

Diet, Digestion, and Nutrition

Nutritional Needs

- Carbohydrate
- Protein
- Fat
- Vitamins
- Macrominerals: Ca, Mg, Na, P, K
- Microminerals: Zn, I, Fe, Cu...

Energy Needs and Body Size

All else being equal:

- Stomach capacity increases with body mass (capacity/kg is constant)
- Energy requirement/kg decreases with increasing body mass
- So...
 - on same quality diet, small animals need to eat more per kg of body mass
 - larger animals can eat lower quality diets

Pygmy shrew

Weight: 4-5 g
 Heartrate: 800-1300 bpm
 Metabolic rate: 7.5 mL O₂/g/h

Elephant

Weight: 3-4 million g
 Heartrate: 27 bpm
 Metabolic rate: 0.07 mL O₂/g/h

Food Quality

Is there good stuff in it?

Can it get the good stuff out?

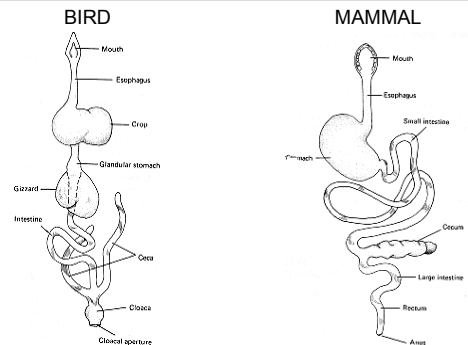
Nutrient density:

Protein content (C:N ratio)
 Caloric content
 Vitamin/mineral content

Digestibility:

C:N ratio
 Lignin content
 Cellulose content
 Defensive compounds
 Moisture content

Animal Digestive Systems



Diet

- **Carnivory: You are what you eat!!**
 - Advantage:
 - Easiest diet style to digest & assimilate
 - **Malnourishment** is usually not a problem
 - Disadvantage:
 - Prey can be rare, difficult to capture, and sometimes dangerous
 - **Undernourishment** is the problem.
 - Adaptations:
 - speed, strength, senses, “cunning,” sharp teeth beaks & claws

Diet

- **Frugivory / Nectarivory: The sweet life.**
 - Advantages:
 - fruits and nectar are easy to digest
 - rich in simple carbohydrates (energy!) & vitamins
 - undefended (plants **benefit** from consumers)
 - Disadvantages:
 - poor in protein & minerals
 - availability varies a lot in space and time
 - Adaptations
 - mobility, long tongues & narrow snouts/beaks, simple or reduced teeth, weak gizzard

Diet

- **Granivory: plant infanticide**
 - Advantages:
 - nutritionally rich (carbos, fat, & protein)
 - can be cached (stored)
 - Disadvantages:
 - sometimes heavily defended
 - hard shell (coconut)
 - toxins (apricot pit)
 - tannins (inhibit protein digestion, acorn)
 - availability varies a lot in space and time
 - Adaptations
 - gnawing teeth / cracking bills, strong gizzard, cacheing behavior, physiological capacity to detoxify, mobility

Diet

- **Herbivory: The world is green!**
 - **but it's prickly, tastes bad, and has high C:N ratio**
 - Advantage
 - plants are abundant and don't move
 - Disadvantages:
 - low protein, minerals
 - may lack some essential amino acids
 - often difficult to digest
 - plants can defend themselves!
 - physical defenses (spines, hairs, bark)
 - chemical defenses (secondary compounds)
 - **malnourishment** is a big problem

Diet

- **Herbivory: cont'd**
 - Adaptations
 - grinding teeth
 - large, complex fermenting digestive systems
 - relatively few bird species are strict herbivores
 - Those that are have high-throughput, low efficiency strategy

Diet

- **Herbivory: cont'd**
 - Herbivores tend to be picky
 - Foods with lower C:N ratio (high protein)
 - Foods with low chemical defenses
 - Note examples in book (Chapter 7)

Strategies for Herbivory

Koalas feed almost exclusively on leaves of *Eucalyptus* trees

Very high in tannins (inhibit protein digestion) & other chemical defenses

Adaptations:

- slow metabolism
- large cecum for fermentation
- specialized bacteria digest tannin-protein complexes

Strategies for Herbivory

Canada geese are among the few strict avian herbivores

Adaptations:

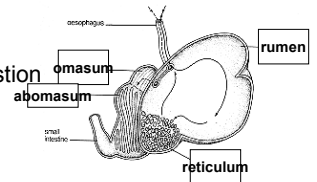
Mobility allows them to seek out high-quality foods (grains, new growth)
High-throughput, low-extraction digestive system

Ruminants

- Means “chewers”
- Mammals that chew & re-chew their food to break it down
- Complicated, multichambered stomach
- Examples:
 - Bovids (cattle family)
 - Bison, antelope, buffalo, sheep, goats
 - Pronghorn
 - Cervids (deer family)
 - Camelids (camels, llamas, etc.)
 - Giraffes

Rumen Anatomy

- Rumen - stores & ferments
- Reticulum – filters & ferments
- Omasum – filters & absorbs
- Abomasum
 - true stomach
 - begins own digestion



Ruminant Benefits

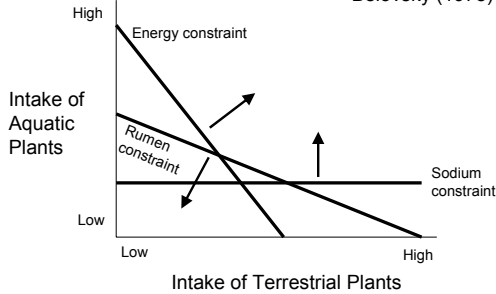
- bacteria break down cellulose, but can't capture all the energy
- bacteria can detoxify plant secondary compounds
- produce fatty acids as by-product
- bodies of microbes high in protein
- microbes produce B vitamins
- microbes can adapt (slowly) to changing diet

Problems with Ruminants

- Cannot instantly adapt to change in diet
- animal does not directly utilize sugars (bacteria get them first)
- with lower quality forage, passage rate decreases
- gut capacity a limiting factor

Diet of Moose (*Alces alces*)

Belovsky (1978)



Hind Gut Fermenters (Cecalids)

- Stomach and small intestine are simple
- Large intestine is complex and, well, large
- Large cecum serves as fermentation chamber
- Some have evolved coprophagy
- Examples:
 - Rabbits & Hares
 - Equids (horse family)
 - Wombats & Koalas
 - Some birds

Differences between Ruminants and Cecalids

Function	Ruminants	Cecalids
Ability to efficiently digest cellulose	Yes (60%)	Yes (45%)
Ability to utilize dietary sugars directly	No	Yes
Ability to utilize protein from fermentative microbes	Yes	No

Diet Changes with Needs

- Mallard ducklings (*Anas platyrhynchos*) feed mainly on invertebrate animals, adults are primarily herbivorous
- White-tailed deer are predators! Will snack on songbird nestlings to acquire protein & minerals

Nutrition: Things to Remember

- Major types of nutrients
- How body size affects energy requirements
- Different diets, their advantages and disadvantages
- Adaptations, especially for digesting herbivorous diet (ruminant, cecalid)