Lecture 05 – Animal Form and Function

1. What is an animal?
    a. Eukaryotic
    b. Multicellular
    c. Heterotroph
        i. Specifically, feeds by ingestion (not absorption)
2. Adaptations for movement
    a. Flexible cell membranes
    b. Nervous and muscular tissue
    c. Glycogen as storage product
    d. Some animals sessile, but even they generally have motile life stage
3. Form is function
    a. Functions:
        i. Exchange materials with environment
        ii. Maintain internal conditions
        iii. Live within physical laws of the universe
    b. Forms:
        i. Adaptations:
            1. Heritable traits that increase ability to survive and reproduce
            2. Fitness trade-offs
            3. Physics important to understanding how organisms interact with environment
    c. One important feature: size
        i. As size increases, surface area and volume both increase, but volume increases much faster
            1. SA = $6(l^2)$
            2. Volume = $(l)^3$
            3. In other words, small animal has high surface area:volume
            4. Large animal has low surface area:volume
        ii. Transport relies on diffusion
            1. For simple organisms, transport occurs across plasma membrane

a. Puts a cap on size for simple organisms

2. For animals, some do use diffusion
    a. Usually adapted to bring lots of surface area into contact with envi
3. Larger, more complex organisms have transportation issues: too much volume to supply by diffusion across surface area
    a. Requires specialization!

iii. Tissues: specialized cells working together for some function

1. Types
    a. Connective Tissue
        i. Binds and supports other tissues
        ii. Types:
            1. Loose connective tissue
            2. Tendons/Ligaments
            3. Bone/Cartilage
            4. Blood
            5. Fat
        iii. Defined by elaborated extracellular matrix, often many types of fibers
    b. Muscle Tissue
        i. Ability to contract
        ii. Allow movement
        iii. Types:
            1. Skeletal – voluntary, striated
            2. Smooth – involuntary, unstriated
                a. Allows organs to contract
            3. Cardiac – involuntary, straited
    c. Nervous Tissue
        i. Neurons: generate/conduct electrical signals between cells
            1. Coordinate organism Responses

ii. Glial cells: Surround, support neurons; variety of important functions

d. Epithelial Tissue

i. Interface between organism and environment

1. Diffusion between environment and transport systems occurs here
2. (For example, food in gut is broken down, diffusion of particles across epithelium)

2. Tissues which rely on diffusion often have greater surface area
3. Organized into organs

iv. Transport is one component of larger size, but many others

v. Mass increases with volume; therefore, mass increases faster than surface area

1. Problem: organisms are "held up" by cross-sectional area of leg
2. Larger organisms need legs which are relatively larger

vi. Size and metabolism

1. Large organism has larger <u>basal metabolic rate</u> (rate of oxygen consumption) than small animal
    a. That makes sense: large animal needs more food to supply tissues
2. But, per kg, small animal has much higher metabolism
    a. In mass, 1 elephant = 200,000 mice
    b. 200,000 mice need WAY more food than 1 elephant
    c. Partly due to surface area:volume
        i. Small organisms ramp up metabolism, because they're losing more heat to envi
            1. "live fast"
        ii. Large organisms slow down metabolism, because they don't have enough digestive surface area to provide for faster metabolism
            1. "live slow"

4. Homeostasis
    a. Stability of chemical and physical conditions within an animal

b. The environmental conditions may differ, but the internal state is kept within some tolerable range
    i. Important, because most systems work best under narrow range of conditions
c. Two approaches:
    i. Conformation: Allow internal conditions to change with environment
    ii. Regulation: Animal uses internal mechanisms to control conditions
d. Maintaining Homeostasis
    i. Negative Feedback mechanism: effectors reduce or oppose change in internal condition
        1. Sensor: senses external or internal environment
        2. Integrator: 'decides' whether response is necessary to maintain homeostasis
        3. Effector: generates some response to change condition
e. Body temperature
    i. Thermoregulation
    ii. Ectotherm: ("outer-heat") relies on heat energy from the environment
        1. Benefits
            a. Require much less food/ food of lower quality
            b. Greater % energy to growth and reproduction
        2. Costs
            a. When cold, sluggish
            b. Greater predation risk in cold
            c. Less environmental flexibility
    iii. Endotherm: ("inner-heat") produces enough heat during metabolism to heat self
        1. Benefits:
            a. Can be active during cold/night
            b. More energy = extreme phenotypes (flight, distance running)
        2. Costs:
            a. Metabolic heat = MUCH more food required
            b. Less energy for growth and reproduction
    iv. Homeotherms: (same temperature) keep body temperature constant

1. Usually endotherms

v. Poikilotherms: (varied temperature) allow body temperature to vary depending upon environmental conditions
    1. Usually ectotherms
vi. Heat exchange
    1. Mechanisms
        a. Radiation
        b. Conduction
        c. Convection
        d. Evaporation
    2. Balancing heat loss/gain
        a. Insulation: protect against heat loss
            i. Doubly important for endotherms, which use their own metabolism to generate heat
        b. Behavioral regulation
        c. Countercurrent exchange
            i. Warm blood traveling toward extremities is in close contact with cold blood returning
            ii. Limits heat loss to envi
        d. Torpor: Reduce metabolic rate and allow body temperature to drop
        e. Hibernation: Torpor that lasts for weeks or months
        f. Evaporation/convection

Focal Questions

1. What is an animal?
2. How are animals adapted to movement?
3. What are the fundamental functions that animals must accomplish? How does their form allow for them to accomplish those functions?
4. What is an adaptation?
5. How does surface area relate to volume? Understand this relationship, in terms of the needs of organisms of variable sizes. (Specifically, transport of materials, structural support required, and metabolism)
6. Know the four tissue types. Be familiar with their roles and how their form impacts their function.

7. Understand Basal metabolic rate. Understand how size affects both absolute and relative BMR.
8. What is homeostasis? Why is it important to maintain?
9. What is the difference between conformers and regulators?
10. How does negative feedback maintain homeostasis?
11. Compare and contrast endothermy and ecothermy. What are the pros and cons of both systems of thermoregulation?
12. What are the four mechanisms of heat exchange? How can animals behaviorally and physiologically regulate heat exchange?