Animal Organ Systems
(General)

to understand and appreciate the complexity of different kinds of animals we'll focus on the most familiar (and most complex) animal → US

1. Skin (Integumentary System)

outer covering of the animal

(plants also have outer covering but is much simpler in structure and function)

in us it is very complex structure with a variety of functions

eg. per sq inch:
- 15 ft blood vessels
- 4 yds nerves
- 650 sweat glands
- 100 oil glands
- 1500 sensory receptor cells
- >3 million cells total

General Functions of Skin:

1. protection

mechanical
chemical
bacterial
UV → melanin pigment
desiccation →keratin

2. temperature homeostasis

>temp → sweat glands, flushing
<temp → arrector pili, pale

3. excretion

affects fluid & electrolyte balance
sweat glands release:
water, salts, ammonia
oil glands release:
lipids, acids

4. sensation

touch (light touch, wind, etc)
pressure
heat
cold

pain

some animals use skin for respiration

in some the skin color is important in behaviors:
- communication
- camoflage
- etc

our skin is made up of several Layers:

Epidermis
- upper layers dead, filled with **keratin** (waxy protein)
- for protection from pathogens and waterproofing
- replaced every 35-45 days

Dermis (=hide)
- strong, flexible, connective tissue
- gives skin its strength and resilience
- gel-like matrix
- rich in nerves, receptors, blood vessels, lymph vessels
- hair follicles and sweat glands extend into it

animal skins may have additional structures:

- scales
- hair
- claws or nails
- horns or antlers
- secrete shells
- glands (scent, oil, sweat, poison,etc)

2. Skeletal System

especially terrestrial animals

(in land plants support was also an important consideration; xylem-sclerenchyma, wood)

different kinds:

exoskeleton
endoskeleton
hydrostatic skeleton

Functions of human skeleton:

1. **support**
   strong and relatively light; 20% body weight

2. **movement**
   framework on which muscles act
   act as levers and pivots

3. **protection**
   brain, lungs, heart, reproductive system

bone is active tissue:
→equiv. of skeleton is replaced every 7 years

3. Muscular System

unique to animals
→ animals are much more active than any other kingdom

General Functions:

1. **movement**
   any kind of body movements

   sessile vs **motile**

   voluntary – skeletal muscles

   crawling, running, flying, swimming, burrowing, etc

   involuntary – internal organs, heart

   moving foods and materials through digestive system

   pumping blood through arteries and veins

2. **In warm blooded animals: Heat Generation**

   warm blooded vs coldblooded

   all animals alive today except birds and mammals are "cold blooded"

important for warm blooded animals like us

4. Digestive System

like fungi, and many protists and bacteria, animals are heterotrophs
→ take in organic food

the food is much more complex

most food that we eat cannot be directly used by the body

→too large and complex to be absorbed

→chemical composition must be modified to be useable by cells

generally digest the food after it is eaten,
not before as in fungi or some plants

We need food for:
→nutrients as **building blocks** for synthesis
→sugars, etc to break down for **energy**

digestive system functions to altered the food so that it can be absorbed and used by the body

→physical and chemical digestion
<u>Digestion</u> = all food changes that occur in the alimentary canal

two types of digestion:

physical digestion
breaking large pieces down into smaller pieces
is completed in stomach

chemical digestion
breaking large molecules (proteins, fats, starches, etc)
into small molecules (amino acids, fatty acids, sugars, etc)

→absorption
absorption occurs throughout digestive tract

→collect & eliminate nonuseable components

<u>Organs of the digestive system:</u>

lots of specialization depending on
→how an animal gets its food & what kind of food:

eg. predator, herbivore, parasite,filter feeder, fluid feeder

in some animals the digestive system is a simple sac, opened at one end

→ food to put in, digested and the wastes are "spit out"

in most animals organs of digestive system form essentially a long continuous tube

→ **alimentary canal** (gastrointestinal tract)

mouth→pharynx→esophagus→stomach→ small intestine→large intestine→anus

typically the mouth is armed with the appropriate tools to rip and tear the food into smaller pieces

further down the alimentary canal the food is chemically broken down using enzymes into small molecules that can be easily absorbed

eg. sugars, amino acids, etc

the final part of the digestive system usually consists of an intestine for absorbing the food once it has been prepared

5. The Respiratory System

Respiratory system functions as gas exchange system

oxygen gas is needed as a nutrient;

carbon dioxide gas is a waste product of **cellular respiration** (energy production)

like plants, all animals require O_2 to produce energy

since animals are more active than plants they require more efficient ways to get oxygen

(plants just used simple pores: stomata or lenticels, or pneumatophores)

in very small animals there is no specific "organ"
→ breath through their skin

may have blood or body fluids distribute gasses to body cells

in animals with specific organs air breathing animals have different requirements than those that extract oxygen from water

aquatic animals

Gasses diffuse much slower in water than in air (>density)

water contains 20 times less oxygen than air
→ aquatic organisms must have more efficient respiratory systems
→ high surface area provided by Gills
numerous flaps or feather like structures

no problem drying out
→respiratory organs external, exposed

must keep water moving across gills
→gills in constant motion
→water is constantly pumped over gills

air breathers:

easier to extract O_2 from air: air contains 20 times more air than water

but air dries respiratory surface
→respiratory organs must be protected and kept moist
→ internal
eg. invaginations that branch off digestive tract
eg. In vertebrates the respiratory system branches from the digestive system at the throat

Some terrestrial animals that have returned to water use siphons, bubbles but are really air breathers

eg mosquito larvae, aquatic diving beetles

Some fish have both lungs and gills
→can breath air for short periods of time

in amphibians lungs are not much more than simple bags
→much exchange through mouth and skin

some have both gills and lungs

warm blooded animals (birds & mammals) need much more oxygen and have a much more efficient respiratory system

often the respiratory system is closely associated with some kind of circulatory system to more effectively collect and distribute the oxygen

<u>eg. Human lungs:</u>

some of the most efficient lungs:

→ lots of area for gas exchange

<u>Alveoli</u>

→actual site of gas exchange with blood

microscopic "grapelike clusters"

350 Million alveoli/lung

total surface area ~ 70 (60-80)M^2
(=760 ft^2 ~20'x38')

single cell layer thick (squamous epithelium)

enveloped by capillaries

6. Circulatory System

in small organisms gas exchange and food and wastes enter and leave by simple diffusion

in large, multicellular organisms need some way to move things around from place to place, organ to organ

→large animals have **circulatory system**

(plants had vascular tissue system)

the circulatory system is the major connection between external and internal environment:

→everything going in or out of body must go through the

circulatory system to get to where its going

circulatory system consists of

"**plumbing**" (=blood vessels)

and one or more "**pumps**"(= heart)

can be "open" or "closed" system

in humans blood flows in **closed system** of vessels

over 60,000 miles of vessels (mainly capillaries)

arteries → capillaries → veins

arteries
– take blood away from heart to capillaries
capillaries
-actual site of exchange
venules
– bring blood from capillaries back to heart

in some animals the plumbing is arranged in **two separate circuits**:

pulmonary: heart → lungs → heart

picks up oxygen from the lungs and returns it to the heart

systemic: heart → rest of body → heart

takes oxygenated blood to rest of body

heart is a double pump

7. The Endocrine System

animals are much more active than members of the other two multicellular kingdoms;

they need better coordination and control center than in any other kingdom

→ only members of the animal kingdom have two systems of control

nervous vs endocrine

nervous:

electrochemical impulses
travels along neurons
fast acting
short lived

endocrine:

chemical messengers = **hormones**,
secreted into blood
slower acting
longer lasting

both work together to integrate quick responses with longer lasting reactions to the environment

animals still use hormones for things that have slow response time:

growth, development, reproductive cycles,

8. Nervous System

unique to animals

all life uses chemicals to help coordinate and control activities

eg. plant hormones, but also fungi, bacteria, protists

animals move much more quickly, must respond to things much quicker
→ chemicals may take minutes or hours to produce a response

but use nervous system for quick reactions: movements, emergencies, etc

when quick reflexes, rapid responses are needed we use our nervous system
eg. danger, feeding,

all major animal groups but sponges have some kind of nervous system

in higher animals the nervous system has become organized into the most complex and least understood of all the body's systems

<u>Nervous Reflexes -the simplest circuit</u>

reflex arc = simplest functional circuit in nervous system

many of the body's control systems occur at the most basic functional level of neural activity
→ **reflexes**

reflex = a rapid, automatic, predictable motor response to a stimulus
unlearned
unplanned
involuntary
→ "hard wired" into our neural anatomy

components of a reflex arc:
receptor
sensory neuron
integration center (CNS)
motor neuron
effector

very few *complete* neural circuits are simple reflexes most circuits are much more complex

<u>Kinds of Nervous Systems</u>

animal nervous systems range from very simple to increasingly complex:

eg. Nerve net:
in and under epidermis
two way
no distinct sensory, motor or interneurons

eg. cnidaria

eg. Ganglia and nerve cords
nerve cords can be paired; dorsal, ventral, lateral, etc

eg. flatworms: ladderlike arrangement
eg. insects and worms: segmented ganglia

eg. True brain and spinal cord
in vertebrates only

in vertebrates (us):

nervous system is organized into 2 major subdivisions:
CNS: brain and spinal cord
PNS: cranial nerves and spinal nerves

Vertebrate Brain

in primitive vertebrates the brain is made up of 3 main parts:

1. forebrain
   → smell
2. midbrain
   → vision
3. hindbrain
   → hearing and balance; involuntary reflexes

throughout evolution of vertebrates these three subdivisions become more complex

generally, brain mass increases with body mass

eg. birds and mammals have larger brains than fishes amphibians and reptiles

eg. largest brains: whales and elephants

but humans have ~7x's more brain for relative body size

9. The Senses

monitor and allow organism to respond to its environment

because animals are so active

→ they require a continuous inflow of information from their environment

Protista

eg. some ciliates, eg. Euplotes, have bristles tha seem to function as receptors

eg. some protists, eg. Euglena, and algae have a light sensitive organelle = stigma or eye spot

Plants

seem to depend primarily on chemical regulation

do seem to have some sensory like structures

eg. spines on venus flytrap respond to touch

eg. phytochrome pigment is light sensitive protein found in leaves
→ monitors day/nite cycle related to flowering times

eg. statolith-like starch containing plastids in root cap that allow geotropic response of roots

senses provide direct contact between animal and its surroundings

no animal is completely aware of its environment
→ only selectively aware

eg. those that live in caves depend more on smell and sound

eg. those that live on surface of land rely heavily on sight

eg. those that live in water use smell, currents and vibrations

require sense organs for coordination and control to monitor environment and body's responses to the environment

sense organs are transducers;

Photoreceptors:
ocelli,
compound eyes,
eye with lense

Chemoreceptors:
chemicals,
smell,
taste

Thermoreceptors:
heat & cold

Mechanoreceptors
Hearing
Touch/pressure
Equilibrium:

Osmoreceptors:
salt and water balance

nocioceptors:
pain receptors

baroreceptors:
fluid pressures
water flow and water current receptors

10. Urinary System

having greater metabolism, animals generate more wastes
→ need more effective way to get rid of wastes

excretory wastes = metabolic wastes

→ chemicals & toxins produced by cells during metabolism

eg. Carbohydrates → CO_2 and water
eg. Proteins → nitrogen (ammonia, urea, uric acid)
eg. Lipids → ketones, acetone

also, many metabolic processes produce excess water and/or salt

all organisms must get rid of excess materials and wastes

fungi, protists, bacteria → diffusion;

plants →stomata, converted to "secondary plant products" for defense or support or stored in woody tissue)

typically referred to as "**excretory system**"
main job is to collect and eliminate toxic wastes

excretory wastes = metabolic wastes
→ chemicals & toxins produced by cells during metabolism
In Animals
several organs can serve an **excretory function**:

1. **kidneys**
2. **skin**
   sweat glands rid body of water, minerals, some nitrogenous wastes (ammonia)
3. **lungs**
   rid body of CO2 from energy metabolism of cells
4. **intestine**
   in addition to getting rid of undigested food residue feces also contains some metabolic wastes as well

in larger animals the excretory system may be associated with a circulatory system

12. Reproductive System

propagation of the species
→in terms of evolution
– the *only* reason all the other systems exist

most animals reproduce both asexually and sexually

→ higher animals reproduce only sexually

some go through alternation of generations

animals typically go through more complex stages of development,

sometimes spending years in immature forms