Animal Nutrition I (Ch. 41)
Keywords
Heterotroph
Autotroph
Herbivore
Carnivore
Omnivore
Intracellular digestion
Food vacuole
Extracellular digestion
Gastrovascular cavity
Alimentary canal
Basic parts of alimentary canal
Roles of mouth and stomach in digestion

Categories
I. Autotroph
II. Heterotroph
   A. Herbivore
   B. Carnivore
   C. Omnivore

Alimentary canal: mammalian
Mouth types of digestion
   Mechanical — how?
   Enzymatic—how?

Stomach
   Mechanical
   Mixing and churning
   Chemical
   pH around 2
   Also breaks food down
   Enzymatic

Pepsin
   Breaks down proteins
   Why doesn’t pepsin digest stomach?
   ***Activation of pepsin-gastric glands, chief and parietal cells, HCl, pepsinogen***

Small intestine
   ***Most of the enzymatic digestion occurs here
   ***Why doesn’t the small intestine digest itself?
   Secretion of inactive enzymes (trypsinogen, procarboxypeptidase, chymotrypsinogen) by pancreas,
   activation of trypsin (from trypsinogen) by enteropeptidase, activation of other enzymes (to form carboxypeptidase and chymotrypsin) by trypsin.***
   ***Most nutrient absorption takes place in small intestine
Structure: another example of increasing surface area
   ***Structure of small intestine
   Villi and microvilli
Large intestine (colon)  
Major function is to reabsorb water, much bacteria present here

Variations of vertebrate digestive system Herbivorous mammals
Specialized fermentation chambers

**Coyote vs. Koala**
Why does herbivory require specializations?

Plant tissue
Harder to break up  
Contains cellulose  
Nutrients less concentrated than meat

Structure of cellulose
Only bacteria and protozoa can break down cellulose

***Cecum
Pouch at junction between lg and sm intestine  
Large cecum in rabbits, some rodents, koala, horses  
Full of symbiotic bacteria

***Cecum function
Fermentation chamber  
Bacteria breakdown cellulose

Feces must be reingested. Why?

Ruminant digestion- fermentation where?, re-mechanically digest stomach contents, difference between ruminant digestion and digestion of cellulose with the cecum?

Algal-invertebrate symbiosis
Symbionts are algae  
Algae photosynthesize and provide molecules such as sugars to the host  
Hydra, anemones, giant clams, corals

Chemical signals in animals
Keywords
Reading Ch. 45
- Endocrine system  
- Hormone  
- Neurosecretory cell  
- Steroid  
- Action of steroids  
- Glucose homeostasis  
- Insulin  
- Glucagon

Endocrine system definition
- The internal chemical communication system involving hormones

Hormone
- Chemical signal secreted into body fluids (usually blood)  
- Effective in minute amounts

Hormones act on specific target cells in two ways
Surface receptors
Within target cells (internal receptor)

Surface receptor-how does it work?
Internal receptor-steps in how it works? Used with steroid hormones

Two examples of hormone action
- Glucose homeostasis
- Stress and the adrenal gland

Glucose homeostasis
- **Homeostasis =** The steady-state physiological condition of the body
- Glucose = major fuel of cellular respiration
- **Normal blood glucose level = 5 millimoles per liter**
- How is this regulated?
- First look at when glucose levels are too high
- High blood glucose causes beta cells to release insulin
  1. insulin receptors on body cells and liver cells respond to insulin
  2. liver cells convert glucose to a form of animal starch called glycogen
  3. body cells take up glucose from the blood
  4. this causes the blood glucose level to be restored to 5 mM

What happens if you need to increase blood glucose?
- Low blood glucose causes alpha cells to release the hormone glucagon
- Glucagon stimulates the liver to break down glycogen releasing glucose
- This restores blood glucose levels to 5 mM

Diabetes mellitus
- Greek = copious urine, honey
- Type I - autoimmune disorder - cells of pancreas are targeted - no ability to produce insulin - usually occurs during childhood
- Type II (90%) - reduced responsiveness of target cells or insulin deficiency-usually occurs after age 40

Stress and the adrenal gland
- Short-term response - Epinephrine (adrenaline) and norepinephrine
- Long-term response - ACTH and corticosteroids
- Hypothalamus, pituitary gland, adrenal cortex, adrenal medulla

Short-term stress: medulla of the adrenal gland – know the steps
Some effects of epinephrine and norepinephrine
- **Glycogen broken down to glucose**
- **Increased blood pressure, breathing, metabolic rate**

Long-term stress: cortex of the adrenal gland – know the steps, releasing hormone, ACTH
Corticosteroids (mineral- and gluco- corticoids) released by adrenal cortex

- Some effects: increased blood volume and blood pressure, breakdown of protein and fats

Nervous systems

Keywords
- Nervous system functions
- Structure of a neuron
- Membrane potential
- Sodium potassium ATPase
- Action potential
- Depolarization
- Voltage gated ion channels
- Action potential propagation
- Node of Ranvier

Structure of a neuron
- Cell body
- Dendrites (input)
- Axon (output)

Membrane potential
- Living cells have an electrical potential across their membranes
- The inside of the cell is more negatively charged than the outside
- This difference in charge is called the membrane potential
- Usually between -50 to -100 mV

What is the basis for the membrane potential?
- Two causes:
  1) differences in ionic composition of intracellular and extracellular fluid
  2) selective permeability of the plasma membrane

Ionic composition of intracellular and extracellular fluid
- Cation (positively charged ions) composition
- Intracellular fluid - primary cation is K⁺, Na⁺ is low
- Extracellular fluid - primary cation is Na⁺, K⁺ is low
- Anion (negatively charged ions) composition
- Intracellular fluid - proteins, amino acids, sulfate, phosphate (A⁻)
  Extracellular fluid - Cl⁻

What will happen to K⁺? Na⁺?

Flow of K⁺ >> Na⁺ therefore net loss of positive charge from cell
- K⁺ will flow out of the cell until the force of the concentration gradient is balanced by the opposing electrical force of around -70 mV from the membrane potential (the sadistic kid/kitty electromagnet concept)

Gradient between extracellular and intracellular fluid favors loss of K⁺ from the cell
- Negatively charged ions will want to follow to balance the loss of (+) charge, but since the intracellular anions are large molecules like amino acids and proteins, they cannot diffuse out.

This makes the inside of the cell more negatively charged than the outside
- But, there is also a gradient favoring the diffusion of Na⁺ into the cell from the outside
- This could prevent negative charge from building up inside, but it doesn’t. Why not?

Two reasons:
- Low Na⁺ permeability due to few open Na⁺ channels
Sodium-potassium ATPase

- Active transport
- Each pumping cycle pumps 3 Na\(^+\) out and 2 K\(^+\) in at the expense of 1 ATP.

Excitable cells

- Most cells have a stable membrane potential of around -70 mV
- Excitable cells can generate changes in their membrane potentials
- Excitable cells include neurons and muscle cells

Action potential

- Excitable cells can change their membrane potential
- When signaling becomes more positive (depolarization)
- The depolarization is called an action potential
- The action potential is the basis for electrical signaling

Hyperpolarization – what does the electrical trace look like?

depolarization - what does the electrical trace look like?

Action potential - what does the electrical trace look like?

Action potentials occur because of voltage gated ion channels

- If the stimulating potential causes the membrane potential to rise about 15-20 mV an action potential results.
- This is due to the opening of voltage gated ion channels
  - voltage gated channels open briefly then shut

Resting state

Initially only Na\(^+\) channels open

- Since there is a large concentration of Na\(^+\) outside the cell, Na\(^+\) rushes in making the intracellular fluid less negatively charged
- This causes the peak of the action potential

Voltage gated K\(^+\) channels also open

- But they are much slower than Na\(^+\) channels
- They are fully open after the peak of the action potential
- K\(^+\) flows out of the cell, and the membrane potential becomes negative again

Tetrodotoxin

- Produced by pufferfish
- Blocks Na\(^+\) channels
- What would be the effect of ingesting tetrodotoxin?

Propagation of the action potential

- Action potential "travels" along the axon to the other end of the cell
- The speed of transmission can be as high as 100 meters per second or 225 mph.
- Propagation is a series of new action potentials that travel along the axon

Propagation: what happens at the level of the ion channels

- First action potential gives rise to a depolarization further along the axon
- Depolarization at second segment results in the opening of voltage gated Na\(^+\) channels and a second action potential occurs
- Second action potential triggers a third action potential, etc.

High performance axons
• Faster signal conduction allows more rapid coordination between sensory input and motor output.
• 2 ways to increase action potential transmission speed
  • Increase axon diameter
  • Nodes of Ranvier (French word don't need to memorize)

**Nodes of Ranvier**
  • Axons of vertebrates are myelinated
  • Insulating layer on axon results from Schwann cells
  • Small gaps of exposed axon surface are present between Schwann cells

**Nervous systems 2**

**Keywords (reading p. 960-976)**
  • Neurotransmitters
  • Acetyl choline
  • Norepinephrine
  • Serotonin
  • Dopamine

**How do neurons communicate with other cells?**
  • Transmitting cell = presynaptic cell
  • Receiving cell = postsynaptic cell
  • Two types of synapse
    • Electrical
    • Chemical

**Chemical synapse**
  • Narrow gap between the neurons called the synaptic cleft
  • Action potential results in release of neurotransmitter by presynaptic cell
  • Neurotransmitter causes depolarization of postsynaptic cell and can result in another action potential

**Chemical synapse: a closer look**
  • Depolarization at the synaptic terminal results in Ca^{++} influx
  • Ca^{++} causes vesicles containing neurotransmitter to fuse with presynaptic membrane
  • Neurotransmitter diffuses into synaptic cleft
  • Neurotransmitter binds to ion channels on the post synaptic membrane

**What happens when neurotransmitter binds to ion channels on the post synaptic membrane?**
  • Ion channels open
• This results in either a depolarization or hyperpolarization (inside becomes more negative)
• Depolarization is stimulatory

**How do the channels close again?**
• Enzymatic degradation of the neurotransmitter
• Uptake of neurotransmitter by other neurons

**Neurotransmitters**
• Acetylcholine (ACh) - excitatory to vertebrate skeletal muscle; other effects at other sites

**Biogenic amine neurotransmitters**
• Norepinephrine
• Dopamine
• Serotonin
• Usually function within the central nervous system

**Dopamine**
• High levels are linked to schizophrenia

**Serotonin**
• Low levels linked to clinical depression
• Prozac: Selective serotonin reuptake inhibitor

**Amino acid neurotransmitters. Examples?**

**Peptide neurotransmitters. Substance P (Pain); endorphins (like morphine)**

**Norepinephrine/serotonin and depression**

**Drug treatments**
• Selective serotonin reuptake inhibitors (SSRI)
  Prozac

How does an SSRI or a monoamine oxidase inhibitor work to increase serotonin availability?

**Gaseous neurotransmitters – nitric oxide (NO) and carbon monoxide (CO)**

**Motor mechanisms**

**Keywords**
• Bundle, fiber, myofibril, sarcomere
• Z-line, thick filament, thin filament
• Actin, myosin, sliding filament model
• Molecular basis for filament movement
• Troponin, tropomyosin
• Sarcoplasmic reticulum
• Integration of synaptic signals
• neurotransmitters

**What is the Structure of skeletal muscle**
• Bundle
• Fiber
• Myofibril
• sarcomere

**What are the Features of muscle cells**
• # of nuclei- multinucleate; formed by fusion of embryonic cells
• length - this results in very long cells

Sarcomere (know the picture and the parts)
- Structure gives muscle a striated appearance
- Z line, thick filaments (myosin), thin filaments (actin)

What is the Sliding-filament model of muscle contraction
Know how the Thick and thin filaments slide past each other
At maximal contraction, there is no space at end of thick filament, and the thin filaments overlap

**Molecular basis for movement of filaments against each other**
this will be on the test for sure. Know the steps

Steps
1. ATP bound, head retracted and unattached
2. Hydrolysis of ATP cocks head
3. Myosin head attaches to actin filament
4. Release of ADP + P_i causes a further conformational change pushing against the actin filament
5. Binding of ATP to myosin head causes dissociation from actin filament
6. Cycle repeats and sarcomere shortens

Control of muscle contraction by Ca^{++} (will be on the test for sure)
- Tropomyosin- blocks the myosin binding sites on the actin filament when muscle is at rest
- Troponin complex-binds calcium and controls the position of tropomyosin
At rest, myosin cannot bind because sites are covered by tropomyosin
During muscle contraction Ca^{++} levels rise. Ca^{++} binds to troponin which then pulls tropomyosin way from the binding sites
What triggers the Ca^{++} rise that induces muscle contraction?
[Ca^{++}] regulated by the sarcoplasmic reticulum

Structure of the sarcoplasmic reticulum
- T tubules - are a network of the fiber plasma membrane that goes deep into the muscle fiber.
- This allows transmission of the action potential into the fiber

Know the Sequence of events leading to muscle contraction
- Motor neuron releases acetylcholine
- Depolarization of the muscle fiber membrane results in action potentials
- Action potentials trigger release of Ca^{++} from the sarcoplasmic reticulum
- Increased Ca^{++} allows actin and myosin to slide against each other

Know the basic characteristics of other muscle types:
- Cardiac muscle - found only in the heart, striated, short cells that are branched, every cell is not enervated by a motor neuron, electrical junctions between cells, separated cells can continue to beat.
- Smooth muscle - involuntary muscle, meshwork of actin and myosin, short irregular shape, every cell is NOT enervated by a motor neuron, gap junctions make electrical connection between cells, can contract in different directions not just shortening

Know the basic types of myosin
Muscle fiber types are the result of different types (isoforms) of myosin
- Type I - slow fibers (aerobic)
- Type II - fast fibers (anaerobic)

**Animal behavior**
Behavior is due to genetics and environment
Behavior is due to proximate and ultimate causes that are due to natural selection
Proximate = stimulus i.e. day length
Ultimate = evolution; spring is a good time to breed
Lovebird experiment, what was it what did it show
Digger wasp experiment, what was it what did it show
What is a sign stimulus?
What is imprinting?
What is classical conditioning?
What is operant conditioning?

Chapter 39 – plant responses to internal and external signals

Responses to light
Not only the presence of light
But also direction, intensity, and wavelength (color)

Two classes of light receptors
Blue-light photoreceptors
Phytochromes (red light)

Various blue-light photoreceptors
Control elongation
Stomatal opening

Phytochromes as Photoreceptors (mostly red light)
Seed germination
Germinate when light and other conditions are near optimal

Biological Clocks and Circadian Rhythms
Processes oscillate during the day.

Plants use photoperiod to detect the time of year- photoperiodism
Day length will effect:
the timing of seed germination
bud formation
flowering.

Gravitropism
Plants may detect gravity by the settling of statoliths
Specialized plastids containing dense starch grains

Drought
Plants respond to water deficit by reducing transpiration
Deeper roots continue to grow

Flooding
Enzymatic destruction of cells creates air tubes that help plants survive oxygen deprivation during flooding

Defense against herbivores
Physical defenses:
thorns & spines
Chemical defenses
distasteful or toxic compounds

Concept 39.2: Plant hormones help coordinate growth, development, and responses to stimuli
Hormones: are chemical signals that coordinate different parts of an organism
Tropisms are often caused by hormones
A Survey of Plant Hormones
Auxin and cell wall expansion
Gibberellins and Germination

Chapter 38

Plant “cloning”
Vegetative Propagation
Clones from Cuttings
Grafting

Test-Tube Cloning and Related Techniques
• Cells divide to form undifferentiated callus
• Hormones can initiate differentiation of shoots and roots.
• New plant can be propagated from a recombinant DNA containing cell

Maize
• Is a product of artificial selection by humans
  – Corn would die without humans- no mode of seed dispersal

Plant biotechnology uses genetic engineering
• Plant biotechnology has two meanings
  – Innovations in the use of plants to make products of use to humans
  – Use of genetically modified (GM) organisms (GMOs) in agriculture and industry
    Introduce genes from distantly related species or modify expression of native genes.
  – genes from two different sources (often different species) are combined in vitro
• Objective of improving the efficiency and effectiveness of agriculture.
• Productivity: more food from less land
  – Optimize source/sink relationships
  – Improve tolerance to environmental conditions
• Improve nutritional quality:
  – amino acid composition of seeds more appropriate for human/mammalian nutrition
• Manipulating vitamin content
  – ‘Golden Rice’ uses daffodil genes to produce B-carotene in rice

Insect-resistances (Bt toxin from bacteria)
• Genetically engineered plants can be made insect-resistant

Debate over Plant Biotechnology
• Ethical issues
• There are concerned about the unknown risks

Double muscled animals
• animal lacks a functioning myostatin or if the myostatin receptor is blocked, larger muscles developed

Spider goat
• alternate harvesting method involves extracting the silk protein from the milk of transgenic goats that have the spider silk gene inserted into their DNA.

Glofish
• zebrafish with fluorescent proteins extracted from jellyfish inserted into their DNA to make them glow green, orange, or red.

The first synthetic cell
• $40 million dollar project
• Synthesized genome then injected into a cell.
• Synthesized genome took over cell and became first synthetic life form

Chapter 37

Concept 37.1: Soil is a living, finite resource
   Minerals
   Water with solutes
   Gases
   Living organisms
   Organic matter
   Sand, silt, and clay

Top Soil- combo of organic and inorganic material
   Horizon A is the most rich in nutrients
   fresh earthworm casts are richer in available nitrogen and phosphates

Plant nutrients - Anions
   Nitrate (NO3-), phosphate (H2PO4-) & sulfate (SO42-)
   Not bound tightly to negatively charged soil and release easy
   But also leach out into ground water

Plant nutrients - Cations
   Magnesium (Mg2+), potassium (K+) & Calcium (Ca2+)
   Bound tightly to negatively charged soil
   Roots use cation exchange: H+ for cation minerals

Fertilizers
   Enriched in nitrogen (N), phosphorus (P) and potassium (K)
   Nitrogen synthesized with large fossil fuel energy input

From a tiny seed to a large plant
   Jan Baptista van Helmont 17th century
   A small willow tree into a pot with approx 90.9 kg of soil
   After 5 years the tree weighed approx 76.8 kg but the soil weight only lost 0.06kg!

Macronutrients and Micronutrients
   More than 50 chemical elements

Concept 37.3: Plant nutrition often involves relationships with other organisms
   Symbiotic nitrogen fixation
Rhizobacteria
Mycorrhizae

Symbiotic plants and nitrogen-fixing bacteria occur in the legume family (peas, beans, and other similar plants)
  Legumes have root nodules
  Composed of plant cells that have been “infected” by nitrogen-fixing Rhizobium bacteria

The Two Main Types of Mycorrhizae
  Ectomycorrhizae
  Endomycorrhizae

Plants also have nutritional adaptations that use other organisms in nonmutualistic ways:
  Epiphytes
  Parasites
  Carnivorous plants