**AP Biology Summer Assignment**

Read the PowerPoints for Chapters 44, 46, & 52 that have been printed out for you. In addition to them, use the Bozeman Biology Video Links, as well as the Internet to assist you in answering the accompanying short answer packets.

The Bozeman Biology Video Links are an extremely useful resource that we will continue to use throughout the school year. On a separate sheet of paper take notes on each video as you watch them.

This completed assignment is due on Friday, September 14, 2018. They will be used to assess how much of the material was understood, as well as count as a grade for Quarter 1.

If you have any questions along the way, feel free to contact Mrs. Grimner or Mrs. Cleere at the following email address:

- dgrimner@levittownschools.com
- kcleere@levittownschools.com

We will check our email accounts once a week during the summer, so remember to give us time to respond.

See you in September! 😊
Please read the following announcement Friday June 1st, and Monday - Friday the week of June 4th.

All students enrolled in AP Biology for the 2018-2019 school year must attend a meeting on Wednesday June 6th to pick up their summer assignment. You have the option of coming before school at 7 AM or directly after school at 2:30 PM in room 314. If you cannot make either one of these meetings you must find Mrs. Grimner or Mrs. Cleere at some point before Wednesday to get your materials.
Bozeman Biology Videos
http://www.bozemanscience.com

**AP Biology Introduction:**
- The New AP Biology Exam-A User’s Guide

**Systems:**
- Organ Systems:

**Nervous System:**
- The Nervous System
  - [http://www.bozemanscience.com/nervous-system](http://www.bozemanscience.com/nervous-system)
- Flight or Flight Responses
  - [http://www.bozemanscience.com/fight-or-flight-response](http://www.bozemanscience.com/fight-or-flight-response)
- The Brain
  - [http://www.bozemanscience.com/the-brain](http://www.bozemanscience.com/the-brain)

**Endocrine System:**
- The Endocrine System
  - [http://www.bozemanscience.com/endocrine-system](http://www.bozemanscience.com/endocrine-system)
- Positive and Negative Feedback loops
- Response to External Environments:

**Immune System:**
- The Immune System
  - [http://www.bozemanscience.com/immune-system](http://www.bozemanscience.com/immune-system)
- Cell Communication
  - [http://www.bozemanscience.com/037-cell-communication](http://www.bozemanscience.com/037-cell-communication)
- Plant and Animal Defenses
1. Label the CNS and PNS on the diagram below.

2. Briefly describe the parts/functions of the human nervous system.
   a. CNS: _____________________________________________________________
   b. PNS: _____________________________________________________________
   c. Somatic: _________________________________________________________
   d. Autonomic: _______________________________________________________
   e. Sympathetic: _____________________________________________________
   f. Parasympathetic: _________________________________________________
3. Label the diagram of a typical neuron.

4. Label the different types of neurons and make notes about their function.
5. Trace the reflex pathway by naming the structures.

6. How does an impulse propagate down the axon?

_______________________________________________________________________________________________________

_______________________________________________________________________________________________________

7. Describe what happens when an impulse reaches the terminal end.

_______________________________________________________________________________________________________

_______________________________________________________________________________________________________

8. Describe what happens at the synapse.

_______________________________________________________________________________________________________

_______________________________________________________________________________________________________

9. How are “messages” carried...
   a. In neurons ____________________________________________________________
   b. Between neurons ______________________________________________________
10. Make some brief notes about the differential action of the following neurotransmitters:

a. Acetylcholine: ____________________________________________________________________________________
_______________________________________________________________________________________________________

b. Epinephrine (Adrenaline) & Norepinephrine: ____________________________________________________________________________________
_______________________________________________________________________________________________________

c. Dopamine: ________________________________________________________________________________________
_______________________________________________________________________________________________________

d. Serotonin: ________________________________________________________________________________________
_______________________________________________________________________________________________________

11. How does the neuron maintain a -70 mV potential?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

12. Draw in the charges and appropriate ions associated with the axon of a neuron at resting potential.

_______________________________________________________________________________________________________

13. Depict how the polarity changes in the area of the axon that the impulse hits.

_______________________________________________________________________________________________________
14. Detail the stages of the “action potential.” Use the graph and indicate what is happening at the membrane in each stage.
15. Complete the diagram of the sodium-potassium pump by describing what happens in pictures 1 – 6.
16. Indicate the functions of the major components of the human brain and then label the diagram that follows.

a. Cerebrum: ______________________________________________________________________________________
_______________________________________________________________________________________________________

b. Cerebellum: ______________________________________________________________________________________
_______________________________________________________________________________________________________

c. Medulla Oblongata: __________________________________________________________________________________
_______________________________________________________________________________________________________

d. Spinal Cord: ______________________________________________________________________________________
_______________________________________________________________________________________________________

e. Thalamus: ________________________________________________________________________________________

f. Hypothalamus: ____________________________________________________________________________________
Ch. 44: Nervous System
Why do animals need a nervous system?

- What characteristics do animals need in a nervous system?
  - Fast
  - Accurate
  - Reset quickly

Remember… think about the bunny… Poor bunny!
Nervous System

- Central Nervous System (CNS)
  - Brain & spinal chord

- Peripheral Nervous System (PNS)
  - Nerves from senses
  - Nerves to muscles
  - Divided into Somatic (Voluntary) & Autonomic (Involuntary)

- Autonomic
  - Divided into Sympathetic & Parasympathetic
CNS
- Brain & Spinal Cord
- Interneurons

PNS
- Nerves branching off CNS
- Sensory & motor neurons

Somatic
- Voluntary
- Controls skeletal muscles

Autonomic
- Involuntary
- Controls cardiac & smooth muscles

Sympathetic
- Fight or Flight Response
- Increases heart rate
- Dilates pupils
- Stimulates glucose release
- Inhibits digestion

Parasympathetic
- Rest & Digest Response
- Decreases heart rate
- Constricts pupils
- Stimulates digestion
Nervous System Cells

- Neuron
  - Nerve cell

- Structure fits function
  - Many entry points for signal
  - One path out
  - Transmits signal

Diagram:
- Dendrites → Cell body → Axon
- Myelin sheath
- Synaptic terminal
- Synapse

Signal direction: dendrite → cell body → axon
Fun Facts About Neurons

- Most specialized cell in animals
- Longest cell
  - Blue whale neuron
    - 10-30 meters
  - Giraffe axon
    - 5 meters
  - Human neuron
    - 1-2 meters

Nervous system allows for 1 millisecond response time
Myelin Sheath

- Axon coated with insulation made of myelin cells
  - Speeds signal
    - Signal hops from node to node
  - 330 mph vs. 11 mph

Multiple Sclerosis
- Immune system (T cells) attacks myelin sheath
- Loss of signal
Synapse

Junction between nerve cells

- 1st cell releases chemical to trigger next cell
- This is where drugs affect nervous system
Types of Neurons

Sensory neuron
(from senses)

Interneuron
(brain & spinal chord)

Motor neuron
(to muscle or gland)
Primitive Brain

- The “lower brain”
  - Medulla oblongata
  - Pons
  - Cerebellum

- Functions
  - Basic body functions
    - Breathing, heart, digestion, swallowing, vomiting
  - Homeostasis
  - Coordination of movement
Higher Brain

- **Cerebrum**
  - Hemispheres
  - Left = right side of body
  - Right = left side of body

- **Corpus Callosum**
  - Major connection between 2 hemispheres
Division of Brain Function

- **Left hemisphere**
  - “Logic side”
  - Language, math, logic operations, vision & hearing details
  - Fine motor control

- **Right hemisphere**
  - “Creative side”
  - Pattern recognition, spatial relationships, non-verbal ideas, emotional processing, parallel processing of information
Cerebrum Specialization

- Regions of the cerebrum are specialized for different functions
- Lobes
  - **Frontal**
  - **Temporal**
  - **Occipital**
  - **Parietal**
Limbic System

Controls **basic emotions** (fear, anger), involved in emotional bonding, establishes emotional memory
Simplest Nerve Circuit (RSIME)

- **Reflex** or automatic response

  - Rapid response
    - Automated
  - Signal only goes to spinal cord
    - No higher level processing
  - Advantage
    - Essential actions
    - Don’t need to think or make decisions about
      - Blinking
      - Balance
      - Pupil dilation
      - Startle
Eye Blink or Pain Withdrawal Reflex (RSIME)

- Stimulus
- Receptor in skin
- Spinal cord
- White matter
- Gray matter
- Interneuron
- Sensory neuron
- Motor neuron
- Effector (muscle)
Neurons & the Nature of Neural Signals
Transmission of a Signal

- **Think Dominoes!**
  - **Start the signal**
    - Knock down line of dominoes by tipping 1st one
      → Trigger the signal
  - **Propagate the signal**
    - Do dominoes move down the line?
      → No, just a wave through them!
  - **Re-set the system**
    - Before you can do it again, have to set up dominoes again
      → Reset the axon
Transmission of a Nerve Signal

- Neuron has similar system
  - Protein channels are set up
  - Once first one is opened, the rest open in succession
    - All-or-nothing response
  - A “wave” action travels along neuron
  - Have to re-set channels so neuron can react again
Cells: Surrounded by Charged Ions

- Cells live in a sea of charged ions
  - **Anions (negative)**
    - More concentrated *within the cell*
    - $\text{Cl}^-$, charged amino acids ($\text{aa}^-$)
  - **Cations (positive)**
    - More concentrated in the *extracellular fluid*
    - $\text{Na}^+$

channel leaks $\text{K}^+$
Cells Have Voltage!

- Opposite charges on opposite sides of cell membrane
  - Membrane is polarized
    - Negative inside; positive outside
    - Charge gradient
    - Stored energy (like a battery)
Measuring Cell Voltage

Unstimulated Neuron = Resting Potential of -70mV
How does a nerve impulse travel?

- **Stimulus**: nerve is stimulated
  - Reaches **threshold potential**
    - Open Na\(^+\) channels in cell membrane
    - Na\(^+\) ions diffuse into cell
  - Charges reverse at that point on neuron
    - Positive inside; negative outside
    - Cell becomes **depolarized**

The 1st domino goes down!
How does a nerve impulse travel?

- **Wave**: nerve impulse travels down neuron
  - Change in charge opens next Na\(^+\) gates down the line
    - “Voltage-Gated” Channels
  - Na\(^+\) ions continue to diffuse into cell
  - “Wave” moves down neuron = **Action Potential**

The rest of the dominoes fall!
How does a nerve impulse travel?

- **Re-set**: 2nd wave travels down neuron
  - \(K^+\) channels open
    - \(K^+\) channels open up more slowly than \(Na^+\) channels
  - \(K^+\) ions diffuse **out of** cell
  - Charges reverse back at that point
    - **Negative** inside; **positive** outside

![Diagram of nerve impulse](image-url)
How does a nerve impulse travel?

- Combined waves travel down neuron
  - Wave of opening ion channels moves down neuron
  - Signal moves in one direction → → → → →
    - Flow of $K^+$ out of cell stops activation of $Na^+$ channels in wrong direction

Ready for next time!
How does a nerve impulse travel?

- **Action potential propagates**
  - Wave = *nerve impulse or action potential*
  - Brain → finger tips in **milliseconds**!
Voltage-Gated Channels

- Ion channels open & close in response to changes in charge across membrane
  - $\text{Na}^+$ channels **open quickly** in response to depolarization & close slowly
  - $\text{K}^+$ channels **open slowly** in response to depolarization & close slowly

Structure & function!
How does the nerve re-set itself?

- After firing a neuron has to re-set itself
  - $\text{Na}^+$ needs to move back out
  - $\text{K}^+$ needs to move back in
  - Both are moving \textbf{against} concentration gradients

- Need a pump!!!
How does the nerve re-set itself?

- **Sodium-Potassium Pump**
  - Active transport protein in membrane
    - Requires ATP
  - 3 Na\(^+\) pumped out
  - 2 K\(^+\) pumped in
  - Re-sets charge across membrane

That's a lot of ATP! Feed me some sugar quick!
Neuron is ready to fire again!

resting potential
1. **Resting Potential**

2. **Stimulus reaches**
   **Threshold Potential**

3. **Depolarization**
   Na\(^+\) channels open; K\(^+\) channels closed

4. **Na\(^+\) channels close;**
   K\(^+\) channels open

5. **Repolarization**
   reset charge gradient

6. **Undershoot**
   K\(^+\) channels close slowly

**Action Potential Graph**

- Membrane potential
- 0 mV
- -50 mV
- -70 mV
- -80 mV
- 10 mV
- 20 mV
- 30 mV
- 40 mV
- 50 mV
- 60 mV
- 80 mV

- **Depolarization**
  - Na\(^+\) flows in

- **Repolarization**
  - K\(^+\) flows out

- **Threshold**
- **Hyperpolarization (undershoot)**
- **Resting potential**
- **Resting**

---

AP Biology
Myelin Sheath

- **Axon coated with Schwann Cells**
  - Insulates axon
  - Speeds signal
    - Signal hops from node to node
    - **Saltatory conduction**
  - 150 m/sec vs. 5 m/sec (330 mph vs. 11 mph)
Multiple Sclerosis

- Immune system (T cells) attack myelin sheath
- Loss of signal
What happens at the end of the axon?

Impulse has to jump the **synapse**!
- Junction between neurons
- Has to jump quickly from one cell to next

How does the wave jump the gap?
Chemical Synapse

- **Events at synapse**
  - Action potential depolarizes membrane
  - Opens **Ca$$^{++}$$ channels**
  - Neurotransmitter vesicles fuse with membrane
  - Release neurotransmitter to synapse → diffusion
  - Neurotransmitter binds with protein receptor
    - Ion-gated channels open
  - Neurotransmitter degraded or reabsorbed

We switched... from an electrical signal to a chemical signal
Nerve Impulse in Next Neuron

- **Post-synaptic Neuron**
  - Triggers nerve impulse in next nerve cell
    - Chemical signal opens ion-gated channels
    - \( \text{Na}^+ \) diffuses into cell
    - \( \text{K}^+ \) diffuses out of cell
    - Switch back to voltage-gated channel

Here we go again!
Neurotransmitters

- **Acetylcholine**
  - Transmit signal to skeletal muscle

- **Epinephrine (Adrenaline) & Norepinephrine**
  - Fight-or-flight response

- **Dopamine**
  - Widespread in brain
  - Affects sleep, mood, attention & learning
  - Lack of dopamine in brain associated with Parkinson’s disease
  - Excessive dopamine linked to schizophrenia

- **Serotonin**
  - Widespread in brain
  - Affects sleep, mood, attention & learning
Neurotransmitters

- Weak point of nervous system
  - Any substance that affects neurotransmitters or mimics them affects nerve function
  - Gases: Nitrous oxide, carbon monoxide
  - Mood altering drugs:
    - Stimulants
      - Amphetamines, caffeine, nicotine
    - Depressants
      - Quaaludes, barbiturates
  - Hallucinogenic drugs: LSD, peyote
  - SSRIs: Prozac, Zoloft, Paxil
  - Poisons
Acetylcholinesterase

- Enzyme which breaks down acetylcholine neurotransmitter
  - Acetylcholinesterase inhibitors = neurotoxins
    - Snake venom, sarin, insecticides

![Diagram of acetylcholinesterase enzyme with active site highlighted in red and snake toxin blocking the active site highlighted in green.](image)
Questions to ponder...

- Why are axons so long?
- Why have synapses at all?
- How do “mind altering drugs” work?
  - Caffeine, alcohol, nicotine, marijuana...
- Do plants have a nervous system?
  - Do they need one?
Ponder this...
Any Questions??
Why are hormones needed?
- Chemical messages from one body part to another
- Communication needed to coordinate whole body
- Daily homeostasis & regulation of large scale changes
  - Solute levels in blood
    - Glucose, Ca++, salts, etc.
  - Metabolism
  - Growth
  - Development
  - Maturation
  - Reproduction
Animals rely on 2 systems for regulation:

- **Endocrine System**
  - System of ductless glands
  - Secrete chemical signals directly into blood
  - Chemical travels to target tissue
  - Target cells have receptor proteins
  - Slow, long-lasting response

- **Nervous System**
  - System of neurons
  - Transmits “electrical” signal & release neurotransmitters to target tissue
  - Fast, short-lasting response
Regulation By Chemical Messengers

- **Neurotransmitters** released by neurons
- **Hormones** release by endocrine glands

![Diagram of neurotransmitter and hormone pathways](image)
Classes of Hormones

- **Protein-based Hormones**
  - Polypeptides
    - Small proteins: insulin, ADH
  - Glycoproteins
    - Large proteins + carbohydrate: FSH, LH
  - Amines
    - Modified amino acids: epinephrine, melatonin

- **Lipid-based Hormones**
  - Steroids
    - Modified cholesterol: sex hormones, aldosterone
How do hormones act on target cells?

- **Lipid-based Hormones**
  - **Hydrophobic** & lipid-soluble
    - Diffuse across cell membrane & enter cells
    - Bind to receptor proteins in cytoplasm & nucleus
    - Bind to DNA as transcription factors
    - Turn on genes

- **Protein-based Hormones**
  - **Hydrophilic** & not lipid soluble
    - Can’t diffuse across cell membrane
    - Bind to receptor proteins in cell membrane
    - Trigger secondary messenger pathway
    - Activate internal cellular response
    - Enzyme action, uptake or secretion of molecules...
**Action of Lipid (Steroid) Hormones**

1. Steroid hormone enters the blood.
2. Steroid hormone binds to receptor protein in the cytoplasm.
3. Steroid hormone-receptor complex becomes transcription factor.
4. DNA is transcribed into mRNA.
5. mRNA is read by ribosome.
6. Protein is synthesized.
7. Protein is secreted.

**Examples:**
- Secreted protein = growth factor (hair, bone, muscle, gametes)
Action of Protein Hormones

1. protein hormone binds to receptor protein.
2. receptor protein activates G-protein which activates enzyme.
3. enzyme activates cAMP which acts as secondary messenger.
4. cAMP activates enzyme which produces an action.
5. action in target cell produces response.

Diagram:
- Protein hormone binds to receptor protein.
- Receptor protein activates G-protein.
- G-protein activates enzyme.
- Enzyme activates cAMP.
- CAMP acts as secondary messenger.
- Secondary messenger system.
- Response in target cell.
Ex: Action of Epinephrine (Adrenaline)

1. Epinephrine (adrenal gland) is released to the blood.
2. Epinephrine binds to a receptor protein in the liver cell membrane, activating G protein.
3. G protein activates adenylyl cyclase, which produces cAMP.
4. cAMP activates protein kinase-A (PKA).
5. PKA activates phosphorylase kinase.
6. Phosphorylase kinase activates glycogen phosphorylase.
7. Glycogen phosphorylase breaks down glycogen into glucose, which is released to the blood.

Signal transduction occurs, leading to an increase in glucose levels in the blood.
Benefits of a 2° Messenger System

Amplification!
Cascade multiplier!
FAST response!

1. Signal receptor protein
2. Amplification
3. GTP G protein
4. Activated adenylyl cyclase
5. cAMP protein kinase
6. Enzyme product
7. Amplification!
Negative Feedback

- An increase in a substance or activity inhibits the process leading to the increase

- Also known as feedback inhibition

- Very common control mechanism in the body and nature

- Works just like a thermostat
Maintaining Homeostasis

- Hormone 1 lowers body condition
- Hormone 2 raises body condition

Specific body condition

Gland

High

Low

Negative Feedback Model
Controlling Body Temperature

**Nervous System Control**

The hypothalamus controls body temperature through nerve signals. When the body temperature is high (37°C), the hypothalamus signals the skin to sweat and dilate surface blood vessels to cool the body. When the body temperature is low, the hypothalamus signals the muscles to shiver and constrict surface blood vessels to maintain warmth. This process is regulated by negative feedback.
Regulation of Blood Sugar

Blood sugar level (90mg/100ml)

- **insulin**
  - Body cells take up sugar from blood
  - Liver stores glycogen
  - Reduces appetite

- **glucagon**
  - Triggers hunger
  - Liver releases glucose

- **Neg. Feedback**

Endocrine System Control

Islets of Langerhans

Beta islet cells

Alpha islet cells
Endocrine System Control

Blood Osmolarity

- Osmoreceptors in hypothalamus
- Blood osmolarity
- ADH
- Increased water reabsorption
- Increase thirst
- Blood pressure
- Increased water & salt reabsorption
- Renin
- Aldosterone
- Angiotensinogen
- Angiotensin
- Juxtaglomerular Apparatus
- Negative Feedback
Positive Feedback

- A *change from the normal* range of function elicits a response that *amplifies or enhances* that change

- *Not as common* in the body or nature as negative feedback

- Childbirth, blood clotting, fruit ripening
Positive Feedback

The baby pushes against the cervix, causing it to stretch.

Oxytocin causes the uterus to contract.

Stretching of the cervix causes nerve impulses to be sent to the brain.

The brain stimulates the pituitary to release oxytocin.
Positive Feedback

1. Break or tear in blood vessel wall
2. Clotting occurs as platelets adhere to site and release chemicals
3. Released chemicals attract more platelets
4. Clotting proceeds; newly forming clot grows

Feedback cycle initiated
Feedback cycle ends after clot seals break
Positive Feedback

One fruit ripens

increase stimuli

Other fruits ripen

Ethylene gas released into air

Received by other fruits close by
Nervous & Endocrine Systems Linked

- **Hypothalamus** = “master nerve control center”
  - Nervous system
  - Receives information from nerves around body about internal conditions
  - **Releasing hormones**: regulates release of hormones from pituitary

- **Pituitary Gland** = “master gland”
  - Endocrine system
  - Secretes broad range of “tropic” hormones regulating other glands in body
Tropic Hormones = Target Endocrine Glands

- Thyroid gland
  - thyroid-stimulating hormone (TSH)
- Adrenal cortex
  - adrenocorticotropic hormone (ACTH)
- Growth hormone (GH)
- Gonadotropin hormones:
  - follicle-stimulating hormone (FSH)
  - luteinizing hormone (LH)
  - melanocyte-stimulating hormone (MSH)
- Prolactin (PRL)
- Antidiuretic hormone (ADH)
- Oxytocin
- Hypothalamus
  - anterior pituitary
  - posterior pituitary
- Kidney tubules
- Muscles of uterus
- Melanocyte in amphibian
- Mammary glands in mammals
- Testes
- Ovaries

Bone and muscle
Homology In Hormones

What does this tell you about these hormones?

How could these hormones have different effects?

- Prolactin
  - Mammals: milk production
  - Birds: fat metabolism
  - Fish: salt & water balance
  - Amphibians: metamorphosis & maturation
  - Growth hormone: growth & development

- Are they from the same gene family?
- Did they arise from gene duplication?
Regulating Metabolism

- **Hypothalamus**
  - TRH = TSH-releasing hormone

- **Anterior Pituitary**
  - TSH = Thyroid stimulating hormone

- **Thyroid**
  - Produces thyroxine hormones
  - Metabolism & development
    - Bone growth
    - Mental development
    - Metabolic use of energy
    - Blood pressure & heart rate
    - Muscle tone
    - Digestion
    - Reproduction

\[ \text{tyrosine} + \text{iodine} \rightarrow \text{thyroxines} \]
Goiter

Iodine deficiency causes thyroid to enlarge as it tries to produce thyroxine

Diagram:

- Hypothalamus
  - TRH
    - Anterior pituitary
      - TSH
        - Thyroid
          - Tyrosine + Iodine → Thyroxines
          - Goiter

Diagram showing normal thyroid and goiter conditions.
Endocrine System Control
Regulation of Blood Calcium

**blood calcium level** (10 mg/100mL)

- **↑** Ca++ uptake in intestines
- **↑** kidney reabsorption of Ca++
- activated Vitamin D
- bones release Ca++
- **↓** kidney reabsorption of Ca++
- Ca++ deposited in bones

**Feedback**
Female Reproductive Cycle

- **ovary**
  - estrogen
  - FSH & LH
  - GnRH
  - hypothalamus
- **corpus luteum**
  - progesterone
  - pregnancy
  - hCG
- **pregnancy**
  - fertilized egg (zygote)
- **uterus lining**
  - builds up
  - maintains
  - no
  - menstrual
  - maintains
  - corpus luteum breaks down
  - progesterone drops
- **feedback**
  - estrogen
  - progesterone
  - corpus luteum

**Notes:**
- The cycle begins with the hypothalamus releasing GnRH, which stimulates the pituitary gland to release FSH & LH.
- FSH & LH stimulate the ovaries to release estrogen, which matures the egg and triggers ovulation.
- The egg is released (ovulation), and estrogen builds up the uterus lining.
- If pregnancy occurs, the corpus luteum maintains the uterus lining.
- If not, the corpus luteum breaks down, progesterone drops, and menstruation occurs.

**Key Terms:**
- corpus luteum
- estrogen
- progesterone
- FSH & LH
- GnRH
- hypothalamus
- pituitary
- ovaries
- uterus lining
- menstrual
Effects of Stress

Spinal cord (cross section)

Nerve signals

Nerve cell

Releasing hormone

Hypothalamus

Anterior pituitary

ACTH

Adrenal gland

Adrenal medulla secretes **epinephrine** & **norepinephrine**

Adrenal cortex secretes **mineralocorticoids** & **glucocorticoids**

**MEDULLA**

**(A) SHORT-TERM STRESS RESPONSE**

Effects of **epinephrine** and **norepinephrine**:
1. Glycogen broken down to glucose; increased blood glucose
2. Increased blood pressure
3. Increased breathing rate
4. Increased metabolic rate
5. Change in blood flow patterns, leading to increased alertness & decreased digestive & kidney activity

**(B) LONG-TERM STRESS RESPONSE**

Effects of **mineralocorticoids**:
1. Retention of sodium ions & water by kidneys

Effects of **glucocorticoids**:
1. Proteins & fats broken down & converted to glucose, leading to increased blood glucose
2. Increased blood volume & blood pressure
2. Immune system suppressed
Any Questions??

Robert Wadlow
1918-1940
8' 11"
AP Biology
Ch. 46: Endocrine System & Hormones
Short Answer Questions

1. List a few similarities and differences comparing:
   a. Endocrine System: ___________________________________________________________
   b. Nervous System: ___________________________________________________________

2. What is a hormone?
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

3. Explain the similarities and differences between neurotransmitters and hormones.
   a. Similarities: __________________________________________________________________
       __________________________________________________________________________
       __________________________________________________________________________
   b. Differences: __________________________________________________________________
       __________________________________________________________________________
       __________________________________________________________________________

4. Hormones are carried throughout the body to every cell via the circulatory system. Explain how only specific target cells respond to the hormone when many others do not.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________

5. How do duct and ductless glands differ? Give examples of each.
   __________________________________________________________________________
   __________________________________________________________________________
   __________________________________________________________________________
6. Explain negative feedback. Give an example.

7. Sketch a diagram illustrating the negative feedback example you gave.

8. Explain positive feedback. Give an example.

9. Sketch a diagram illustrating the positive feedback example you gave.
10. Describe the mechanism by which steroid hormones regulate their target cells. (steroid model for hormone action)

___________________________________________________________________________________________________

___________________________________________________________________________________________________

___________________________________________________________________________________________________

11. Describe the general mechanism by which protein or hydrophilic hormones regulate their target cells. (protein model for hormone action)

___________________________________________________________________________________________________

___________________________________________________________________________________________________

___________________________________________________________________________________________________

12. Identify molecules that serve as “second messengers” in a cell?

___________________________________________________________________________________________________

___________________________________________________________________________________________________

___________________________________________________________________________________________________

13. What does the “second messenger” do in the cell?

___________________________________________________________________________________________________

___________________________________________________________________________________________________

___________________________________________________________________________________________________


___________________________________________________________________________________________________

___________________________________________________________________________________________________

___________________________________________________________________________________________________
### PITUITARY HORMONES

<table>
<thead>
<tr>
<th>LOBE</th>
<th>HORMONES</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Thyroid Stimulating Hormone (TSH)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>Adrenocorticotropic Hormone (ACTH)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>Growth Hormone (GH)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>Follicle Stimulating Hormone (FSH)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>Luteinizing Hormone (LH)</td>
<td></td>
</tr>
<tr>
<td>Anterior</td>
<td>Prolactin</td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>Oxytocin</td>
<td></td>
</tr>
<tr>
<td>Posterior</td>
<td>Anti-diuretic Hormone (ADH) {Vasopressin}</td>
<td></td>
</tr>
</tbody>
</table>
## OTHER HORMONES

<table>
<thead>
<tr>
<th>GLAND</th>
<th>HORMONES</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pineal</td>
<td>Melatonin</td>
<td></td>
</tr>
<tr>
<td>Thyroid</td>
<td>1. Thyroxin</td>
<td>1.</td>
</tr>
<tr>
<td></td>
<td>2. Calcitonin</td>
<td>2.</td>
</tr>
<tr>
<td>Parathyroids (4)</td>
<td>Parathormone</td>
<td></td>
</tr>
<tr>
<td>Thymus</td>
<td>Thymosin</td>
<td></td>
</tr>
<tr>
<td>Adrenal Glands (2)</td>
<td>1. Adrenaline/ Noradrenaline (Epinephrine/ Norepinephrine)</td>
<td>1.</td>
</tr>
<tr>
<td></td>
<td>2. Cortisol</td>
<td>2.</td>
</tr>
<tr>
<td>Pancreas – Islets of Langerhans</td>
<td>1. Insulin</td>
<td>1.</td>
</tr>
<tr>
<td></td>
<td>2. Glucagon</td>
<td>2.</td>
</tr>
<tr>
<td>Ovaries (2)</td>
<td>Testes (2)</td>
<td>Stomach</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>---------</td>
</tr>
<tr>
<td>1. Estrogen</td>
<td>Testosterone</td>
<td>Gastrin</td>
</tr>
<tr>
<td>2. Progesterone</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. List the two lines of non-specific defense mechanisms with examples of each.
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

2. What is meant by specific defense? What line of defense is associated with it?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

3. Give examples of “barrier defenses.”
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

4. What is the role of phagocytic leukocytes?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

5. What is the role of the lymphatic system?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

6. How does the lymphatic system aid in immunity?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
7. Outline the significant steps that occur during an inflammatory response?

_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

8. What is an antigen?

_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

9. Identify several differences between the lymphocytes.
   a. B Lymphocytes: ____________________________________________________________________________________
      ____________________________________________________________________________________
      ____________________________________________________________________________________
   b. T Lymphocytes: ____________________________________________________________________________________
      ____________________________________________________________________________________
      ____________________________________________________________________________________

10. Which lymphocytes are involved in the humoral immune response? __________________________

11. Which lymphocytes are involved in the cell-mediated immune response? _____________________

12. What are antibodies (immunoglobulins)?

   ____________________________________________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________

13. List and briefly describe four ways antibodies aid in immunity.

   ____________________________________________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________
   ____________________________________________________________________________________
14. Define active immunity.

15. Label box A and B on the active immunity graph below. It depicts what happens to the antibody concentration in a patient’s bloodstream after an initial exposure to a particular pathogen and then a secondary exposure to that same pathogen.

16. Why is secondary immune response quicker and more robust than primary response?

17. Explain the basic mechanism behind vaccinations?

18. Define passive immunity.
19. What is the role of MHC?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

20. What is the role of cytotoxic T cells (killer T) and describe their mechanism of action?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

21. What are some of the actions of helper T cells?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

22. Explain what happens when a person has an autoimmune disease? Give some examples.
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________

23. What happens when you have an allergy?
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
_______________________________________________________________________________________________________
Ch. 52: Immune & Lymphatic Systems

Fighting the Enemy Within!

lymphocytes attacking cancer cell
Avenues of Attack

- **Points of Entry**
  - Digestive System
  - Respiratory System
  - Urogenital Tract
  - Break in Skin

- **Routes of Attack**
  - Circulatory System
  - Lymph System
Why an Immune System?

- **Attack from outside**
  - Lots of organisms want you for lunch!
  - Animals are a tasty nutrient- & vitamin-packed meal
    - Cells are packages of macromolecules
  - Animals must defend themselves against invaders (*pathogens*)
    - **Viruses**
      - HIV, flu, cold, measles, chicken pox
    - **Bacteria**
      - pneumonia, meningitis, tuberculosis
      - Lyme disease
    - **Fungi**
      - yeast ("Athlete’s foot"…)
    - **Protists**
      - amoeba, malaria

- **Attack from inside**
  - Cancers = abnormal body cells
Lymphatic System

- Production & transport of leukocytes
- Traps foreign invaders

Lymph vessels (intertwined amongst blood vessels)

Lymph node
Development of Red & White Blood Cells

Pluripotent stem cells (in bone marrow)

Myeloid stem cells

Lymphoid stem cells

Red blood cells

Erythrocytes

Platelets

Monocytes develop into macrophages

Neutrophils short-lived phagocytes 60-70% WBC

Basophils

Eosinophils

inflammatory response

fight parasites

Leukocytes

B cells T cells

Lymphocytes

Development of Short-lived Phagocytes

60-70% WBC develop into macrophages

Lymphocytes

Monocytes

Neutrophils
Lines of Defense

- **1st Line:** Non-specific Barriers
  - Broad, external defense
    - “Walls & moats”
  - Skin & mucous membranes

- **2nd Line:** Non-specific Patrols
  - Broad, internal defense
    - “Patrolling soldiers”
  - **Leukocytes** = Phagocytic WBCs

- **3rd Line:** True Immune System
  - Specific, acquired immunity
    - “Elite trained units”
  - **Lymphocytes** & Antibodies
    - B cells & T cells
Non-specific External Defense

- **Barrier**
  - Skin

- **Traps**
  - Mucous membranes, cilia, hair, earwax

- **Elimination**
  - Coughing, sneezing, urination, diarrhea

- **Unfavorable pH**
  - Stomach acid, sweat, saliva, urine

- **Lysozyme enzyme**
  - Digests bacterial cell walls
  - Tears, sweat
Non-specific Patrolling Cells

- Patrolling cells & proteins
  - Attack pathogens, but don’t “remember” for next time
    - **Leukocytes**
      - Phagocytic white blood cells
      - Macrophages, neutrophils, natural killer cells
    - **Complement System**
      - Proteins that destroy cells
    - **Inflammatory Response**
      - Increase in body temp.
      - Increase capillary permeability
      - Attract macrophages
Leukocytes: Phagocytic WBCs

- Attracted by chemical signals released by damaged cells
  - Ingest pathogens
  - Digest in lysosomes

- **Neutrophils**
  - Most abundant WBC (~70%)
  - ~3 day lifespan

- **Macrophages**
  - “Big Eater”, long-lived

- **Natural Killer Cells**
  - Destroy virus-infected cells & cancer cells
Destroying Cells Gone Bad!

- **Natural Killer Cells** perforate cells
  - Release **perforin** protein
  - Insert into membrane of target cell
  - Forms pore allowing fluid to flow in & out of cell
  - Cell ruptures (lysis)
    - **Apoptosis**
Anti-microbial Proteins

- **Complement System**
  - ~20 proteins circulating in blood plasma
  - Attack bacterial & fungal cells
    - Form a membrane attack complex
    - Perforate target cell
    - **Apoptosis**
      - Cell lysis

Diagram:
- Complement proteins form cellular lesion
- Plasma membrane of invading microbe
- Extracellular fluid
- Bacterial cell
Inflammatory Response

- Damage to tissue triggers local non-specific inflammatory response
  - Release chemical signals
    - Histamines & prostaglandins
  - Capillaries dilate, become more permeable (leaky)
    - Delivers macrophages, RBCs, platelets, clotting factors
      - Fight pathogens
      - Clot formation
  - Increases temperature
    - Decrease bacterial growth
    - Stimulates phagocytosis
    - Speeds up repair of tissues
Fever

- When a local response is not enough
  - System-wide response to infection
  - Activated macrophages release **interleukin-1**
    - Triggers hypothalamus in brain to readjust body thermostat to raise body temperature
  - Higher temperature helps defense
    - Inhibits bacterial growth
    - Stimulates phagocytosis
    - Speeds up repair of tissues
    - Causes liver & spleen to store iron, reducing blood iron levels
      - Bacteria need large amounts of iron to grow
Acquired (Active) Immunity

- **Specific defense with memory**
  - **Lymphocytes**
    - B cells
    - T cells
  - **Antibodies**
    - Immunoglobulins

- **Responds to...**
  - **Antigens**
    - Cellular name tags
      - Specific pathogens
      - Specific toxins
      - Abnormal body cells (cancer)
How are invaders recognized?

- **Antigens**
  - **Cellular name tag proteins**
    - **“Self” Antigens**
      - No response from WBCs
    - **“Foreign” Antigens**
      - Response from WBCs
      - Pathogens: Viruses, bacteria, protozoa, parasitic worms, fungi, toxins
      - Non-pathogens: Cancer cells, transplanted tissue, pollen
Lymphocytes

- **B cells**
  - Mature in **bone marrow**
  - **Humoral response system**
    - “Humors” = body fluids
    - Attack pathogens still circulating in blood & lymph
  - **Produce antibodies**

- **T cells**
  - Mature in **thymus**
  - **Cell-Mediated response system**
    - Attack invaded cells

- **“Maturation”**
  - Learn to distinguish “self” from “non-self” antigens
    - If react to “self” antigens, cells are destroyed during maturation
B cells

- Attack, learn & remember pathogens circulating in blood & lymph
- Produce specific **antibodies** against specific **antigen**
- Types of B cells
  - **Plasma cells**
    - Immediate production of antibodies
    - Rapid response, short term release
  - **Memory cells**
    - Continued circulation in body
    - Long term immunity
Antibodies

- Proteins that bind to a specific antigen
  - Multi-chain proteins
  - Binding region matches molecular shape of antigens
  - Each antibody is unique & specific
    - Millions of antibodies respond to millions of foreign antigens
  - Tagging “handcuffs”
    - “This is foreign…gotcha!”

- Each B cell has ~50,000 antibodies
What do antibodies do to invaders?

- **Neutralize**: Binding of antibodies to antigens inactivates antigens by neutralization (blocks viral binding sites; coats bacteria and/or opsonization).
- **Capture**: Agglutination of antigen-bearing particles, such as microbes.
- **Precipitate**: Precipitation of soluble antigens.
- **Apoptosis**: Complement fixation (activation of complement), leads to cell lysis.

Invading pathogens tagged with antibodies are captured by phagocytes, which then eat tagged invaders. Macrophages play a role in this process.
B cell Immune Response

Invader (foreign antigen) tested by B cells (in blood & lymph)

B cells + antibodies

Recognition

Memory cells “reserves”

10 to 17 days for full response

Plasma cells release antibodies

Clones 1000s of clone cells

Captured invaders

Macrophage

B cell Immune Response

10 to 17 days for full response

Invader (foreign antigen) tested by B cells (in blood & lymph)

B cells + antibodies

Recognition

Memory cells “reserves”

1000s of clone cells

Plasma cells release antibodies

Captured invaders

Macrophage
Vaccinations

- Immune system exposed to harmless version of pathogen
  - Stimulates B cell system to produce antibodies to pathogen
    - “Active Immunity”
  - Rapid response on future exposure
  - Creates immunity without getting disease!
  - Most successful against viruses
Jonas Salk
1914 – 1995
April 12, 1955

- Developed first vaccine
  - Against polio
    - Attacks motor neurons

Albert Sabin
1962
oral vaccine
Polio Epidemics

1994: Americas polio free
Passive Immunity

- Obtaining antibodies from another individual
  - **Maternal Immunity**
    - Antibodies pass from mother to baby across placenta or in mother’s milk
    - Critical role of breastfeeding in infant health
      - Mother is creating antibodies against pathogens baby is being exposed to
  
  - **Injection**
    - Injection of antibodies
    - Short-term immunity
What if the attacker gets past the B cells in the blood & actually infects (hides in) some of your cells?

You need trained assassins to recognize & kill off these infected cells!

Attack of the Killer T cells!

But how do T cells know someone is hiding in there?
How is any cell tagged with antigens?

- **Major Histocompatibility (MHC) Proteins**
  - Proteins which constantly carry bits of cellular material from the cytosol to the cell surface
  - “Snapshot” of what is going on inside cell
  - Give the surface of cells a unique label or “fingerprint”

Who goes there? self or foreign?
How do T cells know a cell is infected?

- Infected cells digest some pathogens
  - MHC proteins carry pieces to cell surface
    - Foreign antigens now on cell membrane
    - Called **Antigen Presenting Cell (APC)**
      - Macrophages can also serve as APC
  - Tested by Helper T cells
T cells

- Attack, learn & remember pathogens hiding in infected cells
  - Recognize antigen fragments
  - Also defend against “non-self” body cells
    - Cancer & transplant cells

- Types of T cells
  - **Helper T cells**
    - Alerts rest of immune system
  - **Killer (cytotoxic) T cells**
    - Attack infected body cells
  - **Memory T cells**
    - Long term immunity
T Cell Response

APC: infected cell

recognition

helper T cell

interleukin 1

APC: activated macrophage

recognition

helper T cell

helper T cell

clones

helper T cell

interleukin 2

killer T cell

activate killer T cells

stimulate B cells & antibodies

or
Attack of the Killer T cells

- Destroys infected body cells
  - Binds to target cell
  - Secretes **perforin** protein
    - Punctures cell membrane of infected cell
      - Apoptosis
## Immune System & Blood Type

<table>
<thead>
<tr>
<th>Blood Type</th>
<th>Antigen on RBC</th>
<th>Antibodies in Blood</th>
<th>Donation Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td>__</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>__</td>
</tr>
<tr>
<td>AB</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Matching compatible blood groups is critical for blood transfusions. A person produces antibodies against foreign blood antigens.
Immune Response

- Free antigens in blood
- Antigens on infected cells
- Macrophages (APC)
- Helper T cells
- Cytotoxic T cells
- Memory T cells
- Memory B cells
- Plasma B cells

- Pathogen invasion
- Antigen exposure
- Skin
- Alert

Antibodies: γ γ γ γ
HIV & AIDS

- **Human Immunodeficiency Virus**
  - Virus infects **helper T cells**
    - Helper T cells don’t activate rest of immune system: Killer T cells & B cells
    - Also destroys helper T cells

- **AIDS: Acquired ImmunoDeficiency Syndrome**
  - Infections by opportunistic diseases
  - Death usually from “opportunistic” infections
    - Pneumonia, cancers
How to protect yourself...
Immune System Malfunctions

- **Auto-immune Diseases**
  - Immune system attacks own molecules & cells
    - **Lupus**
      - Antibodies against many molecules released by normal breakdown of cells
    - **Rheumatoid Arthritis**
      - Antibodies causing damage to cartilage & bone
    - **Diabetes**
      - Beta-islet cells of pancreas attacked & destroyed
    - **Multiple Sclerosis**
      - T cells attack myelin sheath of brain & spinal cord nerves

- **Allergies**
  - Over-reaction to environmental antigens
    - Allergens = proteins on pollen, dust mites, in animal saliva
    - Stimulates release of histamine
It’s safe to Ask Questions!