Energy and nutrient relations

Light, Photosynthesis, and Feeding

Physiological ecology

- How individual organisms respond to the abiotic environment:
  - Temperature
  - Water
  - Light
  - Nutrients

Lecture outline

- Light
- Types of photosynthesis
- Heterotrophs and organic molecules
- More inorganic molecules

Nature of light

- Ultraviolet: UV-A: 315 – 380 nm; UV-B: 280 – 320
- Near & far infrared: 700 – 100,000 nm
- Visible: 400 – 700 nm; = PAR

Fate of light—boreal forest

Types of photosynthesis

- \( C_3 \) photosynthesis (\( C_3 \) plants)
- \( C_4 \) photosynthesis (\( C_4 \) plants)
- CAM photosynthesis (CAM plants)
Water efficiencies

- For every gram (dry weight) of tissue produced...
  - C₃ plants lose 380 to 900 g of water
  - C₄ plants lose from 250 to 350 g of water
  - CAM plants lose about 50 g of water

- So why are CAM plants not taking over the world?

Light vs. photosynthesis

- To sum up:
  - Photosynthesis is important
  - Photosynthesis depends on light
  - So, how does photosynthesis actually relate to light?

Light response curve (1)

- Light saturation point

Lecture outline

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Heterotroph feeding categories

- Herbivory: quantity vs. quality
  - Cellulose usually broken down by bacteria and fungi + protozoans, not ‘large’ animals
  - What’s a large animal to do?
Eating plants: quantity vs. quality (2)

Carnivory
- Quantity vs. quality
- Digestive systems compared to a cow?
- Non-invasive diet analysis

Omnivory
- Quantity vs. quality

Detritivory
- Quantity vs. quality
- Peanut butter vs. the cracker

Heterotroph feeding
- We know how plants respond to more ‘food’ (i.e., light)…
- So… how do animals respond to increases in food?

One more aspect to plant quality
- Plants can produce secondary compounds
  - Why “secondary”?
  - Why don’t they always produce them?
- Some reduce digestion (e.g., tannins), others kill (e.g., alkaloids)

Biomass and toxicity responses of poison ivy (Toxicodendron radicans) to elevated atmospheric CO₂

PNAS; 2006

Feed me
Functional response curves

- What organismal factors contribute to shape at
  - Low prey density?
  - High prey density?

Fig. 7.22

Examples with moose

Figs. 7.23 & 7.24

Lecture outline

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Nutrient uptake rate (1)

- Depends on the availability and demand
- Usually described by a Michaelis-Menten eqn
- \( V = \frac{V_{max} \times C_{ext}}{K_m + C_{ext}} \)

Where

- \( V \) = rate of nutrient uptake
- \( V_{max} \) = saturation uptake rate
- \( C_{ext} \) = external concentration of the nutrient
- \( K_m \) = "half saturation constant"

Leonor Michaelis
Maud Menten

Nutrient uptake rate (2)

Michaelis-Menten in action

Fig. 4. Changes in the kinetics of \( NH_4^+ \) uptake by \( Spartina alterniflora \) hypothesized to occur in the salt marsh to olivine gradients.

Bradley & Morris 1990
See anything consistent?

Feeding by moose

Light response curve

Nutrient uptake