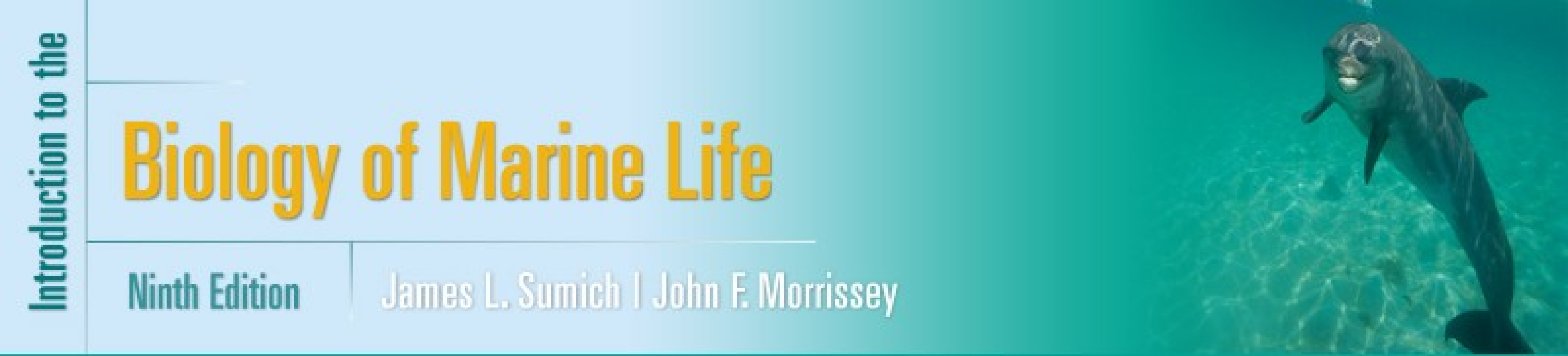
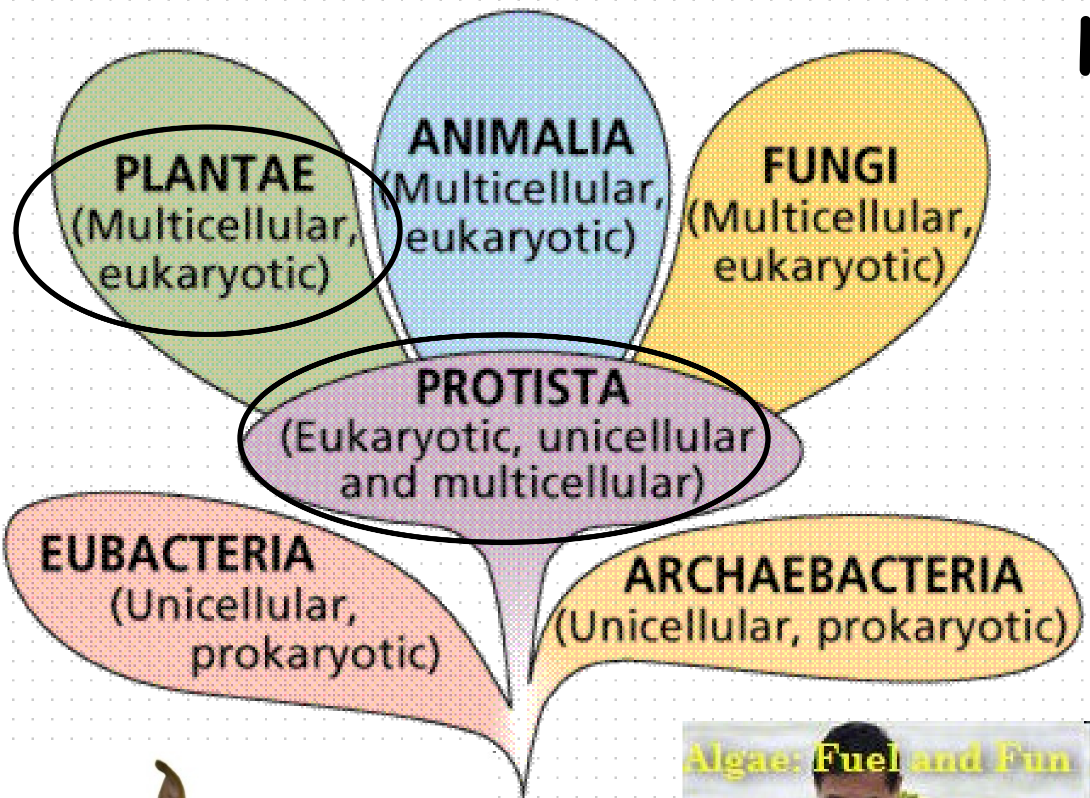



Chapter 4

# Multicellular Primary Producers - I changed the title!!!

# Division Anthophyta




Kingdom Protista

Phylum/Division

Phaeophyta

Rhodophyta

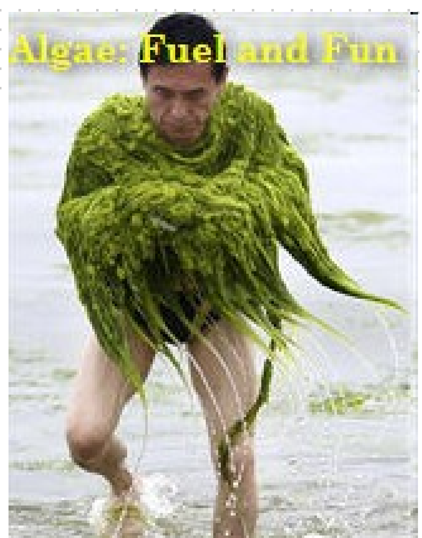
Chlorophyta

Controversial!

No roots, leaves, vascular tissue, flowers or stems in algae!

Kingdom Plantae

Division Anthophyta


http://www.funnyjunk.com/movies/1142418/

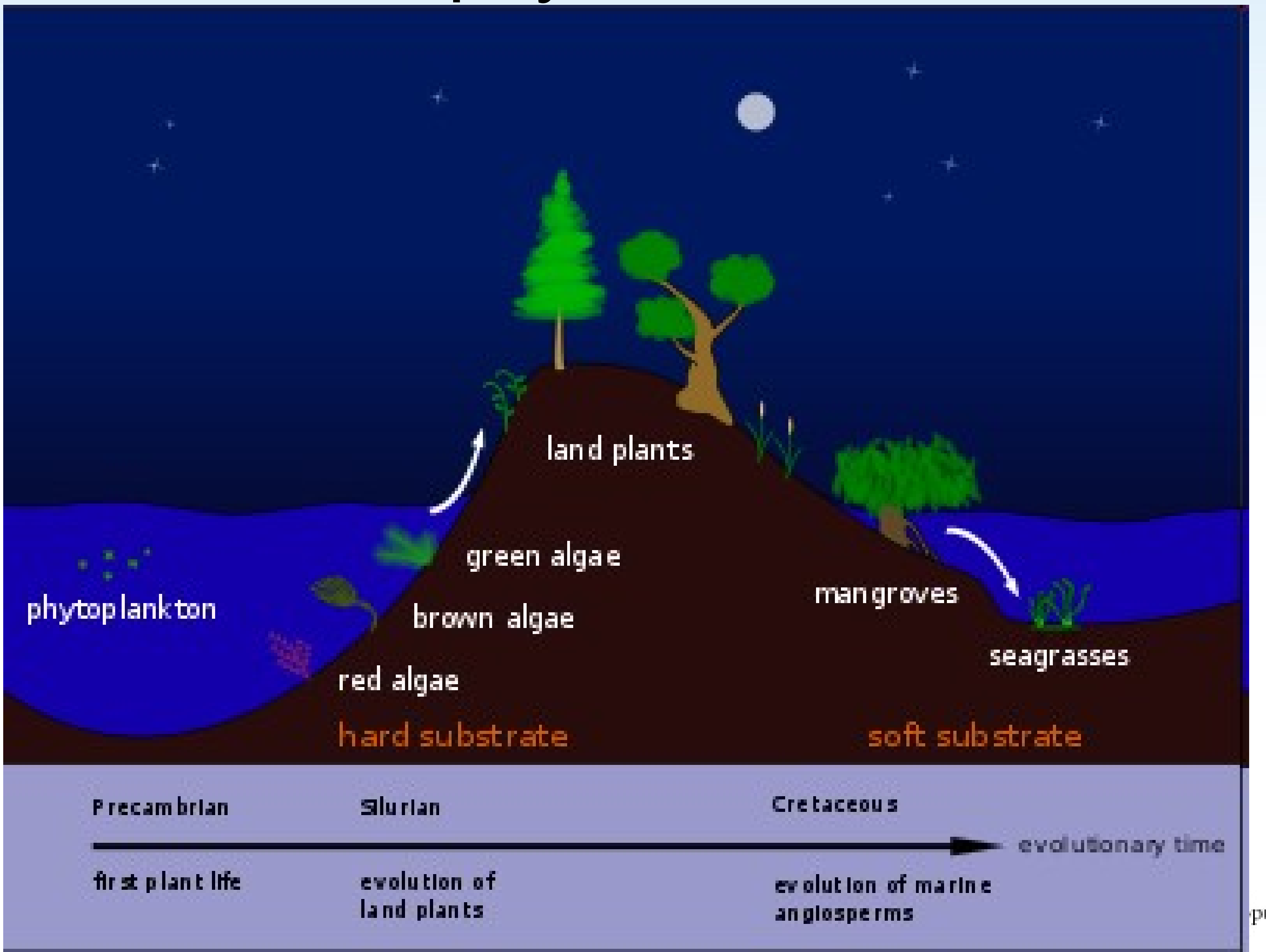
Table 4.1

## Major Divisions of Marine Plants and Their General Characteristics

| Division (common name) | Approximate number of living species | Percentage of species marine | General size and structure | Photosynthetic pigments | Storage products | Habit |
|---|---|---|---|---|---|---|
| Phaeophyta (brown algae) | 1500 | 99.7 | Multicellular, macroscopic | Chlorophyll *a, c*<br>Xanthophylls<br>Carotenes | Laminarin and others | Mostly benthic |
| Rhodophyta (red algae) | 4000 | 98 | Unicellular and multicellular, mostly macroscopic | Chlorophyll *a*<br>Carotenes<br>Phycobilins | Starch and others | Benthic |
| Chlorophyta (green algae) | 7000 | 13 | Unicellular and multicellular, microscopic to macroscopic | Chlorophyll *a, b*<br>Carotenes | Starch | Mostly benthic |
| Anthophyta (flowering plants) | 250,000 | 0.018 | Multicellular, macroscopic | Chlorophyll *a, b*<br>Carotenes | Starch | Benthic |

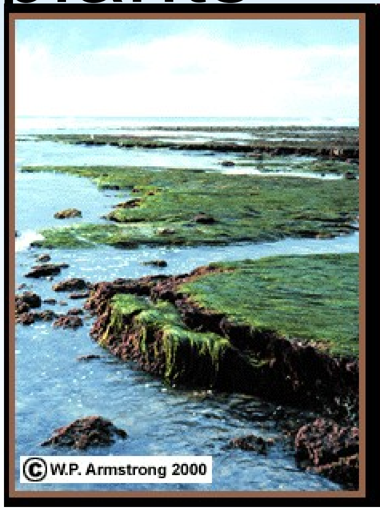
Adapted from Segal et al., 1980; Dawson, 1981; and Kaufman et al., 1989.

# Anthophyte evolution




pub.com)

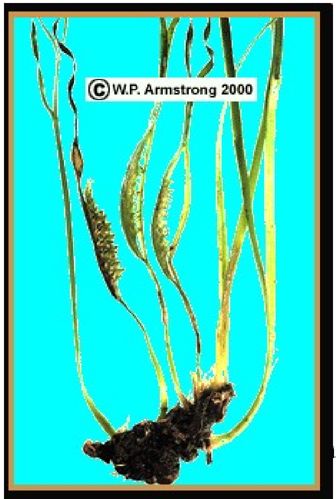
# Division Anthophyta – flowering plants




## Submerged Seagrasses

- About 60 species

- Most seagrasses reproduce:
  - vegetatively via horizontal rhizomes or
  - sexually via underwater pollination of tiny **flowers** followed by **fruit** production


# Division Anthophyta


Submerged Seagrasses


Fig. 4.2 Three common seagrasses from different marine climatic regions: (a) turtle grass, *Thalassia*; (b) eel grass, *Zostera*; and (c) surf grass, *Phyllospadix.*

# Division Anthophyta
## Mammalian Grazers of Seagrasses

- Manatees and dugongs are the only herbivorous marine mammals.

# Division Anthophyta

## Emergent Flowering Plants

- Additional flowering plants, such as marsh grasses and mangals, grow on soft bottoms in the intertidal zone.

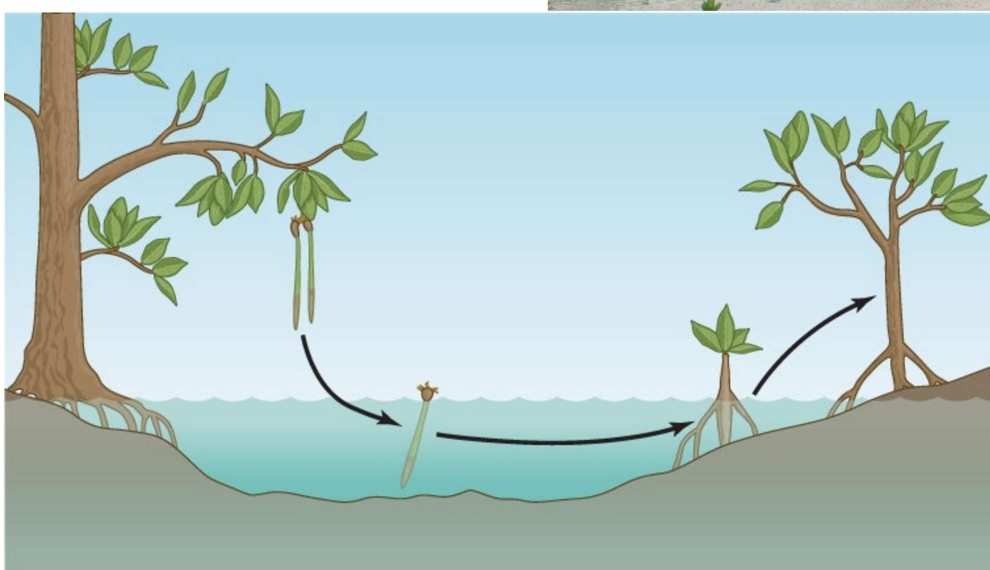


***Salicornia* – Pickleweed!**

***Spartina***

# Division Anthophyta


Emergent Flowering Plants – Mangals (mangroves)



# The seaweeds – no seeds, no flowers

# The Seaweeds

## Structural Features of Seaweeds

- Blades
- Stipes
- Holdfasts
- Pneumatocysts (in some species)


They photosynthesize everywhere!!! Why???

**Haptera make up holdfast**

# What part is what???

## The Seaweeds

Structural Features of Seaweeds

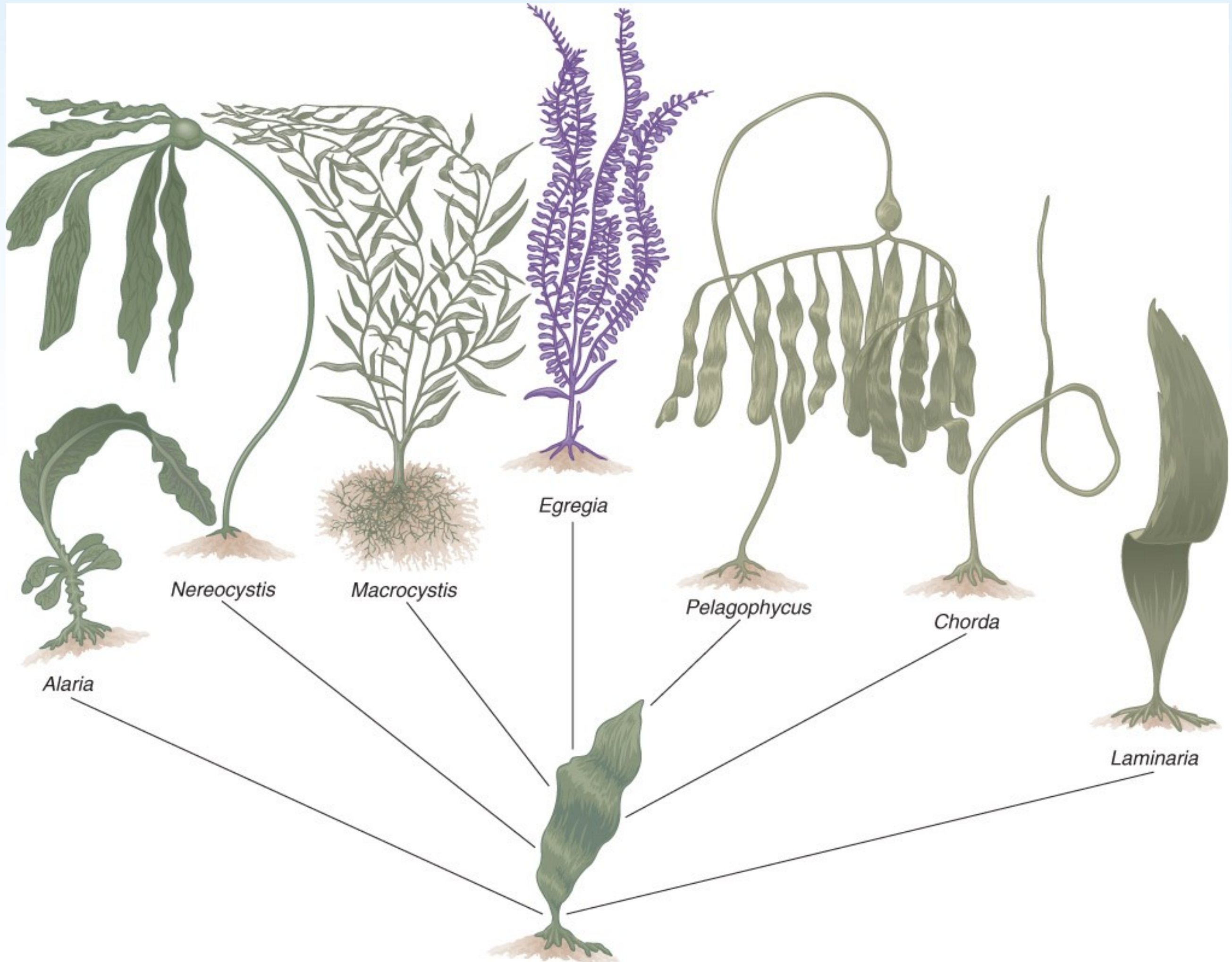
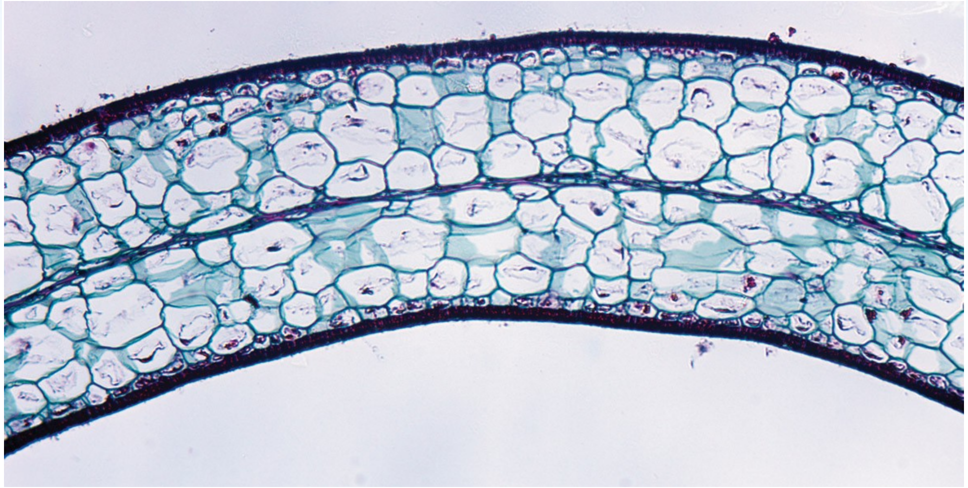



Fig. 4.9 Some large kelp plants of temperate coasts. Each mature plant develops from a young plant with a single flat blade.

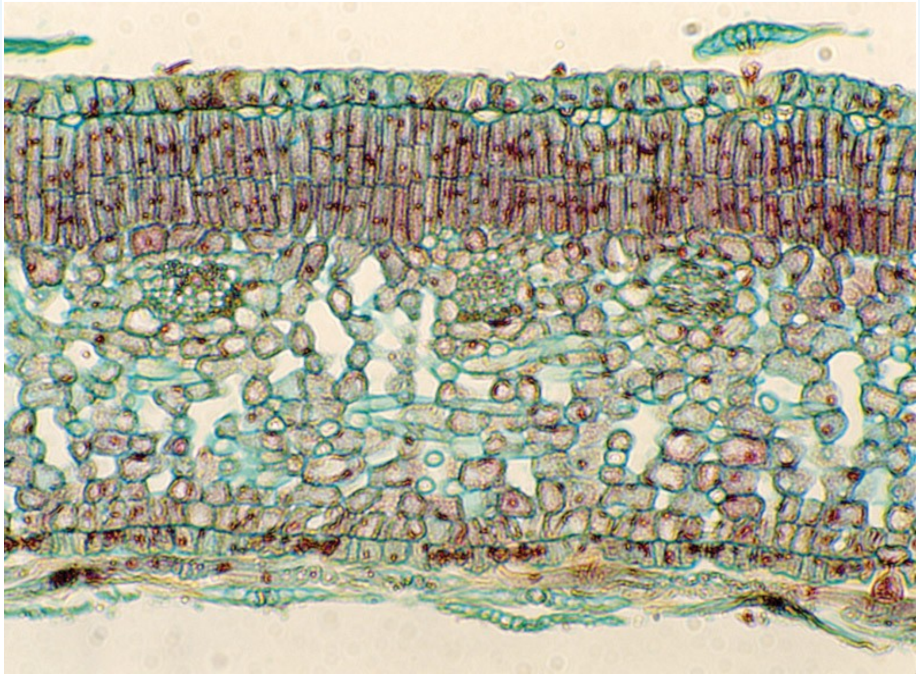
# What do you see??? Compare the two!!!

## The Seaweeds



a © Biodisc/Visuals Unlimited

**Alga**



b © Runk/Schoenberger/Alamy Images

**Flowering plant**

# The Seaweeds

Fig. 4.11 A portion of the floating brown alga, *Sargassum*

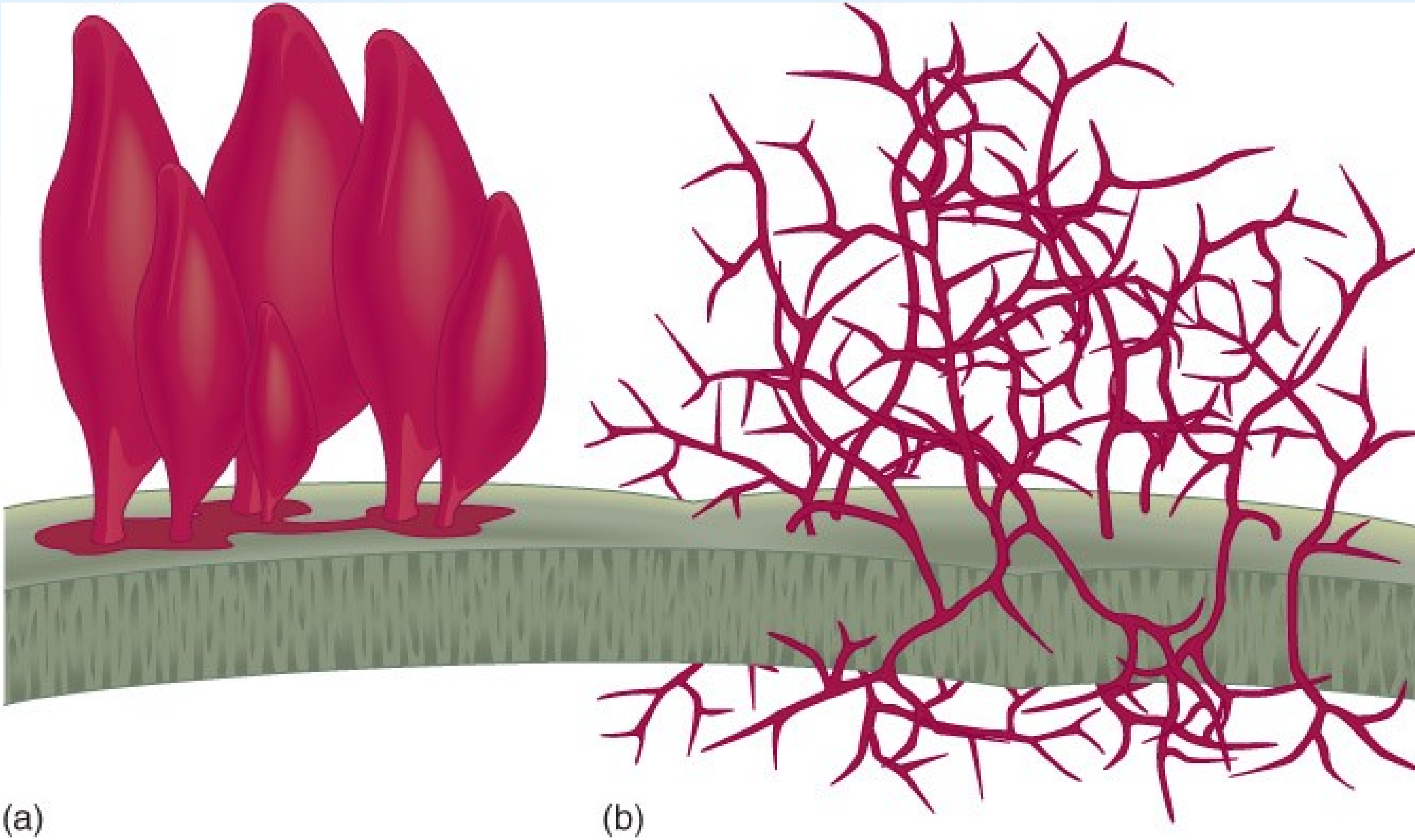
## Structural Features of Seaweeds

http://www.youtube.com/watch?v=pox7Dk7V7M8

Fig. 4.12 Complex interlocking mass of haptera that make up the holdfast of *Macrocystis*.

**What's the difference between a holdfast and a root?**

# The Seaweeds – **epiphytes**!




Holdfasts attached to a leaf of Phyllospadix.

# The Seaweeds

## Photosynthetic Pigments

- Appearance of Chlorophyta (green algae)

Fig. 4.14 A healthy growth of the green alga *Ulva* lies on the sand during low tide.

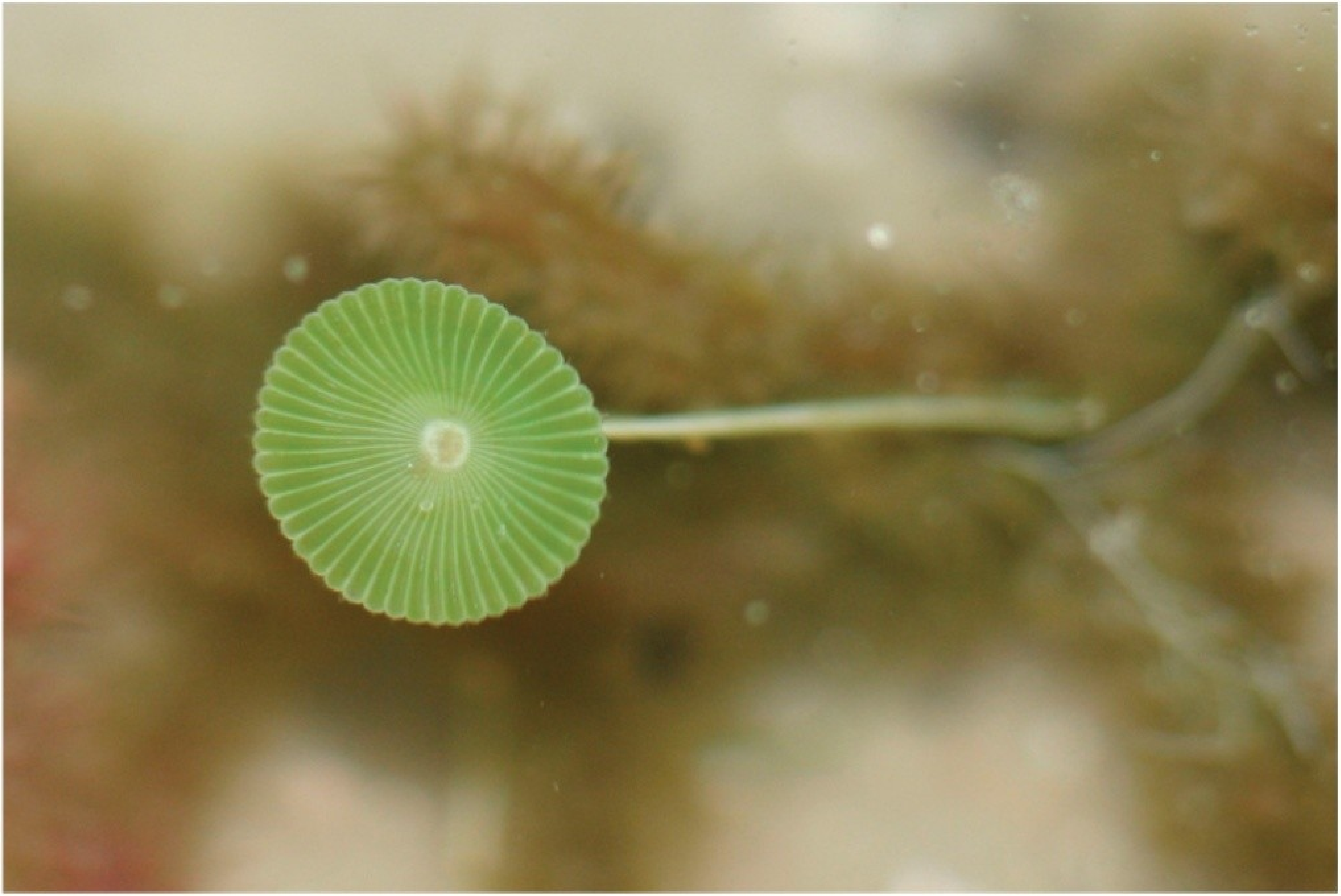
**Green because Chlorophyll dominant!**



*Valonia*



**_Caulerpa_**





***Acetabularia***

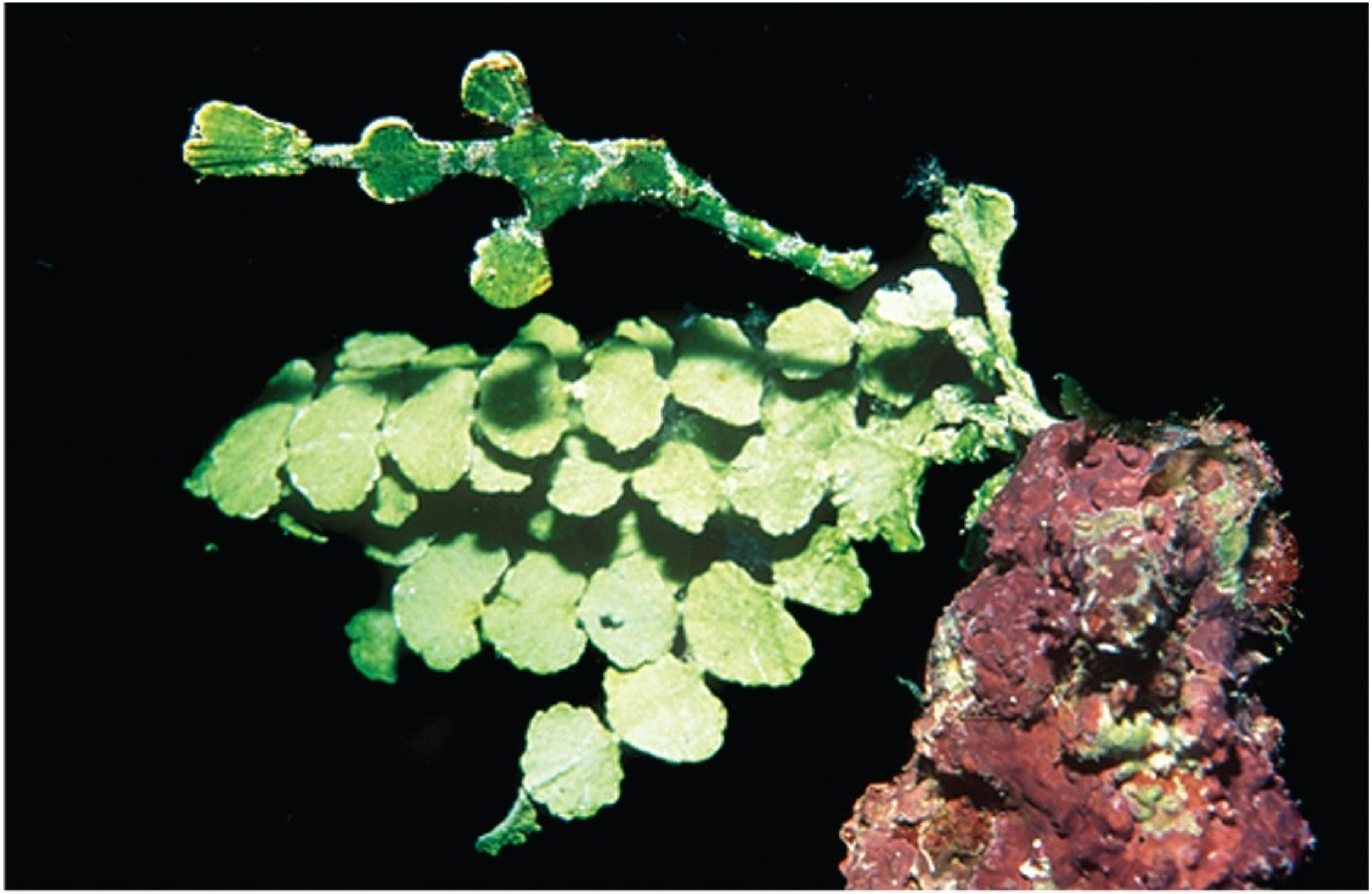
(e)



# *Codium* – Dead Man's Fingers

com)

Fig. 7-4, p. 165



(f)



***Halimeda***

Fig. 7-4, p. 165

# The Seaweeds

## Photosynthetic Pigments

**Kelp = brown**

- Appearance of Phaeophyta (brown algae)

Fig. 4.15 The brown alga *Fucus* growing on a rocky intertidal shoreline.

**Brown (???) Because chlorophyll + fucoxanthin!!!**



# Giant Kelp - *Macrocystis*



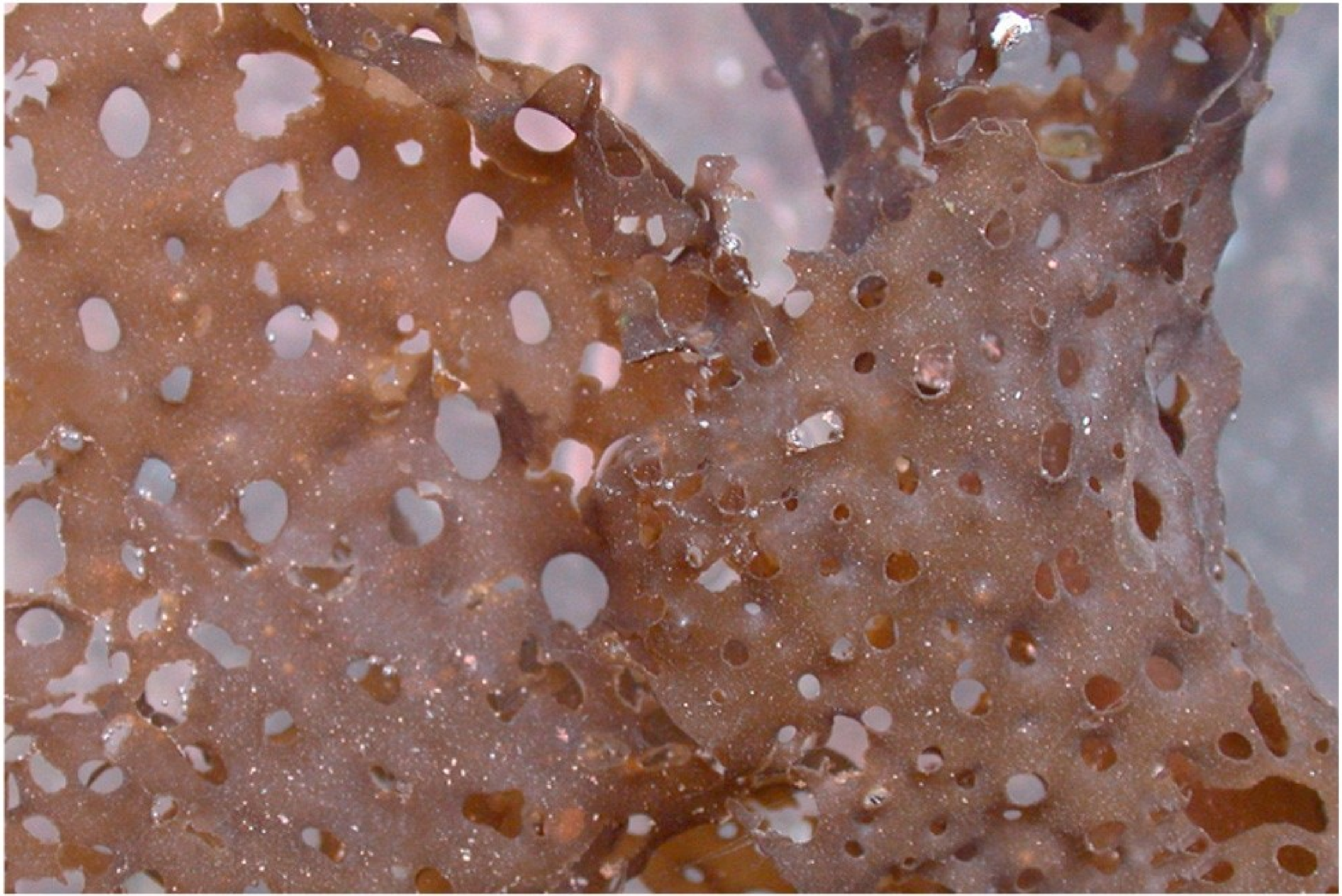
***Sargassum*** **– it's a floater!!!**



***Ascophyllum***



*Postelsia* – **the tough sea palm**



(c)



**_Agarum_ – holes in blade thought to resist waves**

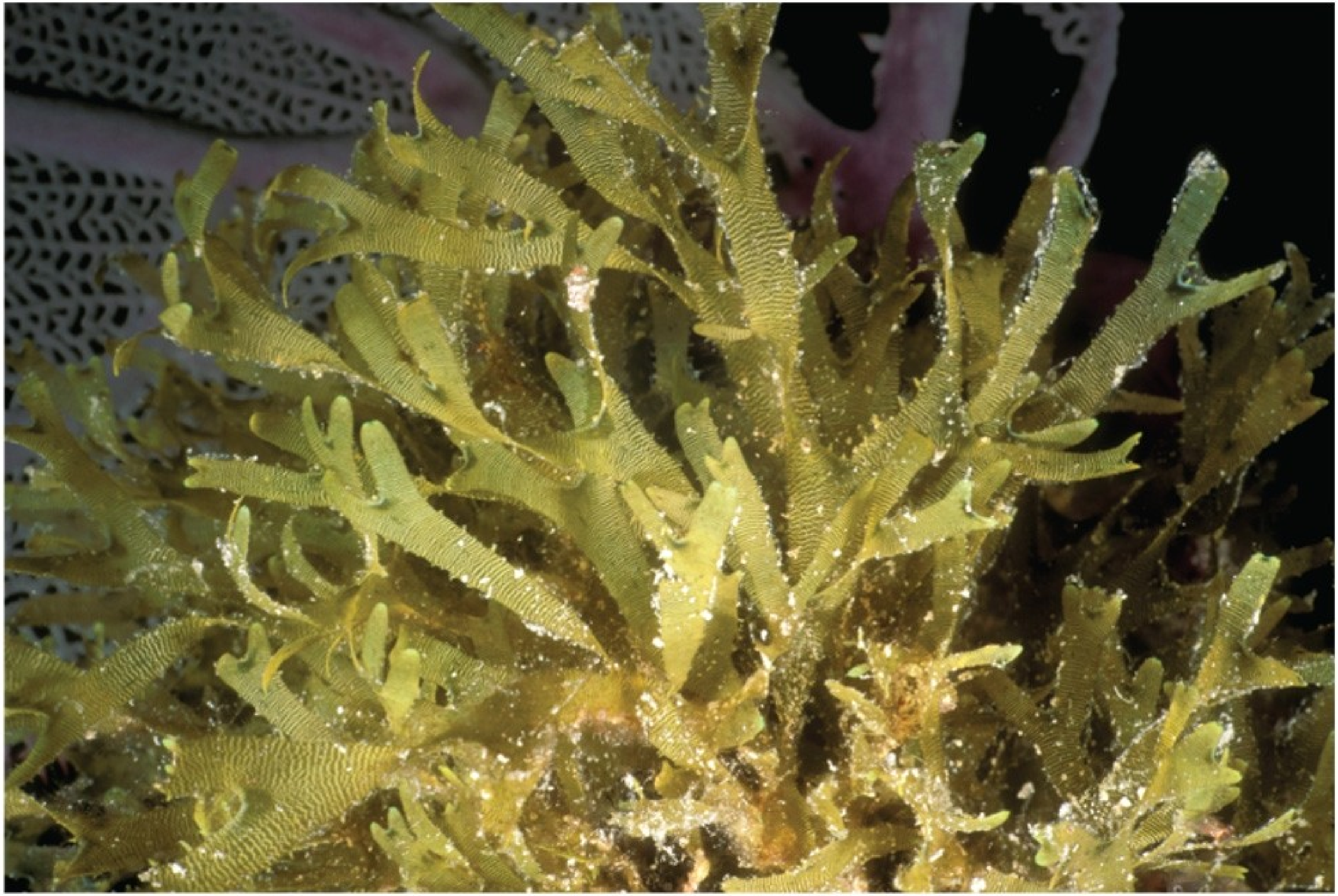
Fig. 7-10, p. 171

(d)



***Padina***

Fig. 7-10, p. 171



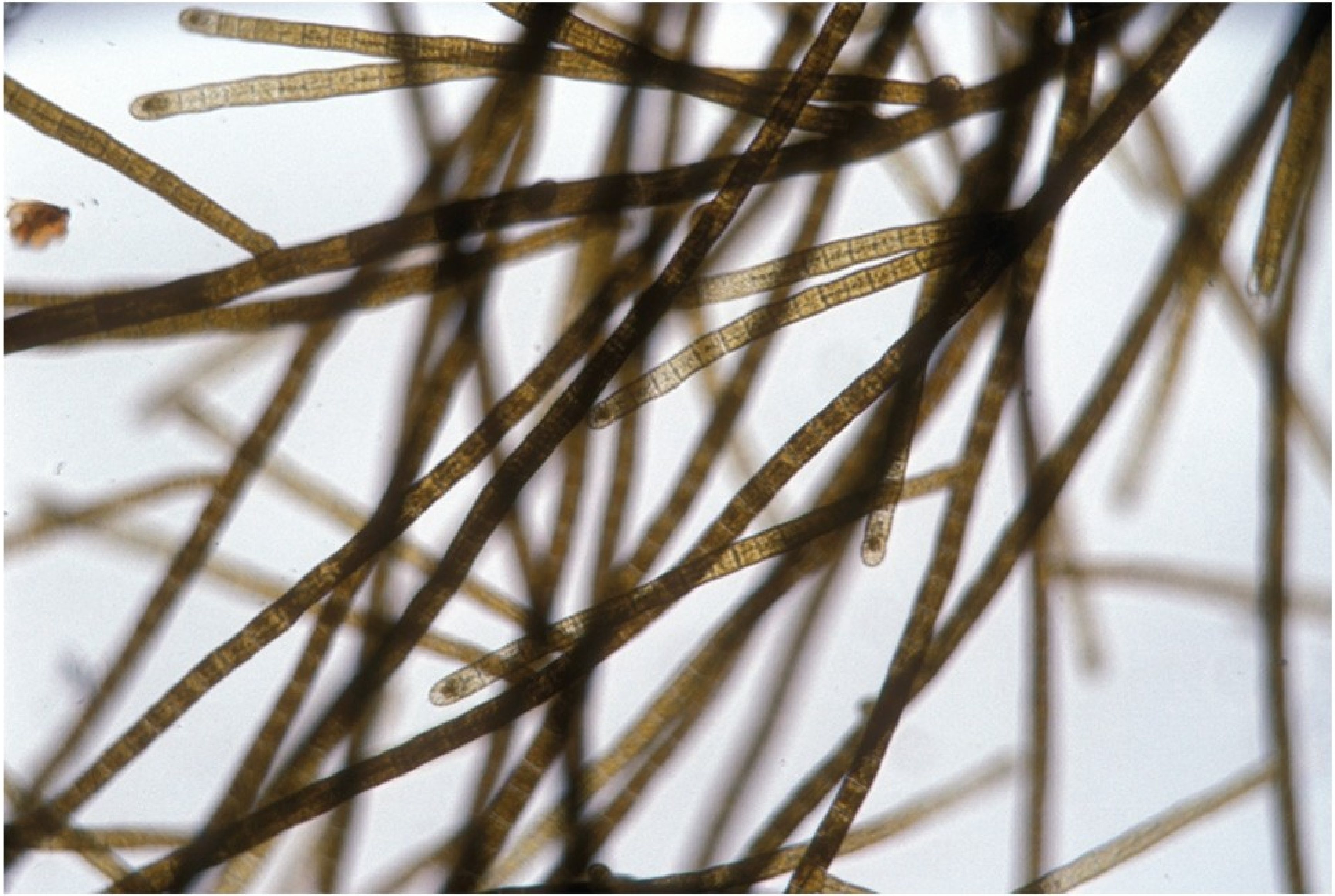
(e)

# *Dictyota*



com)

Fig. 7-10, p. 171



(f)

# *Sphacelaria*



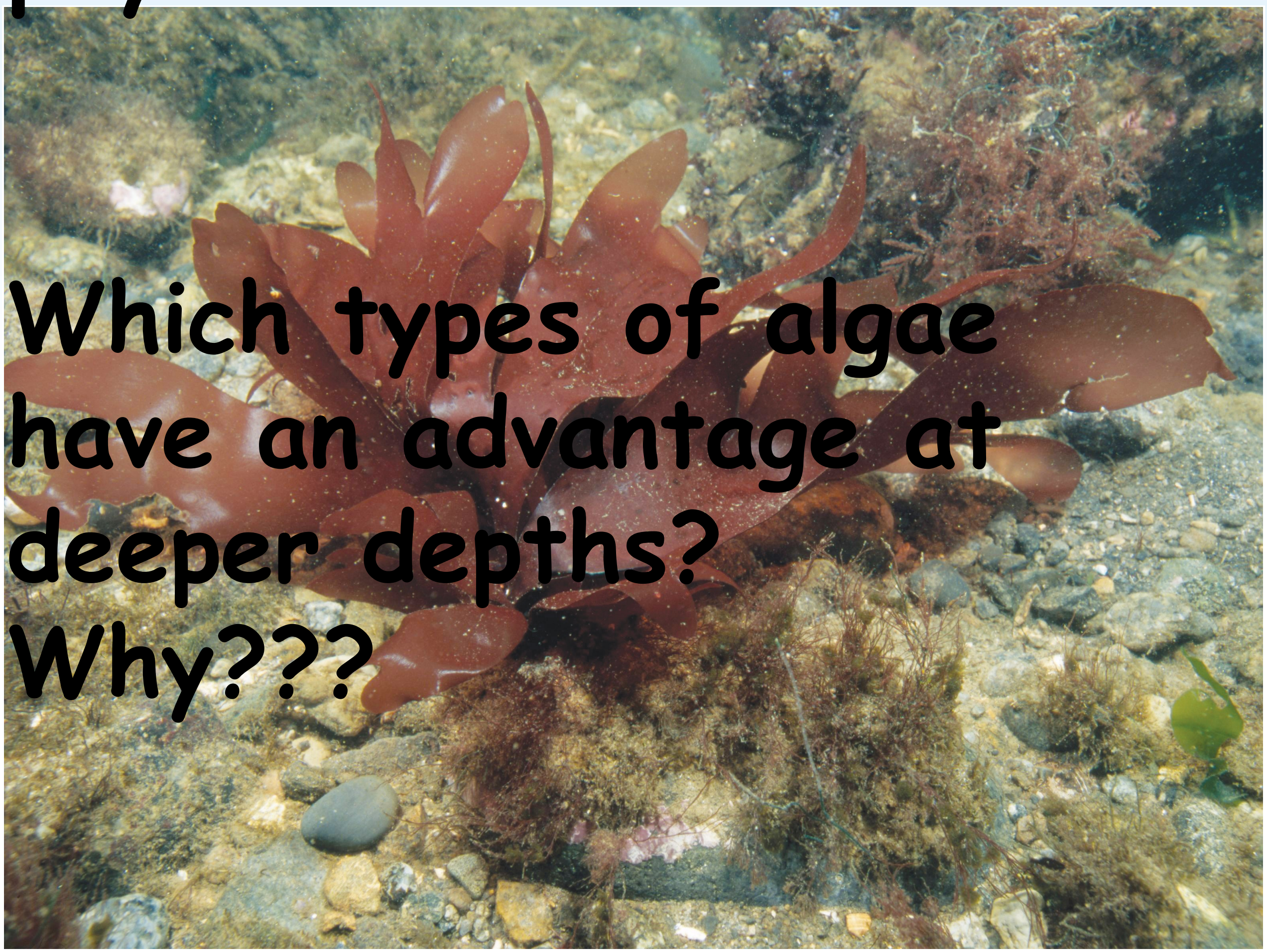
Fig. 7-10, p. 171

**Red because chlorophyll + phycobilins!!!**

# The Seaweeds

## Photosynthetic Pigments

- Appearance of Rhodophyta (red algae)



**Which types of algae have an advantage at deeper depths? Why???**

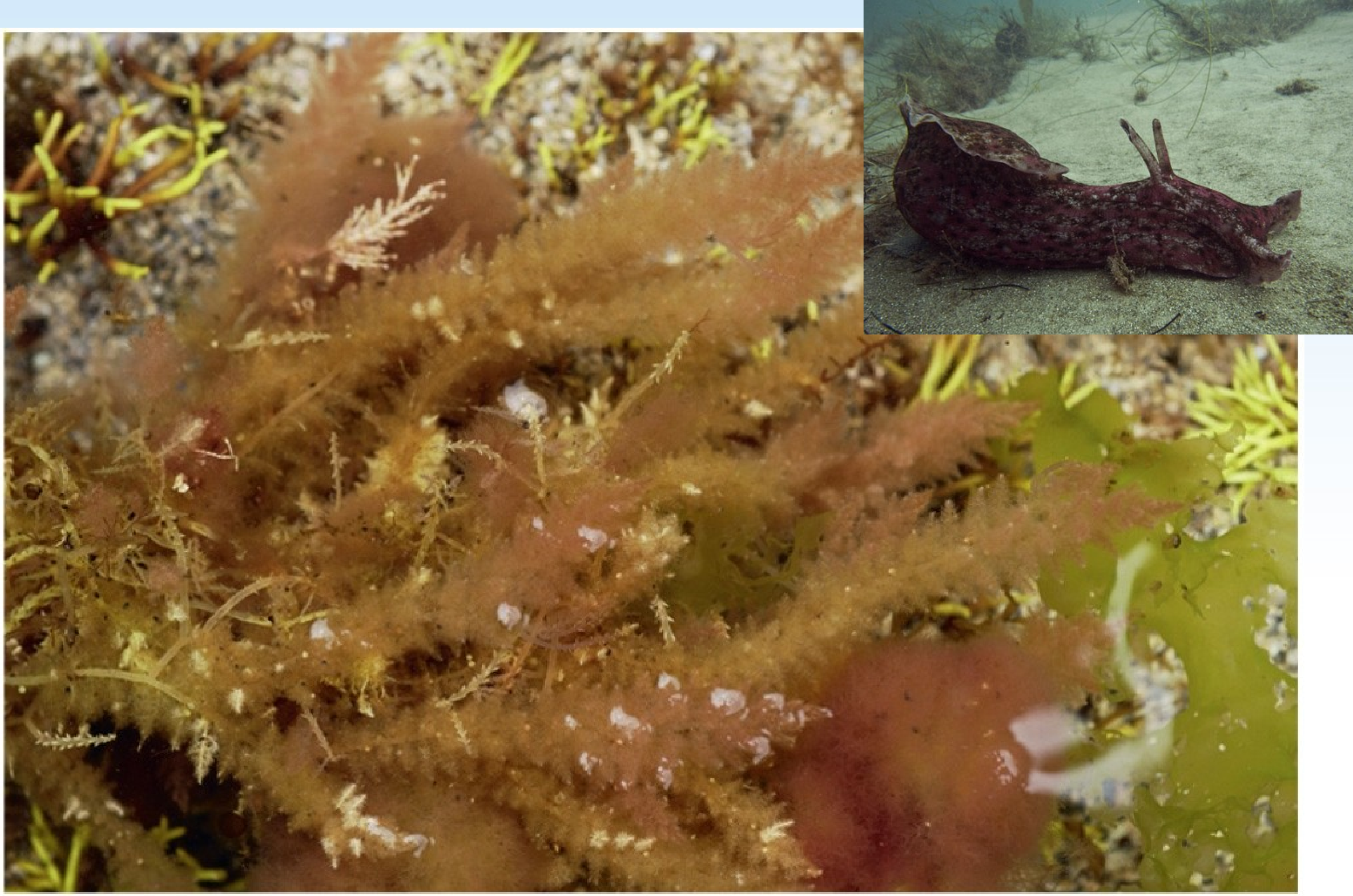
Fig. 4.16 Calcareous red alga, *Jania*, in a small tide pool.

(a)



***Porphyra***

Fig. 7-5, p. 167

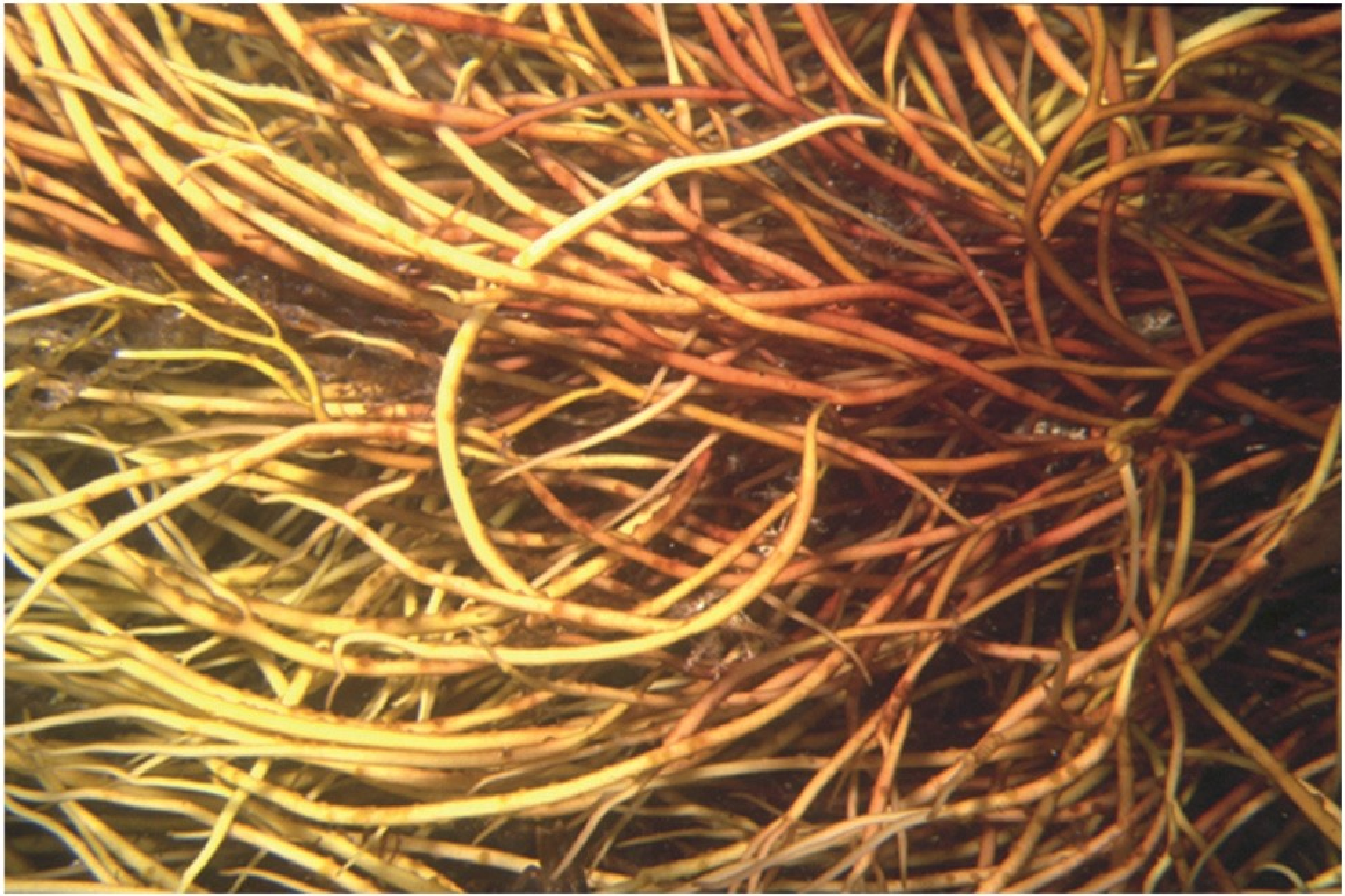


(b)

# *Asparagopsis* – a sea hare's favorite treat!



Fig. 7-5, p. 167

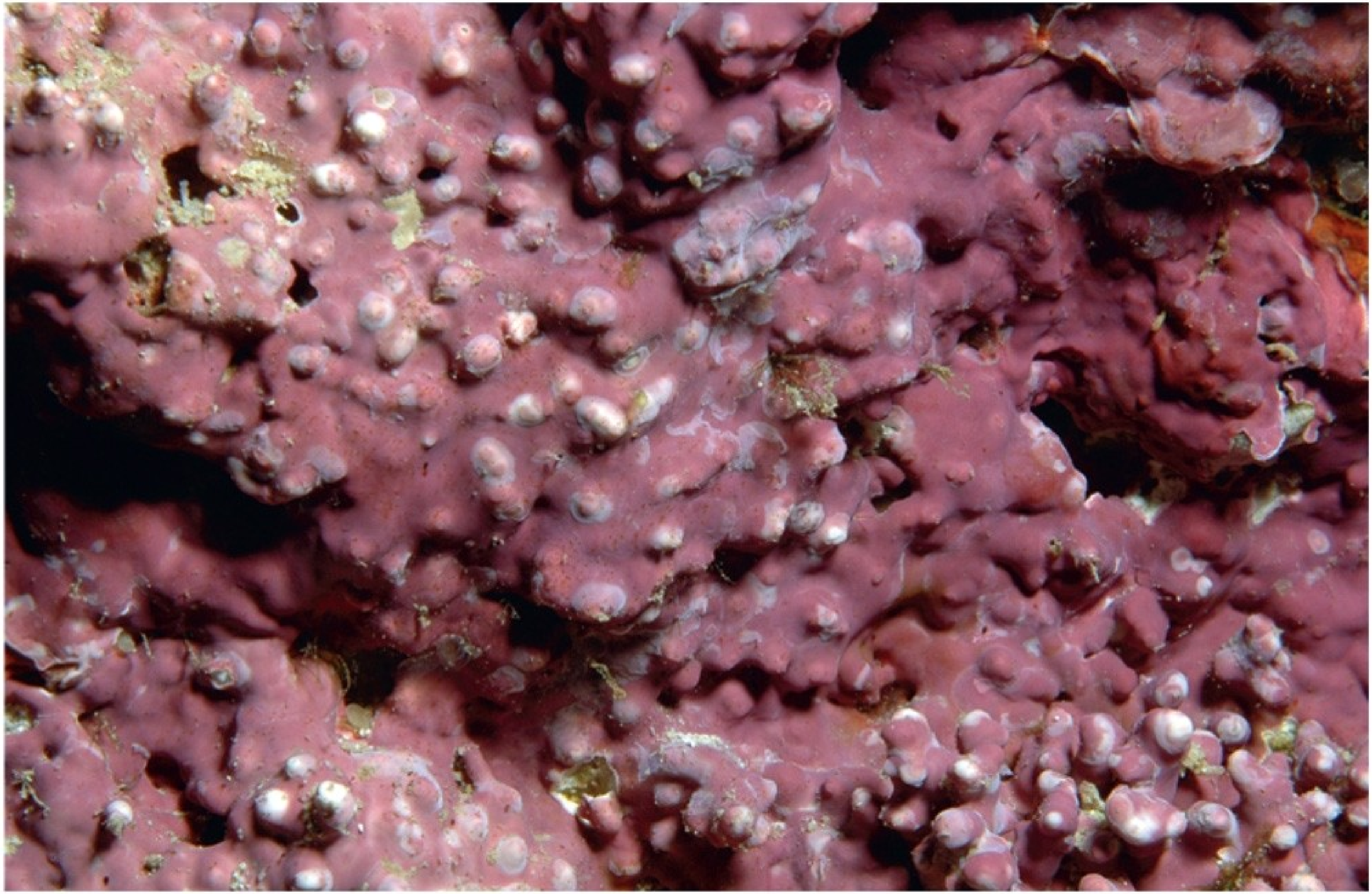


(c)

© 2010 Cengage Learning

# *Gracilaria*

Fig. 7-5, p. 167



(d)



***Porolithon* – encrusting coralline**

Fig. 7-5, p. 167

(e)



***Amphiroa* – branching coralline**

Fig. 7-5, p. 167

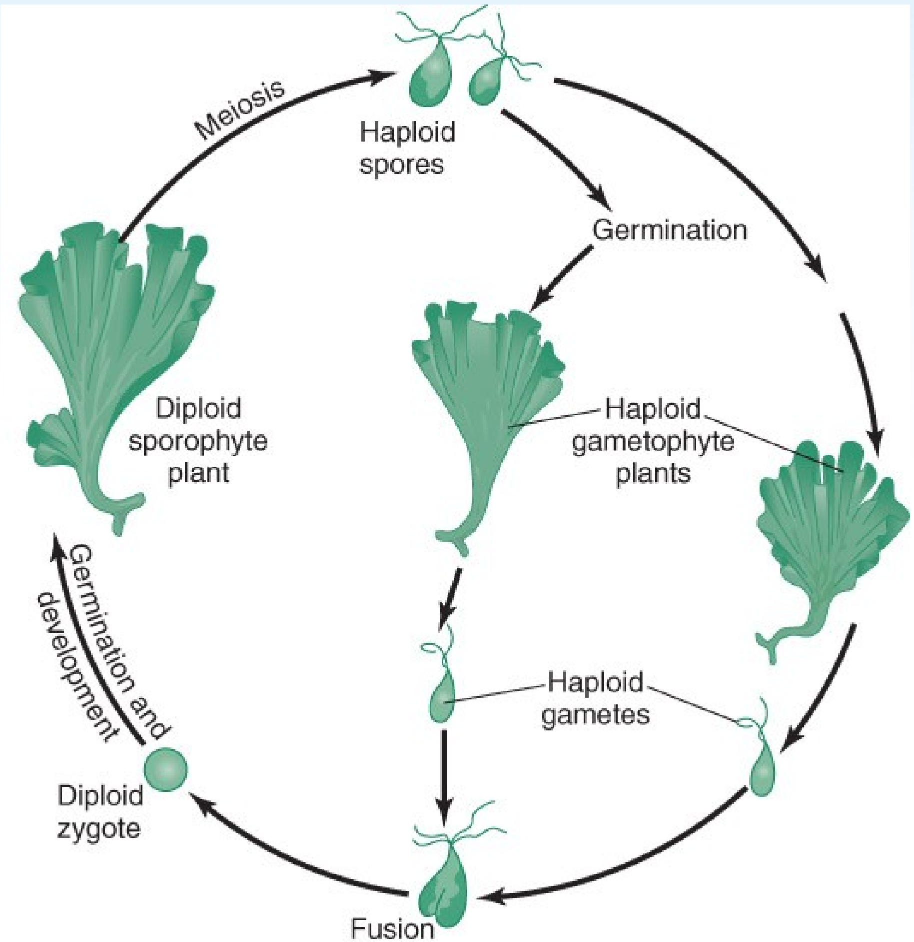
# The Seaweeds

## Reproduction and Growth

- Reproduction in seaweeds can be either:
  - asexual or sexual
- Sexual reproduction tends to follow three patterns, all variations of alternating generations – very similar to plant reproduction!
  - Sporophyte – diploid
  - Gametophyte – haploid
  - Carposporophyte – diploid (red algae only)

**What do sporophytes produce? Gametophytes?**

# The Seaweeds – alternation of generations




Sumich 8/e
Fig. 4.15

Ulva

Reproduction and Growth -

Green Algae

Sporophyte to gametophyte to sporophyte to gametophyte to sporophyte… etc. – more like primitive plants

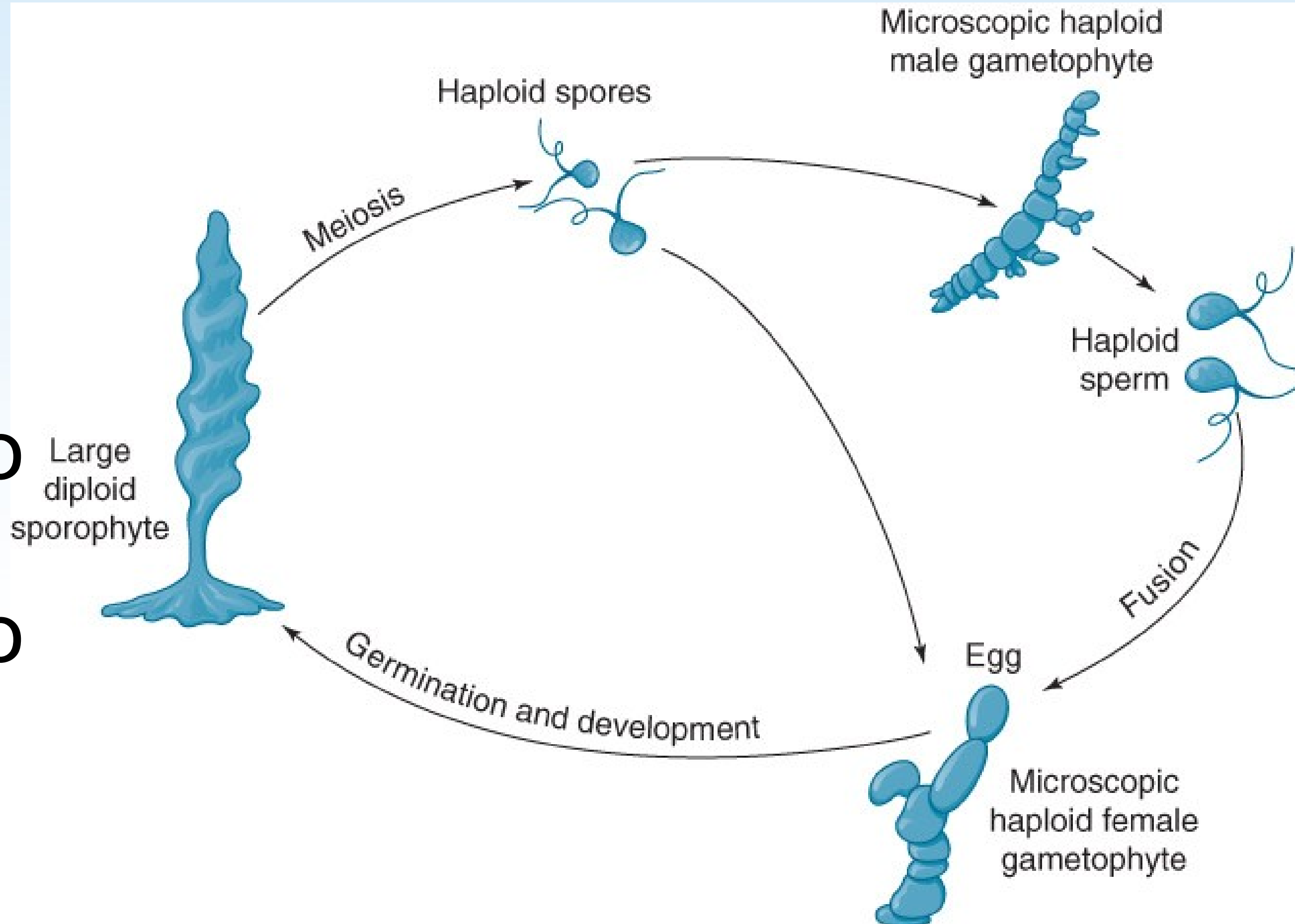
**Sporophytes look like gametophytes!!!**

# The Seaweeds

Reproduction and Growth -

Brown Algae

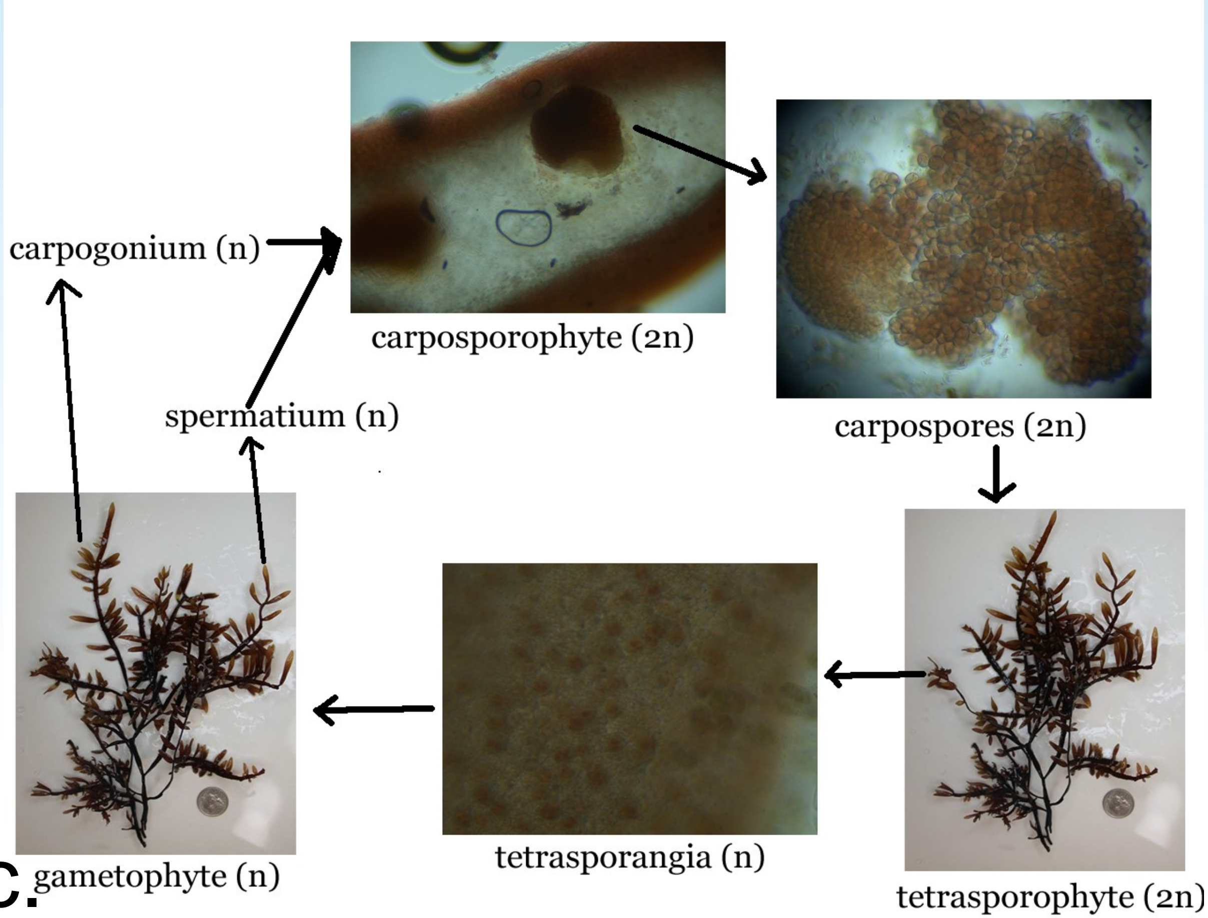
Sporophyte to gametophyte to sporophyte to gametophyte to sporophyte… etc.




*Laminaria* (similar to the cycles of other large kelps) alternates between large diploid sporophyte and **microscopic** haploid gametophyte generations – more like advanced plants!

# Reproduction and Growth - Red Algae

Sporophyte to gametophyte to carposporophyte to sporophyte etc.

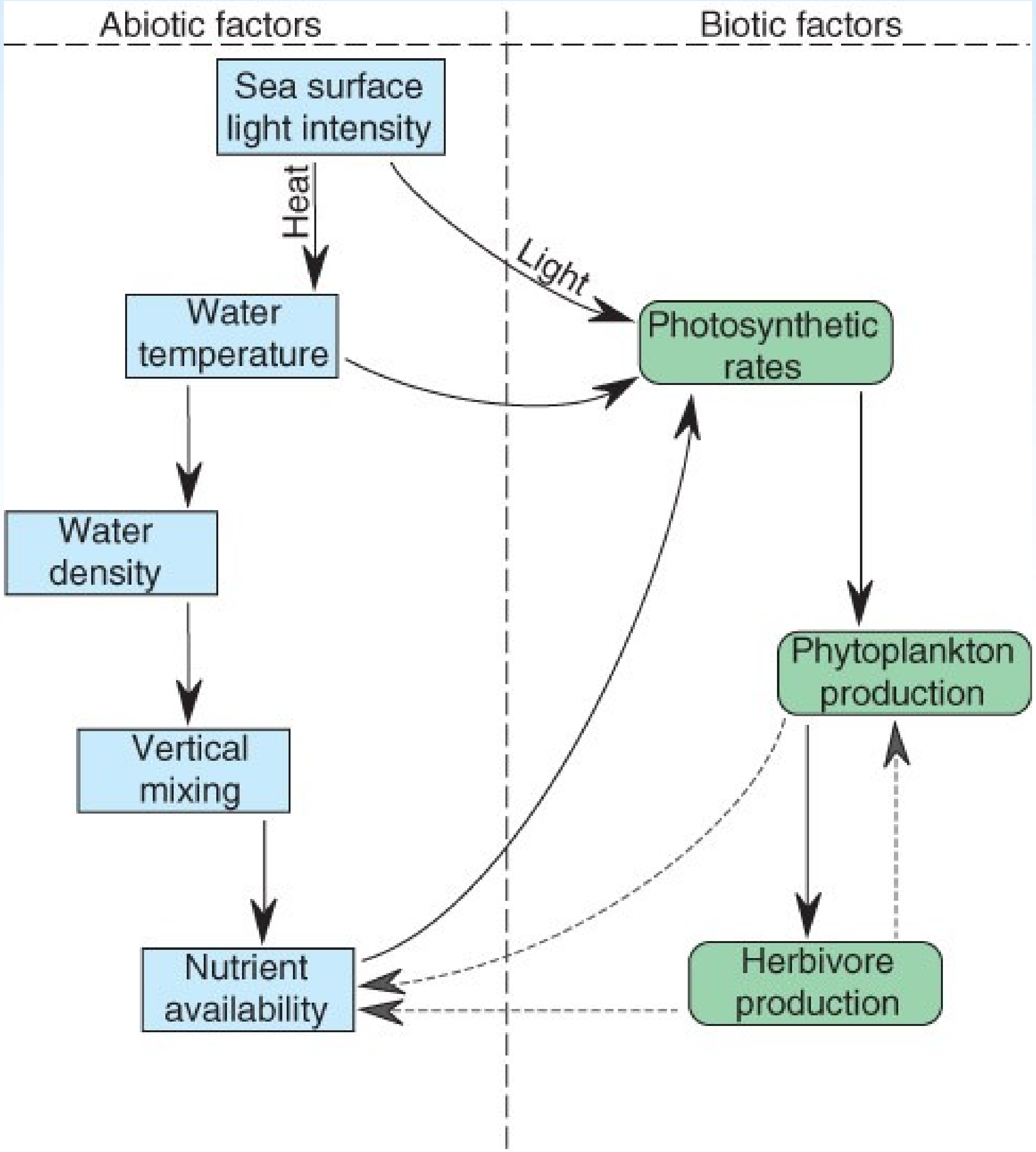


# The Seaweeds

Reproduction and Growth

**http://www.youtube.com/watch?v=fPsOB-sfCAY&feature=related**

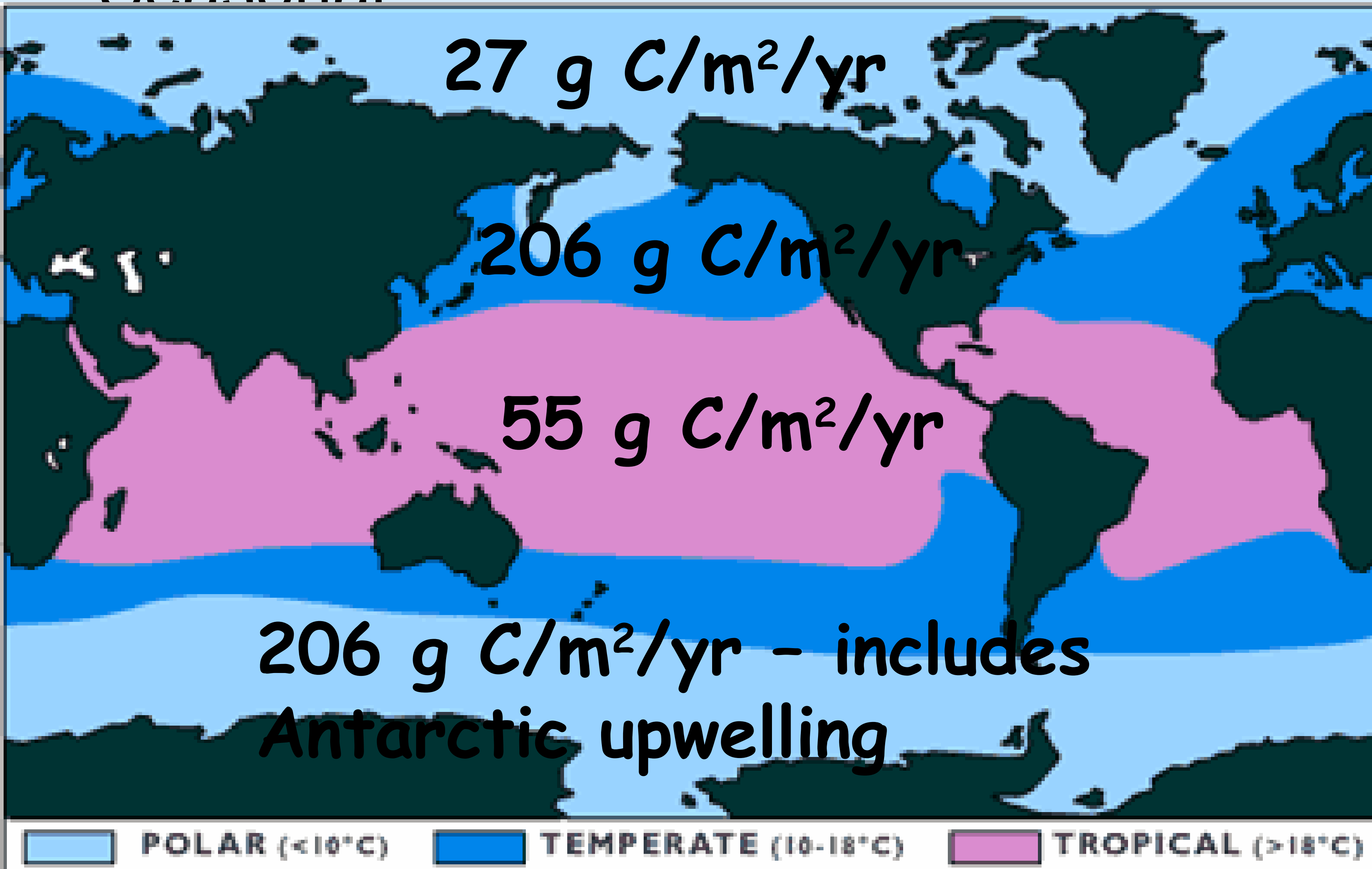
**Over 30 cm/day!!!**




# Seasonal Patterns of Marine Primary Production

**It begins with light!**
**Dotted lines = indirect effect**

Seasonal

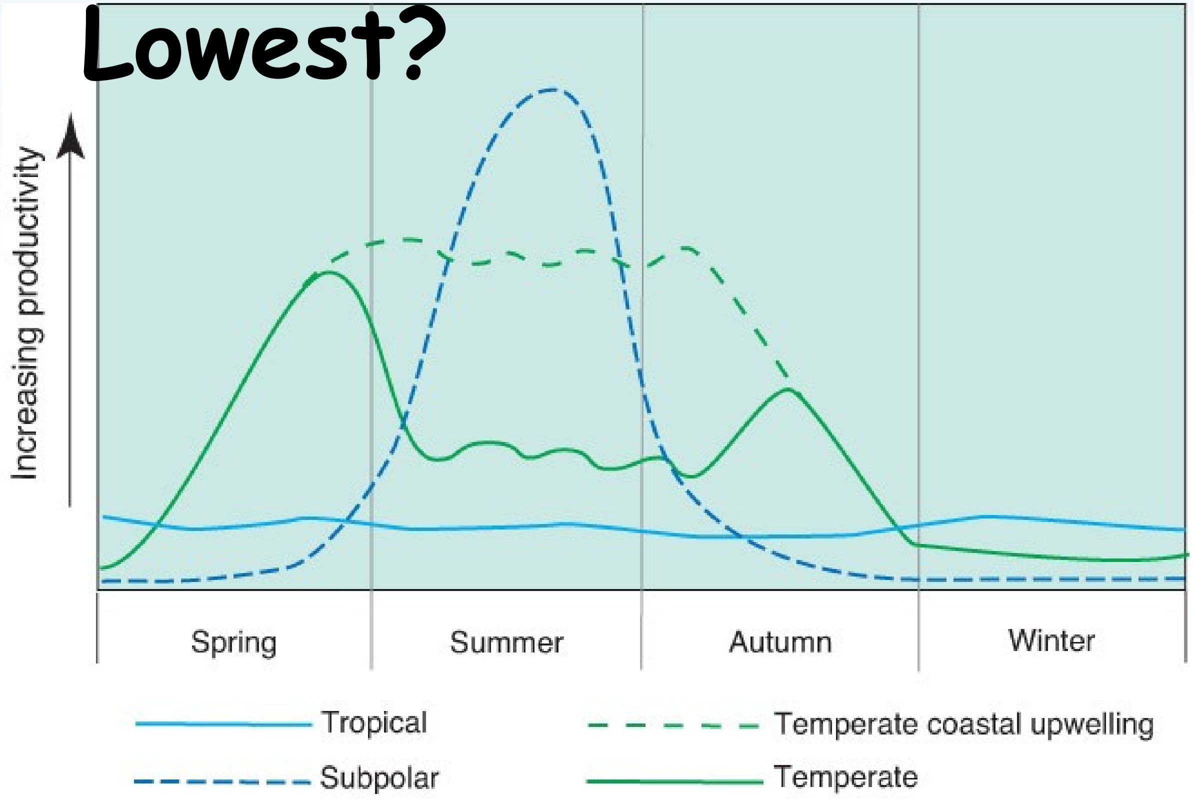



polar seas???

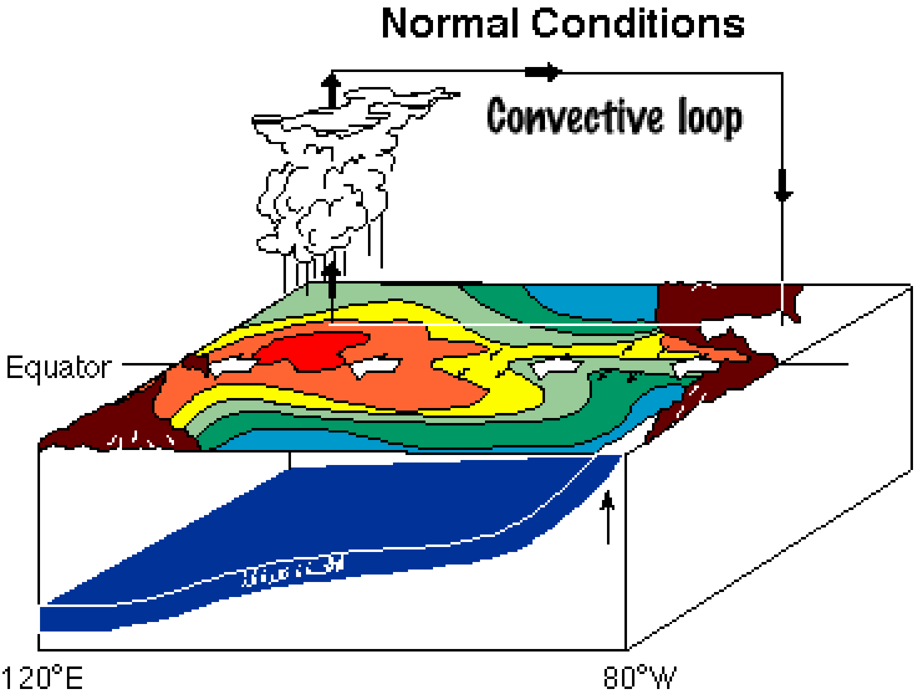
# Seasonal Patterns of Marine Primary Production

**Subpolar = cold**
**Tropical = warm**
**Temperate = us**
**Temperate upwelling = our coasts!**

**Where/when is Primary production highest? Lowest?**

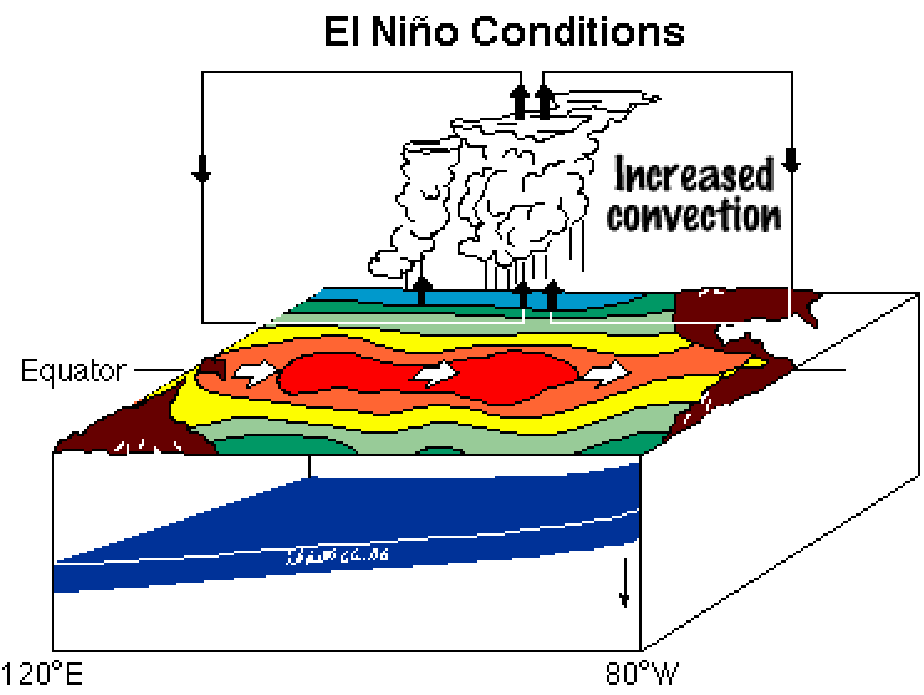


# s of Marine Primary uction




ıduction in areas of coastal
e highest in the sea.

geographic extent.




# Seasonal Patterns of Marine Primary Production – El Nino

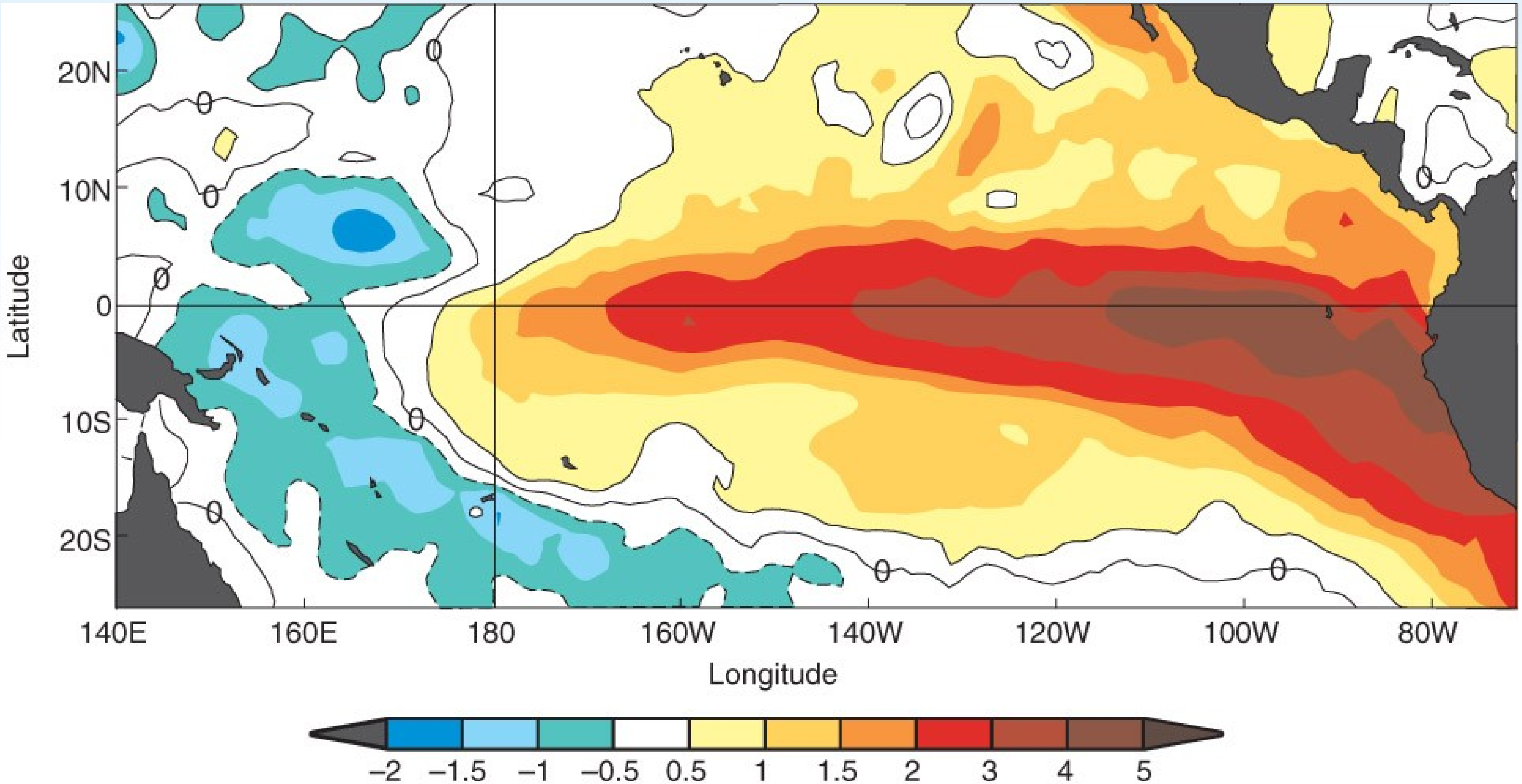



Fig. 4.27 Observed sea surface temperature anomaly, in degrees Celsius, in the Equatorial Pacific Ocean based on a 7-day average in mid-September 1997. Notice the tongue of unusually warm water extending westward from the coasts of Ecuador and Peru.

# Global Marine Primary Production – A summary!

- Spatial variations in primary production are common.
- seasonal variations as well!

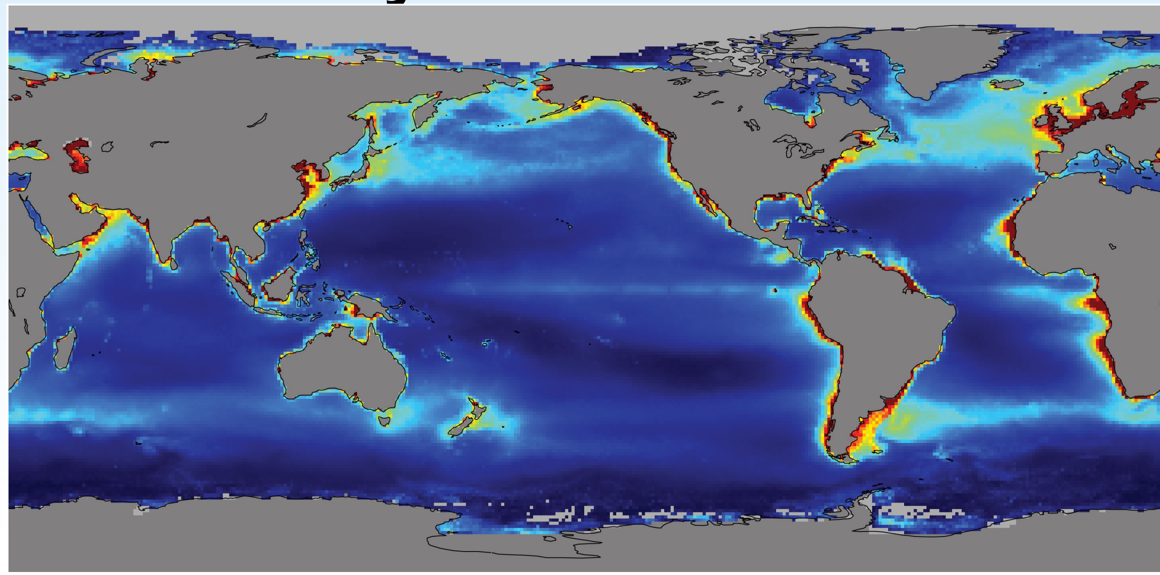


Table 4.2

**Rates of Net Primary Production for Several Ocean Regions**

| Region | Area (3 $10^6$ km$^2$) | Percentage of Ocean | Average (g C/m$^2$/yr) | Total NPP ($10^9$ tonnes C/yr) |
|---|---|---|---|---|
| Open ocean | | | | |
| Tropics and subtropics | 190 | 51 | 55 | 10.45 |
| Temperate and subpolar (including Antarctic upwelling) | 100 | 27 | 206 | 20.60 |
| Polar | 52 | 14 | 27 | 1.40 |
| Continental shelf | | | | |
| Nonupwelling | 26.6 | 7.2 | 290 | 7.71 |
| Coastal upwelling | 0.4 | 0.1 | 1050 | 0.42 |
| Estuaries and salt marshes | 1.8 | 0.05 | 975 | 1.76 |
| Coral reefs | 0.1 | — | 1410 | 0.14 |
| Seagrass beds | 0.02 | — | 937 | 0.02 |
| | | | | 42.50 |

Data from Longhurst et al., 1995; Pauly and Christensen, 1995; Field et al., 1998; and Gregg et al., 2003.

# Global Marine Primary Production

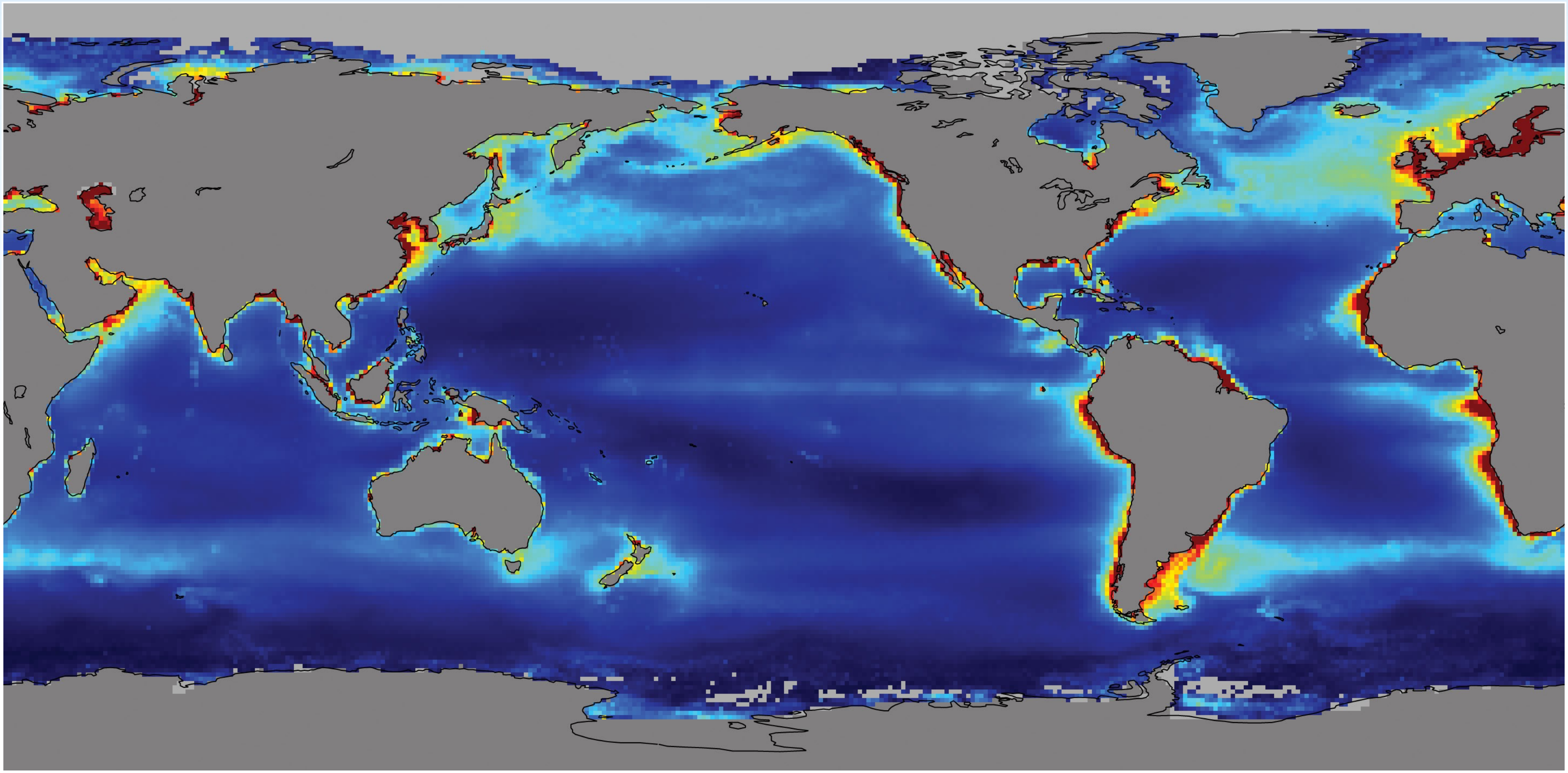


Fig. 4.28 The geographic variation of marine primary production, composed from over three years of observations by the satellite-borne coastal zone color scanner. Primary production is low (less than 50 g C/m²/yr) in the central gyres (magenta to deep blue), moderate (50-100 g C/m²/yr) in the light blue to green areas, and high (greater than 100 g C/m²/yr) in coastal areas and upwelling areas (yellow, orange, and red).

Images by Robert Simmon, NASA GSFC Earth Observatory, based on data provided by Watson Gregg, NASA GSFC