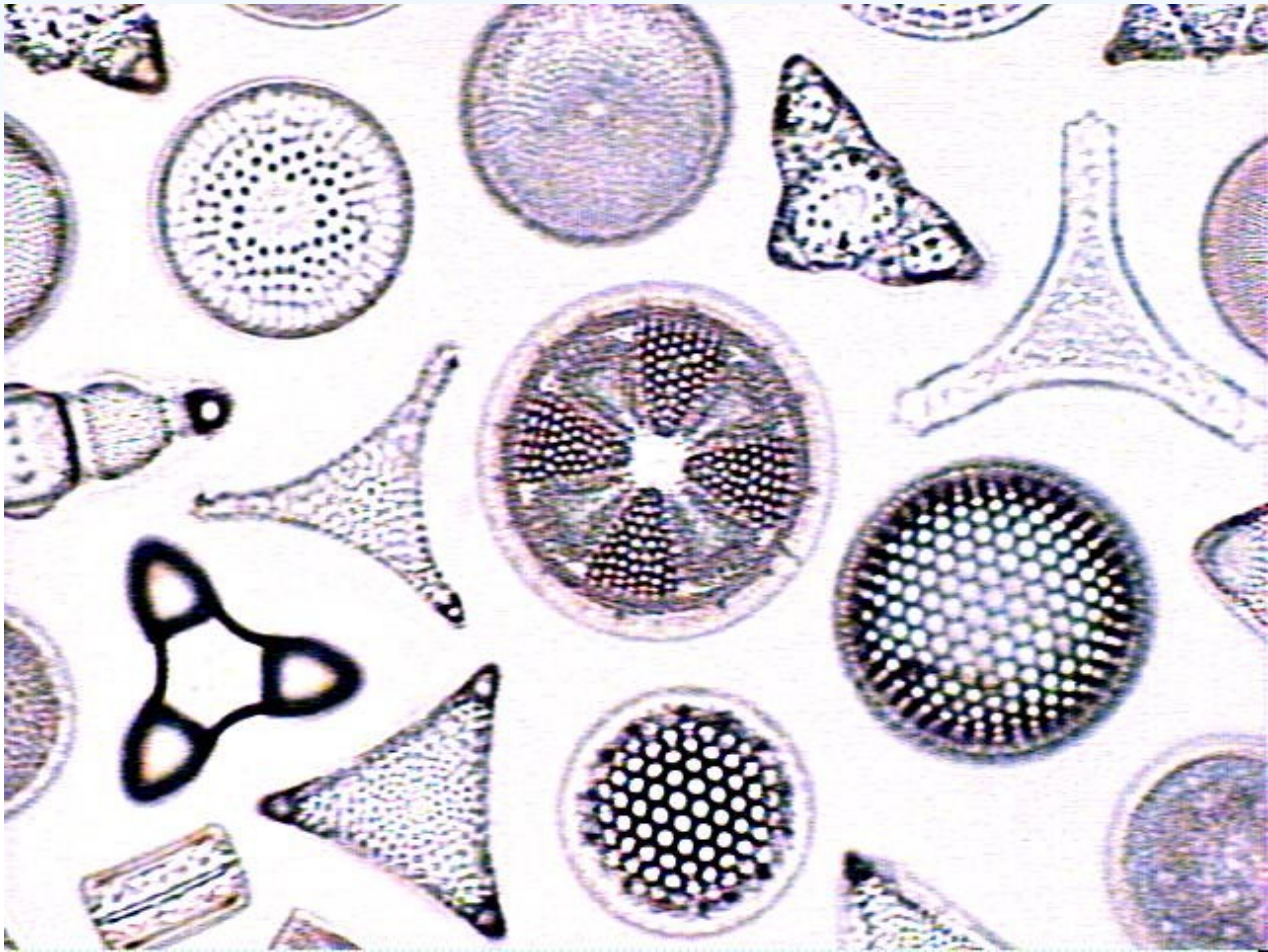
Silicoflagellates



Phytoplankton Groups - Chrysophyta

Diatoms

- MAJOR PHOTOSYNTHESIZERS!!!
- VERY ABUNDANT!!!
- Silica shell



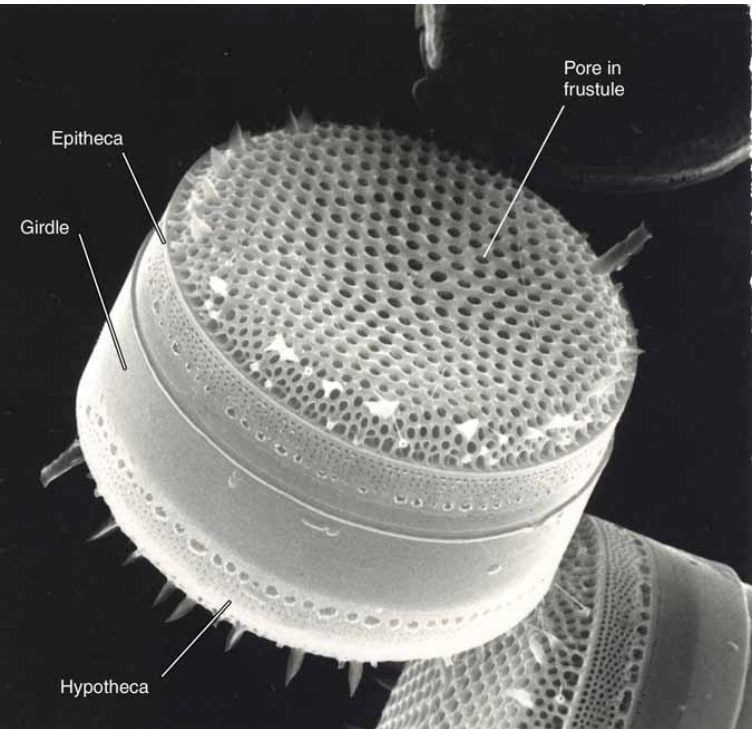
Phytoplankton Groups - Chrysophyta

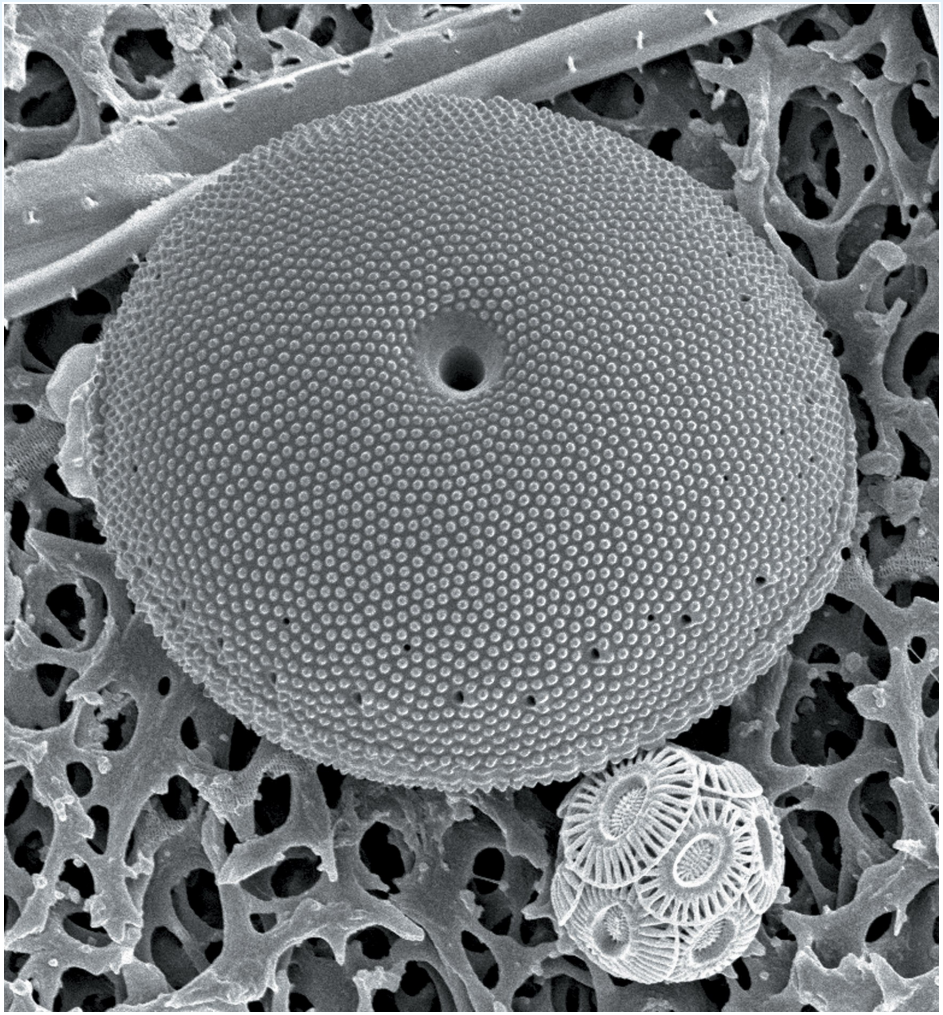
Terms to know:

Frustule

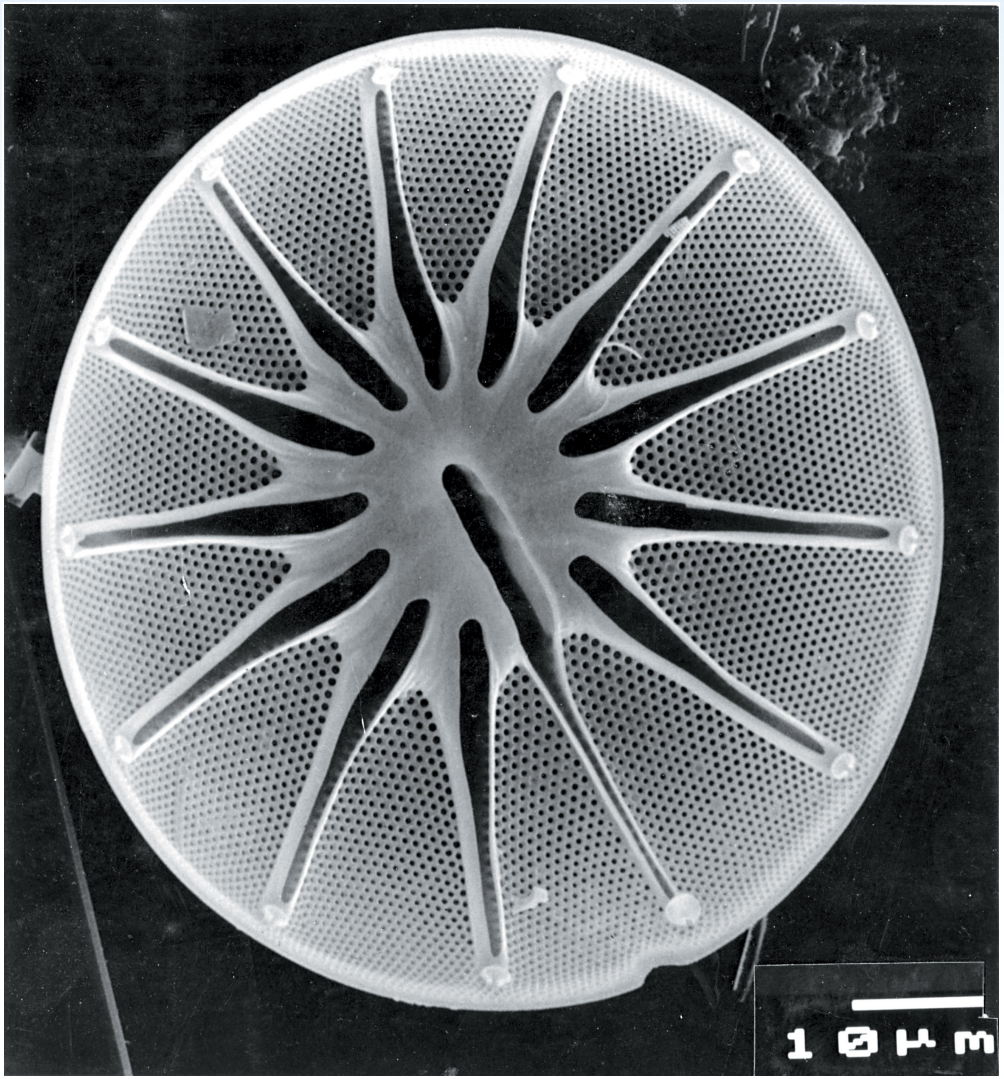
Epitheca

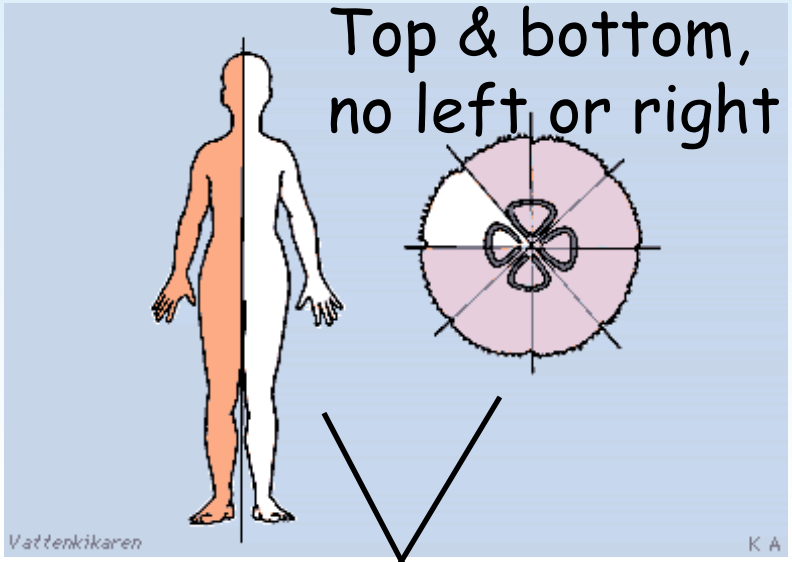
Hypotheca



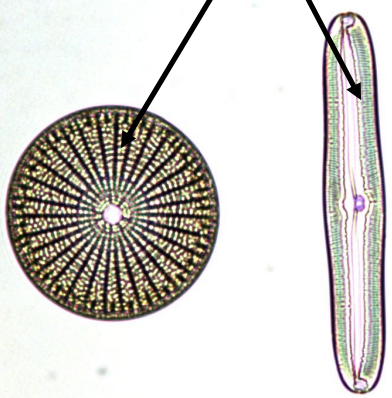


Phytoplankton Groups - Chrysophyta





Centric Pennate



Cool fact – pennate diatoms can move!!!

Phytoplankton Groups

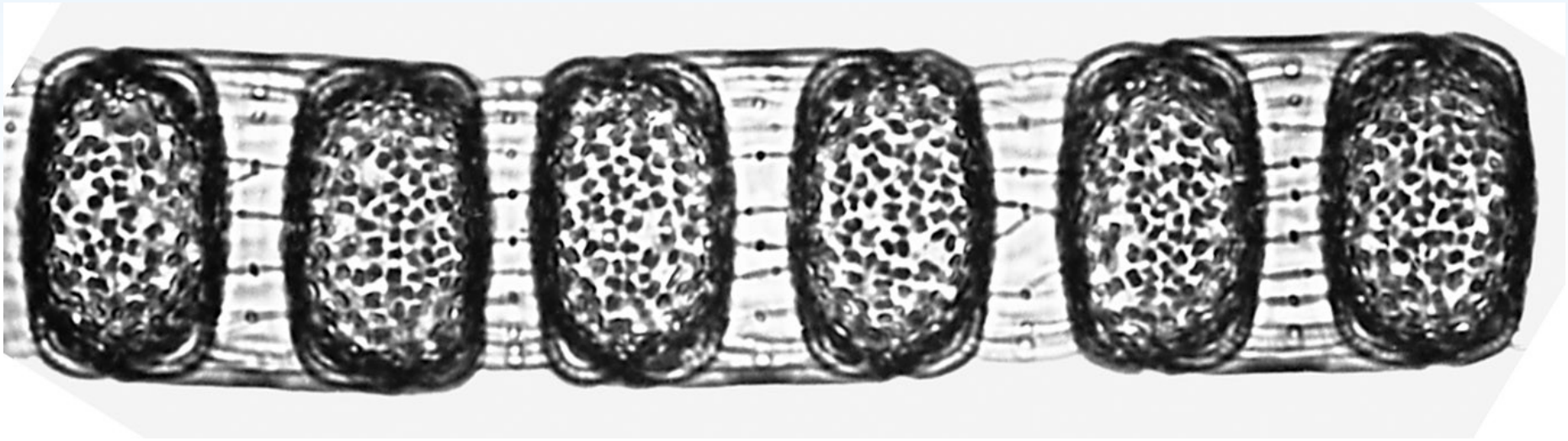
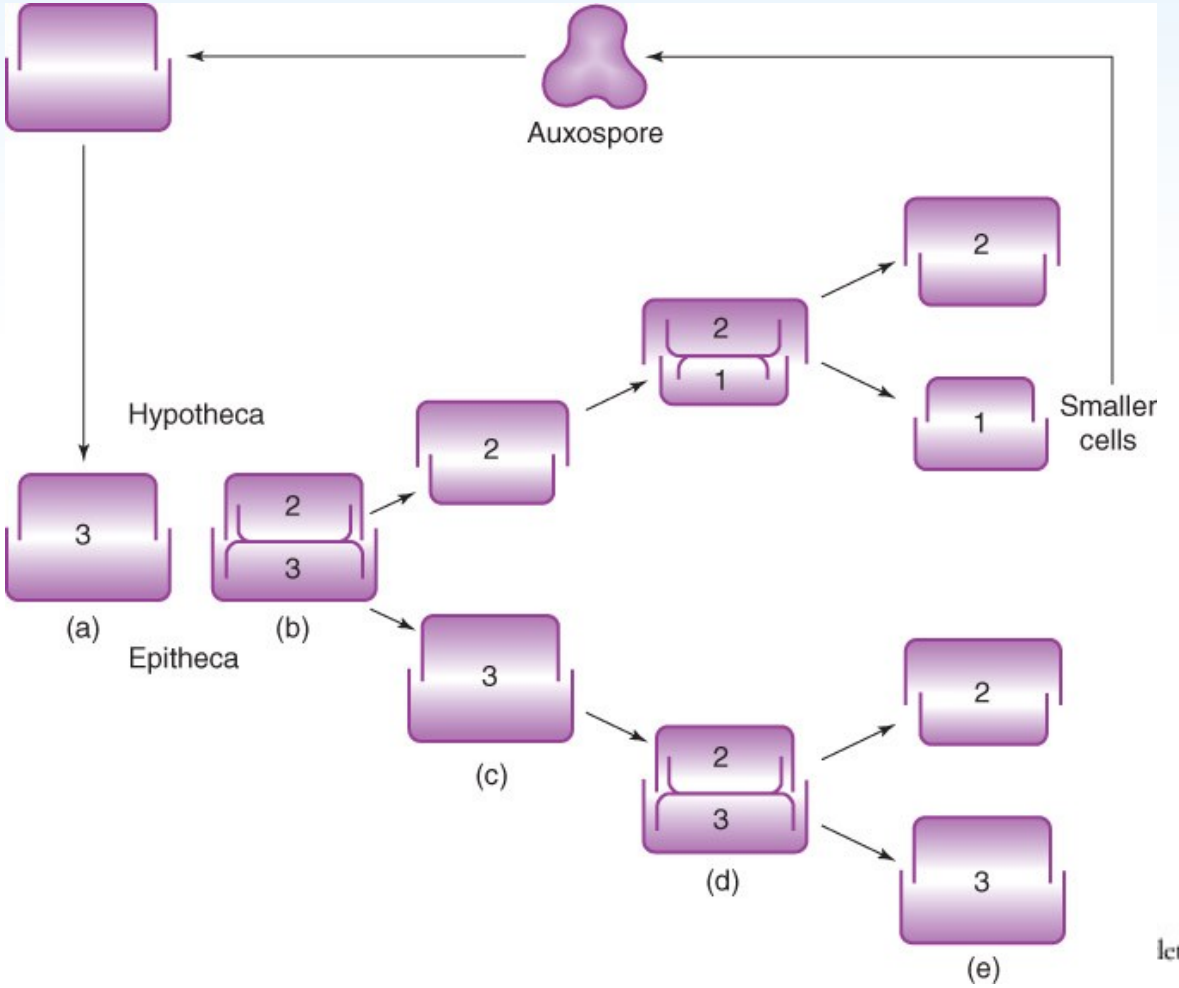


Fig. 3.11 Cells in a chain of *Stephanopyxis* just after synchronized division was completed. The darker half of each cell is the newly formed hypotheca, still connected by a girdle of silicate.

Courtesy of Kohki Itoh

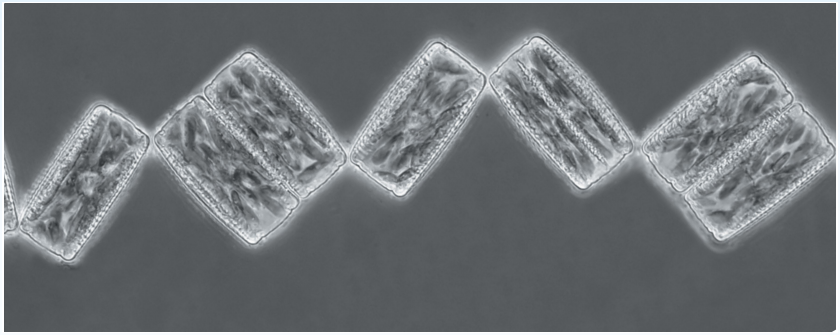
Phytoplankton Groups – Chrysophyta reproduction

- Asexual cell division
  - Not so easy for diatoms!!!

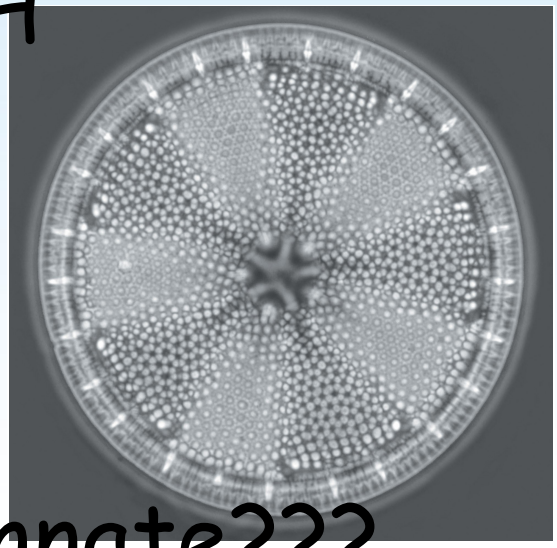


Phytoplankton Groups - Chrysophyta

OOOHHHHHH…AAAAAAHHHH

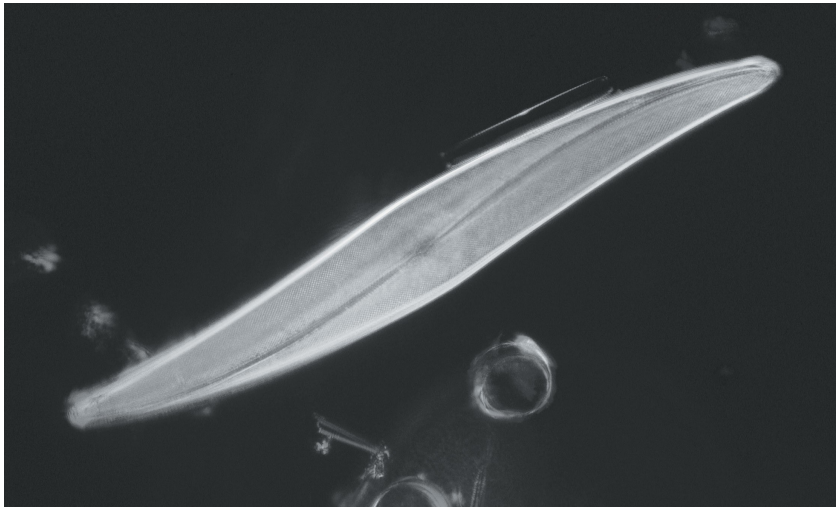


a

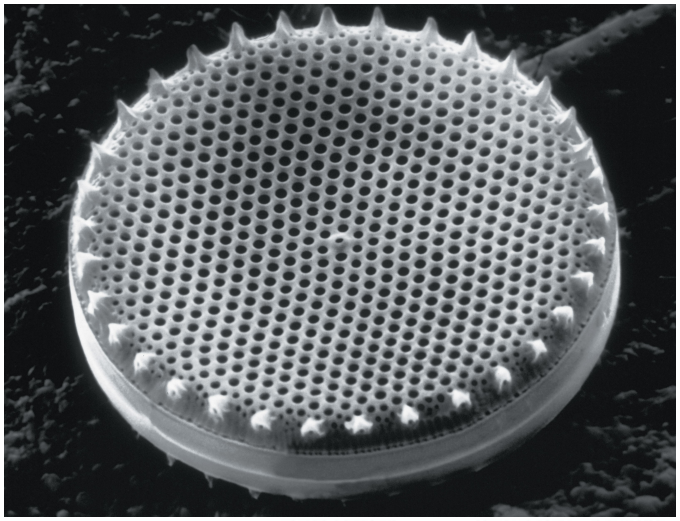


c

Which ones are centric? Pennate???



b



d

Did you hear about the slightly strange centric diatom that turned into a pennate diatom?

He was ex-centric.

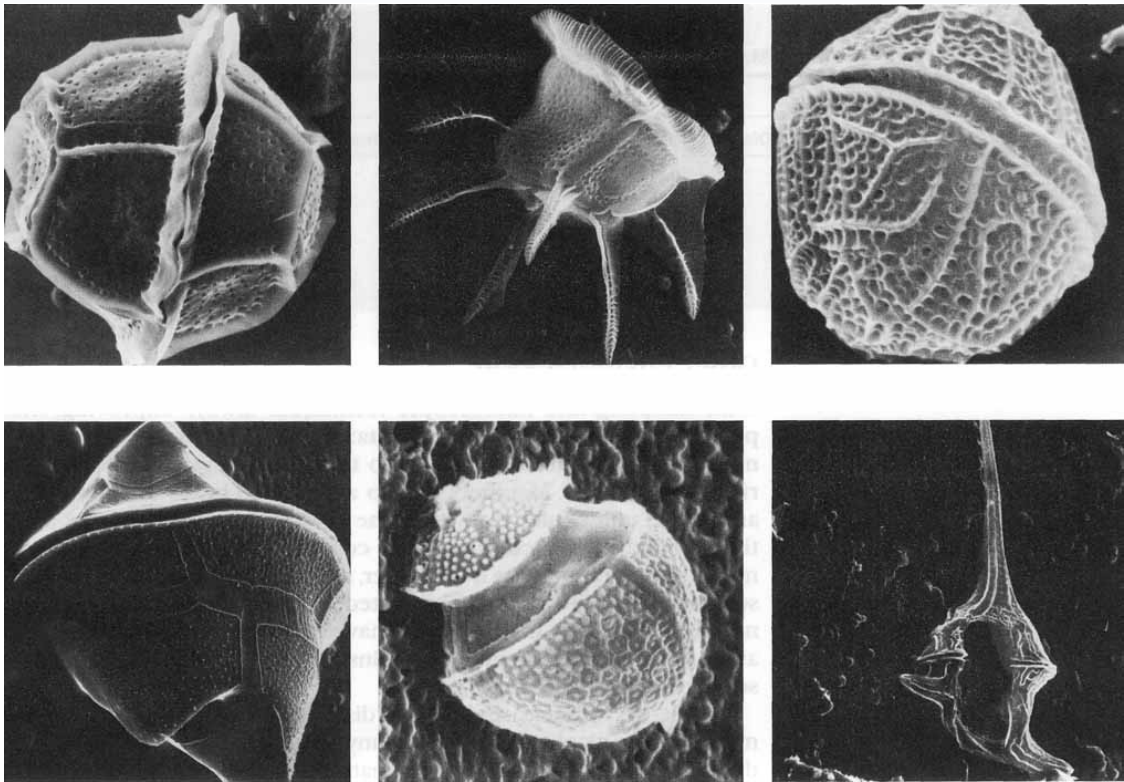
Phytoplankton Groups - Dinophyta

How do most of them get their energy???

They're pretty good at it too!!!

Kingdom Bacteria
- Division/Phylum
- Cyanobacteria

Kingdom Protista
- Division/Phylum
- Crysophyta
- **Division/Phylum**
- **Dinophyta**



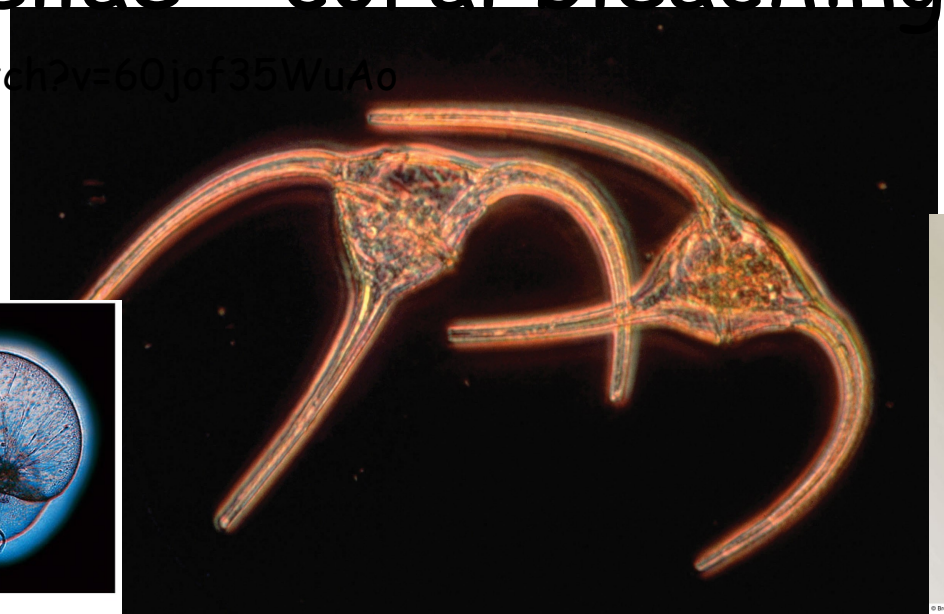
http://www.youtube.com/watch?v=T2xh9-UPSIU&feature=related

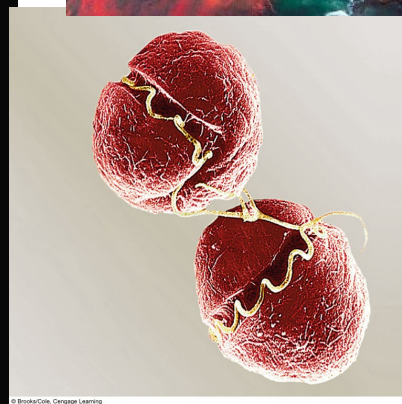
Phytoplankton Groups - Dinophyta

- Common name – dinoflagellates (two flagella)
- Bioluminescence
- Red tides – algal blooms
- Zooxanthellae – coral bleaching

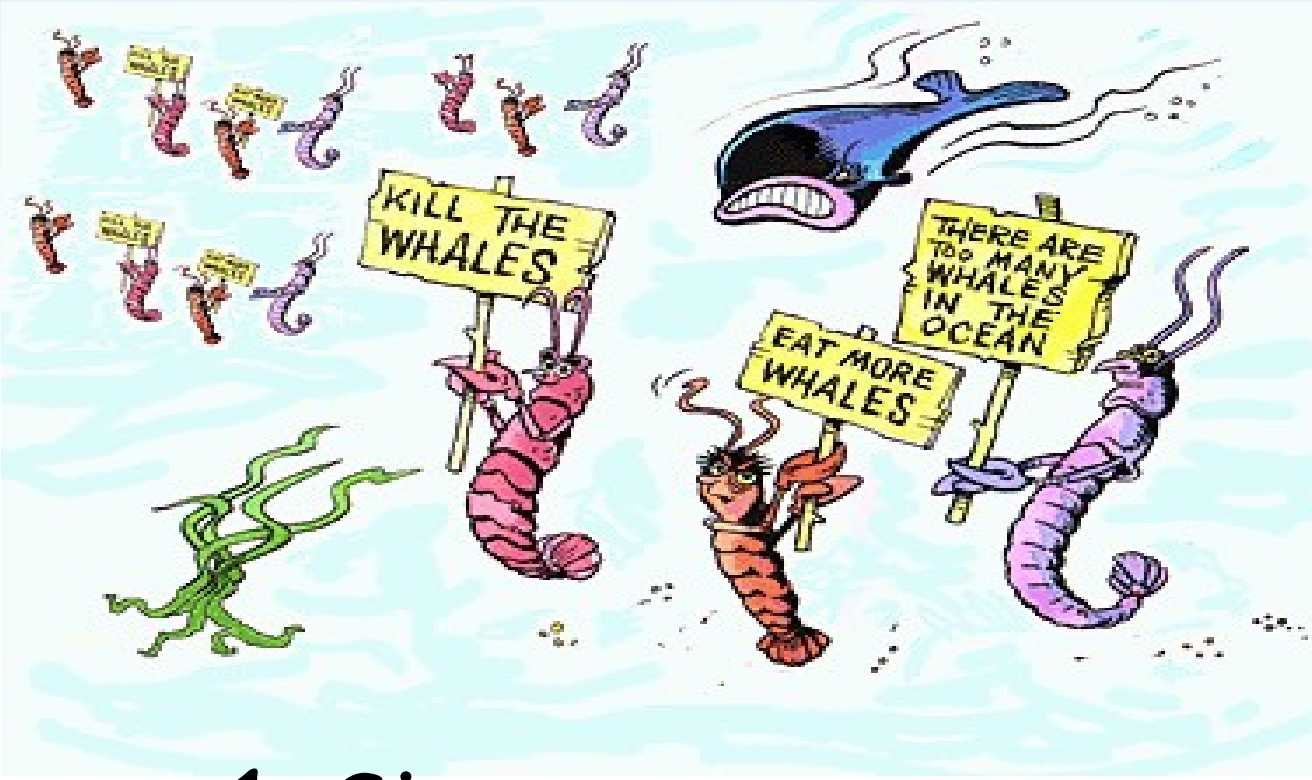
http://www.youtube.com/watch?v=YBk3jA5t8fQ

http://www.youtube.com/watch?v=60jof35WuAo





Adaptations for a planktonic existence



Problem: Sun up top, nutrients below! Don't really move. How do they deal???

1. Size
2. Sinking
3. Unfavorable conditions

Special Adaptations for a Planktonic Existence

1. Size – high surface area to volume ratio = more diffusion = more nutrients

Table 3.2

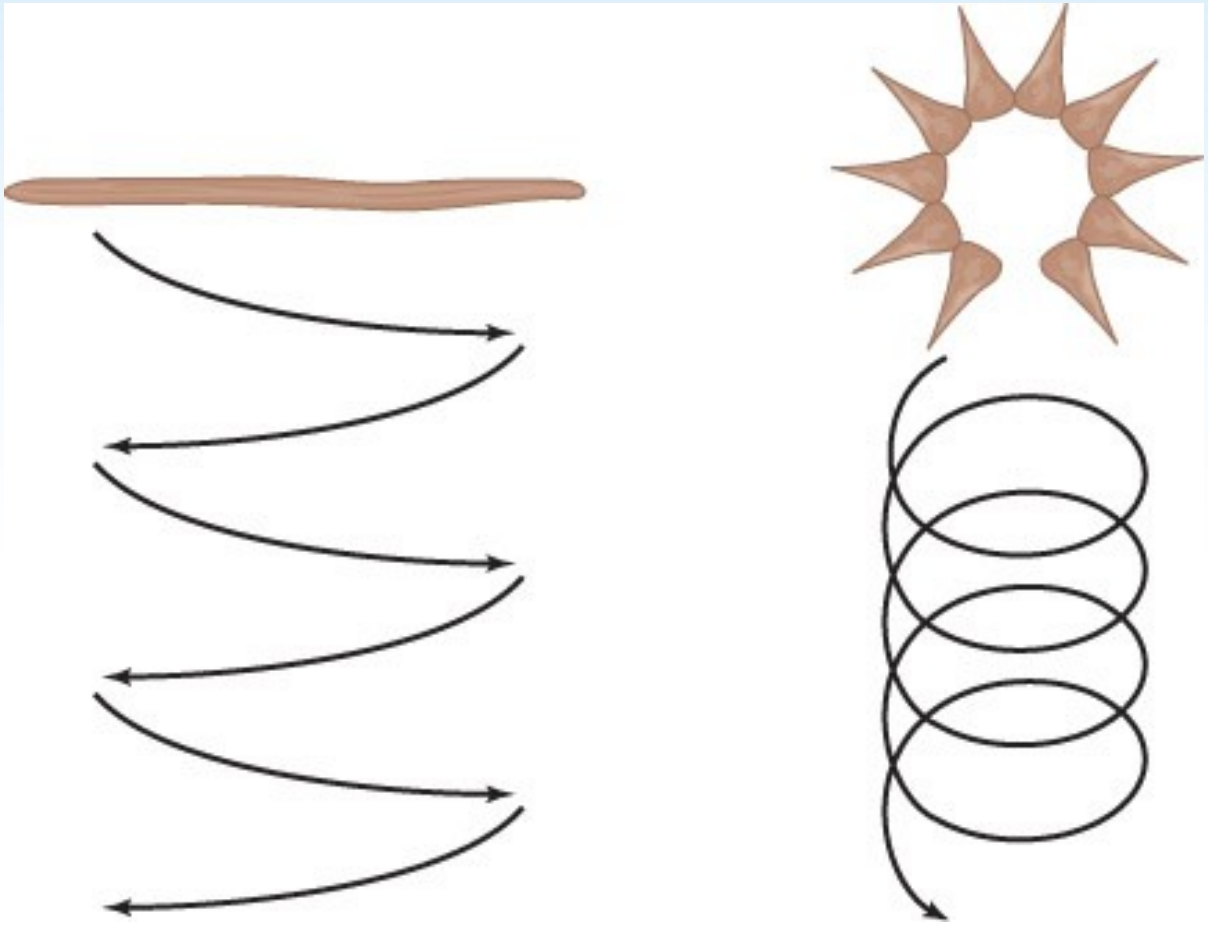
Size Ranges of the Major Groups of Marine Phytoplankton

		Chrysophyta				
	Cyanobacteria	Diatoms	Silicoflagellates	Coccolithophores	Dinophyta	Chlorophyta
Picoplankton	+	+	+	+		+
Ultraplankton	+	+	+	+		+
Nanoplankton		+	+	+	+	+
Microplankton		+			++	

Adapted from Platt and Li, 1986.

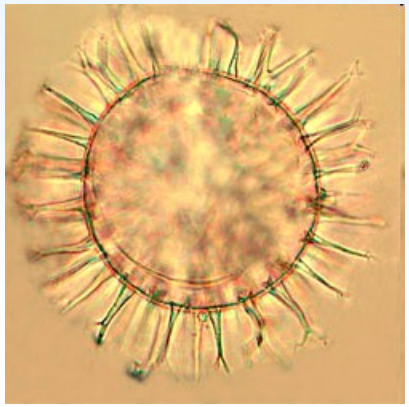
Special Adaptations for a Planktonic Existence

2. Sinking – they don't want to sink too fast. Why?



Shape, gas-filled vesicles, thinner frustules in planktonic diatoms, etc.

Special Adaptations for a Planktonic Existence



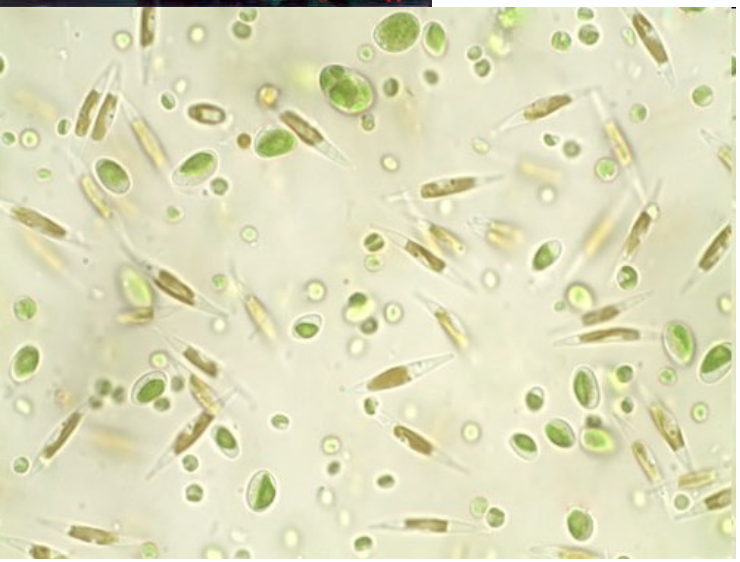
Adjustments to Unfavorable Environmental Conditions

Movement, other energy sources, make more chloroplasts, produce cysts

Fig. 3.19 Inactive resistant stages of two species of *Chaetoceros.*

Primary Production in the Sea

5 – 10% of total primary production (photosynthesis) in ocean

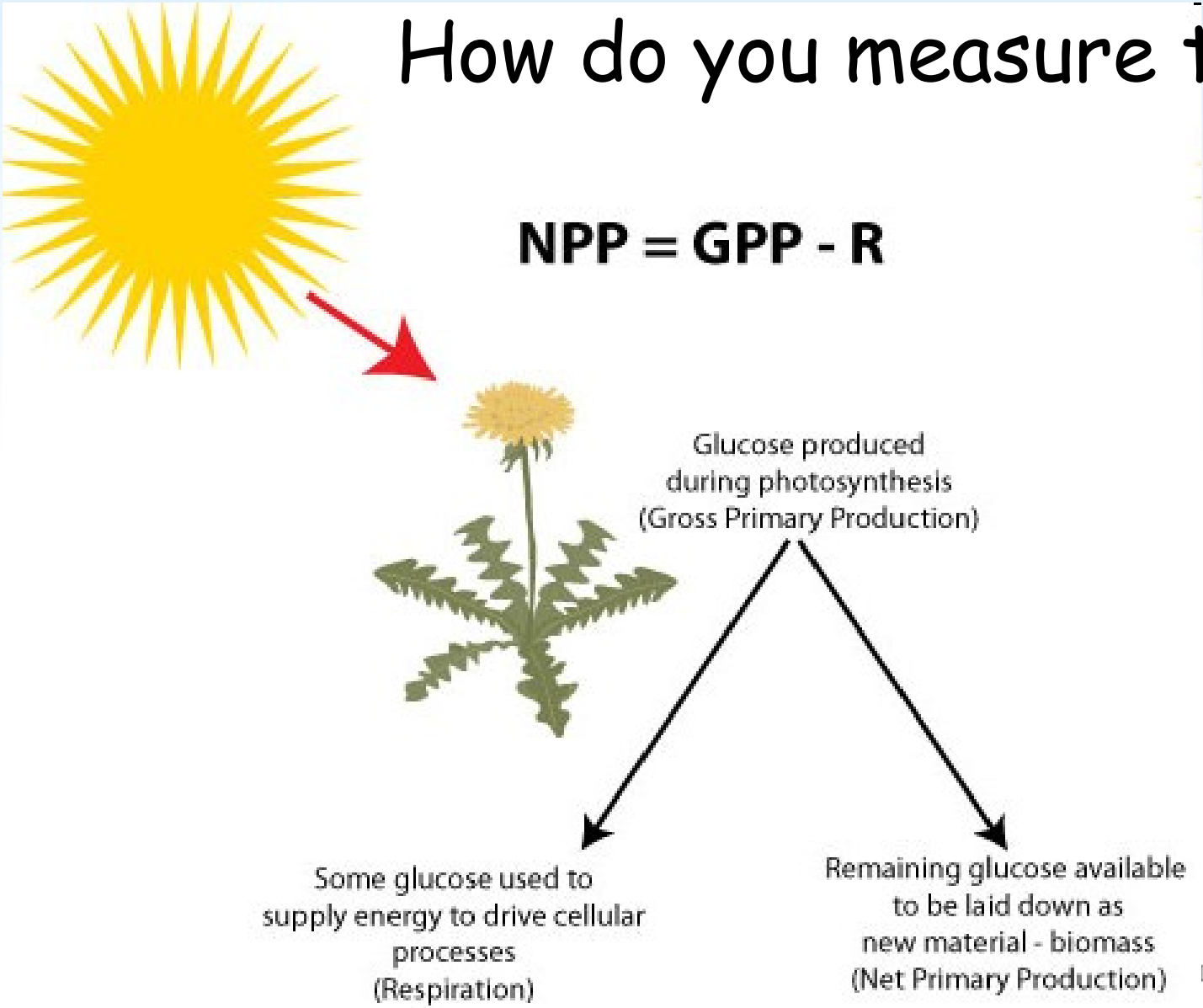


the rest of primary production

How do you measure this?

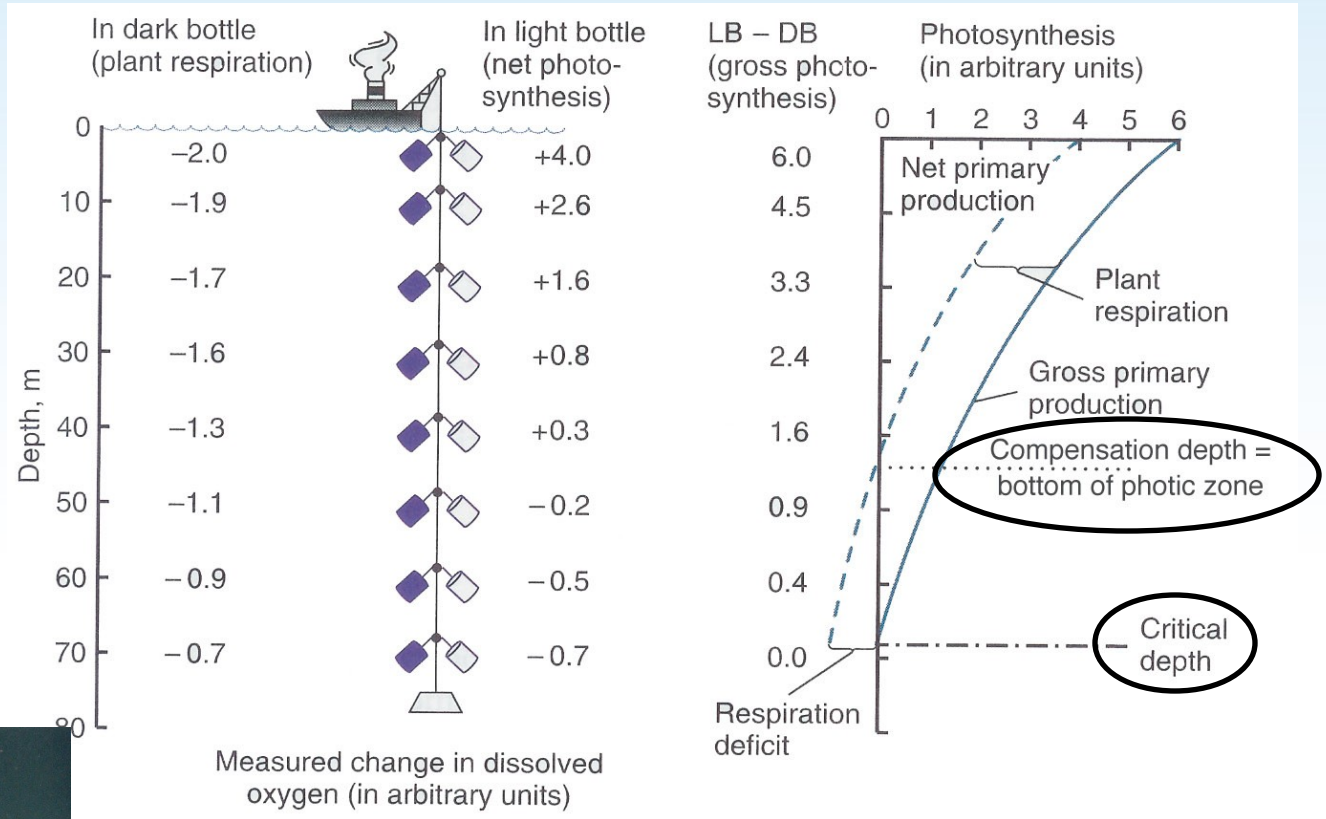
Net primary production & gross primary production

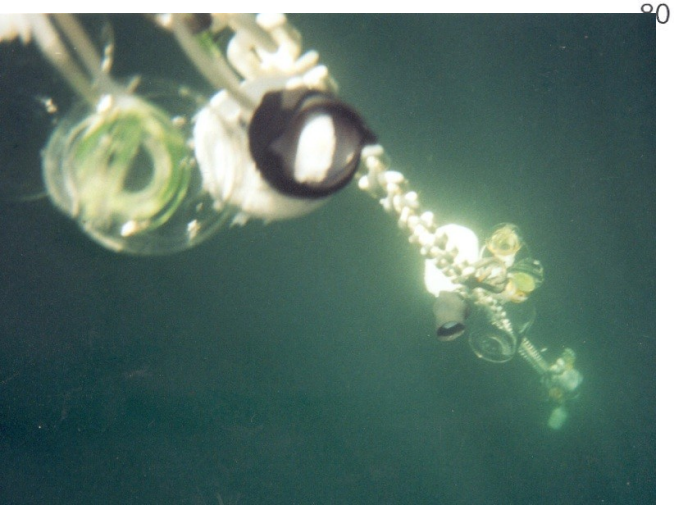
How do you measure this?



Primary Production in the Sea

Measurement of Primary Production





Light bottle/dark bottle (LBDB) technique

Primary Production in the Sea

Measurement of Primary Production

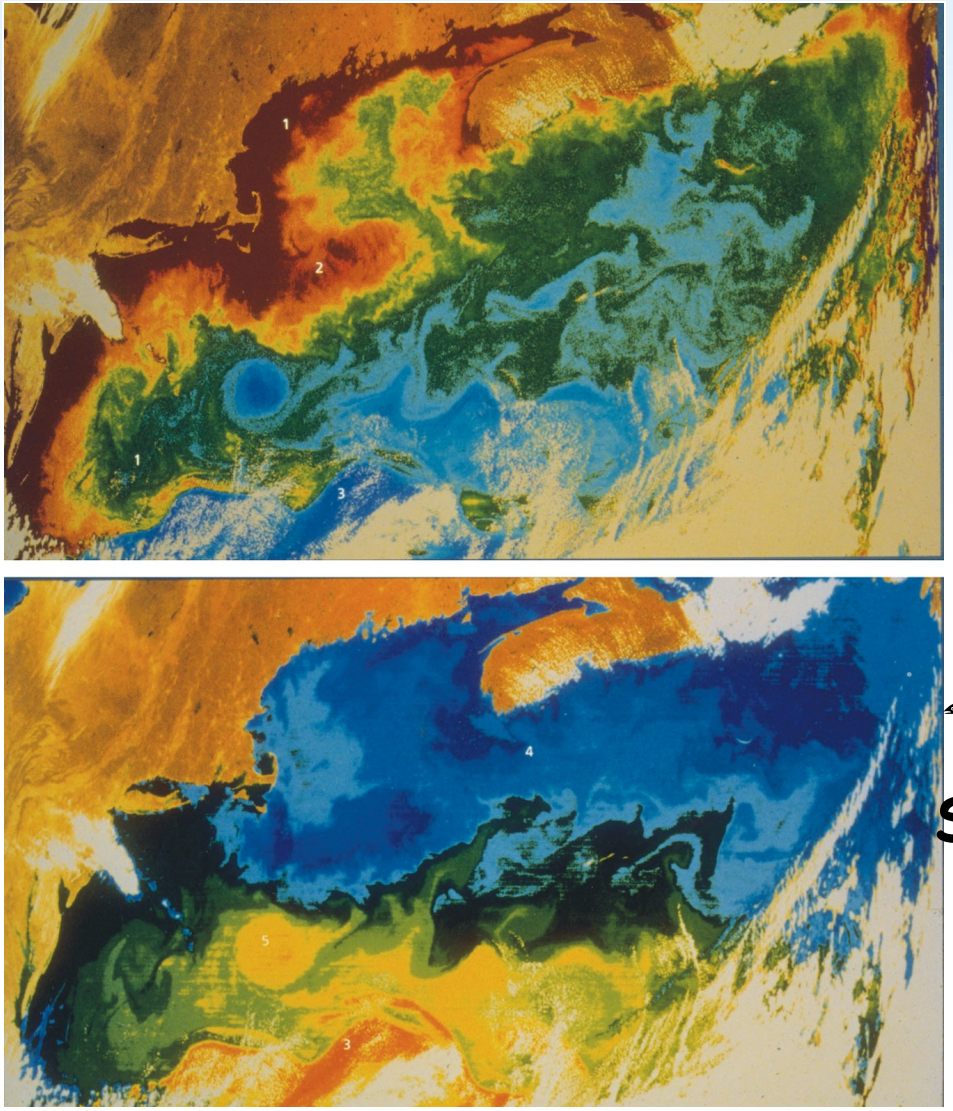


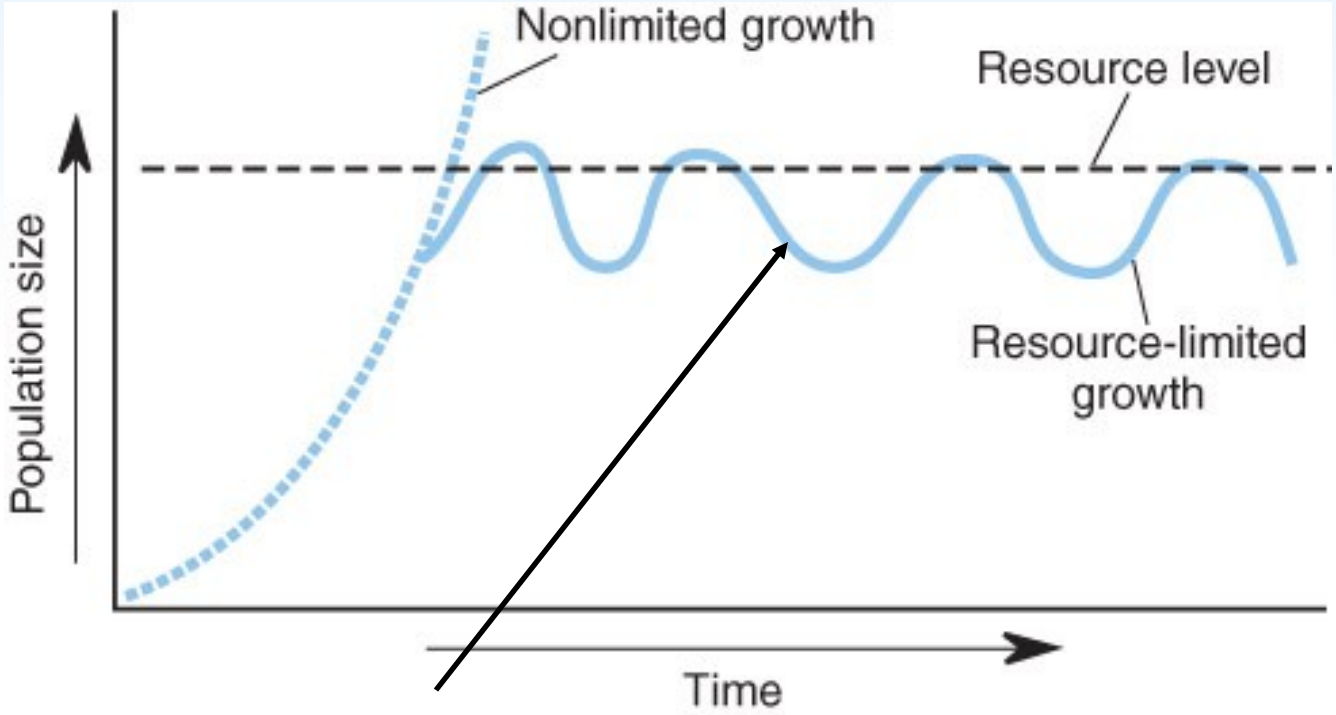
Fig. 3.21 Composite satellite views of the North Atlantic Ocean along the northeast coast of the United States. (Top) Phytoplankton concentrations, ranging from low (dark blue) to high (red). (Bottom) Corresponding sea surface temperature of the area shown, ranging from warm (red) to cold (dark blue). Generally, phytoplankton concentrations are highest where the water is coldest.

- modern remote sensing via satellites

Courtesy NASA

Primary Production in the Sea

Factors That Affect Primary Production

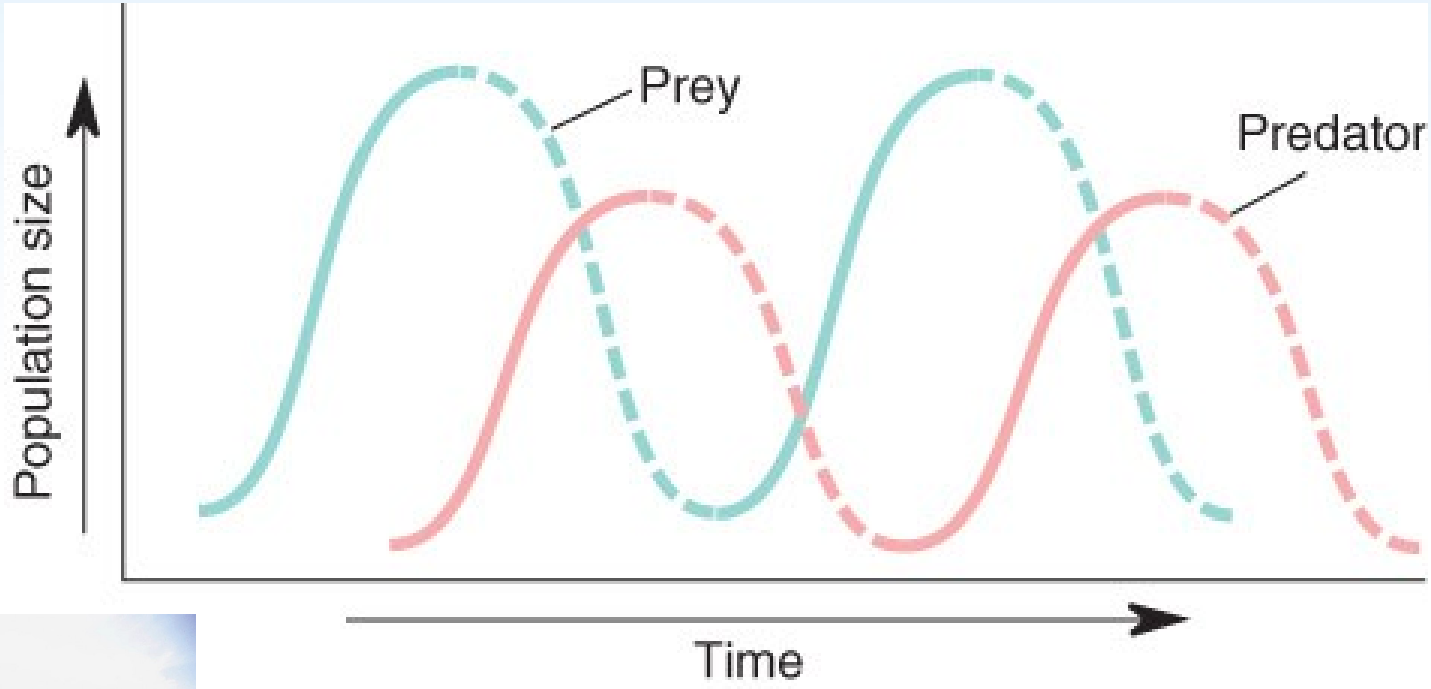


Limiting factor (nutrients, sunlight, space, predators, etc.)

Primary Production in the Sea

Factors that Affect Primary Production

- **1. Grazing**

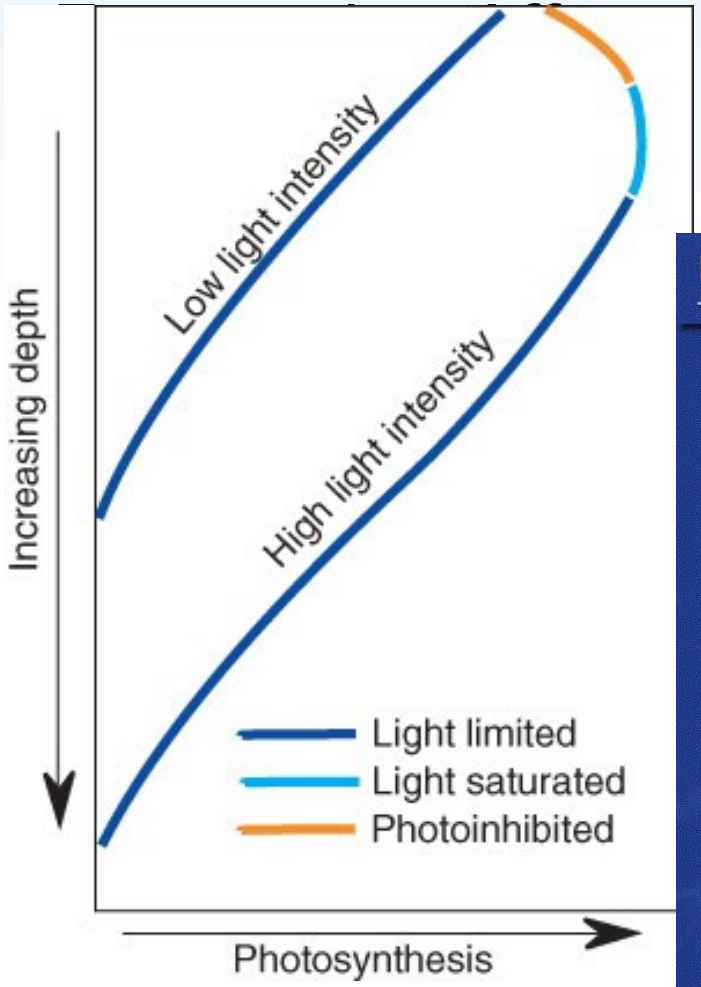


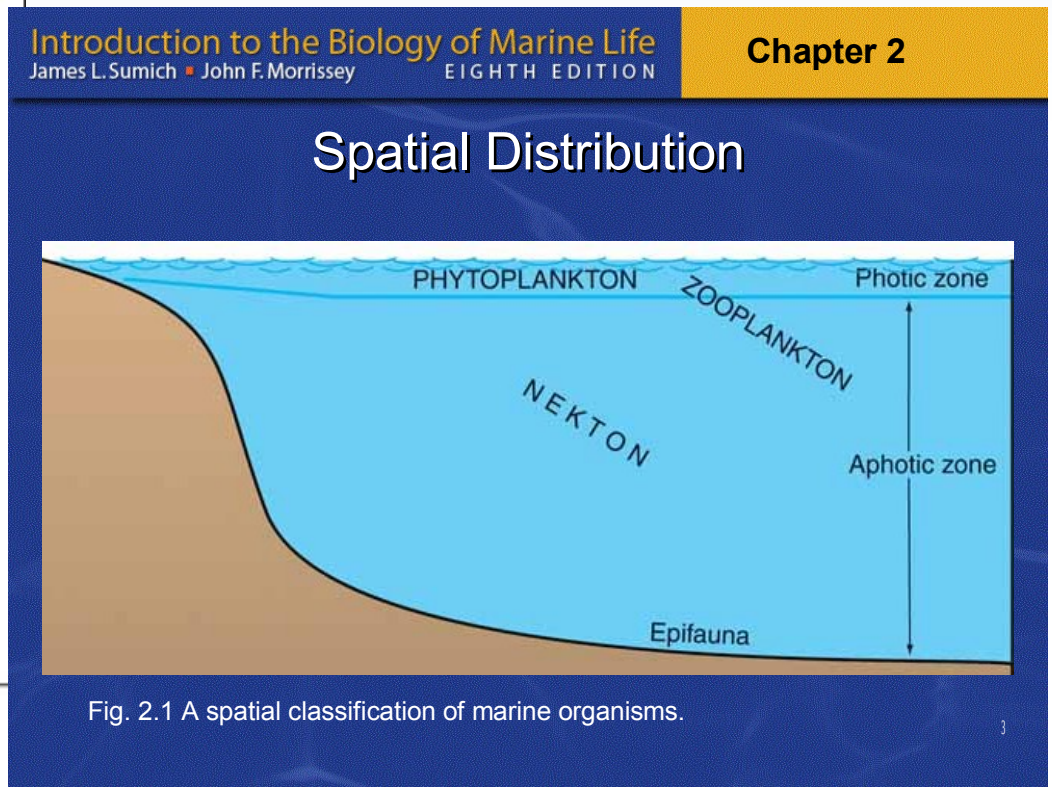
Langmuir cells

Primary Production in the Sea

Factors that Affect Primary Production

- **2. Light**



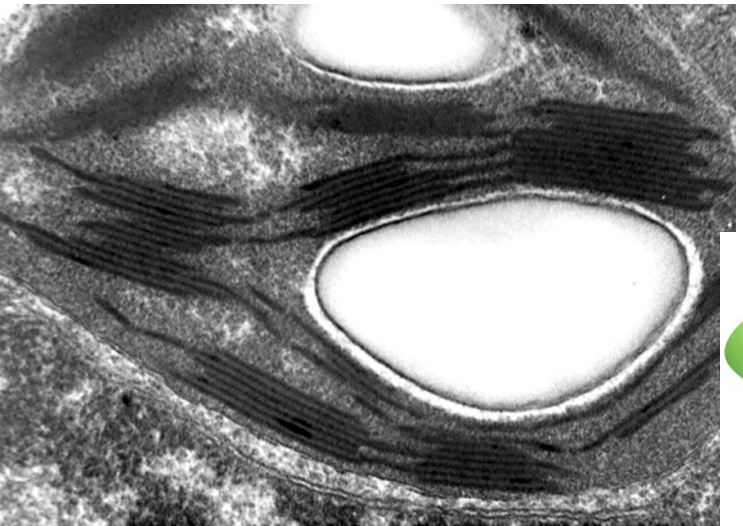


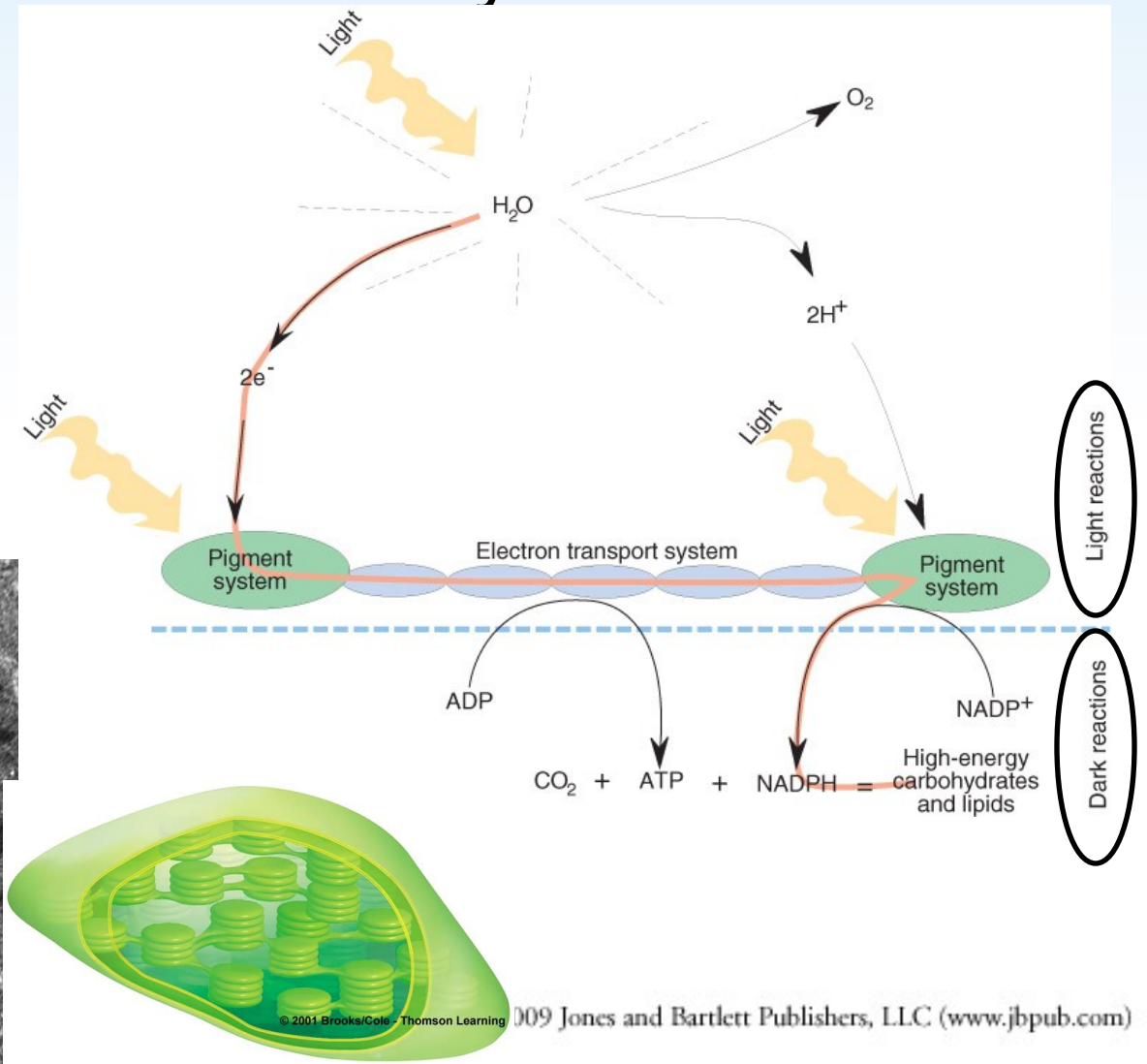
Primary Production in the Sea

Factors that Affect Primary Production

- **Photosynthetic pigments – in chloroplasts!**

Chloroplast- where photosynthesis occurs!

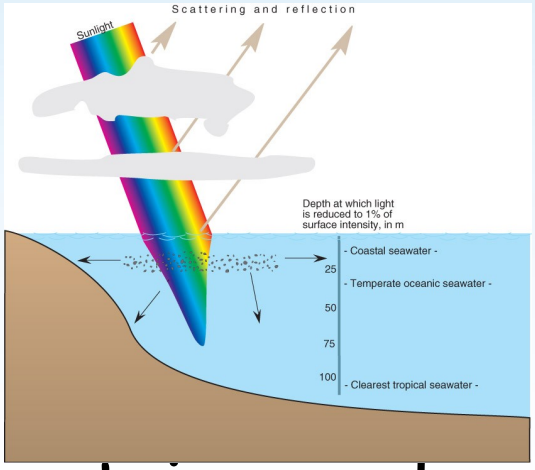




Primary Production in the Sea

Factors that Affect Primary Production

- **Photosynthetic pigments**



Do you see a problem???

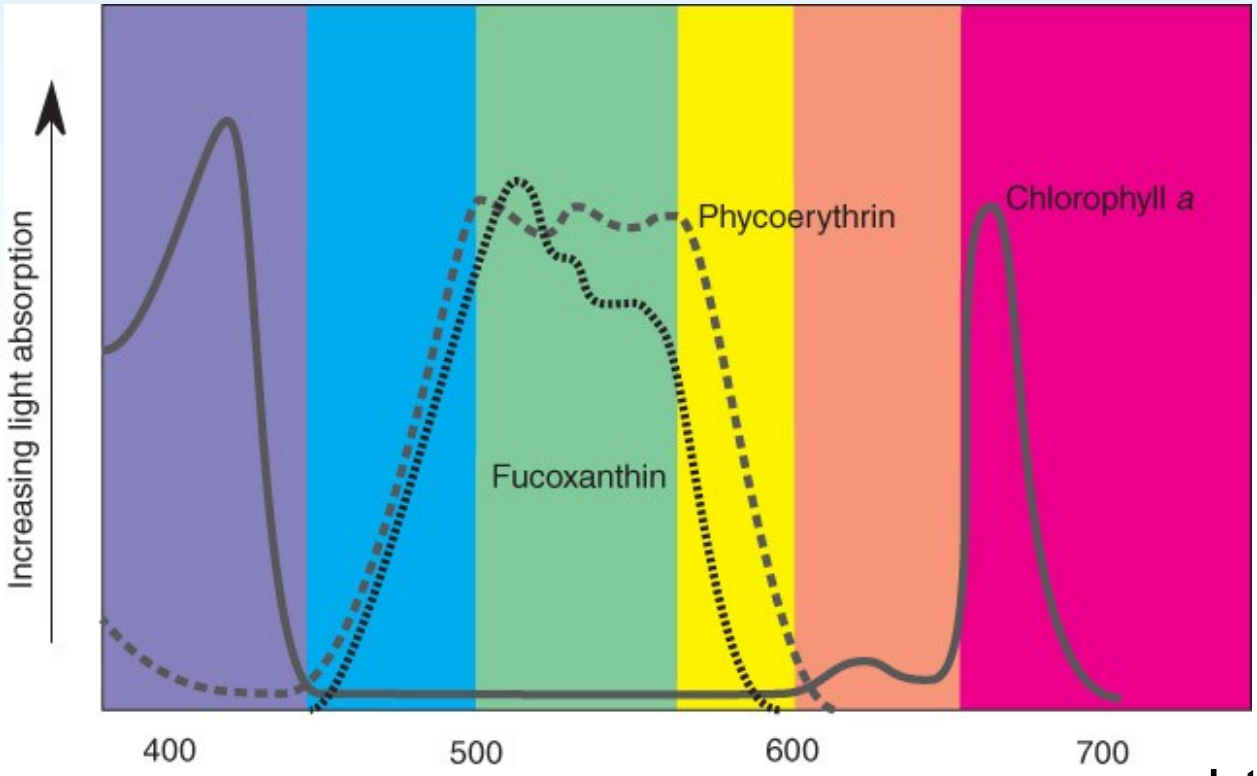
Photosynthesis uses certain wavelengths of light
Color you see are the wavelengths *not* absorbed – why the ocean is blue and leaves are green!!!

Chlorophyll (a & b)

The main photosynthetic pigment
Absorbs violet and red light (appears green)

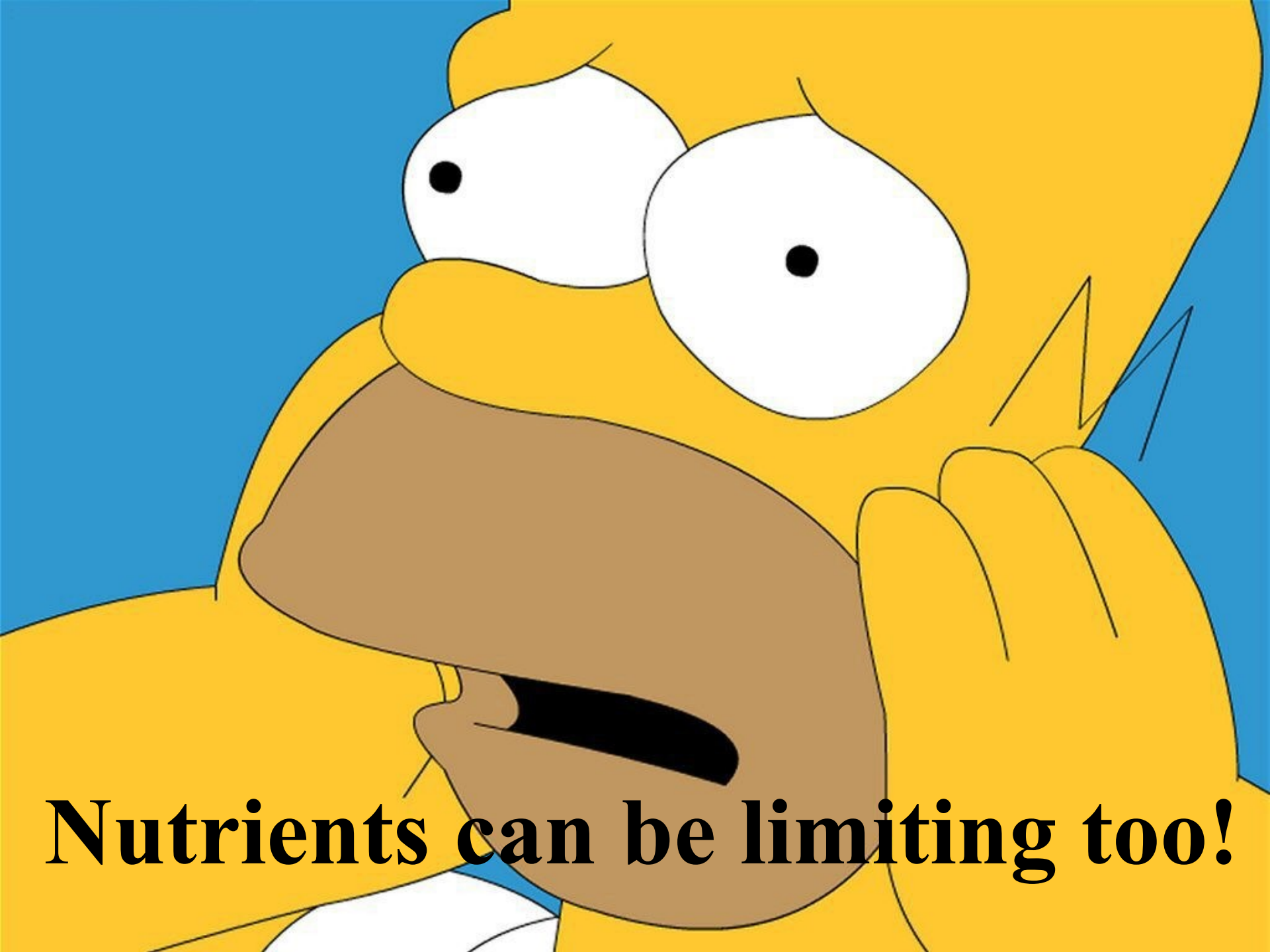
Adapted from Saffo, M. B. BioScience 37 (1987): 6554-664.

Accessory pigments



Much more important in the ocean habitat than on land!!! Why?

http://www.youtube.com/v/IJCVg9M-7S0

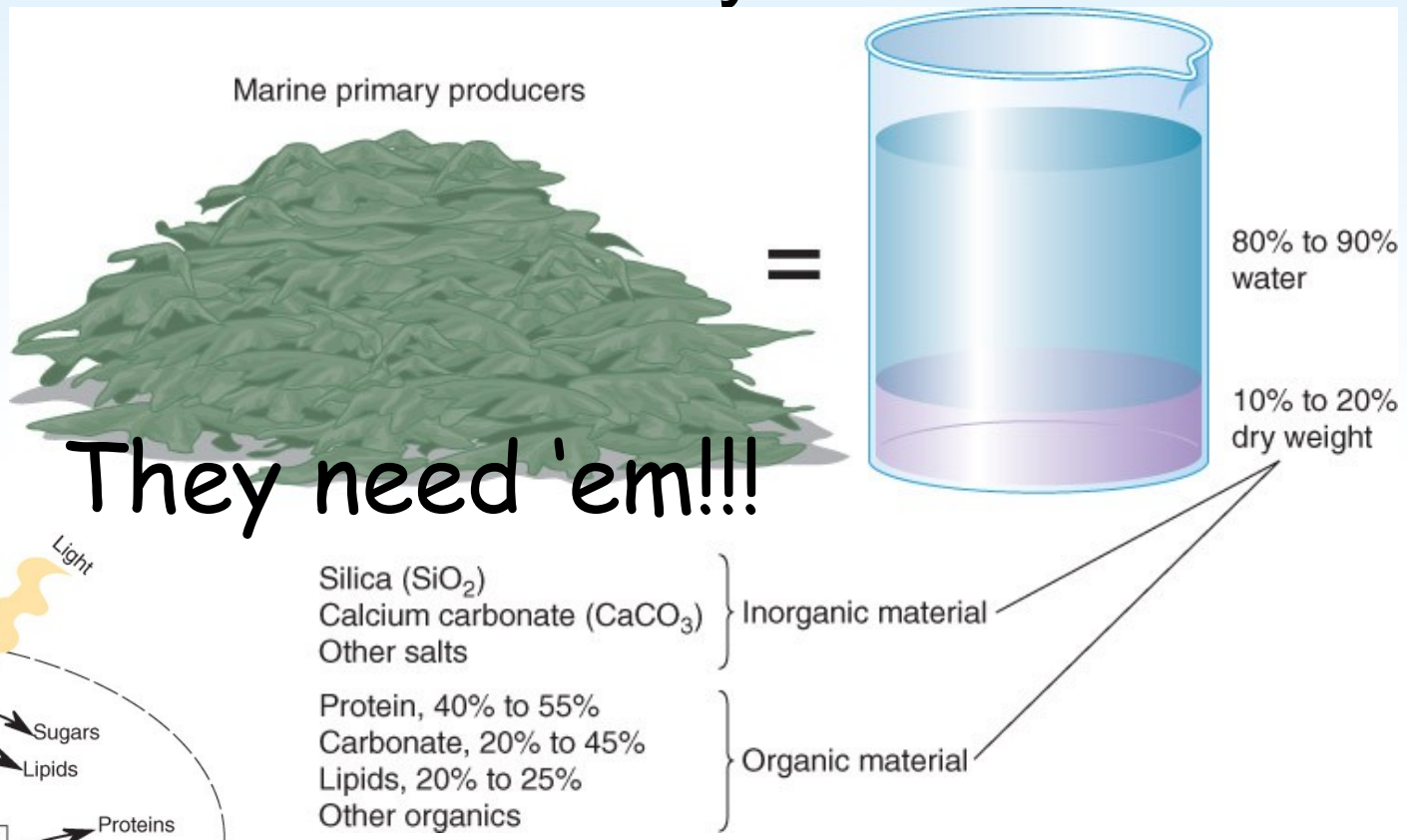

Nutrients can be limiting too!

Primary Production in the Sea

Factors that Affect Primary Production

- **3. Nutrients**

They need 'em!!!



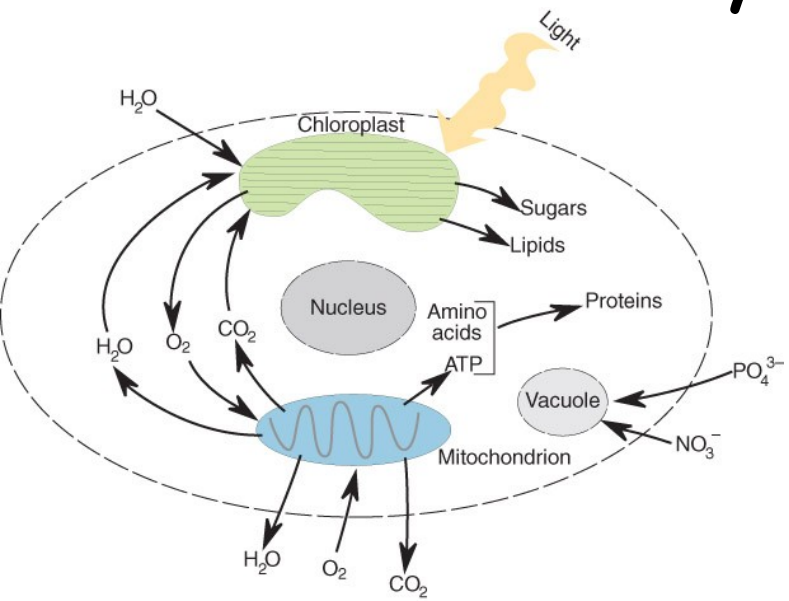
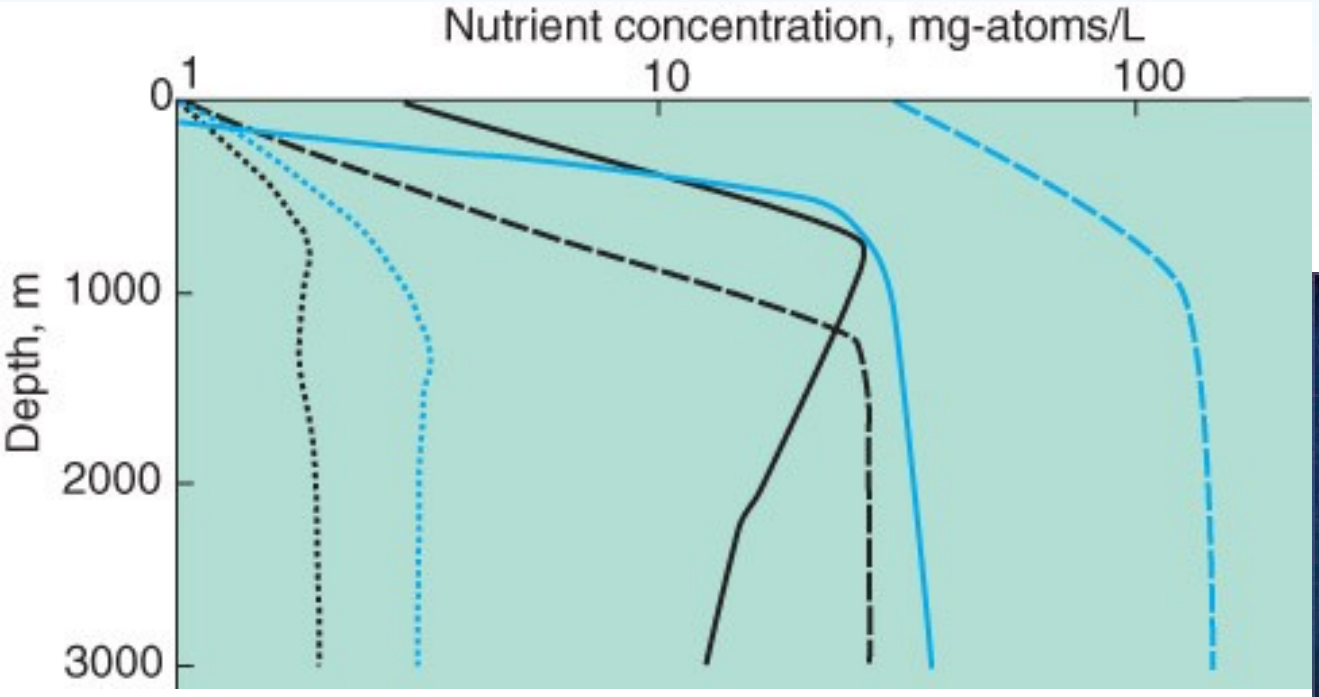


Fig. 3.30 Chemical composition of typical marine autotrophs.

Primary Production in the Sea

Factors that Affect Primary Production



Marine snow

Nutrients sink…so how do they get 'em?

Adapted from Sverdrup, H. U., et al., The Oceans: Their Physics, Chemistry, and Biology. Prentice-Hall, 1942.

Primary Production in the Sea

Factors that Affect Primary Production

Here's one way!

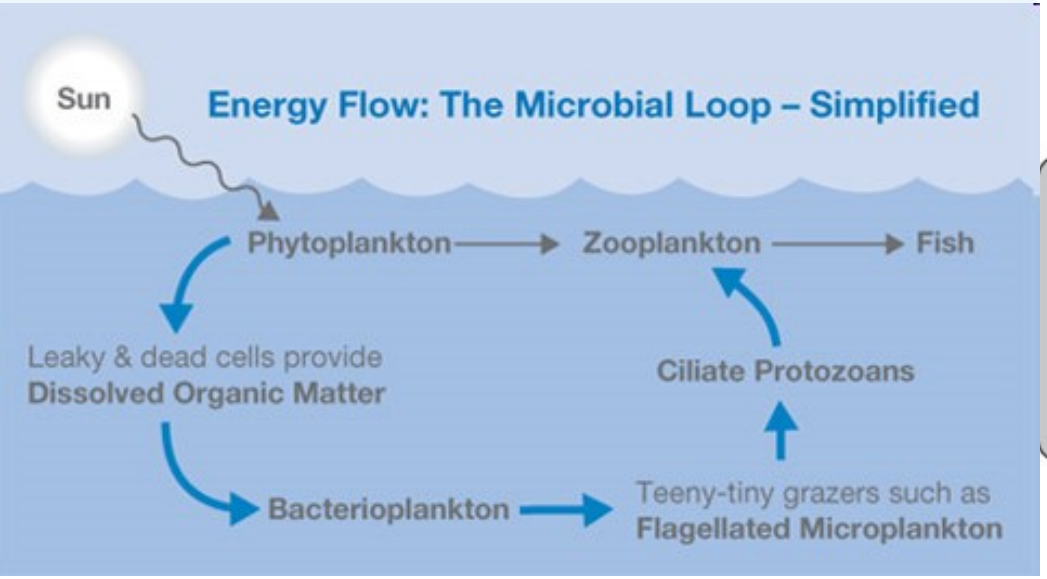
- **Nutrient requirements**

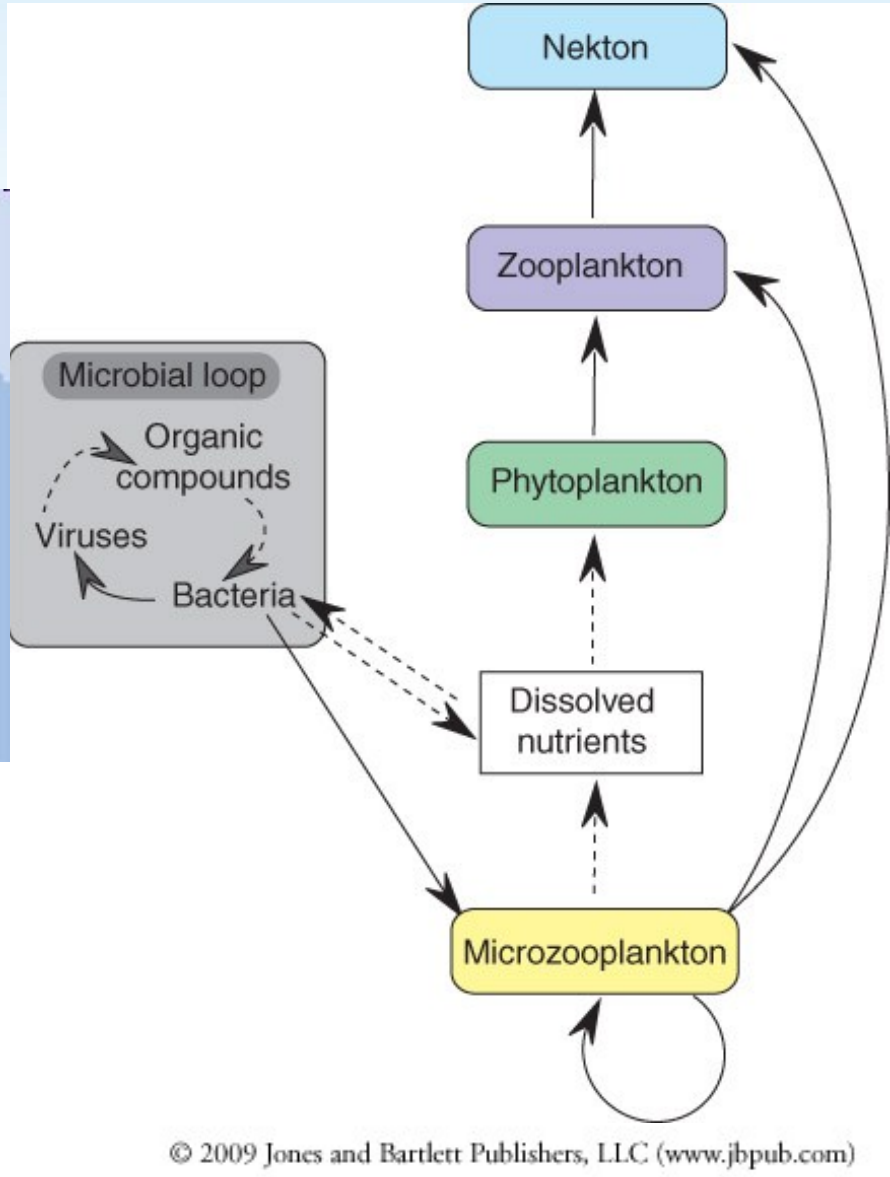
Fig. 3.33 SeaWiFS image of airborne Saharan dust being carried westward over the Canary Islands and beyond into the North Atlantic Ocean.

Image provided by GeoEye and NASA SeaWiFS Project

Primary Production in the Sea

- Nutrient regeneration



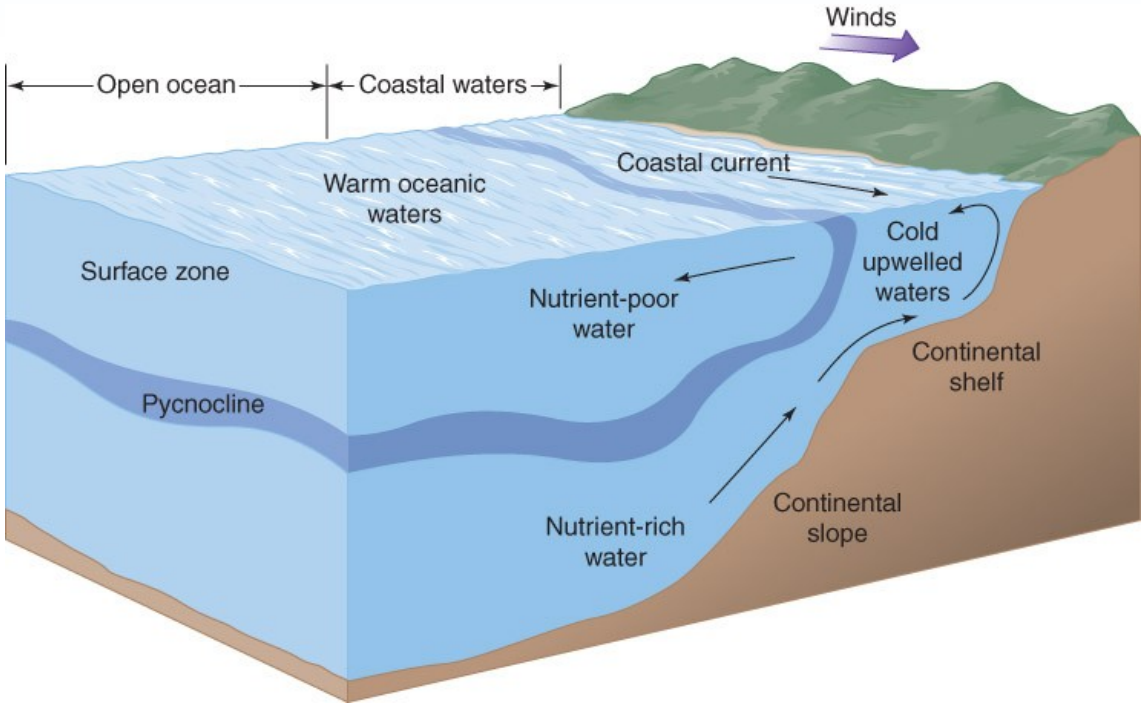


Here's another way!!!
Microbial loops!

Primary Production in the Sea
Factors that Affect Primary Production

Here's another 3 ways!

- **Nutrient Regeneration.**
  - Turbulent mixing – wind, waves, tides
  - Upwelling
  - Convective mixing – based on density changes



Primary Production in the Sea

Where do you think you have highest levels of primary production???

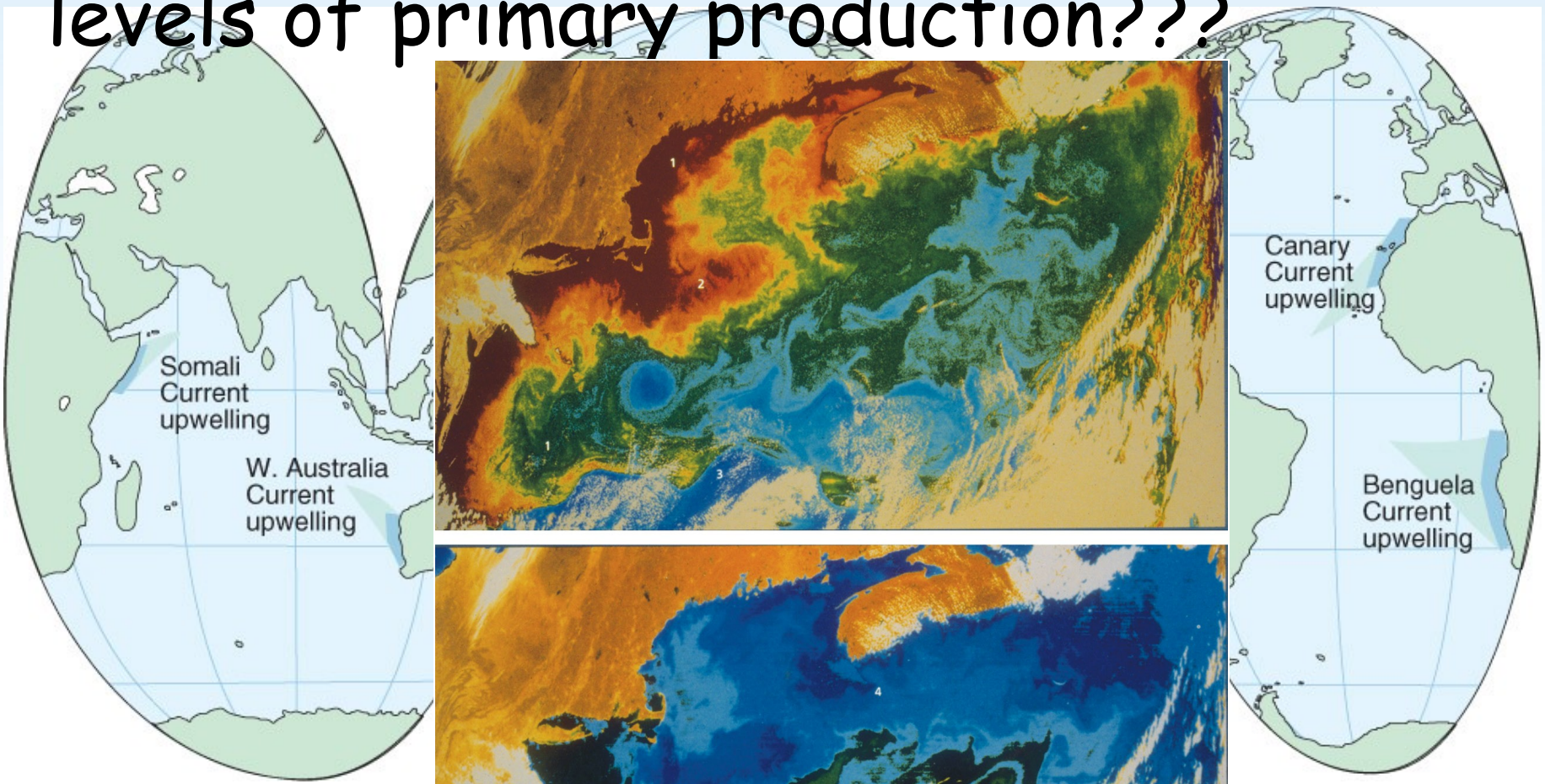


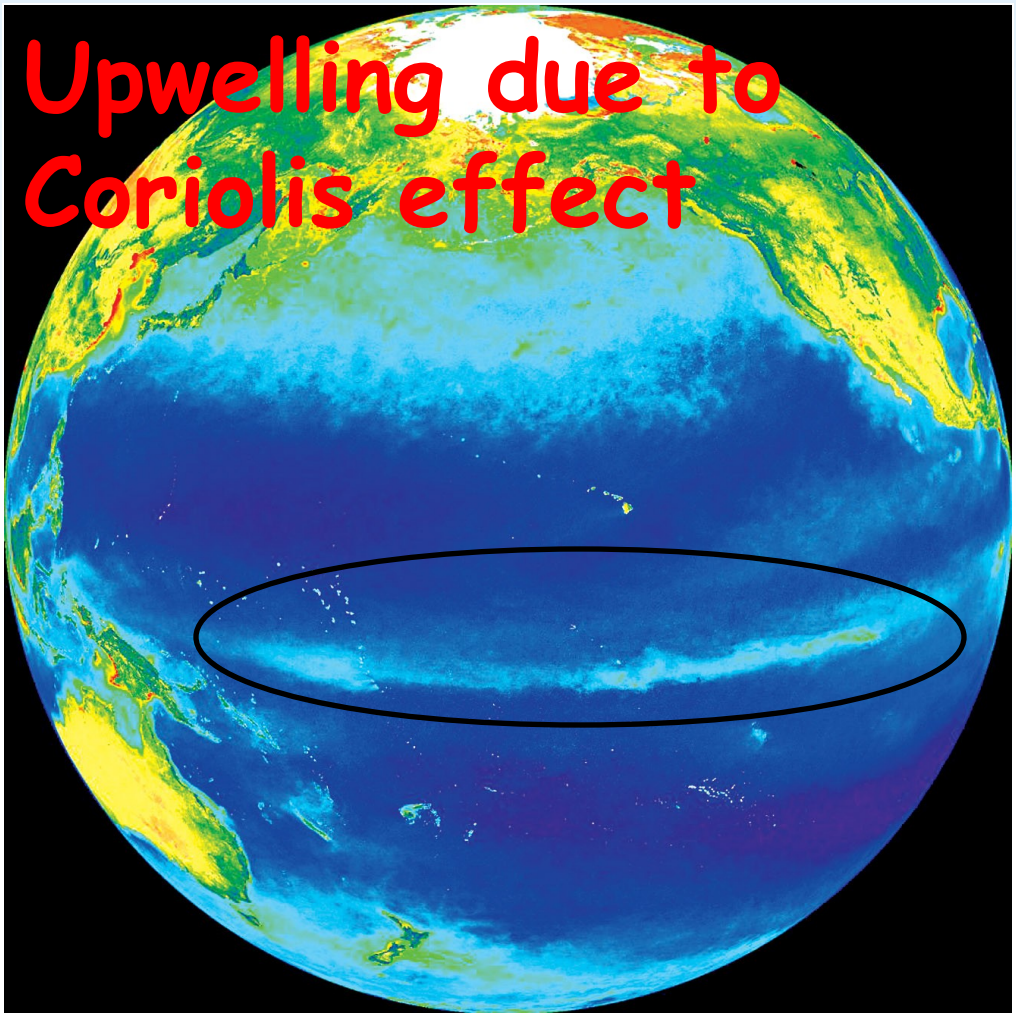
Fig. 3.37 Principal region creased primary

Primary Production in the Sea

Fig. 3.39 In this map of the Pacific Ocean, the deep blue areas are nutrient-poor

Few phytoplankton grow here.

The lighter blue represent areas of upwelling, more productive regions with higher rates of nutrient input and consequently higher phytoplankton biomass.



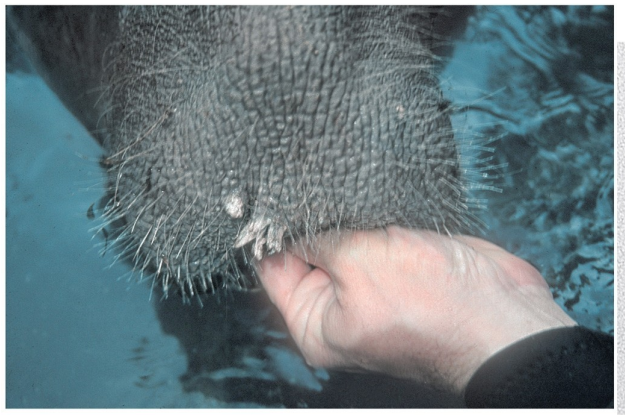
Courtesy of NOAA

http://www.youtube.com/watch?v=wLoslN6d3Ec

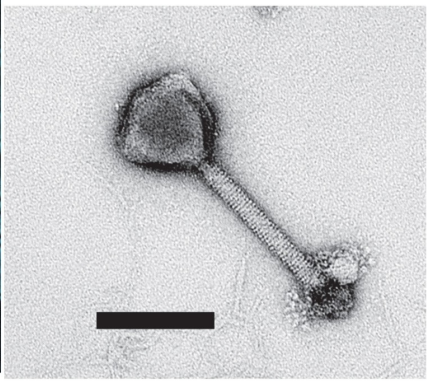
A little bit about marine viruses

- Viruses are diverse and are more abundant than any other organism in the sea – 10X more abundant than bacteria!
- What are they? DNA/RNA w/protein coat
- Are they alive???

Papilloma virus on a manatee



(b)



(a)