Chemistry - continued

- Up to now, talked about dissolved gases and acids (pH)
- Other substances can be dissolved in water
  - Organic (carbon-based) molecules
  - Inorganic materials and nutrients…

Dissolved Organic Carbon (DOC)

- High molecular weight – soluble in water
  - Usually brown in color
  - Foamy
  - Provides UV protection
- Acidification
  - Bleaches the DOC
  - UV then penetrates

Ionic Composition

- Fancy term for salinity (concentration of a salt dissolved by polar water molecules)
- Salt = A substance formed by replacing the H^+ in acid with another positively charged ion (usually a metal)
- Again, in water, salts dissociate into ions (charged particles)

Ionic Composition

- Cations (+)
  - Attracted to a cathode (- charged electrode)
  - $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$
- Anion (-)
  - Attracted to anode (+ charged electrode)
  - $HCO_3^{-} > CO_3^{2-} > SO_4^{2-} > Cl^{-}$

Ionic Composition

- Where do the ions come from?
  - Runoff across soil and bedrock
    - Geological history (glaciers, volcanoes, oceans, tectonic activity, etc.)
  - Atmospheric input
    - Power plant upwind?
  - Rivers and streams
  - Oceans

Ionic Composition

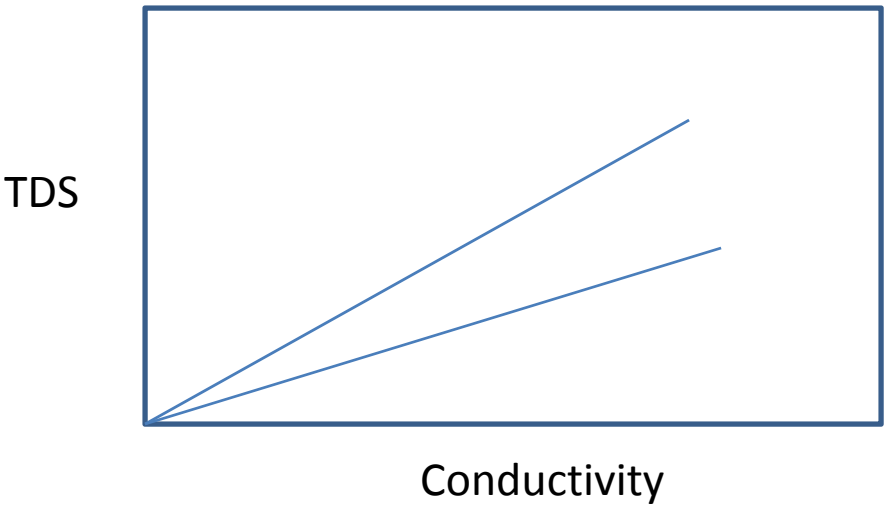
- Concentration in a lake
  - Exorheic – influenced by inflow
  - Endorheic – internally driven
  - Evaporation versus precipitation
    - Salt lakes (evaporation >>>>>> precipitation)
  - Reactivity
    - Conserved ions: Mg^{2+}, Na^{+}, Cl^{-}, K^{+}
    - Dynamic ions: Ca^{2+}, HCO_3^{-}, SO_4^{2-}

Ionic Composition

- River salinity increases downstream
  - 120 ppm by the time reaches ocean
  - Ocean is roughly 32-37 ppt (mostly eroded land)
- Measurement
  1. Total dissolved solids
     - Filter particulate matter out of the water
     - Evaporate filtered water
     - Problem: some loss of CO_2

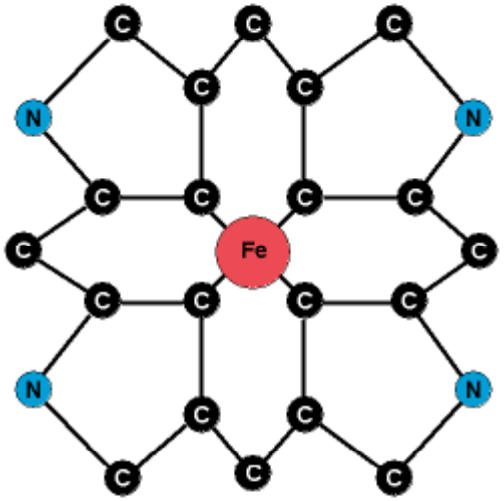
Ionic Composition

- Measurement (continued)
  2. Single ions using colorimetric test
  3. Conductivity (inverse of resistance)
     - microSiemens between electrodes 1 cm apart (µS/cm)



Nutrients

- Necessary for life – differ in requirements
  - Micronutrients < 0.1 % of biomass
    - Too much can be deadly
    - Fe … enzymatic pathways, hemoglobin, protein synthesis.
    - Others
      - Mn, Cu, Zn, Si, Mo, V, Co



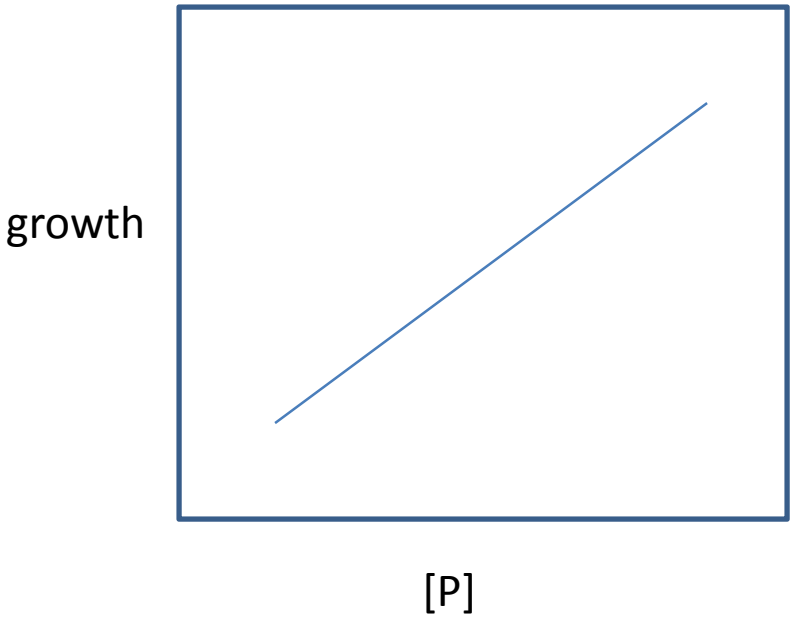
Heme
a porphyrin ring
with **Iron** at the center
transports oxygen in red blood cells

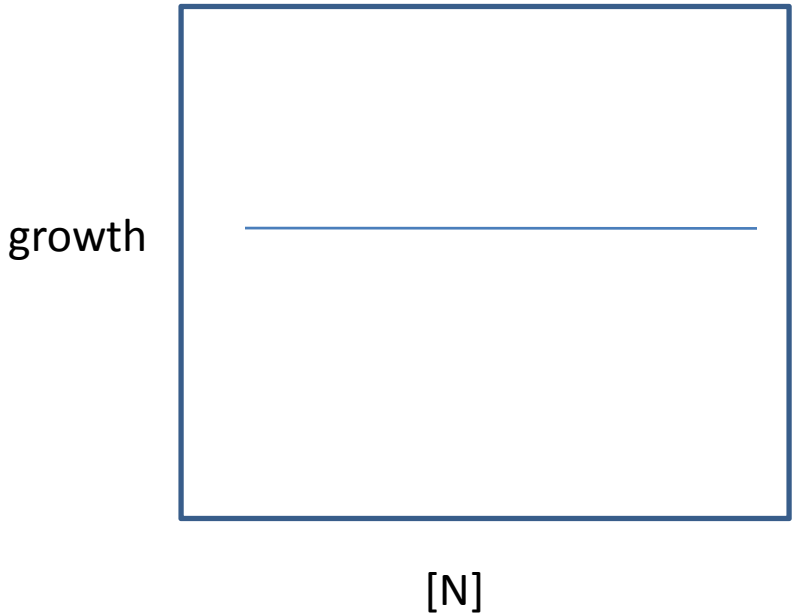
Nutrients

- Macronutrients
  - > 0.1% of biomass
  - C, O, H, N (most of the biomass)
  - P, S, K, Mg, Ca, Na, Cl

Nutrients

- Liebig's Law of the Minimum
  - Growth of organism depends on the one nutrient in shortest supply

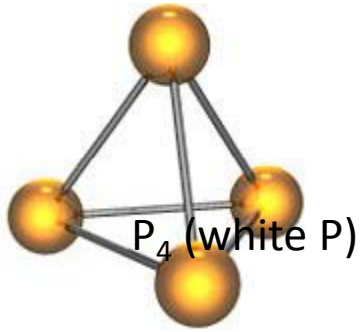




Phosphorus

- Biologically important – limiting for most freshwater plants (other nutrients not limited)
  - Energy source (ATP to ADP)
  - DNA and RNA (protein synthesis)

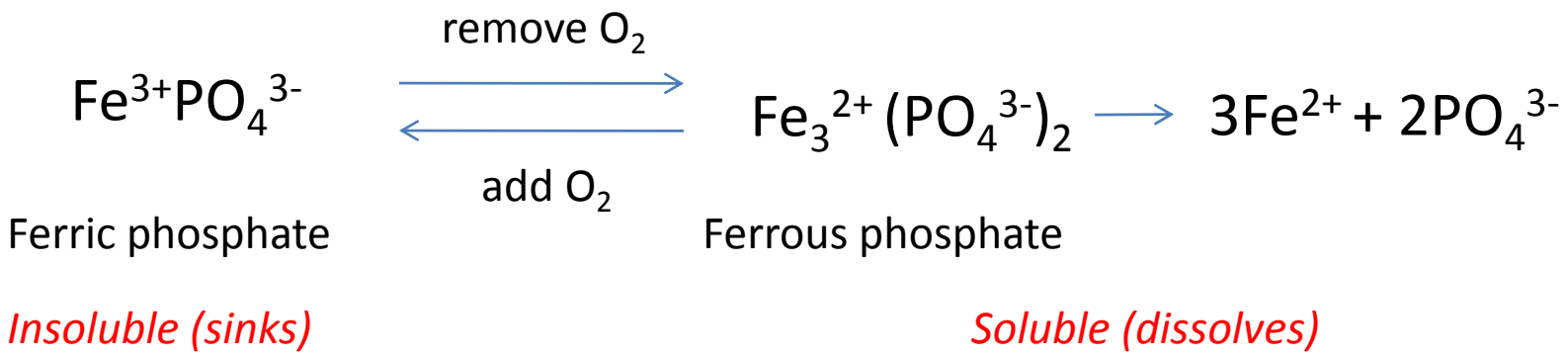
Phosphorus



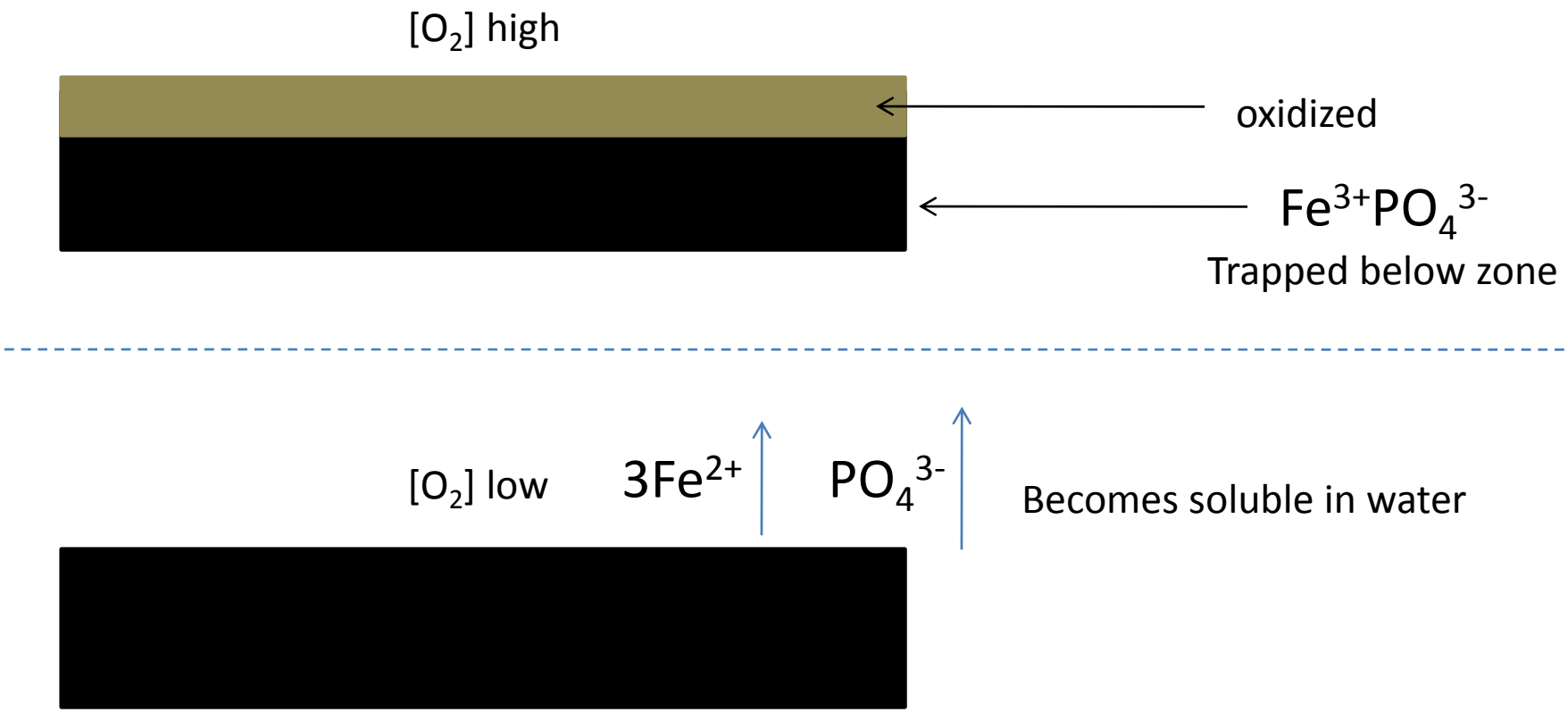
- Highly reactive (and toxic)
  - SRP – soluble reactive phosphorus
- Combines with oxygen
  - PO_4^{3-} (orthophosphate) – soluble and rapidly incorporated into plants
  - HPO_4^{2-} (monophosphate)
  - $H_2PO_4^-$ (dihydrogen phosphate)
- TOTAL P usually 1 µg/L – 200 µg/L

Phosphorus + Iron

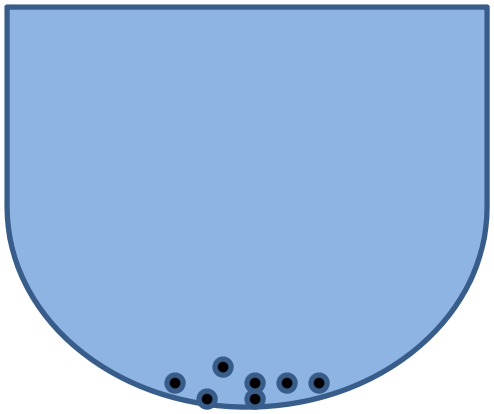
- Iron will combine with orthophosphate when oxygen is available

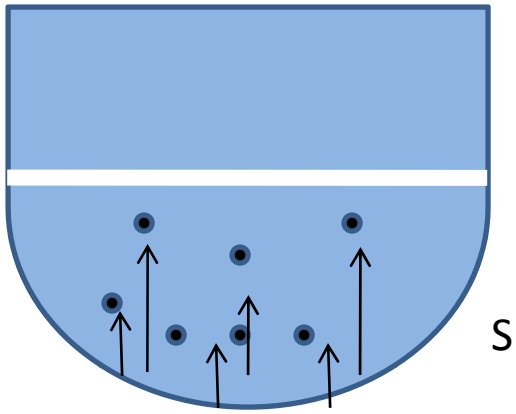


Phosphorus + Iron



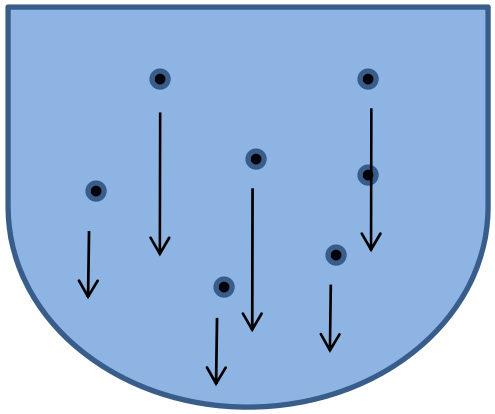
Winter

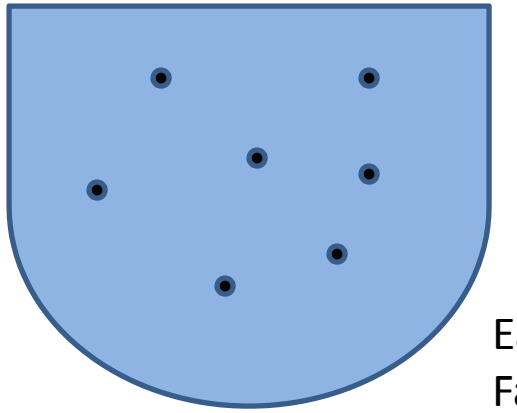




Summer

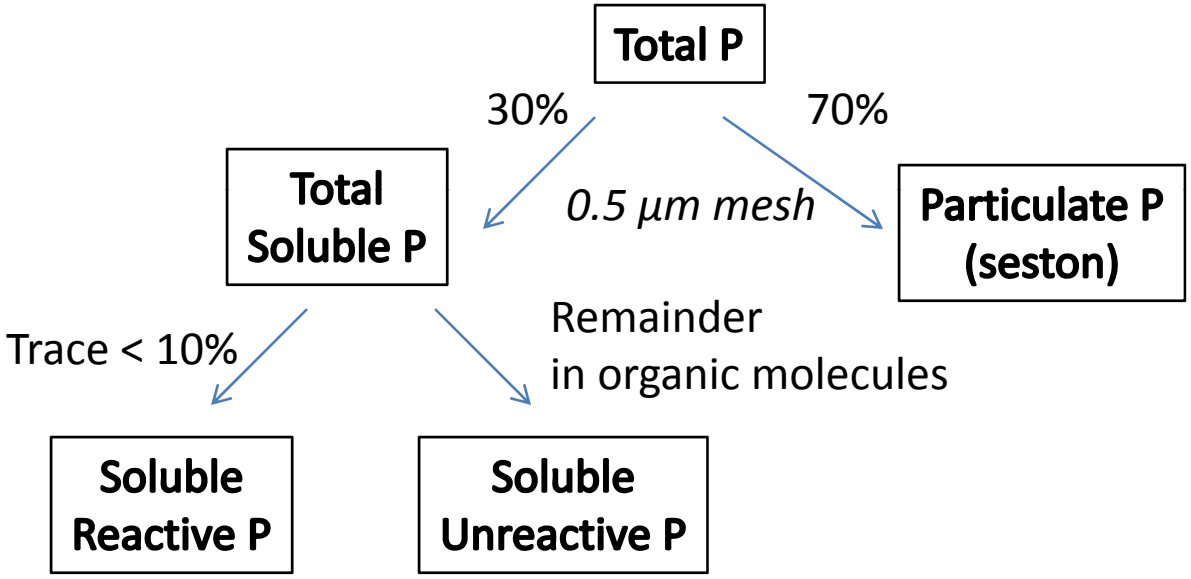
Late
Fall





Early
Fall

Phosphorus budget



Distribution of P

- Erosion and stream inflow
  - 10% PO_4 and 90% PP; sinks to sediments
- Sewage
  - 90% PO_4
- Excretory processes (causes vertical & horizontal stratification)
  - Zooplankton, phytoplankton, and fish
- Internal loading (70% in Campus Lake)

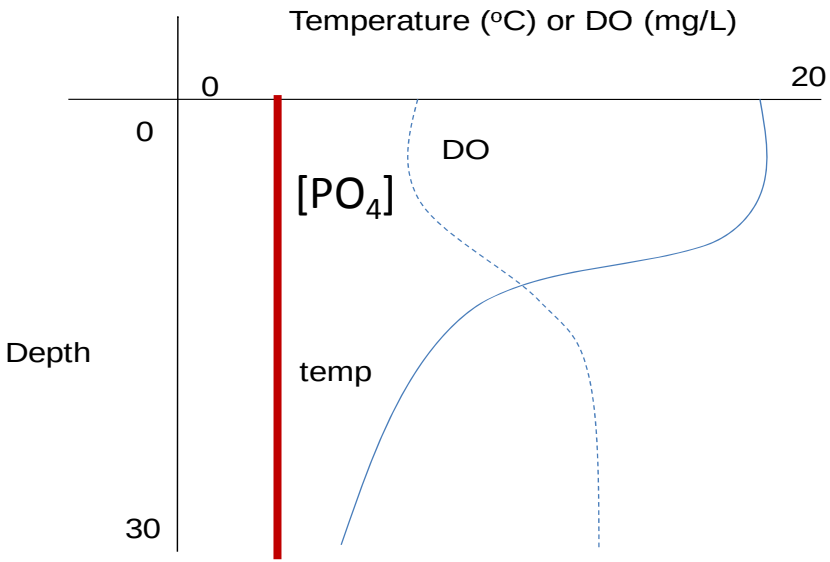
$$Fe_3^{2+}(PO_4^{3-})_2$$

P varies

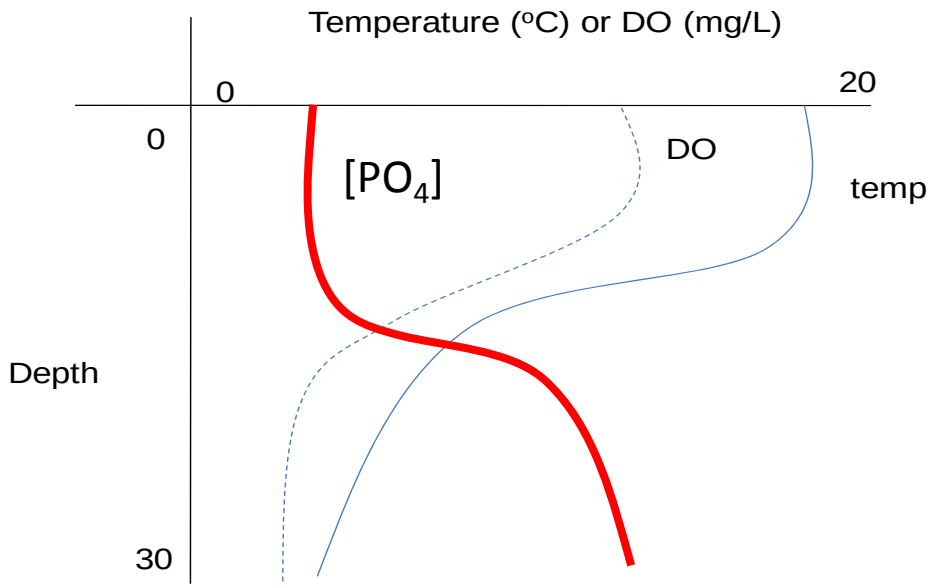
- P availability varies even in productive lakes
  - Sinks
    - Summer hypolimnion
    - Outflow
    - Algal biomass
  - Solution for algae
    - Store phosphate granules
    - Expend energy to uptake P at low concentrations
      - External production of alkaline phosphatase

Summer distributions

Oligotrophic (TO < 5 µg/L)



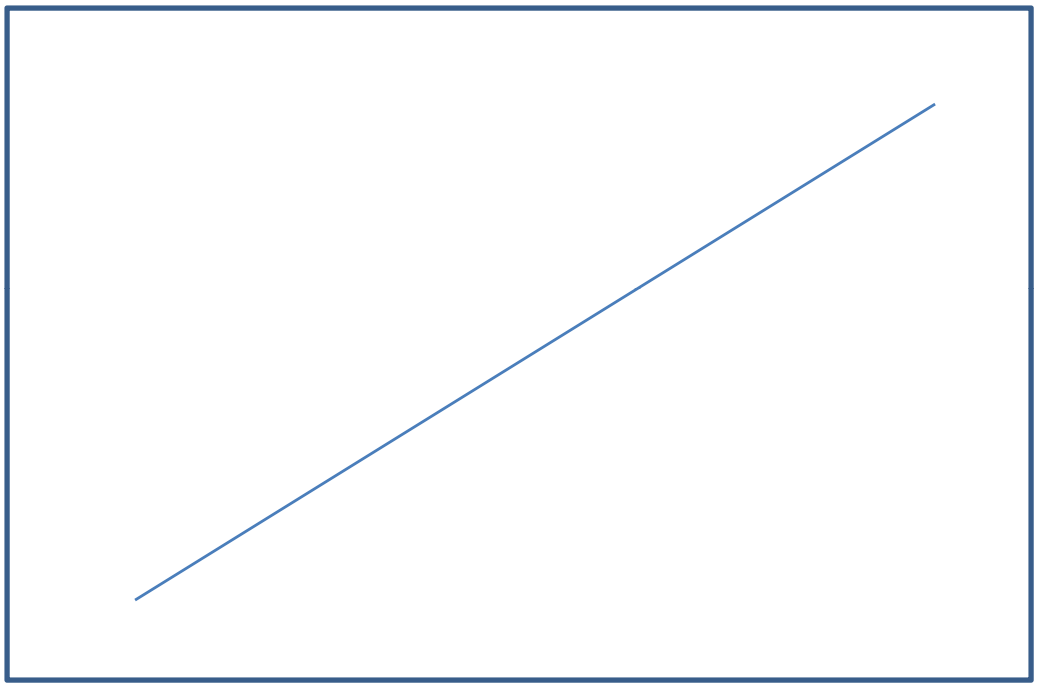
Eutrophic



Cultural eutrophication

- Early 70s – no idea what was limiting growth in natural lakes
- David Schindler - University of Alberta
  - Experimental Lakes Area
  - Split lake in half
    - Half, C + N + P added (no response)
    - Other half, C + P (created blue-green bloom)
- BIG DEAL – P was major component of soap

Chlorophyll
a concentration



TP