BIOL 1030
Introduction to Biology: Organismal Biology, Spring 2011
Section A

Steve Thompson: stthompson@valdosta.edu
http://www.bioinfo4u.net
Regulation – the endocrine and renal systems

Regulation of the body’s metabolism, growth, development, temperature, and fluid balances. In other words just about everything that keeps it in homeostasis.
First the endocrine system.

- Hormones – biochemicals that travel in the bloodstream and alter metabolism in target cells.
- Endocrine gland – groups of hormone-producing cells that release their products into the bloodstream.
- Not all hormones originate in glands, some are produced in scattered cells.
- Exocrine glands release their products into ducts, e.g. sweat, milk, digestive enzymes (these are not hormones, therefore, they are not a part of the endocrine system).
- Pancreas – is a mixed gland with...
- Both endocrine (insulin) and exocrine (digestive enzymes) functions. Another mixed one are the gonads.
Exocrine vs. Endocrine

a. Skin

b. Thyroid
<table>
<thead>
<tr>
<th>Main tissue types</th>
<th>Examples of Locations/Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epithelial</td>
<td>Makes up the bulk of most glands and secretes many types of hormones</td>
</tr>
<tr>
<td>Connective</td>
<td>Blood circulates hormones throughout the body</td>
</tr>
<tr>
<td>Nervous</td>
<td>Parts of the brain secrete some hormones and control release of others; some neurons secrete hormones</td>
</tr>
</tbody>
</table>
Where it’s at and what the parts do.

- **Pineal gland**
  - Produces melatonin

- **Hypothalamus**
  - Produces hormones that stimulate or inhibit the release of hormones from the pituitary gland

- **Pituitary gland**
  - Produces numerous hormones that affect target tissues directly or stimulate other endocrine glands

- **Thyroid gland**
  - Releases thyroid hormones, which regulate metabolism

- **Parathyroid glands** (behind thyroid)
  - Secrete parathyroid hormone, which helps regulate blood calcium

- **Adrenal glands**
  - Produce hormones related to sympathetic nervous system and steroids that help regulate body fluids

- **Pancreas**
  - Releases hormones that regulate blood glucose levels

- **Ovaries (in female)**
  - Produce estrogen and progesterone, which mediate monthly changes in the uterine lining

- **Testes (in male)**
  - Produce testosterone, which promotes sperm maturation and secondary sex characteristics
The nervous and endocrine systems are tightly integrated.

* Together they are called the neuroendocrine system.
* There are many similarities:
  * Some chemicals act as both hormones and neurotransmitters;
  * Some neurons in the hypothalamus release hormones;
* But there are some big differences:
  * Neurons use action potentials and neurotransmitters; versus . . .
  * The endocrine system uses hormones. Plus the . . .
  * Endocrine system communicates much more slowly and for prolonged periods of time. And . . .
* Single neurons influence only a few cells at a time, but hormones circulate throughout the entire body in the blood.
Here's an example as it relates to the renal system.

Hormonal communication generally begins with a part of the neuroendocrine system receiving sensory information and reacting by issuing a command to the body in the form of a hormone.

http://www.valdosta.edu/~stthompson/animations/Chapter30/hormoneComm.swf
Feedback loops control things in the endocrine system.

- As we've seen, this is mainly negative feedback . . .
- Where a sensor monitors a variable, and . . .
- Effectors counteract the change, if it is too high or too low. This is very different from . . .
- Positive feedback, where the . . .
- Process reinforces itself. Which is way . . .
- Less common.
- An example is uterine contractions of childbirth.
Negative feedback in the endocrine system...

- **Gland A**
  - Hormone A acts on target organ to decrease concentration
  - Concentration decreases

- **Gland B**
  - Hormone B acts on target organ to increase concentration
  - Concentration increases

- Normal concentration of biochemical
  - Concentration is too high
  - Concentration is too low

Target organ

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.
Target cells . . .

- Many hormones circulate throughout the body at the same time.
- Each hormone's target cells are those with the specific corresponding receptors.
- Therefore, a hormone does not affect every cell it encounters.
- Receptors may be on the cell surface (water-soluble hormones) or inside the cell (lipid-soluble hormones).
Which brings us to . . . hormone solubility.

- Water-soluble hormones include . . .
  - Peptide hormones – chains of a few to several hundred amino acids – plus several neurotransmitters.
  - The binding of the hormone to its receptor on the surface of the cell activates a second messenger inside the cell.
  - This activates enzymes that produce the hormone’s effects.
  - They generally act quite fast.

- Lipid-soluble hormones include . . .
  - The steroid hormones, which are synthesized from cholesterol.
  - They bind to specific receptors in the cell’s nucleus associated with DNA, which can trigger the production of particular proteins.
  - They have a much slower response time.
Water vs. lipid soluble hormones

**Water-soluble hormones** such as epinephrine, insulin, or human growth hormone circulate in bloodstream.

- Hormone binds to receptor on target cell surface
- Cascade of biochemical reactions ends by activating an enzyme
- Altered cell activity

**Lipid-soluble hormones** such as testosterone, estrogen, or thyroid hormone circulate in bloodstream.

- Hormone passes through cell membrane and binds to interior receptor
- Certain genes activated, leading to production of new proteins
- Altered cell activity

**Effects on cell**

---

**Blood vessel (not to scale)**

- Peptide hormone
- Target cell membrane
- Adenyl cyclase
- G protein
- cAMP
- Effects on cell

---

**Blood vessel (not to scale)**

- Steroid hormone
- Target cell membrane
- Extra-cellular fluid
- Nuclear envelope
- mRNA
- New ribosomal protein molecule
- mRNA
- Nucleus

---

**Cytoplasm of target cell**

- Receptor protein
- Nucleus
Let’s look at ‘em: the hypothalamus and pituitary gland – the foremen of the crew.

* They regulate all of the glands and hormones of the vertebrate endocrine system.
* Hypothalamus – a part of the forebrain.
* Pituitary gland – attached to a stalk extending from hypothalamus. Includes:
  * Anterior pituitary gland – front, which is . . .
    * Controlled by hormones from the hypothalamus. And the . . .
  * Posterior pituitary gland – back, which . . .
    * Does not make hormones. Rather it . . .
    * Stores and releases hormones made by the hypothalamus.
Here's what they look like.

Anterior pituitary pathway
Neurons in the hypothalamus secrete inhibiting or releasing hormones, which enter the bloodstream and travel to the anterior pituitary.

Anterior pituitary gland
Hormones from the hypothalamus act on the cells of the anterior pituitary, inhibiting or stimulating release of anterior pituitary hormones.

Hormones secreted by the anterior pituitary enter the bloodstream and travel to their target tissues.

Posterior pituitary pathway
Neurons in the hypothalamus produce the hormones ADH and oxytocin, which leave the neuron endings in the posterior pituitary. The hormones enter the capillaries and travel to their target organs.

Posterior pituitary gland

Hypothalamus

Neurons from hypothalamus
And all the systems they affect.
The posterior pituitary gland stores and releases hormones.

- **Antidiuretic hormone (ADH) – a.k.a. vasopressin:**
  - Maintains chemical balance of body fluids by regulating water conservation by kidneys (much more in the second portion of the lecture next time on the renal system).

- **Oxytocin:**
  - Stimulates the contraction of cells in the breast and uterus during and after childbirth.
  - It also plays a role in social and sexual bonding!
The anterior pituitary gland...

- Tropic hormones are produced in one gland and influence hormone secretion in another. Tropic hormones from the hypothalamus stimulate (release hormones) or inhibit (turn off the release of hormones) secretion of the anterior pituitary gland hormones. These are...

- Growth hormone (GH) – a.k.a. somatotropin:
  - Promotes growth and development (gigantism and pituitary dwarfism are the result of problems with GH). And...

- Prolactin:
  - Stimulates milk production.
Four other hormones produced in the anterior pituitary are tropic hormones themselves. These are . . .

1) Follicle-stimulating hormone (FSH) – gonadotropin – acts on the gonads;
2) Luteinizing hormone (LH) – also gonadotropin – more in a bit. Plus . . .
3) Thyroid-stimulating hormone (TSH) – acts on the thyroid gland. And . . .
4) Adrenocorticotropic hormone (ACTH) – stimulates glucocorticoid release from the adrenal glands, which pumps up blood glucose levels during times of stress.

And the anterior pituitary also makes . . .

* Endorphins – natural painkillers (endogenous opiate).
### Table 30.1 Hormones of the Hypothalamus and Pituitary

<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Type</th>
<th>Location of Target Cells</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamus</td>
<td>Releasing hormones (e.g., thyrotropin-releasing hormone (TRH), gonadotropin-releasing hormone (GnRH))</td>
<td>Peptide</td>
<td>Anterior pituitary</td>
<td>Stimulate release of hormones from anterior pituitary</td>
</tr>
<tr>
<td></td>
<td>Inhibiting hormones (e.g., growth hormone-inhibiting hormone)</td>
<td>Peptide</td>
<td>Anterior pituitary</td>
<td>Inhibit release of hormones from anterior pituitary</td>
</tr>
<tr>
<td>Posterior pituitary</td>
<td>Antidiuretic hormone (ADH)</td>
<td>Peptide</td>
<td>Kidneys</td>
<td>Helps maintain composition of body fluids</td>
</tr>
<tr>
<td></td>
<td>Oxytocin</td>
<td>Peptide</td>
<td>Uterus, mammary glands, brain</td>
<td>Stimulates smooth muscle contraction; has role in affection and bonding</td>
</tr>
<tr>
<td>Anterior pituitary</td>
<td>Growth hormone (GH)</td>
<td>Protein</td>
<td>Liver</td>
<td>Stimulates production of insulin-like growth factors, which promote tissue growth throughout the body</td>
</tr>
<tr>
<td></td>
<td>Prolactin</td>
<td>Protein</td>
<td>Mammary glands</td>
<td>Stimulates milk secretion</td>
</tr>
<tr>
<td></td>
<td>Follicle-stimulating hormone (FSH)</td>
<td>Protein</td>
<td>Ovaries, testes</td>
<td>In females: stimulates follicle development, oocyte maturation, release of estrogen In males: stimulates sperm production</td>
</tr>
<tr>
<td></td>
<td>Luteinizing hormone (LH)</td>
<td>Protein</td>
<td>Ovaries, testes</td>
<td>In females: stimulates ovulation, progesterone secretion In males: stimulates testosterone secretion</td>
</tr>
<tr>
<td></td>
<td>Thyroid-stimulating hormone (TSH)</td>
<td>Glycoprotein (protein with carbohydrate attached)</td>
<td>Thyroid gland</td>
<td>Stimulates secretion of thyroid hormones</td>
</tr>
<tr>
<td></td>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>Protein</td>
<td>Adrenal cortex, pancreas</td>
<td>Stimulates secretion of glucocorticoids from adrenal cortex and insulin from pancreas</td>
</tr>
</tbody>
</table>
Many glands make hormones that regulate metabolism.

* Among them are the thyroid gland, which produces . . .
* Thyroxine and triiodothyronine, which both increase metabolism in target cells. They are controlled by a . . .
* Feedback loop involving the hypothalamus (TRH), the anterior pituitary (TSH), and the thyroid itself.
* The thyroid hormones both contain iodine; a deficiency of iodine causes goiter, which is a swollen thyroid gland.
* The thyroid also makes calcitonin, which decreases blood calcium levels.
The thyroid's feedback loop controls are shown here.
An animation shows how thyroxine works.

Thyroxine is a water-insoluble hormone that is brought to the target cell via a protein carrier. Because it is lipophilic, thyroxine can easily pass through the cell membrane.

http://www.valdosta.edu/~stthompson/animations/Chapter30/mechanism_of_thyroxine_action.swf
Another one is the . . .

* Parathyroid gland, which is . . .
* Embedded in the thyroid gland. It . . .
* Secretes parathyroid hormone (PTH), which . . .
* Increases calcium levels in blood.
* Excess PTH is correlated with osteoporosis in menopausal woman.
Another are the adrenal glands. 

- They sit on top of the kidneys.
- The adrenal medulla is the inner portion. It secretes...
  - Epinephrine, a.k.a. adrenalin, and...
  - Norepinephrine, a.k.a. noradrenalin;
- They stimulate circulatory and respiratory systems during short-term, high-level stress situations.
- And they are under the control of the sympathetic nervous system.

- The adrenal cortex is the outer portion. It secretes...
  - Mineralcorticoids that maintain blood volume and salt balance;
  - And glucocorticoids (especially cortisol) essential to long-term stress response, by converting amino acids into glucose.
The adrenals in schematic

**Sympathetic nerve signals**
- Adrenal medulla
  - Epinephrine
  - Norepinephrine

**Short-term response**
- Increases heart rate, breathing rate, blood flow, and blood glucose
- Redirects blood flow toward brain and muscles

**Long-term response**
- Suppresses immune system
- Affects metabolism
- Increases retention of sodium ions and water in the kidneys
- Increases glucose synthesis
The pancreas, with the...

* The pancreatic islets, a.k.a. the islets of Langerhans. These are the...
* Endocrine portion of the pancreas. They make:
  * Glucagon – increases blood glucose, and...
  * Insulin – decreases blood glucose.
* Diabetes mellitus is too much blood sugar. It relates to insulin in two ways:
  * Type I (youth) – body does not produce insulin;
  * Type II (adults) – body becomes resistant to insulin (it's an autoimmune disease).
* The opposite is hypoglycemia (low blood sugar).
The pancreas in schematic . . .

And its mixed nature — endocrine and exocrine.
And the feedback loops that control blood sugar levels look like this.
Here's an explanation of diabetes.

The following graphs display blood glucose and insulin levels in people with normal insulin response, and Type 1 and Type 2 diabetics.

http://www.valdosta.edu/~stthompson/animations/Chapter30/problems_with_sugars.swf
The pineal gland also affects metabolism.

- It is a brain structure near the hypothalamus (a.k.a. the brain’s eye), which...
- Produces melatonin.
- Darkness stimulates its production. And the...
- Amount of melatonin in the blood communicates the amount of light to other cells of the body affecting circadian rhythms.
- However, human functions are not well known, though it probably relates to SAD (seasonal affective disorder).
In review, metabolic endocrine functions...

<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Type</th>
<th>Location of Target Cells</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thyroid gland</td>
<td>Thyroid hormones (thyroxine,</td>
<td>Amine</td>
<td>All tissues</td>
<td>Increase metabolic rate</td>
</tr>
<tr>
<td></td>
<td>triiodothyronine)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calcitonin</td>
<td>Peptide</td>
<td>Bone</td>
<td>Increases rate of calcium deposition in bone</td>
</tr>
<tr>
<td>Parathyroid glands</td>
<td>Parathyroid hormone (PTH)</td>
<td>Peptide</td>
<td>Bones, digestive organs, kidneys</td>
<td>Releases calcium from bone, increases calcium absorption in</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>digestive tract and kidneys</td>
</tr>
<tr>
<td>Adrenal medulla</td>
<td>Epinephrine and norepinephrine</td>
<td>Amine</td>
<td>Blood vessels</td>
<td>Raise blood pressure, constrict blood vessels, slow digestion</td>
</tr>
<tr>
<td>Adrenal cortex</td>
<td>Mineralocorticoids</td>
<td>Steroid</td>
<td>Kidneys</td>
<td>Maintain blood volume and electrolyte balance</td>
</tr>
<tr>
<td></td>
<td>Glucocorticoids (e.g., cortisol)</td>
<td>Steroid</td>
<td>All tissues</td>
<td>Increase glucose levels in blood and brain</td>
</tr>
<tr>
<td>Pancreas</td>
<td>Insulin</td>
<td>Peptide</td>
<td>All tissues</td>
<td>Increases cellular glucose uptake</td>
</tr>
<tr>
<td></td>
<td>Glucagon</td>
<td>Protein</td>
<td>Liver, adipose tissue</td>
<td>Stimulates breakdown of glycogen to glucose and of fat to fatty acids</td>
</tr>
<tr>
<td>Pineal gland</td>
<td>Melatonin</td>
<td>Amine</td>
<td>Other endocrine glands</td>
<td>Regulates effects of light–dark cycle on other glands</td>
</tr>
</tbody>
</table>
Controlling reproduction is also an endocrine function.

- The gonads (ovaries and testes) manufacture gametes (egg and sperm cells, respectively), and . . .
- Also secrete hormones (so they are a mixed gland).
- The production is under negative feedback control by the anterior pituitary gland and hypothalamus.
- Female – hormone levels are on a 28 day cycle, they stimulate oocyte maturation, and they are responsible for secondary sexual characteristics.
- Male – no monthly cycle, but they do affect sperm maturation, and secondary sexual characteristics.
- We’ll learn much more about these hormones in a later lecture. For now . . .
The sex hormones...

**Female:**
- Estrogen and progesterone – low levels prompt the hypothalamus to release gonadotropin-releasing factor (GnRH).
- This triggers the anterior pituitary to release FSH and LH, which stimulate all the steps leading to ovulation.
- This causes the release of estrogen and progesterone by the ovaries’ follicle cells, which in turn shuts the whole process down.

**Males:**
- GnRH stimulates the release of FSH and LH (as in females), but this stimulates the testes to make sperm and testosterone.
- Testosterone and inhibin prevent sperm overproduction.
- The adrenal gland of both sexes also makes sex hormones.
Reproductive hormone control

- Hypothalamus
  - GnRH
  - Pituitary gland
    - FSH and LH
      - Ovary
        - FSH and LH stimulate oocyte maturation
    - Estrogen and progesterone inhibit the production of FSH and LH

- Hypothalamus
  - GnRH
  - Pituitary gland
    - FSH and LH
      - Testis
      - FSH and LH stimulate sperm maturation
    - Testosterone and inhibin inhibit the production of FSH and LH
The way steroid hormones work.

Steroid hormones are not water-soluble. They travel in the blood attached to protein carriers.

http://www.valdosta.edu/~stthompson/animations/Chapter30/steroid_hormone_action.swf
Table 30.3  **Hormones Produced in the Ovaries and Testes**

<table>
<thead>
<tr>
<th>Gland</th>
<th>Hormone</th>
<th>Type</th>
<th>Location of Target Cells</th>
<th>Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovaries</td>
<td>Progesterone</td>
<td>Steroid</td>
<td>Uterine lining</td>
<td>Regulates menstrual cycle, maintains secondary sex characteristics in females</td>
</tr>
<tr>
<td></td>
<td>Estrogen</td>
<td>Steroid</td>
<td>Uterine lining</td>
<td>Regulates menstrual cycle, maintains secondary sex characteristics in females</td>
</tr>
<tr>
<td>Testes</td>
<td>Testosterone</td>
<td>Steroid</td>
<td>Skin, muscles, sperm-producing cells</td>
<td>Promotes sperm development, maintains secondary sex characteristics in males</td>
</tr>
</tbody>
</table>
Animals need to regulate other things too.

- They live nearly everywhere, from . . .
- Extremely dry, scorching hot deserts, to . . .
- Frigid arctic tundras and ice fields, to . . .
- Tropical rain forests. Therefore, adaptations have evolved to . . .
- Select for different ways of regulating body temperature, conserving water, and disposing wastes.
Thermoregulation – the ability to balance heat gained from and lost to environment.

- Two routes have evolved:
  1) Ectotherms – lack any internal temperature-regulating mechanism. Therefore, they...
     - Physically move to different areas to gain or lose heat.
     - This uses less energy overall, but is...
     - Dependent on the environment.
  2) Endotherms – generate heat through their own metabolism.
     - This uses a lot more energy. But it is almost...
     - Always ready and is less dependent on the environment.
Endotherms and ectotherms in varied habitats.

Parrots are endotherms in the hot tropics; snakes are ectotherms, often in hot deserts, but capable of living in most places except the very coldest; mice are endotherms that can live almost everywhere.
In endotherms...
Neurons in the hypothalamus receive temperature information from thermoreceptors in the skin and other organs.

Responses may be behavioral (e.g. seek shade) or physiological (e.g. sweating).
Several adaptations help endothermic animals do it.

* One is countercurrent exchange. In this...

* Two adjacent currents of blood flow in opposite directions. This...

* Moves heat from arteries coming from the interior of the body going to the extremities, to veins coming back from the extremities toward the interior.

* Therefore, overall it conserves heat inside the body.

* Other adaptations include:

* Extremity blood vessels constrict, shivering (muscle use creates heat), raising hairs of fur (traps air layer for insulation), huddling, and hibernation.
This is countercurrent heat exchange.
Osmoregulation is another biggy, because critters . . .

* Must control the concentration of ions in their body fluid as the environment changes.
* This is accomplished through the gain and loss of water, of ions, or of both.
* Remember osmosis – the diffusion of water across a membrane;
* Water will leave the cell if the concentration of ions is greater outside the cell, and will enter in the opposite situation.
For example: Kangaroo rats derive most of their water from cellular respiration. We get most of ours from food and liquids. All animals lose water.
Two main types of waste:

1) Feces – undigested and undigestible food (plus lots of archaea and bacteria, more in the digestive system lecture); plus . . .

2) Metabolic wastes produced by cells, including . . .

- Nitrogenous wastes, which are produced mainly from protein degradation.
- That is . . . amino groups (-NH₂) from proteins become ammonia (NH₃), which is toxic in animals. So, animals . . .
- Convert it to other less toxic forms.
Animals use energy to convert ammonia to less toxic forms.

Many fish can just excrete it into the water. But most land animals have to change it into something else.
This all happens in the urinary system.

- Most animals have two kidneys.
- They excrete urea, conserve water and nutrients, regulate blood pH and blood volume. As they do this job, urine forms.
- The urine drains into ureter, which passes it on to the . . .
- Urinary bladder. From there it passes through a . . .
- Single urethra to the outside for elimination.
<table>
<thead>
<tr>
<th>Main tissue types</th>
<th>Examples of Locations/Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epithelial</td>
<td>Enables diffusion across glomerular capsules and kidney tubules; also lines ureters and bladder.</td>
</tr>
<tr>
<td>Connective</td>
<td>Blood (which kidneys filter) is a connective tissue.</td>
</tr>
<tr>
<td>Muscle</td>
<td>Smooth muscle controls flow of blood to and from nephrons; smooth and skeletal muscle sphincters control urine release.</td>
</tr>
<tr>
<td>Nervous</td>
<td>Sensory cells in hypothalamus coordinate negative feedback loops that maintain homeostasis.</td>
</tr>
</tbody>
</table>
The internal parts of the human urinary system are shown here.
The nephron is the kidney’s functional unit!

* Each human kidney has 1.3 million microscopic nephrons. That’s a lot.
* The body’s entire blood supply goes through them every five minutes!
  Wow. But . . .
* Most of the fluid the nephrons process is reabsorbed into the blood.
* Only about 1.5 L of urine is produced per day.
Let's zoom in.

Don't get bogged down with all the details.
What's the blood do there?

* The renal artery (one per kidney) branches finer and finer until delivering blood to a glomerulus (capillary bed) in each nephron (this word is important).
* It exits out another arteriole to the peritubular capillaries where water and useful ions are reabsorbed back into the blood. From there it . . .
* Empties into venules which converge and will leave the kidney as the renal vein.
* A nephron consists of two main parts:
  1. The glomerular (Bowman’s) capsule – receives fluid from glomerulus; and a . . .
* The fluid drains into a collecting duct and out of kidney.
Three processes:

1) Filtration – urea, nutrients, and water enter glomerular capsule leaving cells and large proteins behind in blood;

2) Reabsorption – salts, water, and nutrients are moved back into blood;

3) Secretion – waste substances are actively transported out of blood and into the renal tubule for elimination in urine.
Glomerular capsule...

- Surrounds the glomerulus.
- Blood pressure drives substances out of blood and into the capsule.
- There are three functional regions of the tubule (details):
  1) Proximal convoluted tubule;
  2) Nephron loop; and . . .
  3) Distal convoluted tubule.
In turn... the proximal convoluted tubule...

* Is the most important site of selective reabsorption.
* Specialized cells transport Na\(^+\) out of the tubule and water follows (osmosis);
* Secretion also occurs there.
* Secretion of H\(^+\) and reabsorption of HCO\(_3\)^- help regulate the blood's pH.
The nephron loop . . .

- Creates a concentration gradient in the renal medulla.
- Blood in the peritubular capillaries flows countercurrent to the filtrate flow direction.
- The descending limb cells are permeable to water but impermeable to ions and urea, so Na\(^+\) concentration increases.
- Ascending limb cells are permeable to ions and urea but not to water – Na\(^+\) diffuses out, but further downstream active transport is used.
And the distal convoluted tubule . . .

* Continues salt and water reabsorption.
* Excess K\(^+\) may also be secreted.
* Fluid from several nephrons drains into one collecting duct.
* As the fluid passes through a concentration gradient in the medulla, water may leave the duct making urine more concentrated (under control of the antidiuretic hormone).
But how’s it work together? Again, a pretty complicated system, but, what’s the main point? That’s what matters.
Negative feedback controls water balance in the body.

- Antidiuretic hormone (ADH) from the posterior pituitary is a key player.
- More ADH makes the collecting duct more permeable so more water is reabsorbed. This makes more concentrated urine.
- Alcohol inhibits ADH which can result in dehydration and the classic symptoms of a hangover.
- Another different example is when blood pressure drops too much, aldosterone from the adrenal cortex stimulates Na⁺ to move out of the distal convoluted tubule, water follows and blood pressure rises.
Negative feedback loops help control water balance too.

- Osmoreceptors in hypothalamus sense increased salt concentration and signal posterior pituitary
  - Posterior pituitary increases ADH secretion
  - ADH increases reabsorption of water from kidney tubules, decreasing water in urine
  -Kidney tubules retain water, increasing volume of urine

- Salt concentration of body fluids increases
  - Salt concentration of body fluids decreases
  - Body fluids too dilute
  - Body fluids too concentrated

- Osmoreceptors in hypothalamus decrease signaling of posterior pituitary
  - Posterior pituitary decreases ADH secretion
That's plenty for now!

* Remember - it's the major concepts that you'll be tested on, not all the little details.

* Plus, a slew of you are being really silly by not getting your old tests back, since the final will come right off them. And the Scantron machine does make mistakes!

* Next lecture we'll cover how we support and move our bodies — bones and muscles.