Aquatic Biology (Biol 372) WI

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HA 407R

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Course Objectives:

• Physical and Chemical properties of water
• Chemical basis for biological production
• Consumers (Macroinvertebrates, fish)
• Ecology and Evolution of Fishes
• Conservation, management of aquatic resources
What is aquatic biology?

- Study of aquatic life
- Rivers, lakes, oceans, estuaries, springs, tree holes
- Running = lotic
- Standing = lentic
- 71% of planet surface, mean depth = 3800m
Why should we study aquatic biol?

• all life is based on water
• life evolved in water
• 47% of vertebrate species are fish
• human civilization founded on waterways for transport, trade, irrigation
• Aquatic habitats are at risk
## Distribution of Water on Earth

<table>
<thead>
<tr>
<th></th>
<th>$10^3$ km$^3$</th>
<th>Percent</th>
<th>Renewal Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oceans</td>
<td>1,310,302.1</td>
<td>97.3</td>
<td>37000 years</td>
</tr>
<tr>
<td>Ice</td>
<td>29,491.9</td>
<td>2.19</td>
<td>16000 years</td>
</tr>
<tr>
<td>Groundwater</td>
<td>6,733.3</td>
<td>0.5</td>
<td>300 years</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>74.1</td>
<td>0.005</td>
<td>280 days</td>
</tr>
<tr>
<td>Atmospheric water</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vapor</td>
<td>13.5</td>
<td>0.001</td>
<td>9 days</td>
</tr>
<tr>
<td>Inland freshwater</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lakes</td>
<td>126.0</td>
<td>0.009</td>
<td>1-100 years</td>
</tr>
<tr>
<td>Inland saline lakes</td>
<td>104.0</td>
<td>0.008</td>
<td>10-1000 y</td>
</tr>
<tr>
<td>Rivers</td>
<td>1.3</td>
<td>0.0001</td>
<td>12-20 days</td>
</tr>
</tbody>
</table>

(from Cole 1994, p2, Wetzel 1975 p1)
Water: Unique properties

Small, polar (universal solvent)

Specific heat = #calories to raise 1 ml by 1°C
- liquid water = 1.0 (high due to H-bonds), ice = 0.5, rocks = about 0.2, aquatic environments are more stable thermally than terrestrial environments

Density
Maximum water density at 3.94°C

Density (g/cm$^3$) = (g/ml)
  Liquid water at 4°C = 1.0
  Pure ice = 0.9168
  Liquid water at 0°C = 0.99987

Water density = 775 x air density → confers buoyancy on aquatic animals
Light

Light controls temperature
→ thermal structure
→ nutrient cycling
→ distribution and abundance of biota
Light

Radiation impinging on lakes depends on:
• angle of incidence → light energy reflected (~5-6%)
• latitude, season, wave action
• snow cover → 75% reflected
• solutes and suspended particulate matter
  → light energy is absorbed and scattered

Degree of absorption depends on wavelength (λ)
  → low λ's (e.g. red) absorbed quickly (fig 5-7)
  → 53% of light energy is absorbed as heat by 1m

  → high λ's (blue/green) penetrate deepest

Water transparency measured by a Secchi disc
Figure 5-5 Surface reflection and backscattering as a percentage of total solar radiation at varying angles of incidence. A, clear, cloudless conditions; B, reflection of diffuse light under moderate cloud cover; C, heavily overcast conditions. (Generated from data in Steleanu, 1961, and from Sauberer, 1962.)
Figure 5-7 Transmission of light by distilled water at six wavelengths (R–720, O–620, Y–560, G–510, B–460, V–390 nm). Percentage of incident light that would remain after passing through the indicated depths of water expressed on a linear (upper) and a logarithmic (lower) scale. (After Clarke, 1939.)
Heat

**Heat In**
generally from solar radiation at surface
also geothermal sources (→ hot springs, etc)
heat from incoming surface runoff

**Heat Out**
evaporation (needs 539.6 cal/g)
thermal radiation
through outflow of surface water

- heat is therefore a surface phenomenon (fig 6-1)
- wind energy (waves) mixes heat to lower levels
Thermal Stratification (fig 8-1)

Spring turnover (by wind)

Summer: warm surface layers are less dense than underlying cooler layers
→ stable zones: (fig 6-3)
  **Epilimnion** - surface, warm
  **Metalimnion** - middle, transitional, narrow zone
  **Hypolimnion** - bottom, cool

Fall turnover (by wind)

Winter → inverse stratification (cooler above than below)
Figure 6-1  Vertical depth profiles of the penetration of solar radiation (S) and temperature (T) in Crooked Lake (A) and interconnected, adjacent Little Crooked Lake (B), Noble-Whitley counties, Indiana, July 18, 1964. (From Wetzel, unpublished data.)
Figure 6-3 Typical thermal stratification of a lake into the epilimnetic, metalimnetic, and hypolimnetic water strata. Dashed lines indicate planes for determining the approximate boundaries of the metalimnion (see text).
Figure 8-1  Idealized vertical distribution of oxygen concentrations and temperature during the four main seasonal phases of an oligotrophic and an eutrophic dimictic lake.