Ecosystem

Today's lecture

- Terminologies related to ecosystems
- Human influence on ecosystems
- Nutrient cycle
- Lake dynamics
- Bacterial population growth

Some terminologies

- Ecosystems: communities of organisms that interact with one another and with their physical environment
- Habitats: the place where a population of organisms lives
- Population: a group of organisms of the same species living in the same place at the same time

Human influence on ecosystems

- Destruction of habitats: deforestration, dam construction, road construction, etc.
- Changes in species population: toxic chemical release, introduction of nonnative species, excessive hunting, etc. (can lead to species extinction)
- Shifts in living conditions: global warming, acid rain, eutrophication, etc.

DDT and Silent Spring

1874: DDT first synthesized by O. Zeidler

1939: P. H. Müller discovered the insect killing ability and won Nobel Prize (1948)

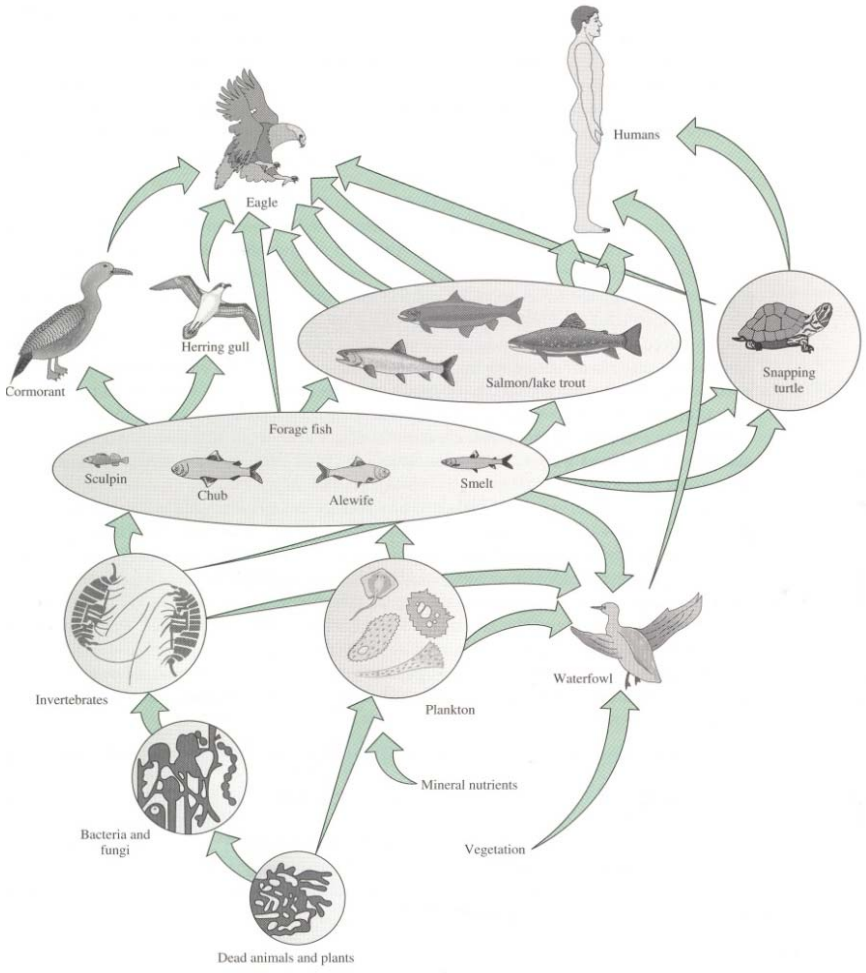
1940s: Widely used as an insecticide (especially for lice-Typhus and mosquito-malaria)

1962: Rachel Carson published “Silent Spring” - described how DDT accumulates in organisms and affect wildlife

1960s: Environmental scientists published researches to support R. Carson’s argument (egg shell thinning by DDT)

1972: DDT banned in the U.S.

Food web and bioaccumulation



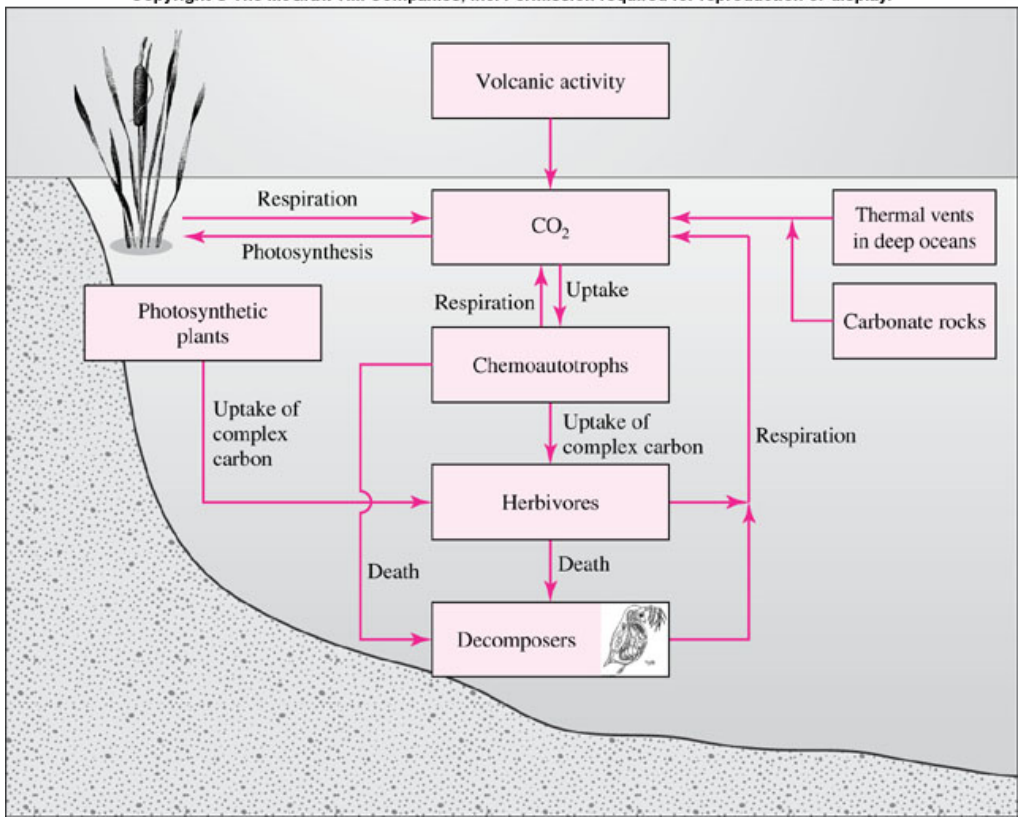
- Chemical accumulation in organisms can result in much higher concentrations in higher trophic level organisms (ex: DDT is stored in the body's fat and is excreted very slowly)

Terminologies related to bioaccumulation

- Bioaccumulation: total uptake of chemicals by an organism from either water or food
- Biomagnification: a process that results in accumulation of a chemical in an organism at higher levels than are found in its own food
- Bioconcentration: the uptake of chemicals from the dissolved phase

Nutrient cycle: C cycle

- Basic building block of life
- Major carbon sink: ocean

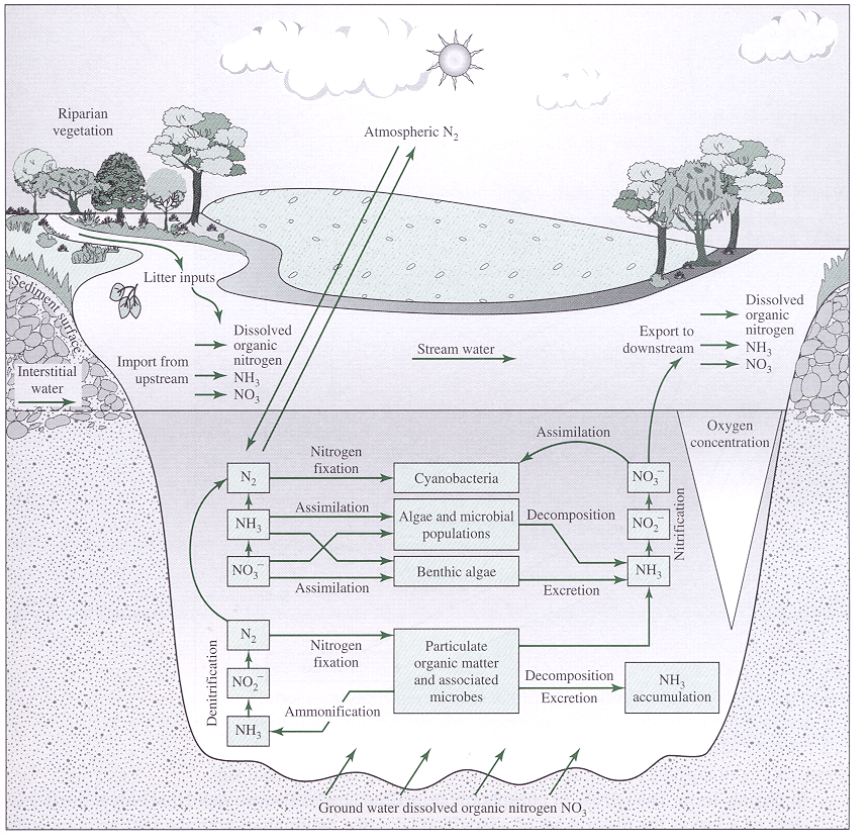


- Relevant processes

- photosynthesis: convert CO_2 to organic matter
- respiration/decay: convert organic matter to CO_2
- fossil fuel combustion: significant input of CO_2 by humans
- settling of dead organisms

Nutrient cycle: N cycle

- Critical element for all lives (protein)
- N_2 in the air: abundant, but not easily available to organisms



- Relevant processes

- nitrification

$NH_4^+ + 2O_2 = NO_3^- + 2H^+ + H_2O$

- denitrification

$2NO_3^- + \text{organic C} = N_2 + CO_2 + H_2O$

- nitrogen fixation

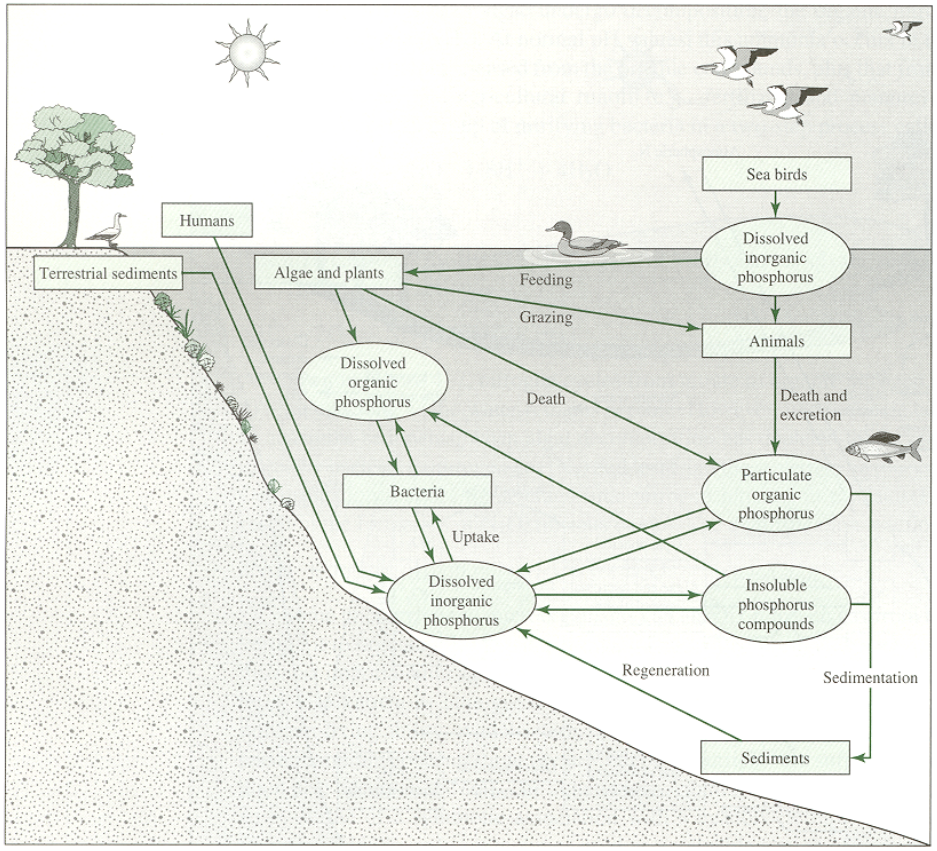
$N_2 + 8e^- + 8H^+ + ATP \rightarrow 2NH_3 + H_2 + ADP + \text{inorganic P}$

- significant human contribution: Haber-Bosch process

$N_2 + 3H_2 \rightarrow 2NH_3$

Nutrient cycle: P cycle

- Another essential nutrient (DNA, RNA, ATP)



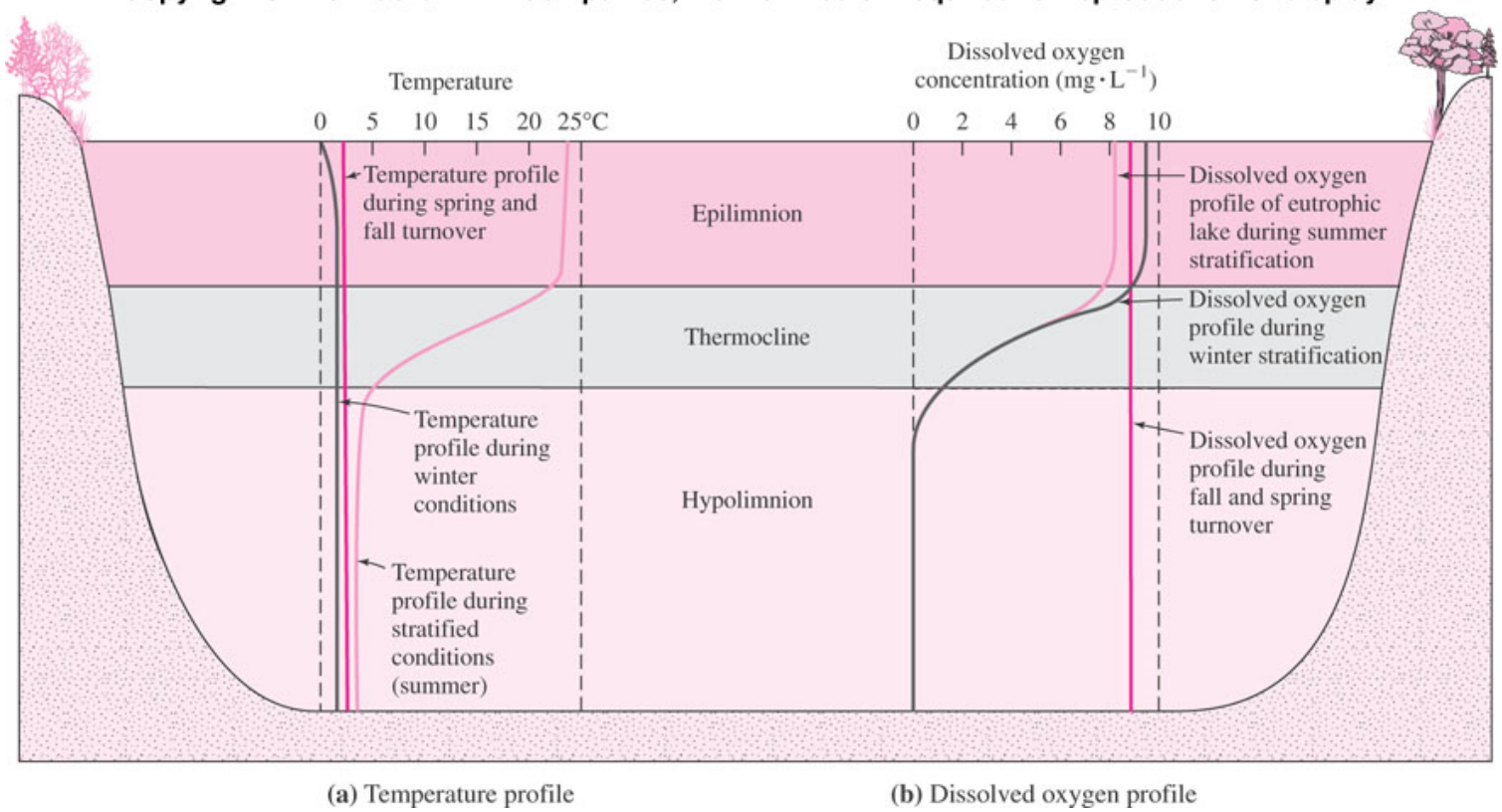
- Relevant processes
  - input from mineral weathering or human contribution (fertilizer, etc.)
  - uptake by plants and algae in a soluble inorganic form (HPO_4^{2-}, PO_4^{3-}, etc.)
  - loss by sediment burial

Lakes

- Seasonal changes
  - responds to seasonal air temperature changes
  - *stratified* during the summer and *overturn* in the fall in temperate climates
  - dissolved oxygen profile is created by the stratification

Lakes

- Seasonal changes



Lake productivity

- Lake productivity: a measure of a lake's ability to support aquatic life (a more productive lake has a higher biomass concentration)
- Controlled by the limiting factor ("Liebig's law of the minimum"*)

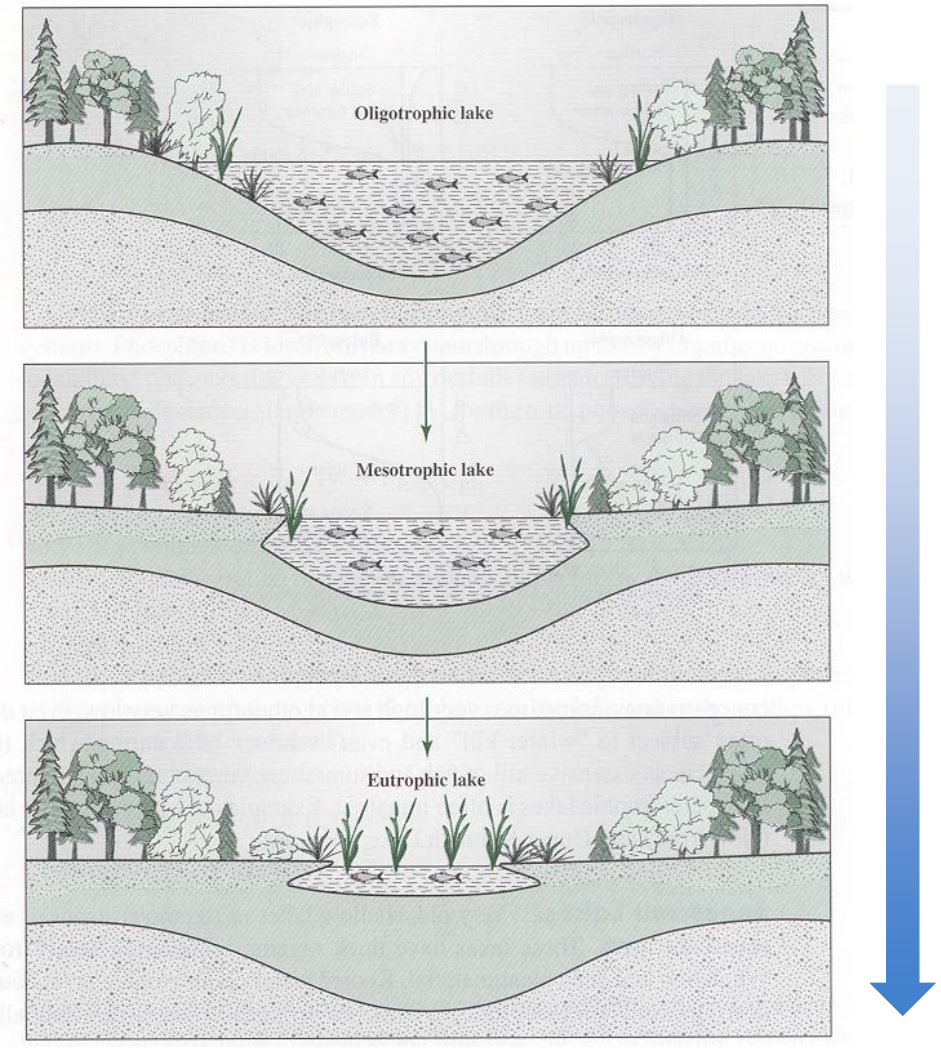
  * *Liebig's law of the minimum*: growth is controlled not by the total amount of the resources available, but by the scarcest resource (limiting factor).

Eutrophication of lakes

- Natural eutrophication: A natural aging process of a lake; may take over thousands of years (an unpolluted lake)

- Cultural eutrophication: accelerated eutrophication through the introduction of high levels of nutrients (a polluted lake)

Natural eutrophication



lake productivity increases over time

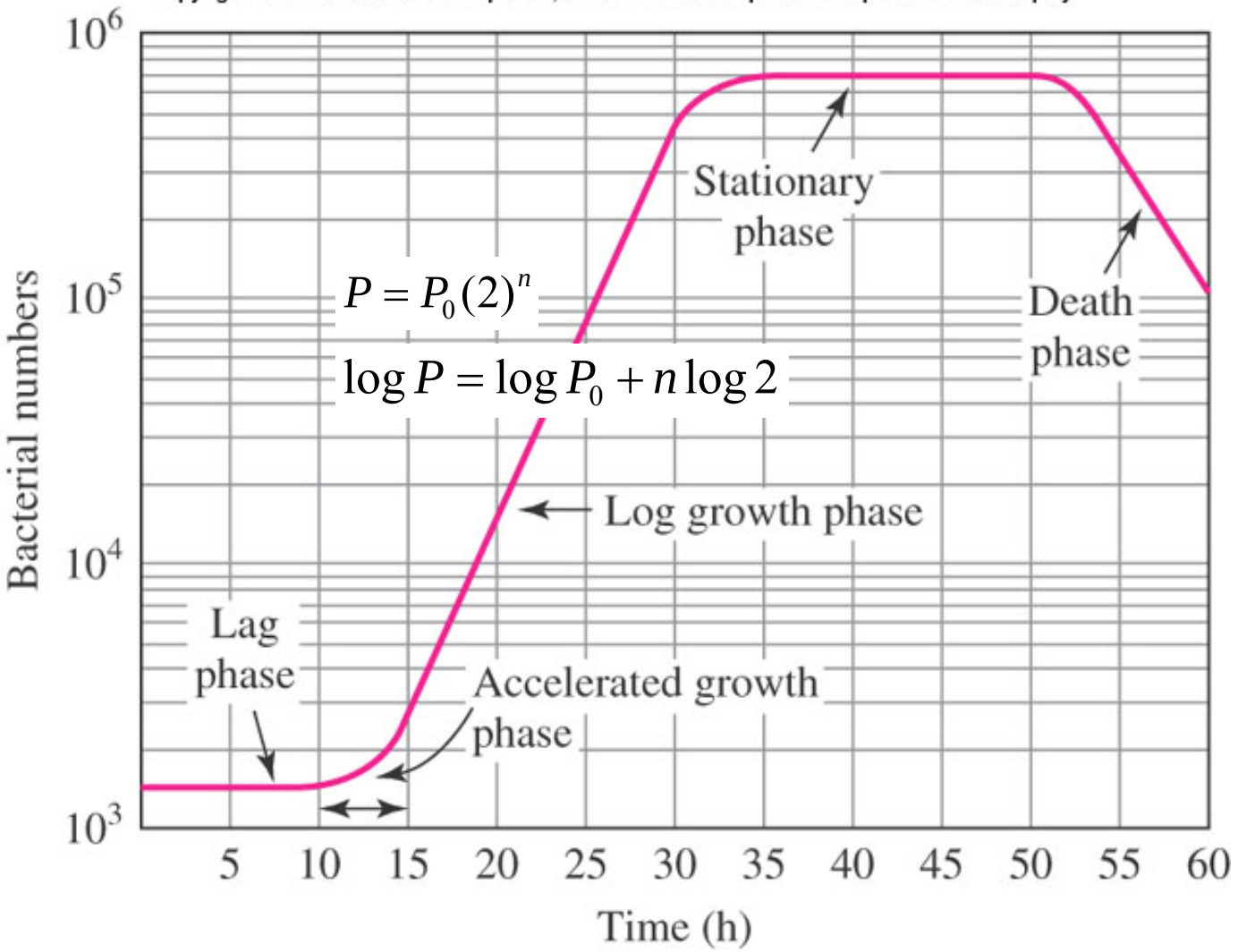
Cultural eutrophication

- Caused by the introduction of high levels of N and P (usually P for lakes and N for coastal waters)
- Sources of nutrients
  - human waste (sewage)
  - animal waste
  - agricultural sites

Cultural eutrophication

- Effect of eutrophication: algal bloom
  - high algae biomass: taste and odor problems, aesthetic problem
  - deposition of dead algae: oxygen depletion in the bottom → fish kills
  - harmful algal bloom: some algal species produce toxic materials (ex: microcystin by cyanobacteria)

Bacterial population growth (pure culture)



Bacterial population growth (pure culture)

Q: If the initial density of bacteria is 10^4 cells/L at the end of the accelerated growth phase, what is the number of bacteria after 25 generations? (assumption: the bacteria are still at the log growth phase at the end)

Reading assignment

- Textbook Ch5 190-192, 197-205, 206-207, 216-225