



Chapter 40:
Basic Principles of Animal Form and Function
AP Biology 2013

1

Form and Function

- * Comparative studies show that form and function are closely related
- * Natural selection can fit the form (anatomy) to the function (physiology) by selecting, over many generations, what works best among the available variations in a population.

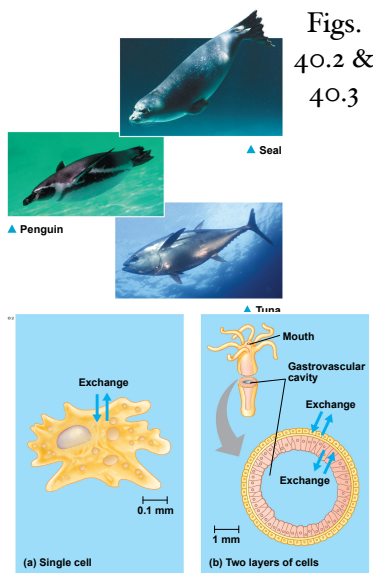


Fig. 40.1

2

Physical Laws and Form

- * Ability to perform specific actions depends on size and shape
- * Convergent evolution reflects different species' independent adaptation to similar environmental changes
- * Size and shape have a direct effect on how the animal exchanges energy and materials with its surroundings (substances dissolved in an aqueous medium diffuse and transport across cell membranes)
- * Ex. single celled protists have sufficient surface area to service its volume
- * Ex. multicellular organisms with a sac body plan have body walls that are only two cells thick



Figs. 40.2 & 40.3

3

Organisms with Complex Body Plans

- * More complex multicellular organisms have highly folded internal structures specialized for exchanging materials
- * In vertebrates, the space between cells is filled with interstitial fluid which allows for movement of material in and out of the cell

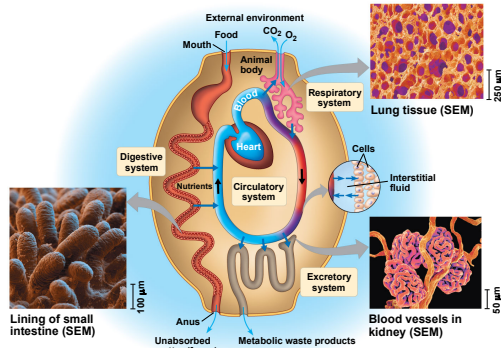


Fig. 40.4

4

Form and Function with Levels of Organization

- * Animals are composed of cells
- * Cells are grouped together with those of common structure and function to make up tissues
- * Tissues make up organs, which make up organ systems
- * Types of tissues include: epithelial, connective, muscle, and nervous

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Types of Tissues

- * Epithelial tissue - covers the outside of the body and lines the organs and cavities within the body
- * Contains cells that are closely joined
- * Nervous tissue - senses stimuli and transmits signals throughout the animal
- * Contains neurons (transmit impulses) and glial cells (nourish and insulate neurons)

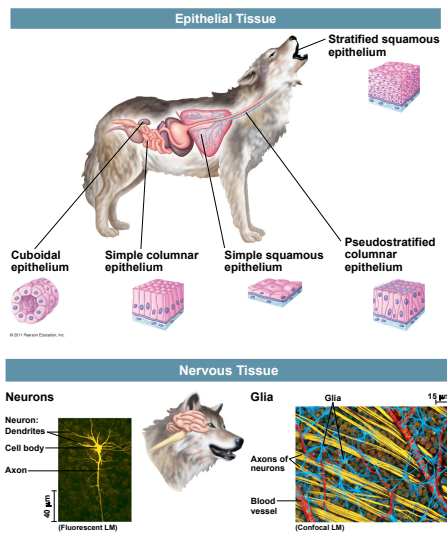


Fig. 40.5

6

Types of Tissues

- * Connective tissue - function to bind and support other tissue; sparsely packed cells scattered throughout the extracellular matrix
- * In vertebrates there are six major types of connective tissue:
 - * Loose connective tissue (holds organs into place)
 - * Cartilage (flexible support material)
 - * Fibrous connective tissue (tendons - attach to bone; ligaments - connect bones at joints)
 - * Adipose tissue (stores fat)
 - * Blood (composed of blood cells and cell fragments)
 - * Bone (mineralized form of skeleton)

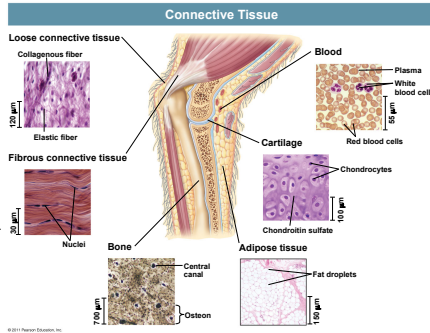


Fig. 40.5

Types of Tissue

- * Muscle tissue - composed of long cells called muscle fibers capable of contracting in response to nervous signals
- * Skeletal muscle [striated muscle] (responsible for voluntary movement)
- * Smooth muscle (responsible for involuntary body activities)
- * Cardiac muscle (responsible for contraction of the heart)

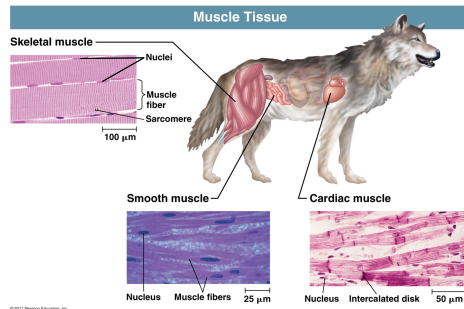


Fig. 40.5

Organs and Organ Systems

- * In all but the simplest animals, different tissues are organized into organs
- * In some organs, tissues are arranged in layers
- * Organ systems carry out the major body functions of most animals

Organ System	Main Components	Main Functions
Digestive	Mouth, pharynx, esophagus, stomach, intestines, liver, pancreas, anus	Food processing (ingestion, digestion, absorption, elimination)
Circulatory	Heart, blood vessels, blood	Internal distribution of materials
Respiratory	Lungs, trachea, other breathing tubes	Gas exchange (uptake of oxygen; disposal of carbon dioxide)
Immune and lymphatic	Bone marrow, lymph nodes, thymus, spleen, lymph vessels, white blood cells	Body defense (fighting infections and cancer)
Excretory	Kidneys, ureters, urinary bladder, urethra	Disposal of metabolic wastes; regulation of osmotic balance of blood
Endocrine	Pituitary, thyroid, pancreas, adrenal, and other hormone-secreting glands	Coordination of body activities (such as digestion and metabolism)
Reproductive	Ovaries or testes and associated organs	Reproduction
Nervous	Brain, spinal cord, nerves, sensory organs	Coordination of body activities; detection of stimuli and formulation of responses to them
Integumentary	Skin and its derivatives (such as hair, claws, skin glands)	Protection against mechanical injury, infection, dehydration, thermoregulation
Skeletal	Skeleton (bones, tendons, ligaments, cartilage)	Body support, protection of internal organs, movement
Muscular	Skeletal muscles	Locomotion and other movement

Coordination and Control

- * Mediated by the endocrine and nervous systems
- * Endocrine system transmits chemical signals (hormones) to receptive cells throughout the body via blood
- * May affect one or more regions throughout the body
- * Usually slow acting but have long lasting effects

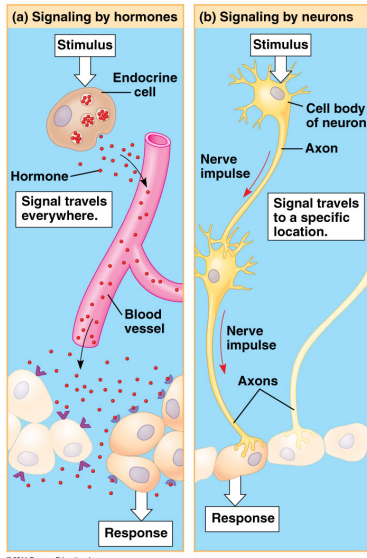
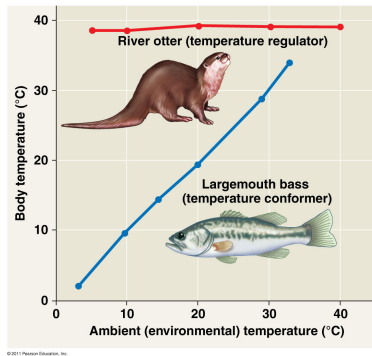


Fig. 40.6

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Internal Regulation

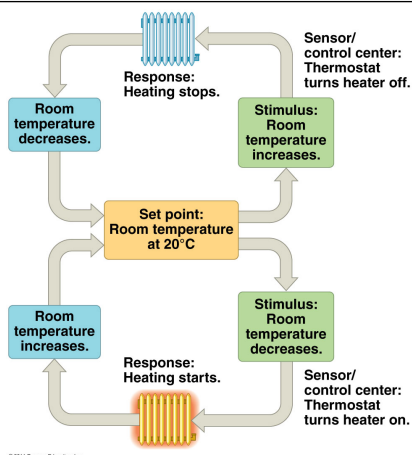
- * Internal environment of vertebrates is called the interstitial fluid and is very different from the external environment
- * Homeostasis - balance between external changes and the animal's internal mechanisms that oppose changes
- * Regulating animals - using internal control mechanisms to modulate internal change in the face of external environmental fluctuations
- * Conforming animals - allows internal conditions to vary with certain external changes



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Homeostasis

- * Moderation of changes in the internal environment
- * Homeostatic control mechanism has three components:
 - * Fluctuations above or below the **set point** serve as a **stimulus**; this is detected by a **sensor** and triggers a **response**
- * Most function by negative feedback (buildup of end product shuts the system off)
- * Some function by positive feedback which involves a change in some variable that triggers mechanisms to amplify the change



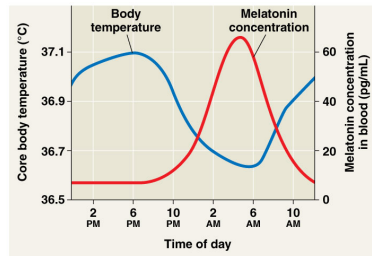
- * Acclimatization - homeostasis adjusts to the external environment

Fig. 40.8

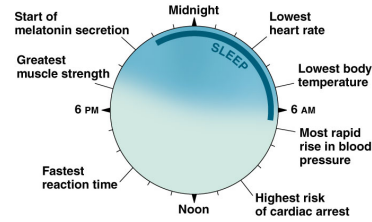
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Circadian Rhythm

- * Set points can change with age or show cyclic variation
- * Circadian rhythm relates to physiological changes that occur roughly every 24 hours



(a) Variation in core body temperature and melatonin concentration in blood



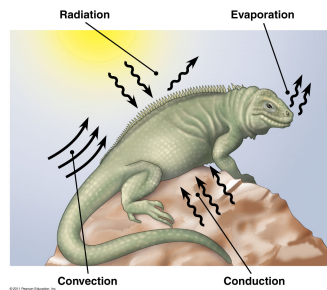
(b) The human circadian clock

Fig. 40.9

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Thermoregulation

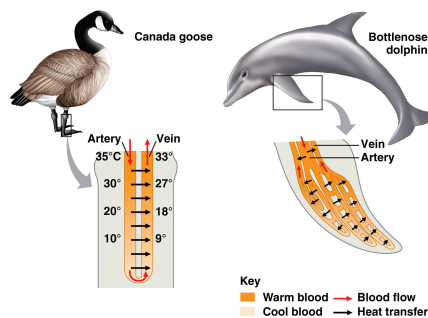
- * Process by which animals maintain an internal temperature within a tolerable range
- * Endothermic - bodies are warmed by heat generated by metabolism (ex. birds and mammals)
- * Typically have higher metabolic rates because it buffers animals' internal temperatures against external fluctuations and enables the animal to maintain a high level of aerobic metabolism
- * Ectothermic - gain their heat from external sources (ex. amphibians and reptiles)
- * Have lower metabolic rates and generally tolerate greater variations in internal temperature



Figs. 40.11

Thermoregulation

- * Physiological and behavioral adjustments that balance heat gain and loss
- * Insulation is an adaptation in mammals and birds
- * Reduces flow of heat between animal and environment (ex. feathers, fur, blubber)
- * In mammals the integumentary system acts as insulating material
- * Many endotherms and some ectotherms can alter the amount of blood flowing between the body core and skin
- * Vasodilation - blood flow to skin increases (causing heat loss)
- * Vasoconstriction - blood flow to skin decreases (lowering heat loss)

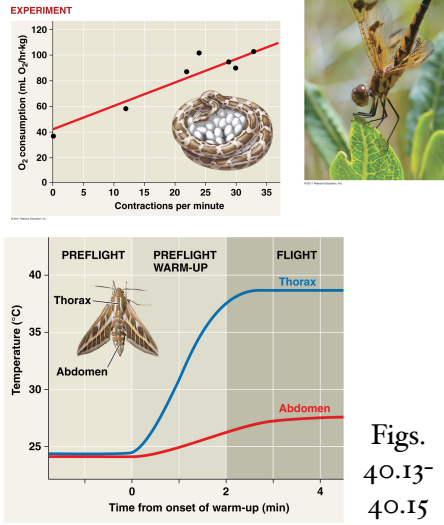


Countercurrent Heat Exchange

Figs. 40.12

Thermoregulation

- * Evaporative cooling with sweat, panting, or bathing
- * Behavioral response: postures that enable them to minimize or maximize absorption of heat
- * Some animals can regulate body temperature by adjusting their rate of metabolic heat production
- * Shivering
- * Mammals regulate by complex negative feedback system that involves several organ systems

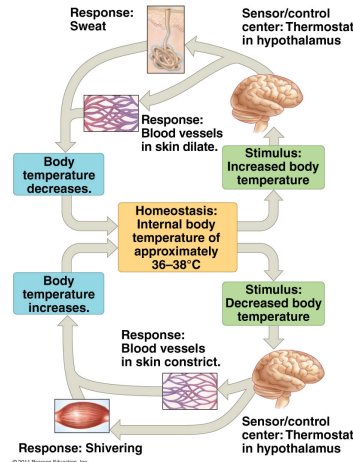


Figs. 40.13-40.15

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- * Humans use the hypothalamus to function as a thermostat
- * Many animals can adjust to a new range of environmental temperatures over a period of days or weeks
- * Acclimatization may involve cellular adjustments or in the case of birds or animals of insulation and metabolic heat production

Thermoregulation



Figs. 40.16

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Energy to Sustain Form and Function

- * Require chemical energy for growth, repair, physiological processes, regulation, and reproduction
- * Bioenergetics - flow of energy through an animal
- * Limits animals behavior, growth, and reproduction
- * Determines how much food the animal needs
- * Harvest energy from food and once digested, it is converted to ATP to power cellular work
- * Remaining energy can be used for biosynthesis
- * Metabolic rate is the amount of energy an animal uses in a unit of time
- * Can be measured by amount of oxygen consumed

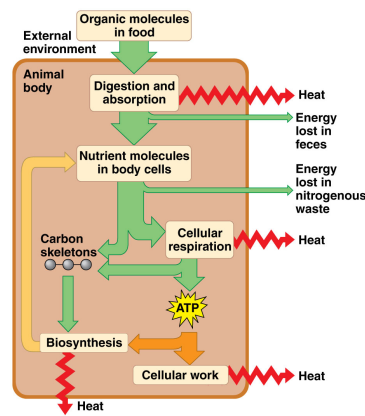
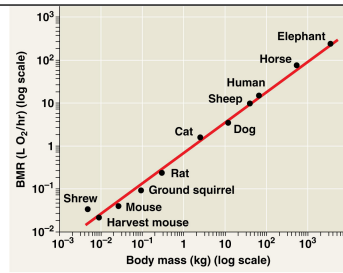


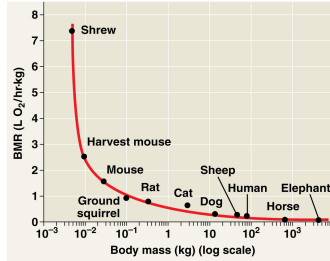
Fig. 40.17

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Bioenergetic Strategies and Metabolic Rate



(a) Relationship of basal metabolic rate (BMR) to body size for various mammals



(b) Relationship of BMR per kilogram of body mass to body size

Fig. 40.19

- * Metabolic rate is impacted by size (inversely related - smaller have higher rates per gram) and activity
- * Basal metabolic rate (BMR) - endotherm at rest
- * Standard metabolic rate (SMR) - ectotherm at rest

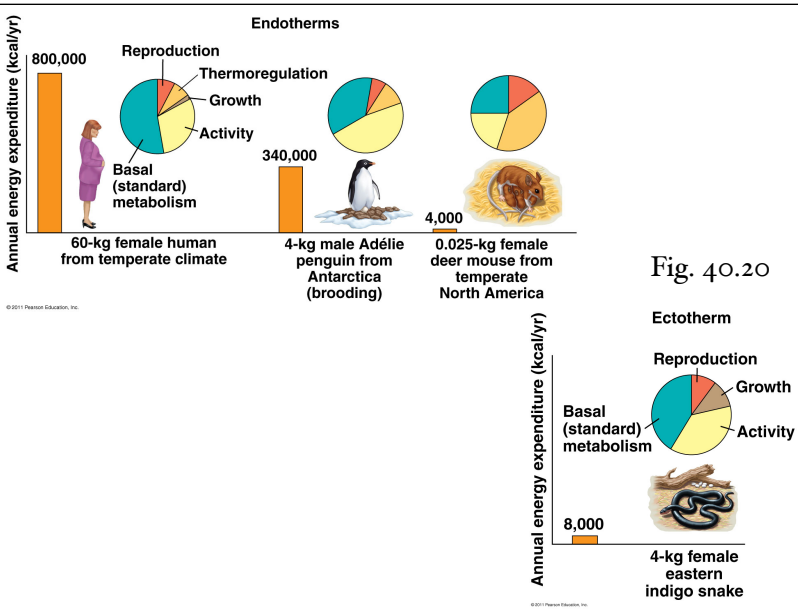


Fig. 40.20

Torpor

- * Torpor - adaptation that enables animals to save energy while avoiding difficult or dangerous conditions
- * Physiological state in which activity is low and metabolism decreases
- * Hibernation is long-term torpor - adaptation to winter cold and food scarcity during which the animal's body temperature declines
- * Estivation (summer torpor) - enables to survive long periods of high temperature and scarce water supplies
- * Daily torpor is exhibited by many small animals and birds and adapted for feeding patterns