Need some help with respiratory systems?

1. CH. 48

Need some help with circulation systems?

1. CH. 49: P. 940-946

Need some help with membrane potentials, ion channels, etc.?

1. Ch 5: Cellular Membranes (ion channels p. 98)
2. Ch 15: Cell Signaling and Communication
Fig. 44.6 – Resting Potential

What shifts cell to an action potential?

The tendency of $K^+$ ions to diffuse out leaves an excess of negative charges inside the cell, creating the resting potential.
**F. 44.9 Action Potential**

The action potential is a sudden, brief reversal of charge in the membrane potential. The membrane potential at any given time depends on how many and which channels are open.

- **Activation gates of some Na⁺ channels open, depolarizing the cell to threshold.**
- **Additional voltage-gated Na⁺ channel activation gates open, causing a rapid spike of depolarization and even hyperpolarizing the cell.**
- **All gated channels close. The cell returns to its resting potential.**
- **Open K⁺ channels create the resting potential.**
- **Gated Na⁺ channel**
- **Voltage-gated K⁺ channel**
- **Inactivated Na⁺ channels**
Hormones
Outline

• Hormones coordinate responses to internal and external cues
• Two major types of hormones and their typical modes of action
• Two examples of hormone actions: hypothalmus/pituitary, stress and the adrenals
• Endocrine disruptors
In multicellular organisms, cells must be able to communicate.

Neurons communicate via CHEMICALS.
chemical communication between cells

- short distance
- long distance
short distance
chemical communication

neurotransmitters
signals transmitted over longer distances need to be carried in the body’s circulatory system

• these are HORMONES
What cells produce hormones?

- endocrine cells
- neurosecretory cells
Notice that hormones have **target cells**

- **endocrine cells**
- **neurosecretory cells**
2 major groups of hormones

1) binding receptors in cytoplasm (steroid hormones)

2) binding receptors in membranes (peptide)
Steroid hormones

structure: derived from cholesterol

- Estradiol - 17β
- Cholesterol
- Testosterone
- Cortisol (hydrocortisone)
Steroid hormones

specificity: by side groups

Estradiol - 17β

Cholesterol

Testosterone

Cortisol (hydrocortisone)
Steroid hormones

1) structure?
   • cholesterol skeleton
2) specificity?
   • side chains
3) solubility?
   • LIPID SOLUBLE
Mechanism of action of steroid hormones

What will a fat-soluble hormone do when it encounters a plasma membrane?

PASS THROUGH IT!
Steroids can pass through the lipid bilayer and bind to a receptor.
Steroids trigger mRNA transcription which synthesizes proteins.....

GENE EXPRESSION in the target cell
Steroids

Observations:
- Cells have different responses to the same hormone.
- Same cell can have different responses at different times.
Steroids
How is that possible?
Different receptors!

Different steroid-receptor complexes will act on different regions of DNA
example: estrogen

• many targets: bone, breast, uterus, prostate gland, cardiovascular tissue, brain
estrogen

• used to think - one receptor

• but: some tissues responded without this particular receptor

• and: sometimes had opposite effects – e.g. tumor growth in some situations and preventing it in others
estrogen

- a second receptor was discovered ~1996
- a third in fish in 2000
Steroid hormones work act at very low concentrations.

How does that work?
One S-R complex triggers many mRNAs. Each mRNA is used to make many proteins.
THE SIGNAL IS AMPLIFIED
2 groups of hormones

1) receptors in cytoplasm
2) receptors in cell membrane (peptide hormones)
Peptide hormones

structure: chains of amino acids
Peptide hormones

specificity: by precise amino acid composition
Peptide hormones

1) structure?
2) specificity?
3) solubility?

- amino acids
- amino acid composition
- WATER SOLUBLE
Mechanism action of water-soluble hormones

What will a water-soluble hormone do when it encounters a plasma membrane?

BOUNCE OFF IT
1. binds receptor in the cell membrane
2. the P-R complex triggers the production of a 2nd messenger
3. activity of enzymes is altered
We Restarted Here on Wednesday
Hermit crabs?
Regions necessary for complete language skills

- Broca’s area – physical control of speech
- Wernicke’s area – control of understanding
  - Speech still possible, but doesn’t make sense
  - Sounds

Human Evolution:
- *H. habilis* – Broca’s
- *H. erectus* – Broca’s and Wernicke’s
- Archaic *H. sapiens* – some speech
Hormones
Love = Chemistry

• Release of oxytocin
  – (Peptide) Hormone from the posterior pituitary

• Release of dopamine
  – neurotransmitter
Steroid hormones

1) structure?
- cholesterol skeleton
- side chains
- LIPID SOLUBLE

2) specificity?

3) solubility?

Mode of action?
Triggers mRNA transcription → gene expression → protein production
2 groups of hormones

1) receptors in cytoplasm
2) receptors in cell membrane
   (peptide hormones)
Peptide hormones

1) structure?
2) specificity?
3) solubility?

- amino acids
- amino acid composition
- WATER SOLUBLE
Mechanism action of water-soluble hormones

What will a water-soluble hormone do when it encounters a plasma membrane?

BOUNCE OFF IT
PEPTIDE HORMONE

1. binds receptor in the cell membrane
2. the P-R complex triggers the production of a 2nd messenger
3. activity of enzymes is altered
PEPTIDE HORMONE

- How much hormone does it take to get a response?

- Peptide hormones initiate an enzyme cascade
1 epinephrine molecule binds to receptor

inactive G protein

active G protein

inactive adenylyl cyclase

active adenylyl cyclase

ATP

cyclic AMP

Each active enzyme activates many substrate molecules

# of molecules affected

1

10

100

1000
cyclic AMP

# of molecules affected

1000

inactive protein kinase

active protein kinase

10,000

inactive kinase

active kinase

100,000

inactive glycogen phosphorylase

active glycogen phosphorylase

1,000,000
Key point: At each step, an active enzyme activates many substrate molecules = amplification in a chemical CASCADE
## Compare the two hormone types

<table>
<thead>
<tr>
<th></th>
<th><strong>steroid</strong></th>
<th><strong>peptide</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>Cholesterol</td>
<td>A. Acids</td>
</tr>
<tr>
<td><strong>binds receptor</strong></td>
<td>in cytoplasm</td>
<td>in cell membrane</td>
</tr>
<tr>
<td><strong>events triggered by H-R complex</strong></td>
<td>gene expression</td>
<td>2nd messenger and changed enzyme activity</td>
</tr>
</tbody>
</table>
endocrine glands in vertebrates

Fig 42.2
examples of hormone systems and actions

1. central role of the hypothalamus-pituitary complex
2. hormonal responses to stress
1. Hypothalamus and pituitary integrate many major endocrine glands
The pituitary is actually two separate glands: the anterior pituitary and the posterior pituitary.
The posterior pituitary releases a few hormones into general circulation. One is antidiuretic hormone (ADH).
neurosecretory cells in **hypothalamus** secrete **releasing hormones** into blood

these stimulate anterior **pituitary** to secrete **tropic** (stimulating) **hormones**

*Fig 42.8*

- these stimulate **targets**, which can be other **endocrine glands**
releasing hormones

\[ \text{Hypothalamus} \]

\[ \text{Portal blood vessels} \]

\[ \text{Posterior pituitary} \]

\[ \text{Anterior pituitary} \]

\[ \text{endocrine glands} \]

\[ \text{tropic hormones} \]

Multiple Feedbacks: Fig 42.8
some pituitary tropic hormones and their targets (T 42.1)

• growth hormone - bones
• follicle-stimulating hormone - ovaries, testes
• thyroid stimulating hormone - thyroid
• ACTH - adrenal cortex
• endorphins - brain
2. **STRESS** requires integration of many body functions

- short term responses
- long term responses
Life has its stresses
maybe you can identify with this...
short term responses handled by medulla of the adrenal glands

- nervous system *(acetylicholine)* stimulates the adrenal medulla to secrete adrenalin
adrenalin binds receptor in membrane

Flight –or-fight response:
• raises blood glucose
• increase metabolism
• Increases heart rate
longer term responses handled by cortex of the adrenal glands
definition: the cortex is stimulated by endocrine signals
Hypothalamus releasing hormone stimulates pituitary to secrete ACTH, which stimulates release of corticosteroid hormones.
some effects of corticosteroids on targets

• Kidneys: retain sodium and water to help maintain increased blood pressure and nerve firing

• Proteins and fats broken down to glucose
STRESS requires integration of many body functions

- short term responses - neural input, membrane receptors
- long term responses - endocrine input, cytoplasmic receptors
general features of hormones and how they work

• there are 2 broad classes of hormones -
• Why do hormones act at very low concentrations?
general features of hormones and what they do

- hormones have target cells
- pairs of hormones often work in opposition to each other
Endocrine Disruptors

- aka Endocrine-Activating Chemicals
  *Hormone Mimics*
- example: atrazine - the most commonly used herbicide in the U.S
Atrazine

- short half life, easily metabolized
- several PPM in ag. runoff
- drinking water safe at 3 PPB
  limited exposure OK to 200 PPB
Amphibians in Decline

Amphibian Decline Hotspots

(Vredenburg 2002)
Amphibian Deformity
world-wide amphibian decline

- those with aquatic larval stage in the worst shape
- endocrine disruptors?

- atrazine known to have endocrine effects in mammals
sex steroids in frogs

- African- Clawed Frog
- estrogen treatment = 100% females
- androgen = larynx growth, no effect on gonads

PNAS 100:5476-5480 (2002)
test effect of atrazine

- atrazine exposure during development?
- larynx size, testosterone levels in adults
0.01-25 ppb atrazine

- good news: NO effects on mortality,

- bad news: ALL except lowest dose produced gonadal abnormalities

= multiple gonads, both male and female gonads in 20%
Multiple gonads and hermaphroditic
Atrazine decreases larynx size
Atrazine decreases male testosterone

- 25 ppb
- treated males had same level of testosterone as females
Atrazine appears to

- stimulate estrogen effects
- inhibit androgen effects
- may have disruptive effects on aquatic vertebrates
- Cause of declines?
“Our stolen future”
by Theo Colburn
Effects on People?