ESRM 350

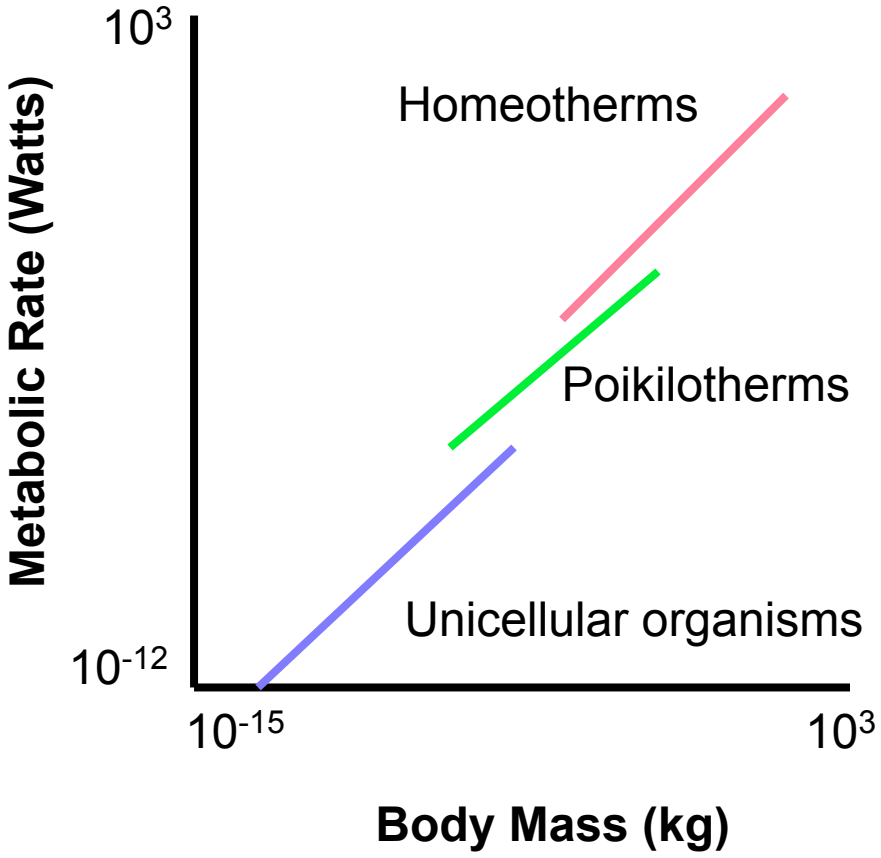
Food and Feeding

Autumn 2016

“One cannot think well, love well, sleep well, if one has not dined well.”

- Virginia Woolf, *A Room of One’s Own*

Living Requires Energy



- Multicellular organisms expend more energy than single-celled organisms
- Large animals expend more energy than small animals
- Homeotherms expend more energy than poikilotherms

Hemmingsen (1960)

A Key Problem for Wildlife

- Taxa we will cover in this class (mammals, birds, reptiles, amphibians) are **heterotrophs**
  - i.e., they subsist on energy packaged in other organisms
- Challenge 1: energy packaged in other organisms is limited
- Challenge 2: other organisms "don't want" to be consumed
- Heterotrophs are under pressure to be efficient (both in finding and processing food)

Finding Food

Foraging: The process of searching for, handling, and consuming food

4 Kinds of Foragers

- **Herbivores**
  - Consume plant material (may kill the plant, but usually do not)
    - Grazers – eat grasses and herbaceous vegetation
    - Browsers – eat woody vegetation

White rhinoceros (*Ceratotherium simum*), a grazer

4 Kinds of Foragers

- **Predators**
  - Consume all or part of other animals, killing them in the process

4 Kinds of Foragers

- **Parasites**
  - Consume parts of other animals (**hosts**) without killing them
    - have negative effect on the host
    - rare among wildlife species (e.g., common vampire bat, *Desmodus rotundus*)

4 Kinds of Foragers

- **Scavengers**
  - Consume dead organic material
    - have no direct effect on populations that produce these resources
    - important in the recycling of nutrients within ecosystems

Black vultures (*Coragyps atratus*), a scavenger

Differences Between Predators and Herbivores

Some Energy Values

- Fat – 9.45 Kcal/g
- Protein – 5.65 Kcal/g
- Seeds – 5.07 Kcal/g
- Leaves – 4.23 Kcal/g
- Cellulose (plant cell walls) – 4.18 Kcal/g

- Predation offers access to high-quality food, but energy is scarce and hard to obtain
- Herbivory offers access to plentiful but hard-to-digest food
- Smallest homeotherms can’t live on plants

A Key Question for Foragers

Which food items to eat?

Trade-offs

- **Trade-off:** situation where benefits of a change in one trait are linked to a costly change in another
  - benefits and costs paid in the currency of fitness (reproduction and survival)
  - e.g., growth versus reproduction
  - key to understanding wildlife evolution, ecology

Stearns (1989) *Functional Ecology*

A Key Question for Foragers

Which food items to eat?

- Consumption of any food item will provide benefits (e.g., energy), entail costs (e.g., risk of injury, time to find, handle food that cannot be used to continue searching)
- **Optimal** decision: chose foods that maximize the ratio of benefits to costs
- Answer a function of **trade-off** between benefit of eating a food item and value of ignoring it
  - **no free lunch**

Optimal Diet Theory

- There are many potential prey items: how do you choose?
  - Optimization criterion: net energy intake rate

$$E_{net} = E_{in} - E_{out}$$

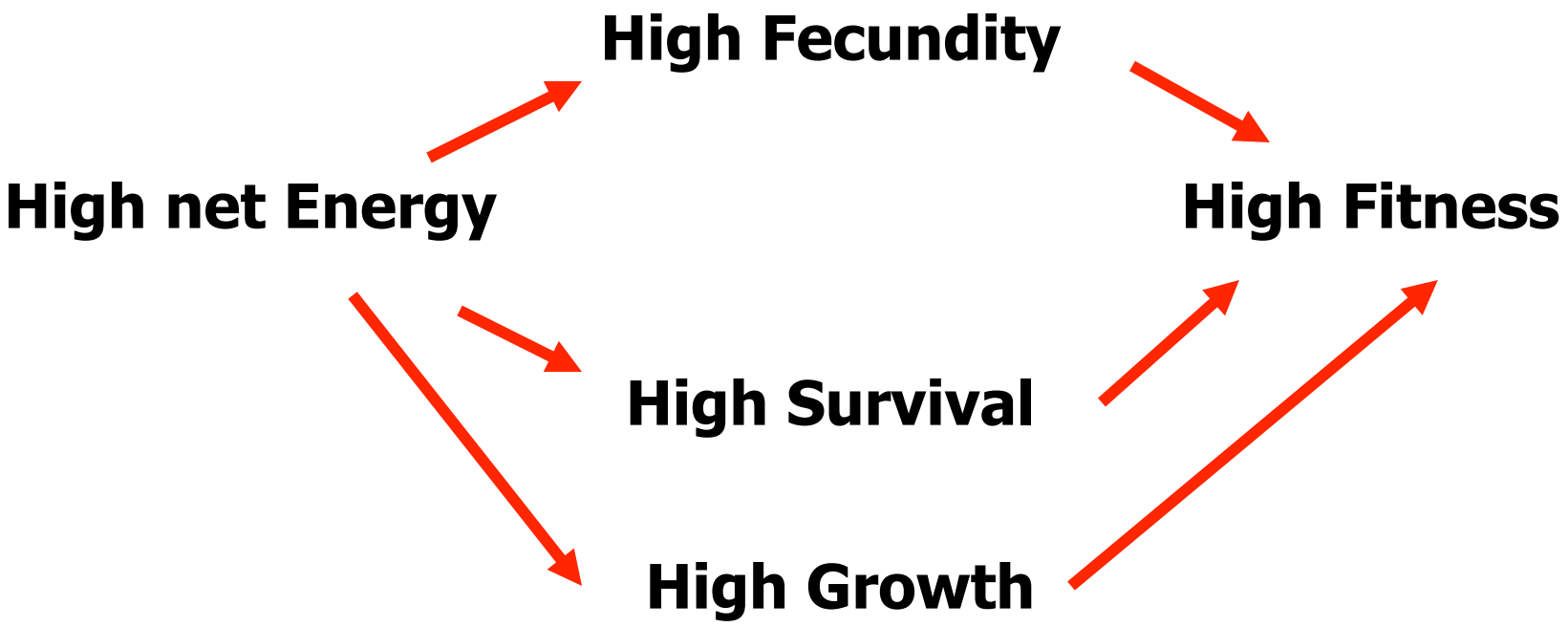
$$E_{rate} = \frac{E_{in} - E_{out}}{T_{Foraging}}$$

Maximize This!

MacArthur and Pianka (1966) *American Naturalist*

Why a High E_{net}?

- Need minimum energy to stay alive, why want more?



Why is *Rate* Important in Getting Energy (low T_F)?

- Foraging can be dangerous
  - could become a meal while getting a meal
- Lost opportunities: when you are foraging you aren't engaging in other behaviors that may increase fitness
  - Mating
  - cleaning (preening)
  - social behavior
- Result: try to get high net energy as quickly as possible!

What Foods to Eat: Optimal Diet

- What is the best food type?
- All food items have
  - benefits: food value (energy)
  - costs
    - energetic costs of capture and handling
    - time costs (handling time)
  - **Profitability**

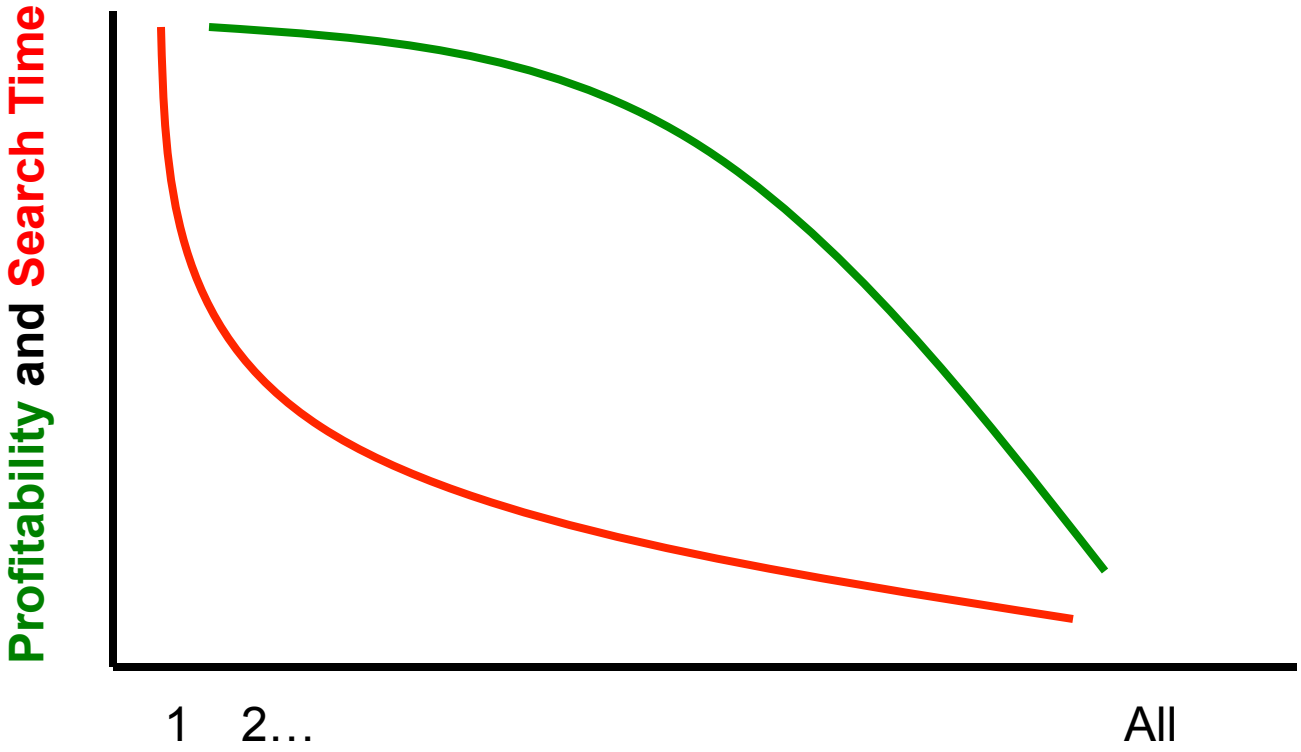
$$\frac{B}{C} = \frac{E_{net}}{T_h} \; or \; \frac{E_{gross} - E_{handling}}{T_{handling}}$$

Optimal Diet Breadth

- Most foragers can't simply eat only the most profitable food item
  - usually in short supply
- Thus, the optimal diet usually consists of two or more food items
- Key is predicting how *broad* the diet will be

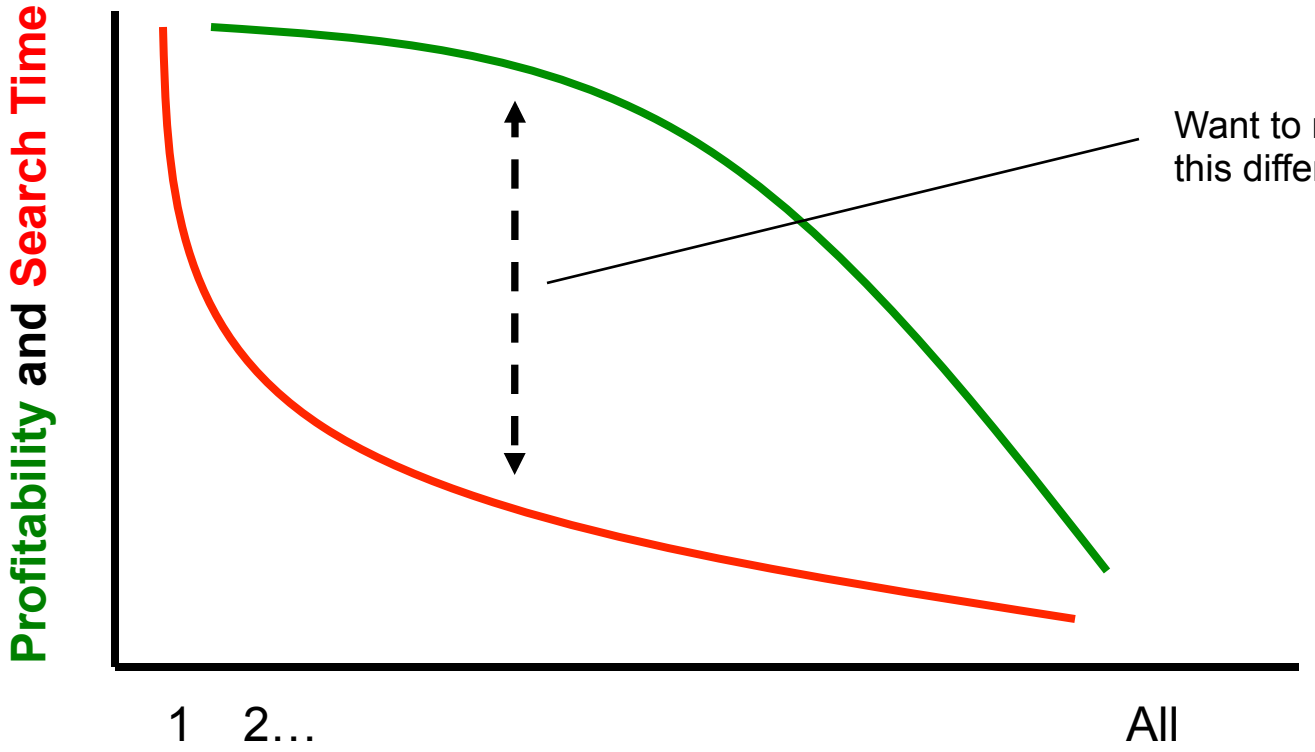
Koala (*Phascolarctos cinereus*) rely solely on eucalyptus

Predicting Optimal Diet Breadth



$$E_{rate} = \frac{E_{in} - E_{out}}{T_{Foraging}}$$

Predicting Optimal Diet Breadth



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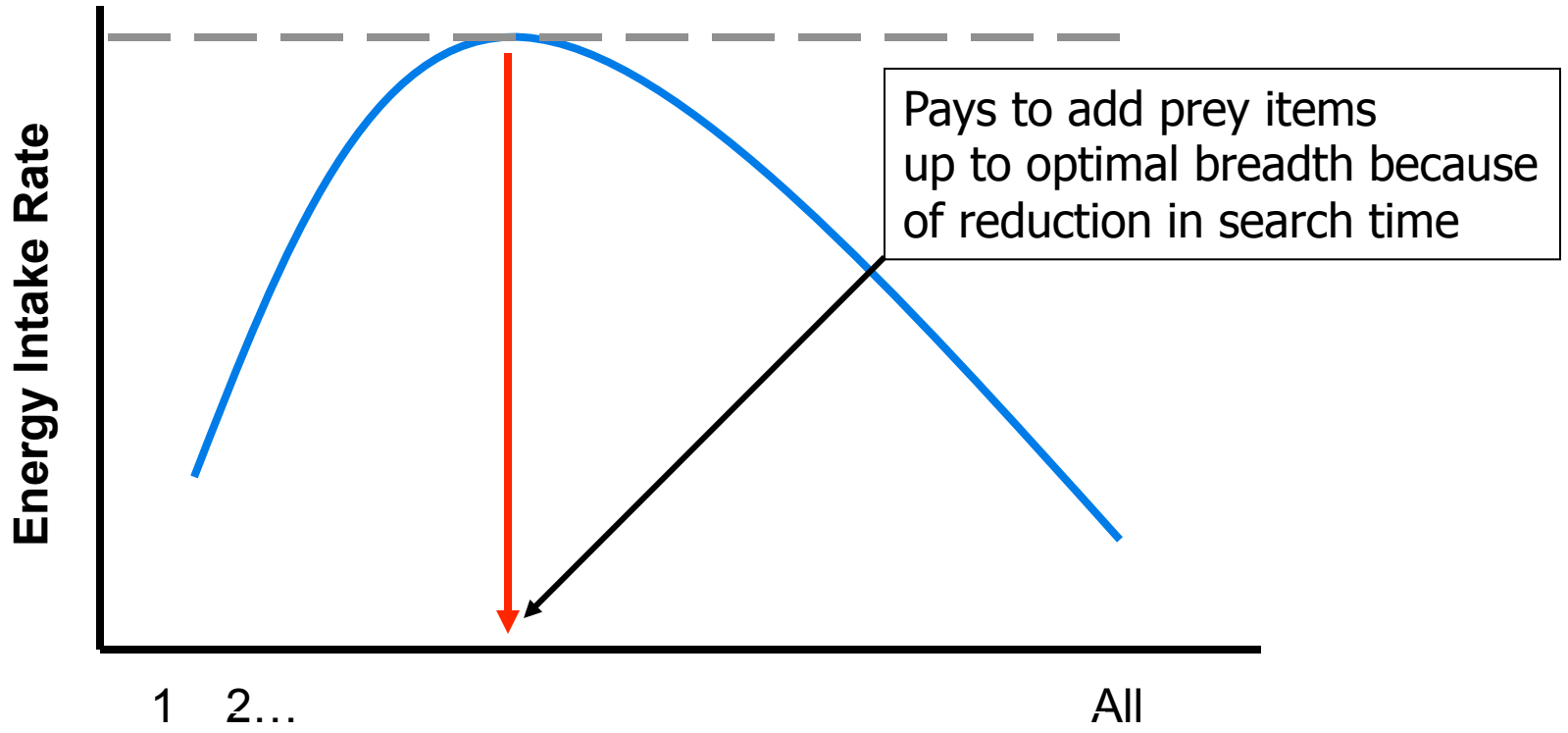
Predicting Optimal Diet Breadth



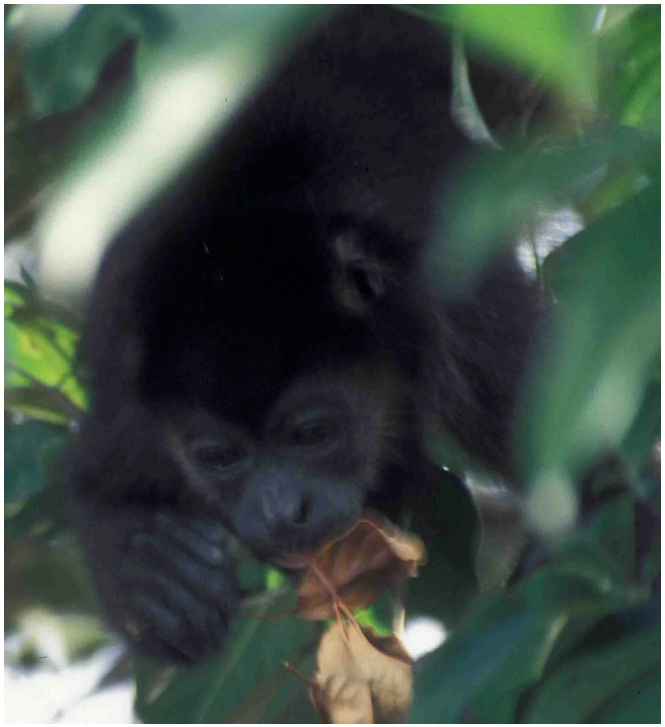
$$E_{rate} = \frac{E_{in} - E_{out}}{T_{Foraging}}$$

Processing Food

The physical process of extracting energy and nutrients from consumed food (i.e., digestion)

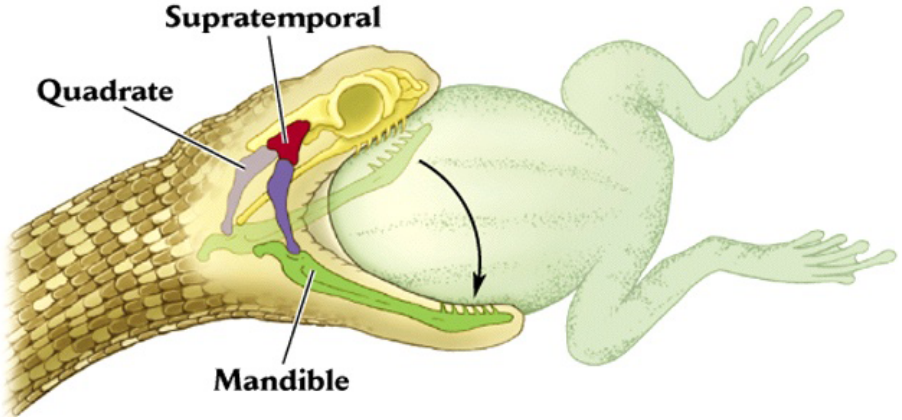
Foragers Have Morphological Adaptations for Processing Food

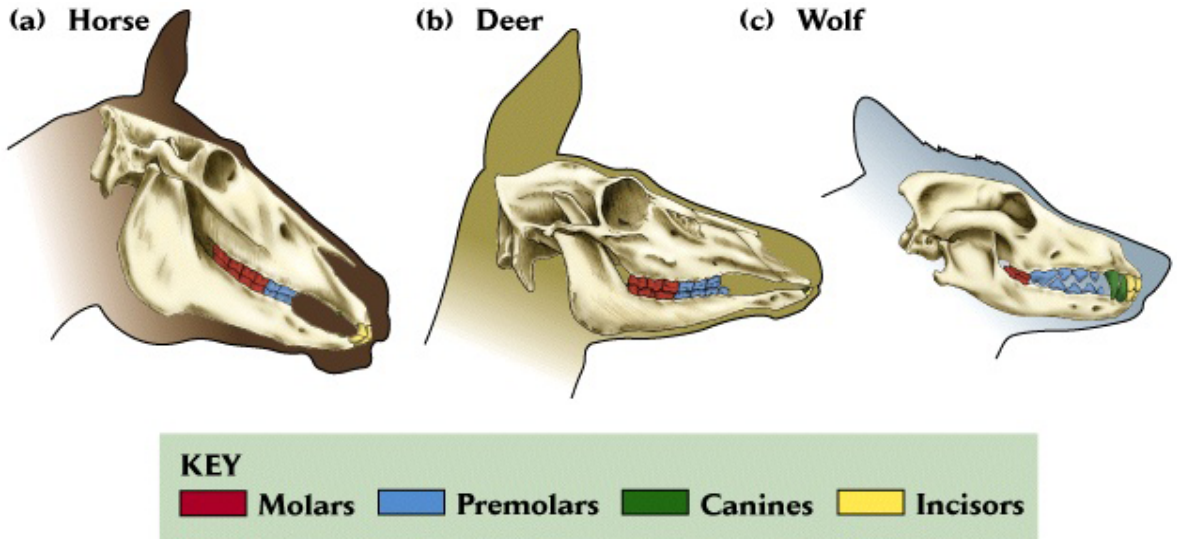
- Modification of limbs to manipulate prey
  - e.g. tearing vs grasping



Foragers Have Morphological Adaptations for Processing Food

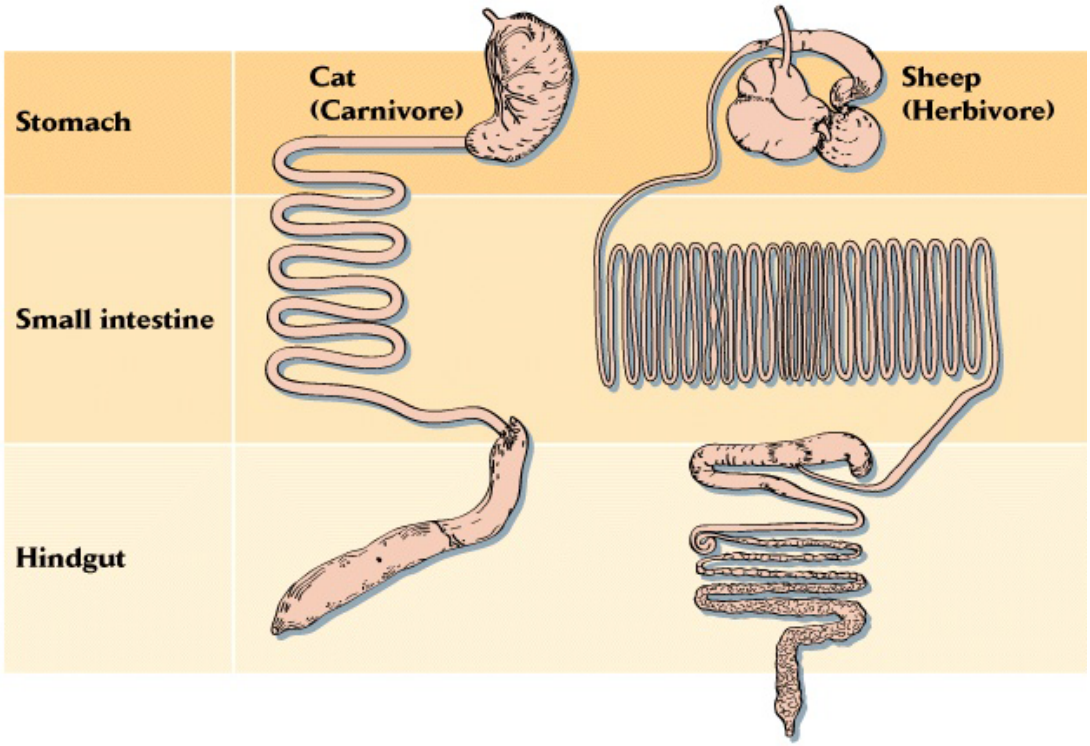
- Jaws and teeth are adapted to diet
  - e.g., crushing vs tearing vs browsing





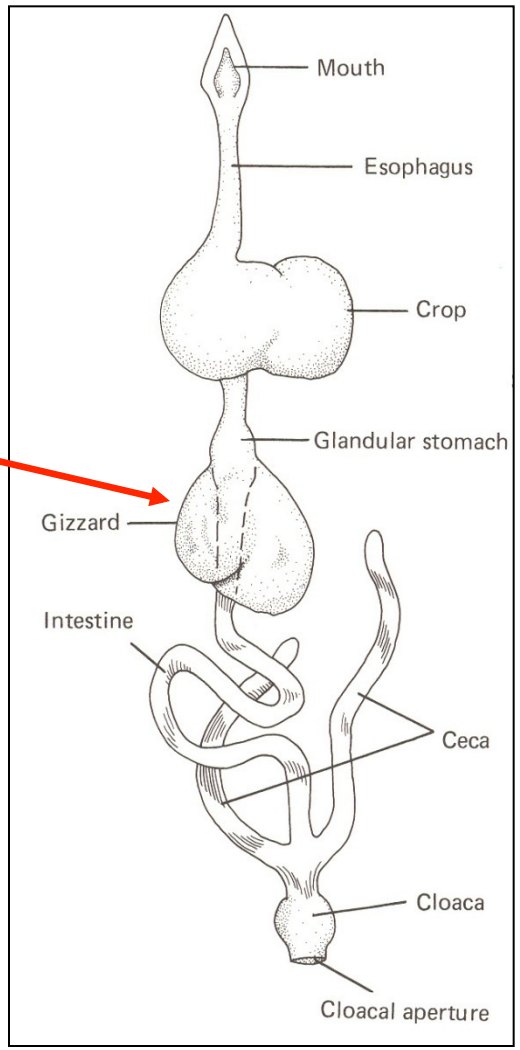
Foragers Have Morphological Adaptations for Processing Food

- Digestive systems reflect diet
- Plant eaters have elongated digestive tracts with fermentation chambers
  - Length increases surface area (to extract limited nutrients)
  - chambers contain microbes (e.g., bacteria) that aid in digestion



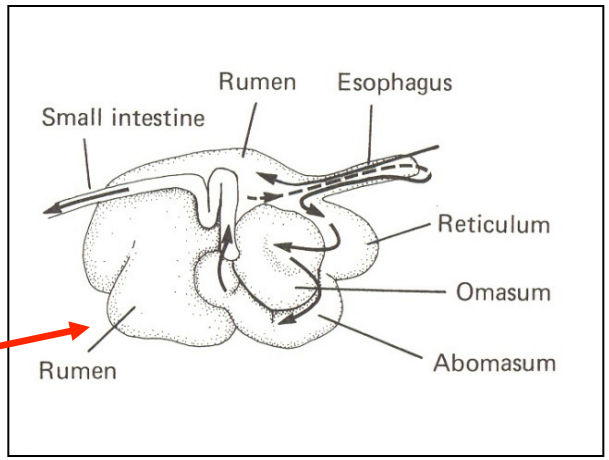
Herbivore Digestion

- Need to mechanically break down plant material
  - Birds have gizzards (muscular grinding)



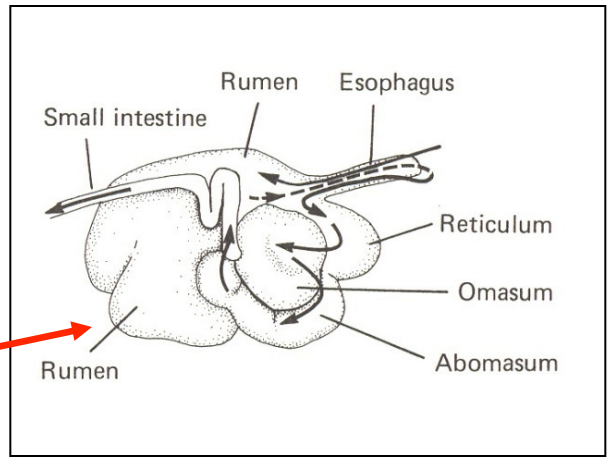
Herbivore Digestion

- Need to mechanically break down plant material
  - Some mammals (ruminants) have rumen used as a mechanical filter (allows regurgitation and rechewing)



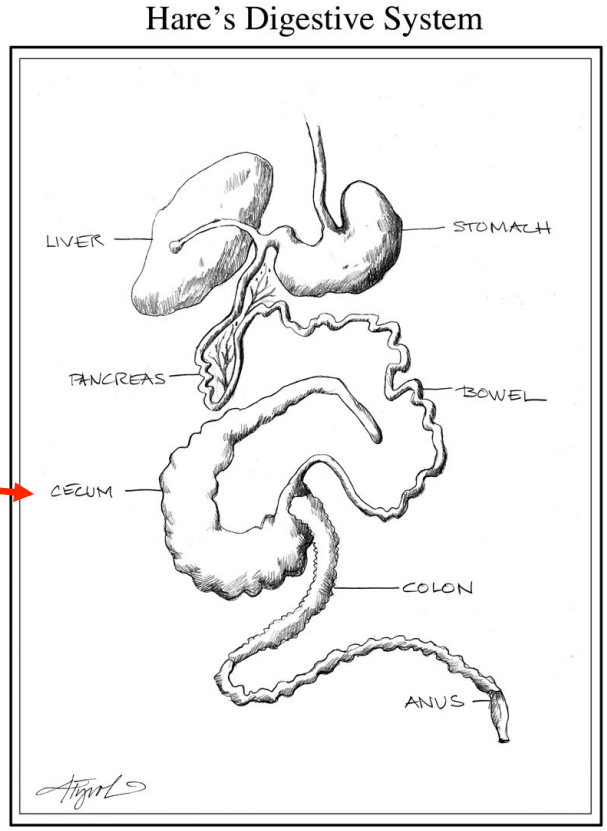
Herbivore Digestion

- Need to ferment plant material
  - Rumen also contains billions of microbes (bacteria, protozoa, fungi) that break down cellulose, release nutrients



Herbivore Digestion

- Need to ferment plant material
  - In other mammals (hindgut fermenters), microbes for plant digestion are in the cecum and large intestine



In Focus: Natural History

- Hindgut fermentation is less efficient than rumination
  - Often requires coprophagy (double processing)
  - e.g., brown hares (*Lepus europaeus*)

Hare fecal pellets emerge highly processed