

Animal Adaptations



Animal Adaptations

- I. Animals and Nutrient Acquisition
- II. Animal Response to Thermal Environment
- III. Animal Adaptations to Moisture
- IV. Response to Light

Animal Adaptations

- I. Animals and Nutrient Acquisition
 - Animals need to derive energy from organic (carbon) compounds
 - Plants become the ultimate source for these energy → CONFLICT!!!!
 - How to convert plant tissue into animal tissue? (different chemical composition)

I. Animals and Nutrient Acquisition

- Mean of acquiring nutrients
- Animals classified based on means of acquiring food resources:
 - Herbivores → plant tissue
 - Carnivores → animal tissue
 - Omnivores → plant & animal
 - Detritivores → detritus



I. Animals and Nutrient Acquisition

- **Herbivory:** consumption of plant material (primary consumers)
 - Grazers → leaf material (i.e., grasses)
 - Browsers → wood material
 - Granivores → seeds
 - Frugivores → fruit

I. Animals and Nutrient Acquisition

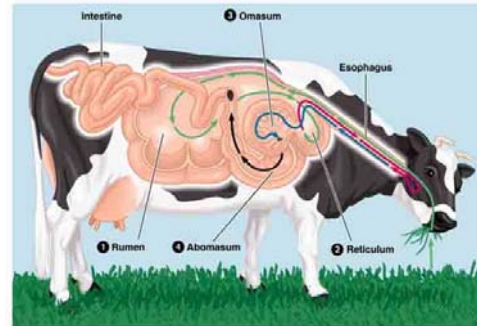
- Herbivores → dietary problems
- Diets rich in carbon, low in protein
- Carbohydrates locked in indigestible cellulose (proteins locked in chemical compounds)
- Depend on bacteria and protozoa (inside digestive track)

I. Animals and Nutrient Acquisition

- **Ruminants** (i.e., cattle and deer)
 - Anatomically specialized for digestion of cellulose
 - Complex digestive system (4 compartment stomach and long intestine)
 - Rumen
 - Reticulum
 - Omasum
 - Abomasum (true stomach)



Ruminant stomach



I. Animals and Nutrient Acquisition

- Other adaptations by herbivores
 - Long intestines (slow the passage of food)
 - Caecum → blind pouch attached to the colon where fermentation occurs
 - Coprophagy → ingestion of fecal matter for further extraction of nutrients
 - Herbivorous fish feed on algal growth
 - Thin-walled stomachs (low stomach pH), pharyngeal jaws, microbial fermentation, etc.

I. Animals and Nutrient Acquisition

- **Carnivory:** consumption of animal tissue, flesh eaters (secondary consumers)
- Herbivores as the energy source
 - First-level carnivores → feed on herbivores
 - Second-level carnivores → feed on 1st level

I. Animals and Nutrient Acquisition

- Carnivores → not faced with digestive constraints based on food quality
- Major problem in food quantity
- As feeding level increases, numbers decrease because of limited energy sources

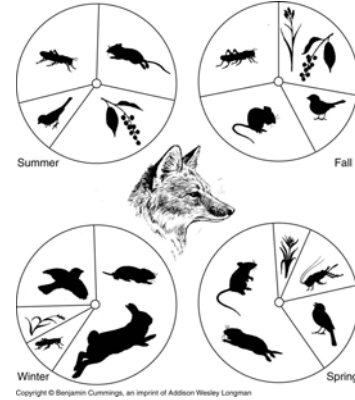
I. Animals and Nutrient Acquisition

- Carnivores
- Short intestines and simple stomachs
- Stores and mixes food
- Enzymes and hydrochloric acid speed digestion

I. Animals and Nutrient Acquisition

- **Omnivory:** feeding on more than one trophic level (i.e., plants and animals)
- Varies with seasons, stages in life cycle, size and growth

Food habits of the red fox (*Vulpes vulpes*) varies with season



I. Animals and Nutrient Acquisition

- **Detritus feeding:** feed on dead organic material (detritus)
- Mostly invertebrates
- Closely related to the breakdown of organic matter and decomposition

I. Animals and Nutrient Acquisition

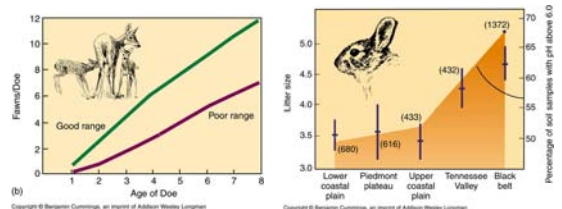
- Nutritional needs
 - Animals require mineral elements and 20 amino acids, of which 14 are essential
 - Remember elemental nutrients!!!
 - Plants → ultimate source of most nutrients, thus quantity and quality of plants affects consumers directly
 - Reproductive success, survival, growth, etc. → FITNESS

I. Animals and Nutrient Acquisition

- Nutritional needs
 - Nitrogen content → directly related to food quality (high N)
 - Low C:N → good
 - High C:N → not so good
 - As the nitrogen content of the food increases, assimilation of plant material improves

I. Animals and Nutrient Acquisition

- Nutritional needs
 - Mineral availability and deficiencies can influence the abundance, distribution, and relative fitness of animals



I. Animals and Nutrient Acquisition

- Link between food source, species morphology, and behavior
 - High consumer diversity = wide array of potential food sources
- Conflict:
 - Acquiring and assimilating the resource
 - Influence the evolution of characteristics
 - Physiology, morphology, and behavior



Animal Adaptations

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Animal Adaptations

- I. Animals and Nutrient Acquisition
- II. Animal Response to Thermal Environment
 - How do animals regulate their temperature in relation to the environment?
 - Is it cold enough for you?
 - How can we make it warmer...or colder?

II. Animal Response to the Thermal Environment

- Maintain a thermal balance
 - Heat gained by the body must be balanced by heat losses (environment)
 - Conduction
 - Convection
 - Radiation
 - Evaporation
- } Remember Plants!
- Metabolic heat production

II. Animal Response to the Thermal Environment

- Maintain a thermal balance
 - How do animals confront thermal stress?
 - Different in terrestrial and aquatic habitats
 - WHY?
 - Air has lower specific heat than water (absorbs less solar radiation)
 - Thus, terrestrial animals subject to more radical environment (potential dangerous changes)

II. Animal Response to the Thermal Environment

- How do animals confront thermal stress?
- Physiologically → 3 major groups
- 1) **Homeotherms**: animals that maintain a fairly constant internal temp regardless of external temps (i.e., birds and mammals)
- 2) **Poikilotherms**: animals that allow their body temp to vary with ambient temps (i.e., inverts, fish, amphibians, and reptiles)
- 3) **Heterotherms**: animals that sometimes regulate their temp and sometimes do not (i.e., bees and bats)

II. Animal Response to the Thermal Environment

- How do they do it?
- 1) Homeotherms → **endothermy** (internal production of heat via oxidative metabolic processes)
- 2) Poikilotherms → **ectothermy** (external sources, rather than metabolism; solar radiation and re-radiation)
- 3) Heterotherms → both endothermy and ectothermy depending on environmental situation

II. Animal Response to the Thermal Environment

- **Poikilotherms** (amphibians, insects)
 - High thermal conductance between the body and the environment
 - Low metabolic rate
 - Body temperature changes with environmental temperature
 - Metabolic rate increases exponentially with increasing temperature (**van't Hoff's rule**)

II. Animal Response to the Thermal Environment

- **Poikilotherms** (amphibians, insects)
 - van't Hoff's rule:
 - For every 10°C rise in temperature, oxygen consumption rates (i.e., metabolism) doubles
 - A generalized version of van't Hoff's rule called Q_{10} or temp coefficient:

$$Q_{10} = R_T / R_{T-10}$$

II. Animal Response to the Thermal Environment

$$Q_{10} = R_T / R_{T-10}$$

- Where R_T = the rate at any given body temperature T
- R_{T-10} = rate at body temperature T - 10°C
- Typically Q_{10} 's are around 2 (thus metabolic rates double for 10°C rise in temp)

II. Animal Response to the Thermal Environment

- **Poikilotherms** advantages and disadvantages:
 - Highly active only when temps are sufficiently warm and sluggish when cool (i.e., snakes)
 - Restricted active life (seasonal)
 - Thus poikilothermic predators secure prey by ambush rather than chase

II. Animal Response to the Thermal Environment

- Poikilotherms advantages and disadvantages:
 - Can reduce metabolic activity when conditions are unfavorable (i.e., extreme temps, water or food shortages)
 - Can colonize areas of limited food and water supply (i.e., deserts)
 - Not limited to minimum size or shape
 - May have maximum-size limitations (not able to absorb enough heat to warm a large body)

II. Animal Response to the Thermal Environment

- Poikilotherms temperature adaptations
 - Small size organisms can exploit habitats with less restraint (remember microclimates)
 - Small organisms (i.e., beetle, small lizard) can adjust to temperature rather quickly (heats up or cools down fast due to small weight) to make maximum use of favorable thermal conditions during the day
 - Can also seek shade in small crevices if temp exceeds

II. Animal Response to the Thermal Environment

- Poikilotherms temperature adaptations
 - Large size organisms (i.e., very large lizard or tortoise) heat slowly, need higher temperatures
 - Difficulty locating shelter; restricted to environments with small seasonal fluctuations
 - Aquatic poikilotherms encounter temperature fluctuations of lesser magnitude (remember the qualities of water as related to air → specific heat)

II. Animal Response to the Thermal Environment

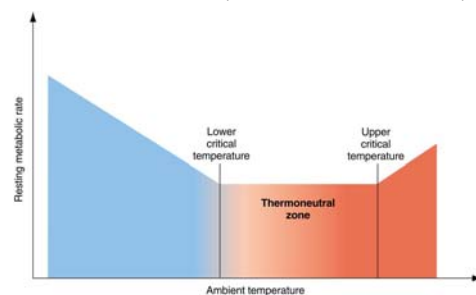
- Poikilotherms temperature adaptations
 - **Heliothermism**: basking in the sun
 - **Evaporative cooling**: organisms that live near water (reduce water loss and body heat loads by getting in and out of water)
 - **Supercooling**: lowering of body temperature below freezing without freezing body tissue: involves the presence of certain solutes (i.e., glycerol)
 - **Diapause**: a resting stage in which there is no feeding, growth, mobility, and reproduction

II. Animal Response to the Thermal Environment

- **Homeotherms** (birds and mammals)
 - Maintain thermal metabolic optimum by oxidizing glucose and other energy-rich molecules
 - Seasonal changes in insulation (i.e., fur, feathers, fat)
 - Increasing or decreasing metabolic heat production

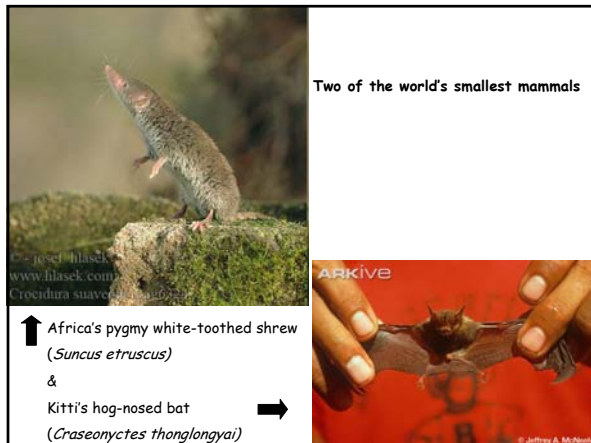
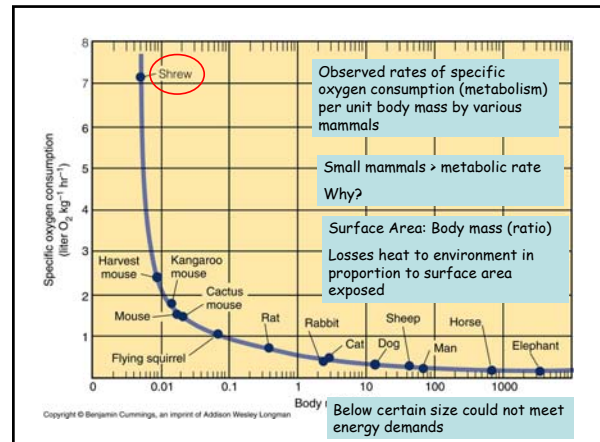
II. Animal Response to the Thermal Environment

- **Homeotherms** (birds and mammals)



II. Animal Response to the Thermal Environment

- **Homeotherms** (birds and mammals)
 - Size restraints:
 - Metabolic rate (oxygen consumption) is inversely proportional to size and mass
 - As body weight increases, the weight-specific metabolic rate decreases (conversely, as body weight decreases, basal metabolism increases)



II. Animal Response to the Thermal Environment

- Homeotherms temperature adaptations
 - Morphological and physiological
 - **Countercurrent heat exchanger**: veins are next to arteries such that warm arterial blood provides heat to cooler venous blood returning to heart (legs of mammals and birds)

II. Animal Response to the Thermal Environment

- Homeotherms temperature adaptations
 - Evaporative cooling → sweating and panting
 - Risk → reduces water balance
 - **Panting**: very rapid shallow breathing that increases evaporation from the upper respiratory tract

II. Animal Response to the Thermal Environment

- Homeotherms temperature adaptations
 - Birds do not sweat → lose heat mostly via radiation, conduction, and convection
 - Panting requires work and adds metabolic heat, >> energy
 - **Gular fluttering**: vibrating their throat sac rapidly with their mouth open (like panting, but a lower cost, << energy)

II. Animal Response to the Thermal Environment

- Homeotherms temperature adaptations
 - **Shivering**: uncoordinated, involuntary, high frequency contraction of muscles to increase temperature
 - Behavior adaptations → nocturnal or diurnal habits (avoidance of extreme heat or cold)

II. Animal Response to the Thermal Environment

- **Heterotherms**: sometimes regulate temperature, sometimes not
 - Example, flying insects
 - When at rest insects are poikilothermic
 - When flying they can produce a lot of heat (high rates of metabolism) by fast movement of wings
 - Usually need the ambient temperature to be warm enough first and must lose excess heat (i.e., butterflies, moths, bees)

II. Animal Response to the Thermal Environment

- Heterotherms temperature adaptations
 - **Torpor**: daily reduction in body temperature to ambient levels in homeotherms (i.e., bats)
 - Reduce energy demands during inactivity
 - Can quickly return body temperature to normal (arousal or rapid activity)
 - **Hibernation**: deeper state of torpor with substantial drop in metabolic rate (i.e., rodents - seasonal dormancy)

II. Animal Response to the Thermal Environment

- Heterotherms temperature adaptations
 - Most animals that hibernate are small (high metabolic rates - European hedgehog, eastern pigmy-possum, hummingbirds, etc.)
 - Unique hibernators → black bear and grizzly bear
 - Build sufficient fat reserves to last them through winter dormancy (metabolism unchanged)
 - During fall can consume > 20,000 calories/day

II. Animal Response to the Thermal Environment

- Heterotherms temperature adaptations
 - Similar to hibernation, some animals employ a summer dormancy called **estivation**
 - During hottest, driest parts of year
 - Some consider it to be the same as hibernation (shallow torpor)

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III. Animal Adaptations to Moisture

- Maintenance of Water Balance
 - Input of water must equal water losses (or else dehydration)
 - Big problem in desert & saltwater environments
 - KIDNEYS → mechanism for maintaining an osmotic balance
 - Maintains water and solute balances in the body

III. Animal Adaptations to Moisture

- Maintenance of Water Balance
- Examples:
 - **Hypo-osmotic** Marine and Brackish Water Organisms (have cells that are more dilute than saltwater)
 - Inhibit the loss of water by osmosis through the body wall and prevent an accumulation of salt in the system

III. Animal Adaptations to Moisture

- Maintenance of Water Balance
- Examples:
 - **Iso-osmotic** Invertebrates in Seawater (Have same osmotic pressure as seawater; i.e., clams and sponges)
 - No problem with osmotic imbalance

III. Animal Adaptations to Moisture

- Maintenance of Water Balance
- Examples:
 - **Hyper-osmotic** Freshwater Organisms (body fluids that are osmotically more concentrated than the surrounding medium)
 - Need to prevent osmotic inflow
 - Ever heard of "drink like a fish"... think also "pee like fish"

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IV. Animal Responses to Light

- The daily and seasonal changes in the light environment can trigger responses in the activities of animals (not just plants)
- Two examples:
 - Circadian Rhythms
 - Tidal and Lunar Rhythms

IV. Animal Responses to Light

- **Circadian Rhythms:** endogenous (internal) rhythm of physiological or behavioral activity lasting ~ 24 hrs
- From Latin "circa" = about and "dies" = day
- "Approximate" match with Earth's rotation or light/dark cycle

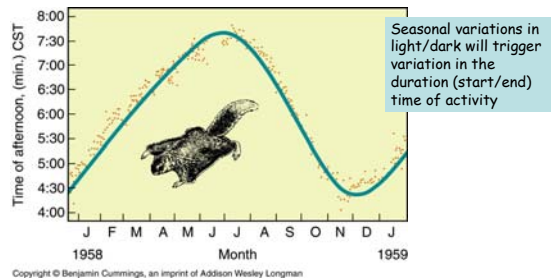


IV. Animal Responses to Light

- Circadian Rhythms (response cues)
 - **The Biological Clock:** the timekeeper of physiological and physical activity in animals → adapts to periods of light/dark
 - **Critical Daylength:** the period of daylight, specific for any given species, that triggers a long-day or short-day response in organisms

IV. Animal Responses to Light

- Circadian Rhythms: Daylength



IV. Animal Responses to Light

- **Tidal and Lunar Cycles**
- Animals that show rhythms that coincide with the cycles of high and low tide
 - Common in intertidal zones animals:
 - European shore crabs (*Carcinus maenas*)
 - Fiddle crabs (*Uca minas* & *U. crenulata*)
 - Grunion (*Leusethes tenuis*) → California fish
 - Can affect reproduction, dispersal, etc.