Taxonomic definitions by Food Sources

• **Autotrophs** -- fix their own organic carbon, e.g. plants, or chemosynthetic bacteria
  - Photosynthetic plants, cyanobacteria: use light for energy to reduce $CO_2$ and inorganic nitrogen phosphorus to make organic molecules (e.g., carbohydrates, lipids, proteins, nucleic acids)
  - Chemosynthetic bacteria: use chemical bond energy for this purpose

• **Heterotrophs** -- eat carbon that other organisms have fixed
  - Detritivores - eat nonliving tissues (dead organisms or material they shed or excrete)
  - Herbivores - eat plants
  - Carnivores - eat animals
  - Omnivores - eat from several of the categories above
Taxonomic definitions of four heterotrophs

-Detritivores - eat nonliving organic matter (dead organisms or material they shed or excrete)
-Herbivores - eat living plants
-Carnivores - eat animals
-Omnivores - eat several of the categories above
Functional definitions:

True Predators:
- Consume many prey in its life
- Kill prey
- Consume entire prey

Grazers:
- Attack many prey in its life
- Rarely kill prey
- Consume only part of each prey

Parasites:
- Attack one or few host individuals
- Rarely kill hosts
- Consume parts of their host

Parasitoids:
- Each juvenile develops from 1 host
- Kills their host
- Consumes entire host
Dichotomous Key to functional definitions

1. Consumed resources mainly derived from other organisms?
   - Yes…2 (= Heterotroph)
   - No…..**Autotroph (Photoautotroph)** (use photons to reduce \( \text{CO}_2 \)); **Chemoautotroph** (derive energy from reduced inorganic chemical bonds)

2. Consumed organisms eaten while alive?
   - Yes….3
   - No….**Detritivore or decomposer**

3. Prey individuals usually killed immediately upon successful attack?
   - Yes….**Predator**
   - No….4
4. Many prey attacked by consumer over its lifetime?
   - Yes... **Grazers, browsers, itinerant suckers, “partial predators”**
   - No... 5

5. Eggs lain by mothers near or on individual prey, whose death is then inevitable?
   - Yes... **Parasitoids**
   - No... 6

6. Consumers spend much of their lives in association with one or few hosts, consuming parts of host which is usually not killed, at least in the short term?
   - **Parasites, pathogens**
Types of herbivory

- Grazing (*sensu strictu*) eat down to substrate
- Browsing (nip tips)
- Root feeding
- Leaf mining
- Stem boring (high damage per mass removed)
- Gall formation
Sometimes:
Food Quality may be more important than Food Quantity

In the case of herbivores especially, it is possible for an animal to be apparently surrounded by its food while still experiencing a food shortage.

Wildebeest in the Serengeti

- Study of balance of energy and multiple chemical elements in living systems
- Redfield Ratio (atoms in phytoplankton and seston (suspended organic matter): \( C (106): N (16): P(1) \)
- Plants: C:N and C:P generally higher than in animals (varies among taxa, tissues, age groups)
- Detritus even worse

\[ \text{Redfield Ratio} \]
Sterner and Elser 2002

Plant C:N = 6.6

Animal C:N:P

C\textsubscript{106}N\textsubscript{16} P

C\textsubscript{106}N\textsubscript{16} P

C\textsubscript{106}N\textsubscript{16} P

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Sterner and Elser 2002

Animals show more strict stoichiometric homeostasis than plants

Problem for herbivores and detritivores: to get enough N (and sometimes P)

Fig. 1.3. Generalized stoichiometric patterns relating consumer stoichiometry to resource stoichiometry. Horizontal and vertical axes are any single stoichiometric measure, such as N content or C:P ratio. A. Points on the 1:1 line (slope 1, intercept 0) represent identical stoichiometry in consumer and resources. This dashed line represents a consumer with stoichiometry that always matches the stoichiometry of its resources. This is the “you are what you eat” model. The solid lines represent consumers that perform constant differential nutrient retention. These represent the “constant proportional model.” B. Strict homeostasis is defined as any horizontal line segment (slope 0, intercept > 0).
Scenedesmus (green alga (desmid))

**Non-homeostatic**

![Graph A](image1.png)

\[ y = 0.94x + 0.14 \]
\[ r^2 = 0.99 \]

![Graph B](image2.png)

\[ y = 1.00x - 0.03 \]
\[ r^2 = 0.99 \]

**Fungi-partially homeostatic**

![Graph A](image3.png)

\[ y = 0.69x - 0.27 \]
\[ r^2 = 0.87 \]

![Graph B](image4.png)
Strongly homeostatic

Bacteria

Fig. 1.6. A strict homeostasis. Bacterial C:N (mean ± standard deviation) does not vary systematically over a wide range of substrate C:N. The trend is not statistically significant in either linear (A) or logarithmic (B) plots. The regulatory coefficient coefficient H can be taken to be essentially infinity, given the apparent zero slope. For a description of homeostasis of bacterial N:P ratios, see Fig. 5.8. Based on Goldman et al. (1987b).

Daphnia
Herbivore Solutions to N limitation

- High throughput (aphids, zebras (cecal digestors))
- Selectivity (stem borers, Thomson’s gazelles)
- Symbiotic partnership (termites, pikas, cows (ruminants))
Some termites have cellulolytic protozoans in their hindgut that allow them to digest wood. Other termites with their own cellulase still need microbial symbionts to decrease C:N of their food...

Option—either reduce C in diet or increase N

Species that separate their nests from their feeding habitats grow fungi, eliminating C via fungal respiration
Species that eventually eat the wood that supports them have anaerobic bacteria in hindguts that fix atmospheric $\text{N}_2$: 30-50% termite nitrogen derives from atmosphere. (Don't burn down their homes as quickly as they would if they burned off carbon.)

Higashi and Abe 1996
Diet Choice

• Specialists (monophagous)
  - Increased efficiency of food detection, handling, assimilation...
  - Other fitness advantages associated with one type of food (shelter, mate finding)

• Generalists (polyphagous)
  - Nutritional balance
  - Avoid over-dosing on one toxin....
  - Increase probability of surviving periods of food shortages...
Even polyphagous species show **preference** for attacking some species over others.

A predator shows a **preference** for a particular type of food if the proportion of that type in the animal’s diet is higher than the proportion in the animal’s environment.

Ranked preference – a preference for the most valuable food types among those available
- Food eaten by carnivores vary little in composition, but they may vary in size or accessibility  Or dangerousness
- Food items can be ranked on a single scale.

Balanced preference – a preference for items that provide an integral part of a mixed and balanced diet.
- Food items eaten by omnivores will differ greatly in content.
Optimal Foraging Theory (Schoener 1971)
To maximize rate of energy intake, should consume an item if

\[ \frac{E_i}{h_i} \geq \text{avg } E/(\text{avg } s + \text{avg } h) \]

\( h = \) handling time
\( s = \) search time (depends on prey density)

Diets get broader when food is scarce, so search time between encounters increases...
Squirrels on campus feed on acorns and pinecones

Proportion of squirrel diet made up of acorns

Relative abundance of acorns on campus

 Preference for acorns

45° Line, if squirrels eat acorns in proportion to their relative abundance in the environment
Squirrels on campus feed on acorns and pinecones

45° Line, if squirrels eat acorns in proportion to their relative abundance in the environment

Switching – preference for food types that are common
Why switch?

Experience: search image, handling practice, enzyme induction

Resource is patchy, and consumer concentrates on more profitable patches until they are depleted.
The preference of a consumer may be fixed, or a predator may switch their preference to the prey type that is most common.

Switching – Preference for food types that are common.

Not switching, always prefer *M. edulis*

Switching: fraction of this prey type eaten increases when this prey type is most abundant
Somatic growth rates of pre-reproductive Ancistrus similar among pools in dry and rainy season (also survivorship. Power 1984. J. Animal Ecol. 53: 357-374.)

Ideal Free Catfish:

- could track pool-to-pool variation in food availability;
- free to settle in best pool at any time

consequently:

- catfish density tracked productivity;
- algal standing crops uniformly scant over 16x range in renewal rate (productivity);
- catfish fitness similar in sunny, crowded pools, and in dark, uncrowded pools.

(Fretwell and Lucas 1972)