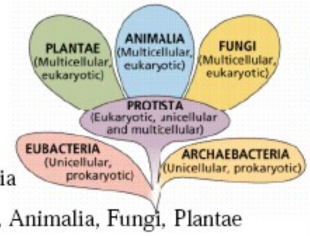
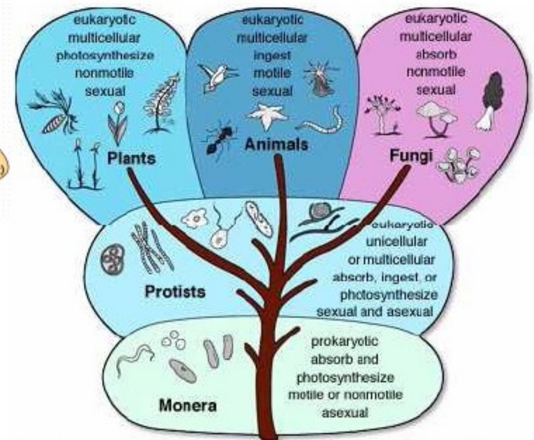
Classification Timeline

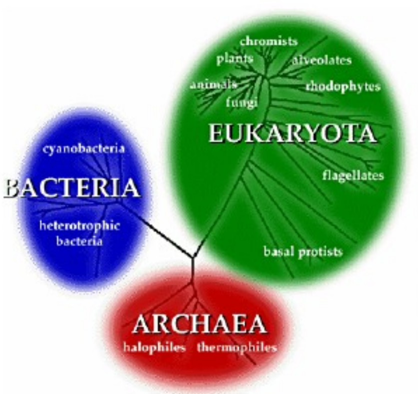


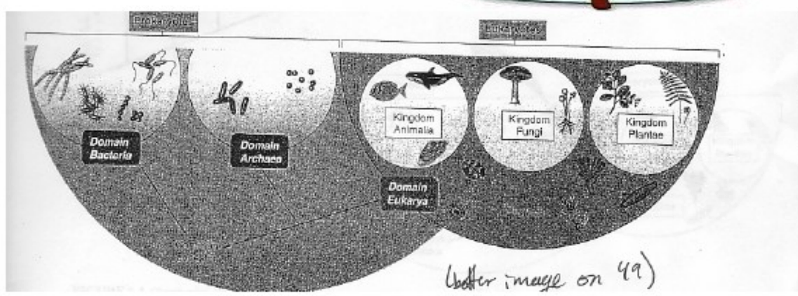
Original Kingdoms: Plantae & Animalia

→ Kingdoms: Plantae, Protista, & Animalia

→ the 5 Kingoms: Monera (Bacteria), Protista, Animalia, Fungi, Plantae







NOW: **Domains (Prokaryotes & Eukaryotes) & Protists & Viruses (Protists & Viruses don't really fall into either domain)**

In addition, analyses of the ribosomal RNA and certain other features of prokaryotic organisms affirm that they should be divided into two groups, called Domains.

Prokaryotes

1) **Eubacteria**: One domain is called the Eubacteria which contains most the common bacteria encountered in the environment.

2) **Archaea:** However, another separate group of prokaryotes has been recognized that differs from the Eubacteria in ribosomal RNA composition, cell wall structure, and metabolism. This Domain is referred to as the Archaea (from Greek meaning "ancient" although there is no definitive evidence that indicates they are older than the Eubacteria).

Eukaryotes

3) **Eucarya**: The third Domain, the Eucarya contains all eukaryotic organisms.

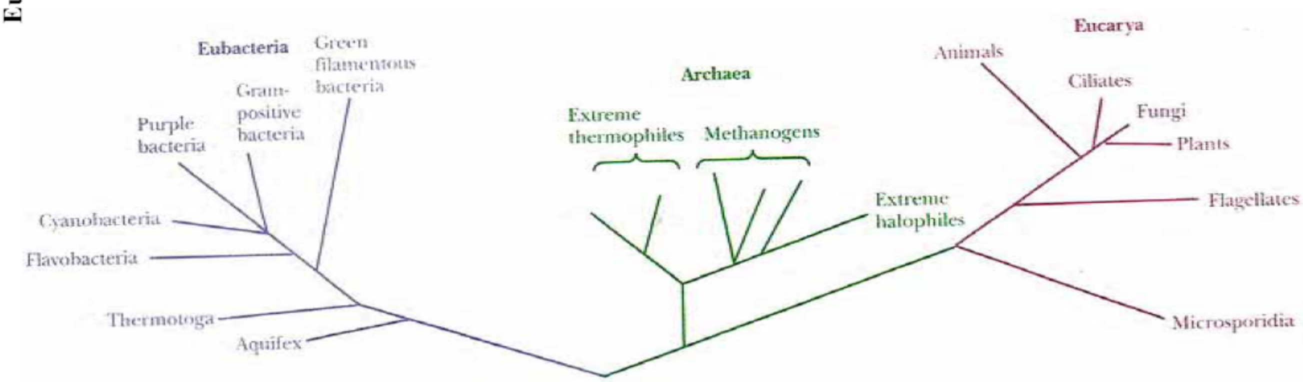


Table 1.2 Characteristics of prokaryotes versus eukaryotes

Characteristic	Prokaryote	Eukaryote
Nuclear structure and function		
Nucleus with bounding membrane	No	Yes
Chromosomes	One	> 1
Mitosis	No	Yes
Sexual reproduction	Rare; only part of genome exchanged	Common; entire chromosome exchanged
Meiosis	No	Yes
Cytoplasmic structure		
Mitochondria	No	Yes[1]
Chloroplasts	No	Yes (if photosynthetic)
Ribosomes	70S	80S[2]
Typical cell volume	$< 5\ \mu m^3$	$> 5\ \mu m^3$

[1]A few primitive eukaryotic microorganisms lack mitochondria.

[2]Some rare, primitive eukaryotic microorganisms have 70S ribosomes.

Growth in the Environment

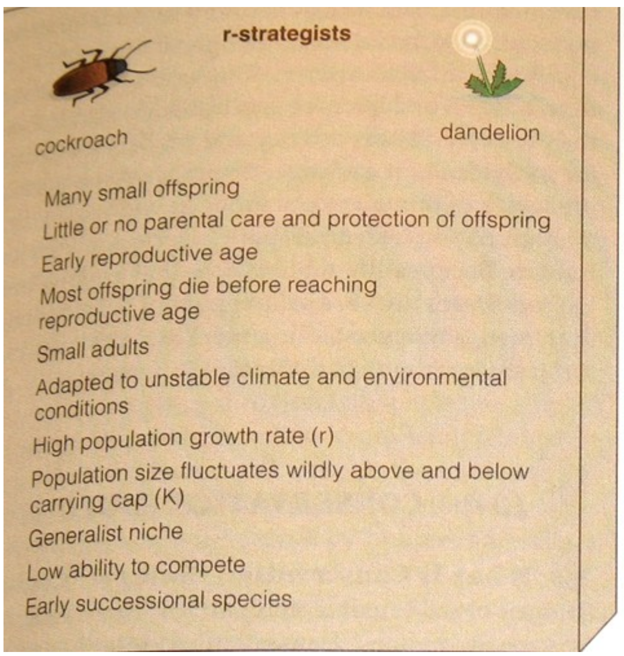
- Sergei Winogradsky (1856-1953), the of father of soil microbiology, introduced the ecological classification system of **autochthonous** versus **zymogenous** organisms.
    - **Zymogenous** (r): adapted to intervals of dormant and rapid growth, depending on substrate availability
    - **Autochthonous (K):** metabolize slowly in soil, utilizing slowly released soil organic matter as a substrate

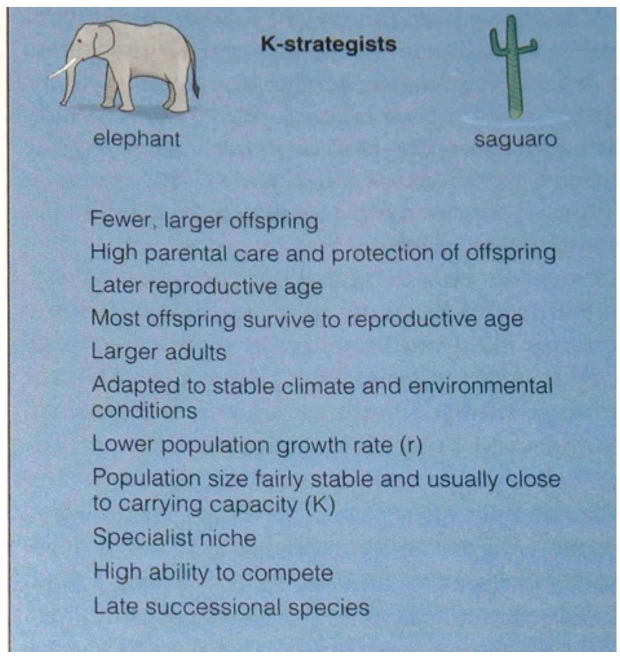
- The most recent theory of classification is founded on the concept of **r and K** strategists.

R-Strategists: "The Invadors." Organisms that respond to added nutrients with **rapid growth rates** and correspond to the older definitions of **zymogenous** or copiotroph.

K-strategists: "The resource monitors" are characterized by a high affinity for nutrients that are present in low concentration, corresponding to the older definitions of **autochthonous** or oligotroph.

- In addition to these two categories, there are the **allochthonous** (introduced) organisms, which are organisms that are introduced into the environment. These are r-strategists





Growth-Rate Models (pp 202-203)

- Basically four models to choose from: 1) **Linear**, 2) **Exponential**, 3) **Logistic**, and 4) **Michaelis-Menten**.

- All have their applications, but it essential that you realize that you are dealing with mixed populations and a single, homogenous organism as is usually done in the laboratory. Interestingly, the theory and the results do work out.

1) Linear growth

- One ordinarily does not think of microbes growing in a linear fashion, but communities have been observed to increase in numbers in a linear fashion.
- This seems to be a model that favors the observations in estuarine locations (why?).

2) Exponential growth

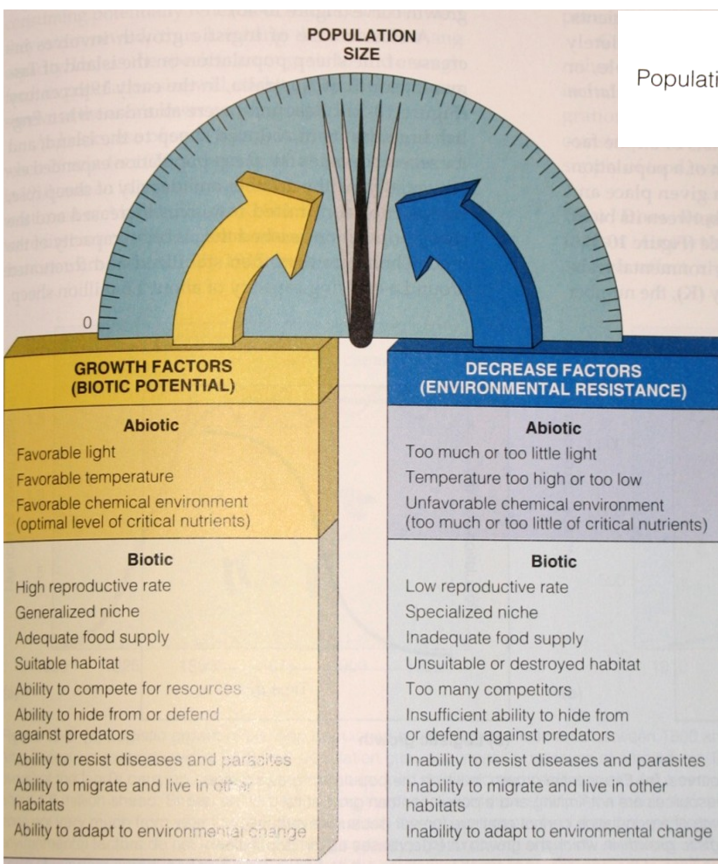
- This is the most commonly observed growth model, and one which is readily observed in natural environments.

3) Logistic growth

- Essentially this is a continuation of the exponential model, except that it takes into consideration that a population cannot continue to grow forever, and must eventually reach some sort of equilibrium or decline.

4) Michaelis-Menten kinetics

- This model has been used to study the turnover of radiolabeled organic carbon compounds (eg; glucose, glutamic acid, acetate).
- It enables one to determine the naturally occurring concentrations of these compound as well as determine their turnover time.



$$\text{Population change} = \begin{pmatrix} \text{Births} \\ + \\ \text{Immigration} \end{pmatrix} - \begin{pmatrix} \text{Deaths} \\ + \\ \text{Emigration} \end{pmatrix}$$

Marine vs. Terrestrial

	Ocean	Land
Temperature	**Thermally stable** (for the most part) 1.9°C / 35°C (general range of 3-5°C) - *Thermophillic Bacteria* (grows at +50°C) can be - found in the ocean at the thermal vents - generally temperature isn't a big deal for microbes	**Thermally Unstable** -88.33°C / 65.55°C
Pressure	**Large pressure differences** 1ATM – 400ATM at depth(~6,000PSI) - barophillic bacteria have evolved such that they need pressure to grow	**Little pressure differences**
Water Activity		
Light	**Limited** to the top 150m - Light is required for photosynthesis (~545-560nm) - thus primary production is limited	**Intense**
Bioluminescence	**Common** (Bacteria, fish, dinoflaggelates, protozoans) - avoid predation - communication - attract prey - mating	Fairly **Uncommon** (Fireflies and Cave Fungi)
Radiation (UV)	No problem	Big problem (global warming, skin cancer, etc.)

Community Ecology: late 1800's, statistics was being re-examined with a focus on quantifying comparisons

Biocenosis

Hierarchy: there are **feedbacks** (outcome of process regulates the process) between the levels (ex. hormone systems are feedbacks b/w Organs & Tissues)

- **Community:** obligatory relationships (acts as a super organism)
- **Species:** almost synonymous with metapopulations
- **Metapopulations:** sum of isolated populations
- **Population**: interbreeding group of organisms
- **Organism**
- **Organs:** self-regulating
- **Tissues**
- **Cells**
- **Organelles**

Community concept is promoted by terrestrial plant ecologists

- **Clements**:
  - looked at US Plant communities and made maps of them
  - If you modify the assemblage they'll return to a predictable type/stage by means of predicable sequences
  - Succession → climax species
  - **Clementian View:** obligatory, superorganism, deterministic, **biological control**
- **Gleason**:
  - studied altered plant communities, found that they didn't always (or even usually) return to the same state

- Clementian View isn't reliable because it can be rigorously tested
- **Gleason View:** communities are formed through random, common needs, and **physical controls**

★ The "Microbial Loop"

- there is ~100x more DOM than bacteria
    - breakdown of DOM is refractory
- Bacteria are the only organisms able to breakdown & recycle the DOM
- However, this is not the only function of bacteria, as previously thought, bacteria are also part of the food web (they are eaten by Bacterivorous Zooplankton)

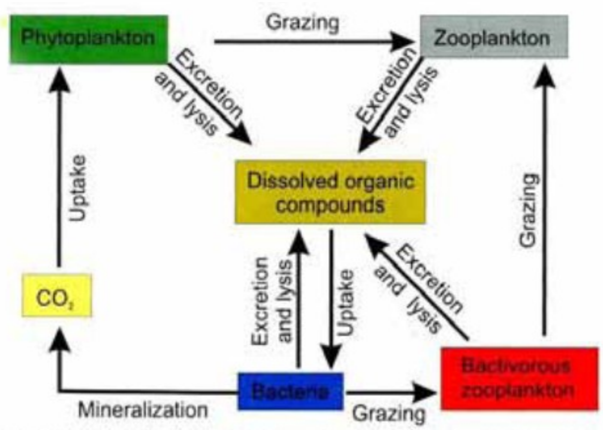
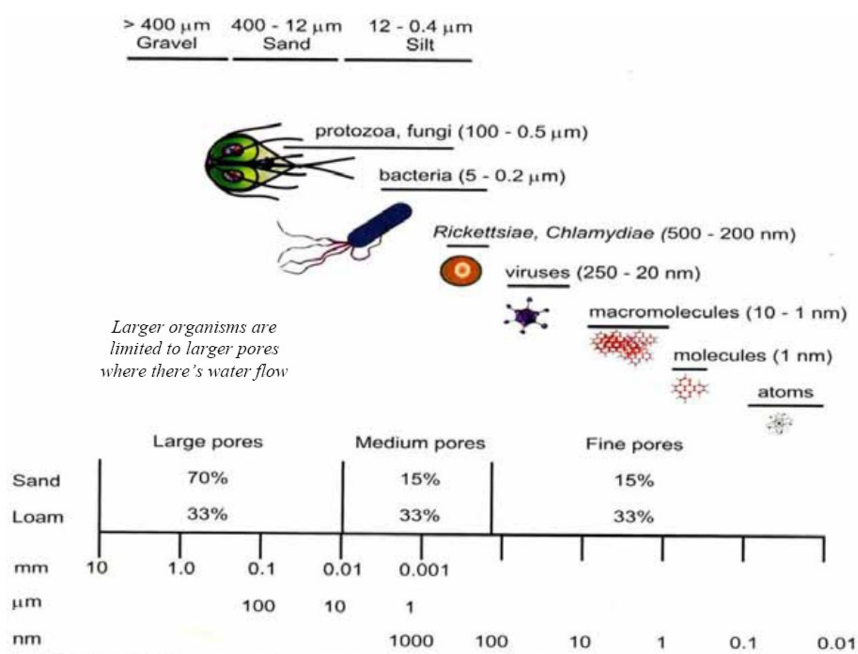


FIGURE 6.1 The microbial loop in the planktonic food web. The microbial loop represents a pathway in which the dissolved organic products are efficiently utilized. The role of bacterioplankton is to mineralize important nutrients contained within organic compounds and to convert a portion of the dissolved carbon into biomass. Grazing by bactivorous protozoans provides a link to higher trophic levels. (Modifed from Fuhrman, 1992.)

Relative size of microbes in comparison to the mineral pore size in which they are found



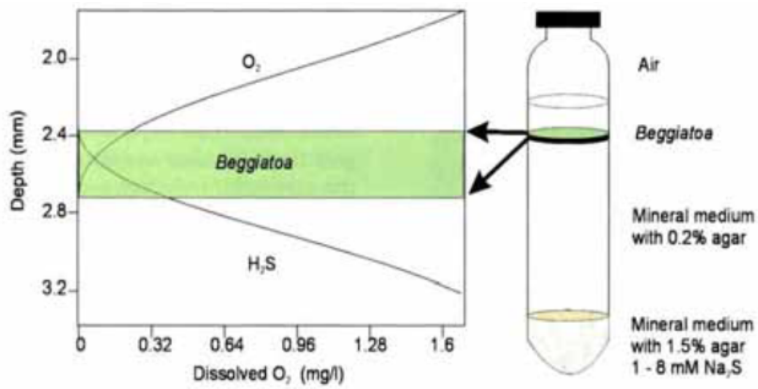


FIGURE 14.14 Cultivation of the sulfur-oxidizing chemolithotroph *Beggiatoa*. At the right is a culture tube with sulfide agar overlaid with initially sulfide-free soft mineral agar. The airspace in the closed tube is the source of oxygen. Stab-inoculated *Beggiatoa* grows in a narrowly defined gradient of H_2S and oxygen as shown. (Adapted from *Microbial Ecology* by R. M. Atlas and R. Bartha. © 1993 by Benjamin Cummings. Adapted by permission.)

Beggiatoa is a sulfur oxidizing chemolithotroph

- As they grow they accumulate sulfur internally
- They grow at the interface between O_2 & H_2O
- They're found along the Gulf of Mexico where there are oil platforms
- They're often in the form of orange mats
- Beggiatoa is a gradient organisms
- It is chemosynthetic (not photosynthetic)

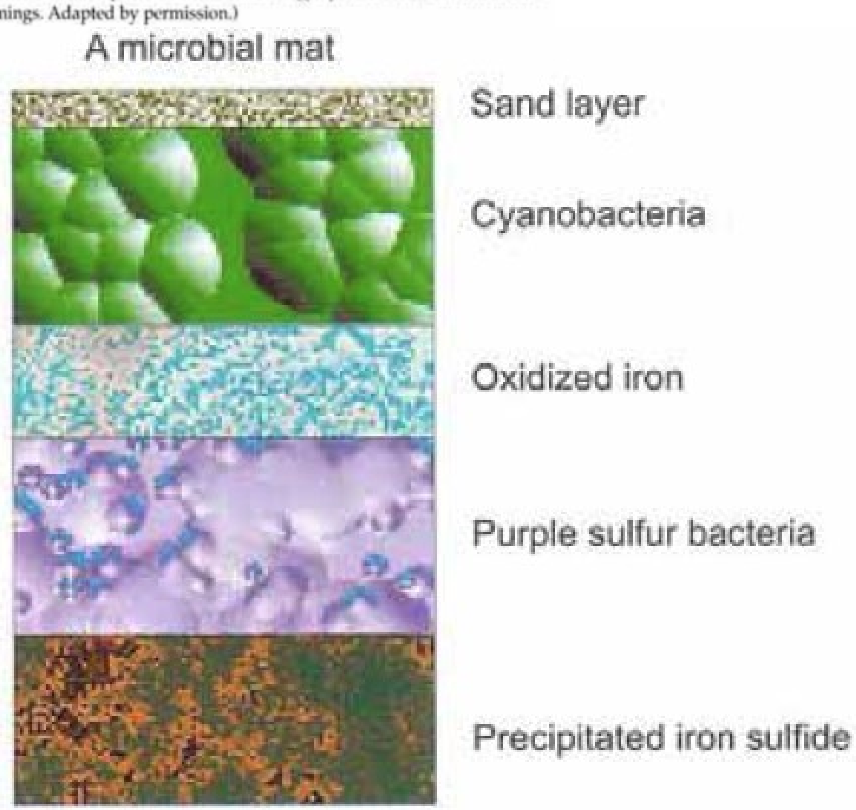
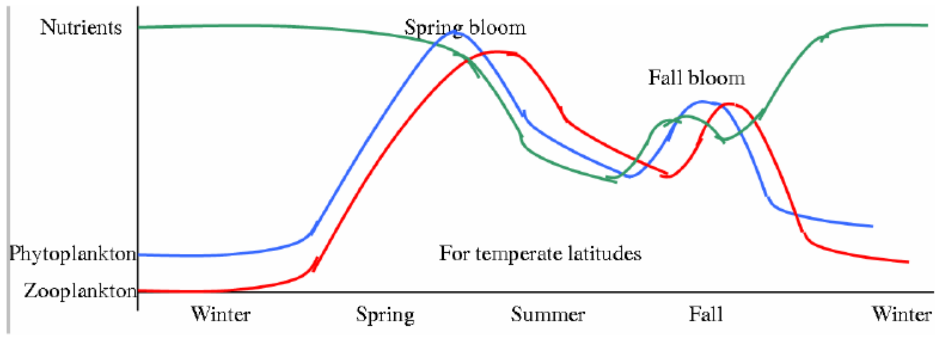


FIGURE 6.4 Schematic drawing of a microbial mat. Cyanobacteria form the surface layer of the microbial mat but may be covered by a layer of sediment, organic debris, or even cyanobacterial sheaths containing a pigment that acts as a sunscreen, blocking excessive ultraviolet radiation. Often a layer of oxidized iron appears below the cyanobacteria, followed by a layer of purple sulfur bacteria that thrive under anaerobic conditions. An extensive zone of sediment enriched in iron sulfide is often present.

The Spring Bloom



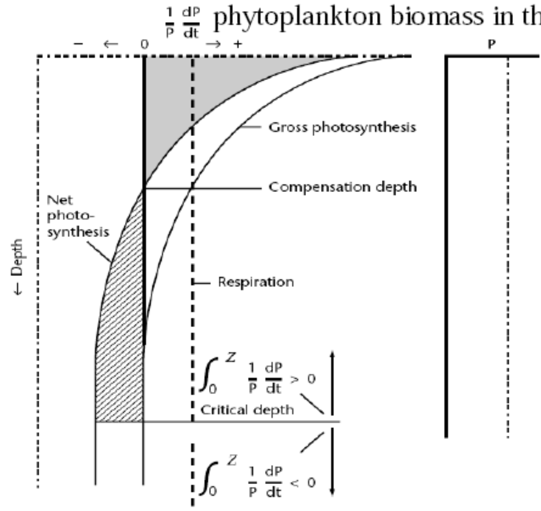
The things that contribute the most to this shift are: 1) ↓ light intensity 2) ↓ heat 3) ↑ wind / storms

Also watch the interactions between phyto- and zooplankton

Winter: no seasonality = no mixing
Spring: Surface waters warm → Seasonal Thermoclyine → ↑ productivity b/c ↑ water column stability =↑ time in the photic zone
Summer: zooplankton eat the phytoplankton and all the nutrients have been exhausted
Fall: winter storms start while water is still warm → ↑ mixing → destroys seasonal T.C. → ↑nutrients = **Vernal bloom**

Critical Depth Theory

History: - Gran measured the Photic Zone using the light-dark bottle method measuring O2 production and considered the problem from a community perspective → **Compensation Depth** (where photosynthesis = respiration ...~20m**)**
- Riley (1946) recognized the importance of stratification in initiating the spring bloom
- Sverdrup (1953) proposed the **critical depth** model to explain the rapid growth and accumulation of phytoplankton biomass in the spring.



Assumptions of the Critical Depth theory:

1) Homogeneous distribution of phytoplankton in water column
2) Nutrients are abundant - initially yes.
3) k is constant with depth
4) Photosynthesis is proportional to I (no photoinhibition)
5) Respiration is constant with depth
6) No heterotrophs

Critical Depth: Above Critical Depth $\Sigma P > \Sigma R$, below it $\Sigma P < \Sigma R$.

Mixing Depth: if its above the Critical Depth → possible bloom;
if its below the Critical Depth → no bloom