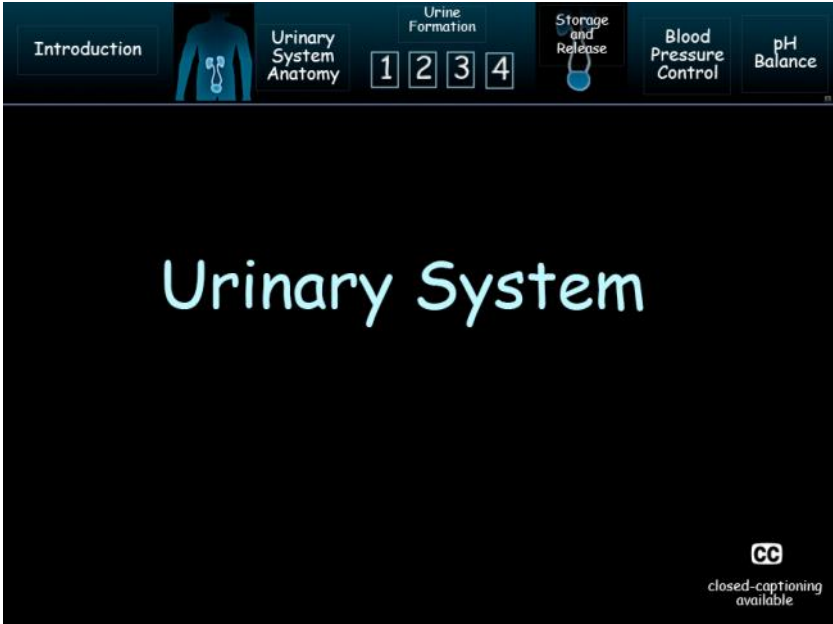
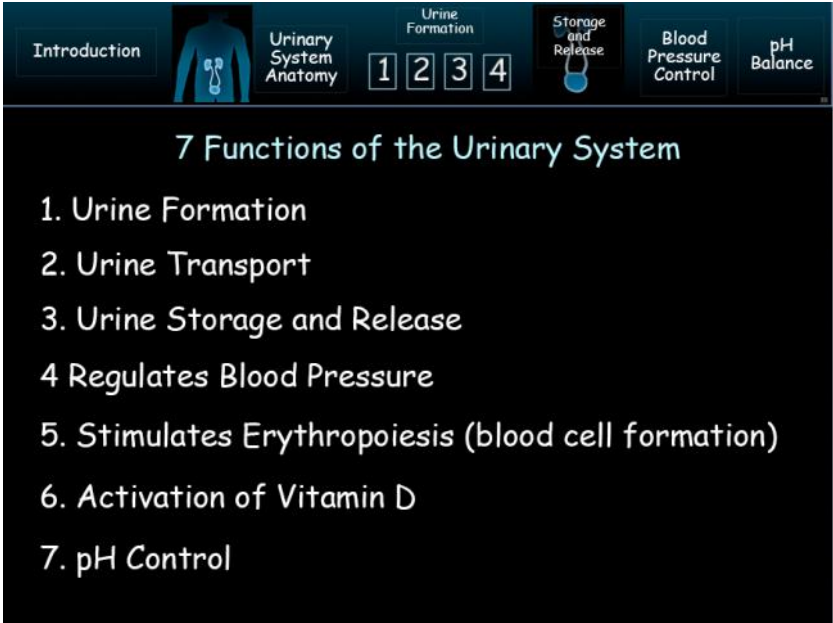


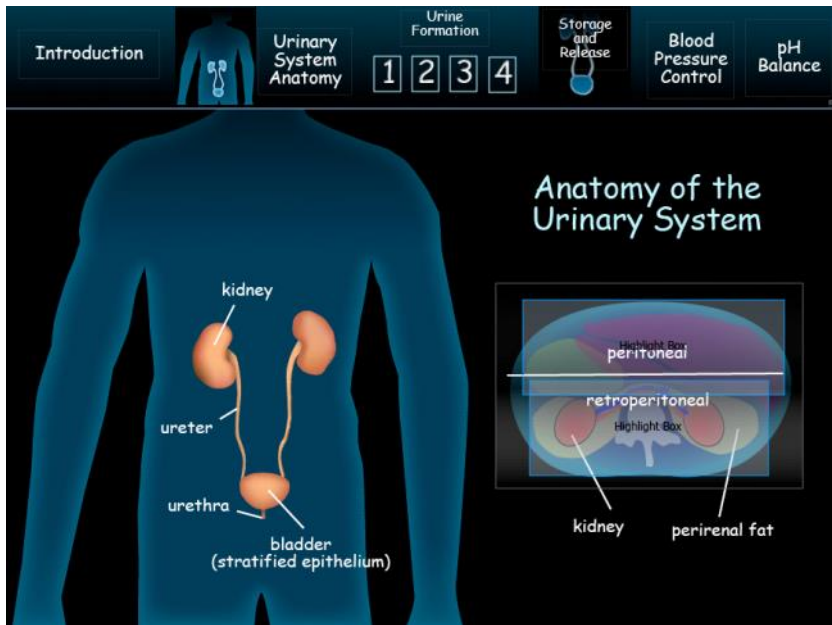
M15 Urinary System

Wednesday, April 24, 2013

4:09 PM

VoiceThread	
swf	http://justabitmoore.weebly.com/urinary-system.html
Captivate	

Slide	Notes
 <p>Slide 1: Urinary System</p> <p>Navigation: Introduction, Urinary System Anatomy, Urine Formation (1, 2, 3, 4), Storage and Release, Blood Pressure Control, pH Balance.</p> <p>CC closed-captioning available</p>	
 <p>Slide 2: 7 Functions of the Urinary System</p> <ol style="list-style-type: none">1. Urine Formation2. Urine Transport3. Urine Storage and Release4. Regulates Blood Pressure5. Stimulates Erythropoiesis (blood cell formation)6. Activation of Vitamin D7. pH Control	<p><input checked="" type="checkbox"/> Script:</p> <p>The urinary system does more than you might think. The obvious function are excretory in urine formation, transport, storage, and release, but it does quite a lot more.</p> <p>Since it is a regulator of how much water stays in the blood, it can impact blood pressure, but it can also stimulate blood cell formation.</p> <p>Vitamin D is made from the interaction of sunlight and you skin, but it gets activated to perform its hormone function by the kidney cells.</p> <p>Your blood must stay within a very narrow range of pH for critical chemical reactions to occur and to prevent damage to cells and tissues. The urinary system is vital to keeping the pH in proper balance.</p>
	<p><input checked="" type="checkbox"/> Let's begin with a big picture view of the urinary system. It is comprised of the kidneys, ureter, bladder, and urethra.</p>



The right kidney is lower than the other due to liver being large.

In a view from above, you can see that the digestive organs are in a separate cavity from the urinary system. The peritoneal cavity houses the digestive organs and has a serous membrane which secretes a small amount of fluid into the cavity that lubricates the organs so they experience very little friction as they move against the body wall.

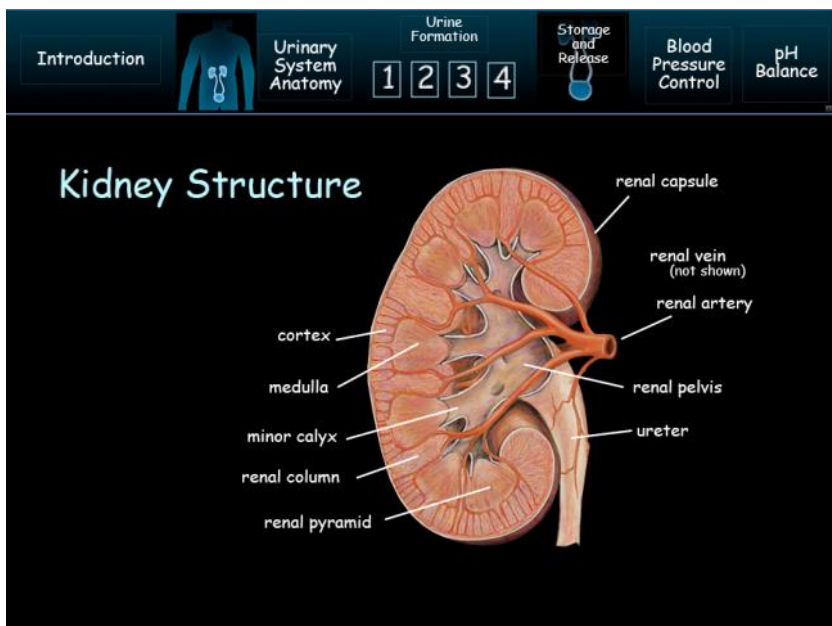
The kidneys are in the retroperitoneal cavity. Literally that means behind the peritoneal cavity. Unlike the digestive organs. The kidneys are not allowed to move much when the body moves. They are held in place by perirenal fat. This fat firmly holds them in place. If someone gets too emaciated, the kidneys can slip causing the ureter to get pinched.

- We will begin examining the urinary system in depth with the kidneys. They are each about the size of clenched fist.

The outer covering of the kidney is the renal capsule. It is made up of fibrous connective tissue.

The renal artery and vein connects the kidney to the circulatory system. As blood enters the kidney it is first taken to the nephron which is housed partially in the cortex and the medulla of the kidney. The medulla has an alternate name of renal pyramid which at the tip is the renal papillae. Renal columns are on either side. The nephrons are the key functional units of the kidney.

The materials removed from the blood are then dumped into the minor and then major calyx (Cay-licks), renal pelvis, and ureter to make its way to the bladder.



Introduction **Urinary System Anatomy** **Urine Formation** 1 2 3 4 **Storage and Release** **Blood Pressure Control** **pH Balance**

Kidney Drag and Drop Activity

minor calyx
renal pyramid
renal capsule
cortex
renal artery
renal pelvis
ureter
medula
renal column
renal vein

Try Again

Undo
Reset
Submit

A good grasp of the anatomy of the kidney is needed, so complete the drag and drop activity to help you master its structure.

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Desk Drawer Analogy

Urine Formation

Step 1: Glomerular Filtration
Step 2: Reabsorption
Step 3: Secretion
Step 4: Reabsorption of Water

One of the best analogies for kidney function is called the **desk drawer analogy**. Suppose you need to clean out a desk drawer. There are basically two ways you could do it. You could open the desk drawer and start picking out the stuff you need to get rid of. When you are done picking out the junk, everything left in the drawer is good, and the drawer is clean.

Alternatively, you could dump *everything*, the junk and the good stuff, onto a newspaper and then put the good stuff back in the drawer. Which way would be more efficient? Obviously, the second way. That's how the kidneys clean the blood. Plasma is "dumped" into the nephron, and then the "good stuff" is pulled back into the blood vessel. The rest becomes urine.

It does it in 4 steps:

1. Glomerular filtration
2. Reabsorption
3. Secretion
4. Reabsorption of water

In some texts, steps 2 and 4 are combined, but we will handle them separately here.

We will look at each of the steps, one by one, in more detail.

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Urine Formation - Step 1: Glomerular Filtration

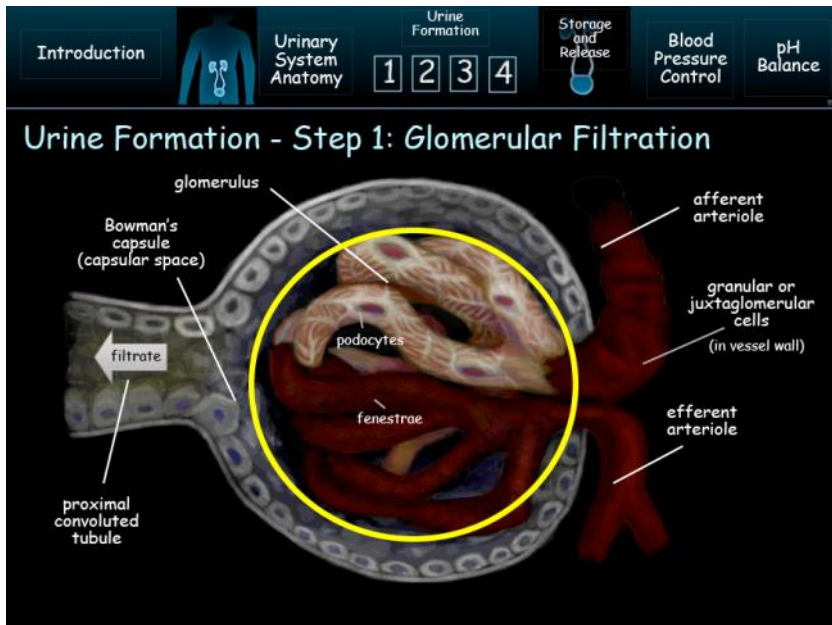
glomerulus
Bowman's capsule (capsular space)
filtrate
afferent arteriole
granular or juxtaglomerular cells (in vessel wall)
podocytes

Step 1 is glomerular filtration. The name is a logical one since it happens primarily in the glomerulus which is housed inside of the Bowman's capsule.

The Bowman Capsule is made up of a parietal layer of simple squamous epithelium. It opens into the proximal convoluted tubule.

The glomerulus receives the blood by the afferent arteriole. Embedded in the arteriole wall are granular cells. Another name for these cells is juxtaglomerular cells.

There are holes in the glomerular capillaries. The holes



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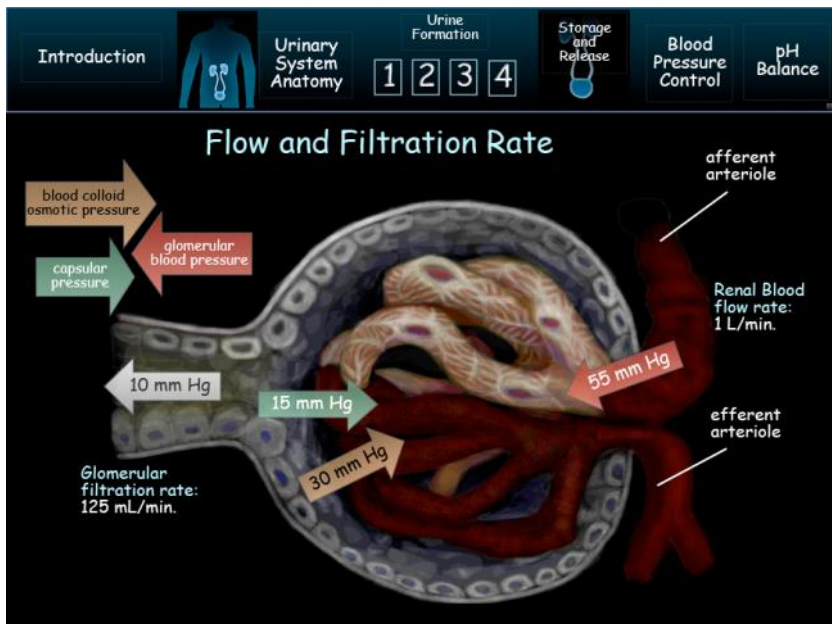
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The glomerulus receives the blood by the afferent arteriole. Embedded in the arteriole wall are granular cells. Another name for these cells is juxtaglomerular cells.

There are holes in the glomerular capillaries. The holes are called fenestrae (fen es tray) and they make these capillaries more porous than other capillaries in the body.

The glomerulus is a visceral layer composed of podocytes which are specialized cells that actually attach to the glomerular capillaries by means of small processes called foot processes.

The purpose of the design is to allow everything but the blood cells and proteins leave the blood vessel. The liquid that has left the blood supply here is called filtrate and it is essentially the same as interstitial fluid in composition.



Notice that the afferent arteriole is considerably larger than the efferent arteriole. There are two reasons for that, one is that the blood supply leaving the glomerulus will have part of the volume removed due to filtering, but the purpose is also to keep the pressure in the glomerulus high enough that the filtrate can leave the glomerulus efficiently.

Average adult have 5 liters of blood and the volume passes through the heart every minute. The blood flow to the kidneys is about 20% of that

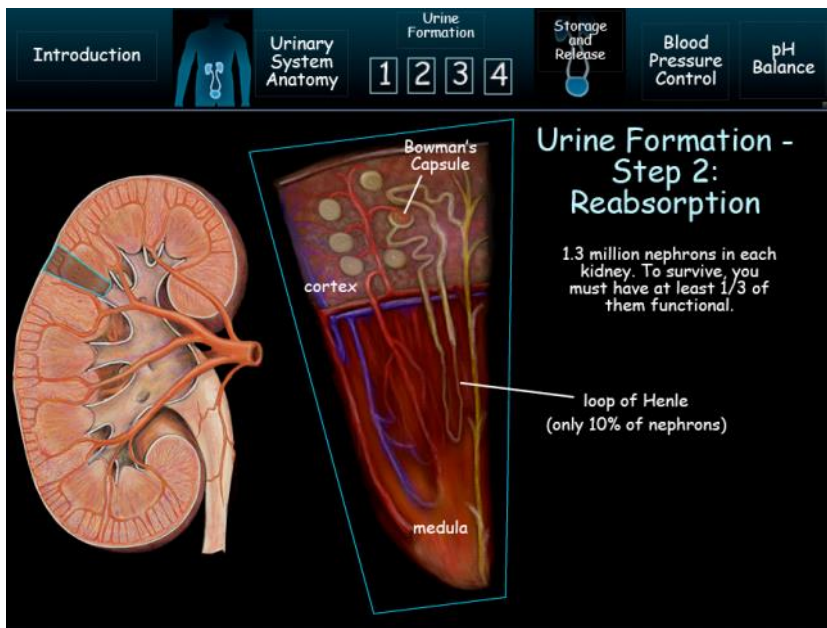
The renal blood flow rate coming through the glomerulus is about 1 liter of blood per minute which is about 1/5 of the total blood supply in your body.

The amount of pressure inside the glomerulus is 55 mm Hg. There are counter-pressures too. Water tries to go back in to the glomerulus because of osmosis. This is colloid osmotic pressure and it amounts to about 30 mm Hg.

There is also capsular pressure that comes from the walls of the Bowman Capsule resisting over-filling by the filtrate. It runs about 15 mm Hg.

Overall then, the outward pressure sending the filtrate down the proximal tube is 10 mm Hg.

If the pressures get out of balance then renal shutdown is a very real possibility because the blood cannot be cleansed. Some possible causes of the pressure drop are hemorrhage or severe dehydration.

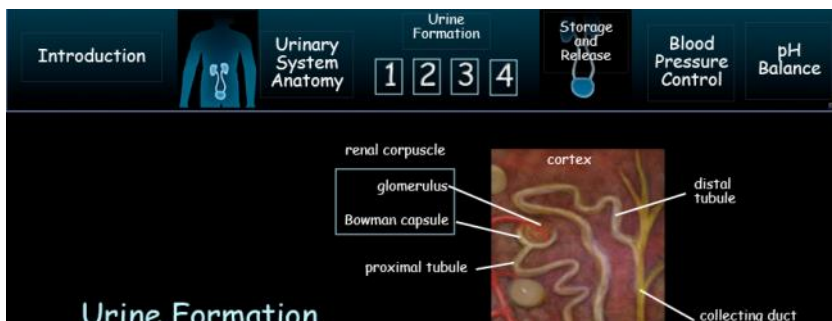


We are now to step 2 of urine formation, reabsorption. Now you will get a chance to see what is happening in the rest of the nephron. Before we get into the names of these new structures, we will get a big picture idea of the process happening here.

There are 1.3 million nephrons in each kidney. To survive, you must have at least 1/3 of them functional. They are located in the cortex and the medulla of the kidney.

You have been introduced to the filtration system that occurs in the Bowman's capsule. The filtrate has a lot of substances in it, including things that you don't want to lose. In our desk drawer analogy, once you dump the whole drawer out, you now are to select what goes back in to the drawer that you want to keep. This is absorption. Some of the good things you want to return to the blood supply are water, sodium, and water-soluble vitamins

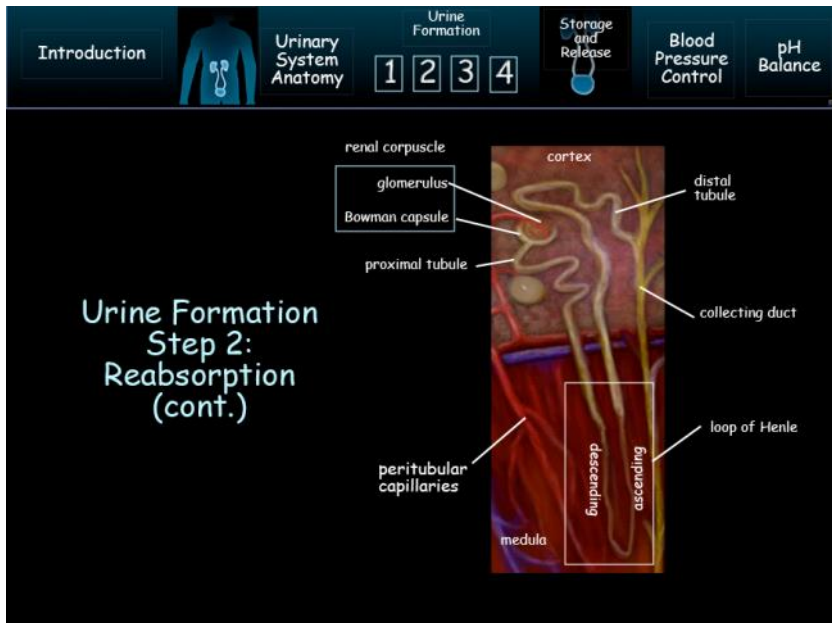
This reabsorption is going to occur in the remaining parts of the nephron such as the loop of Henle. It is a section that narrows and loops back up in the medulla of the kidney. Only 10% of nephrons have the loop of Henle



As the filtrate goes through the tubules and loop of the nephron, they pass close to the network of peritubular capillaries. These capillaries are what the nephron is trying to get the good stuff back to.

Let's continue our filtrate's journey from the Bowman's capsule and glomerulus which together are called the renal corpuscle.

The walls of the nephron tubules are very thin. The one nearest the Bowman capsule is the proximal tubule. It is made up of simple cuboidal epithelium because there



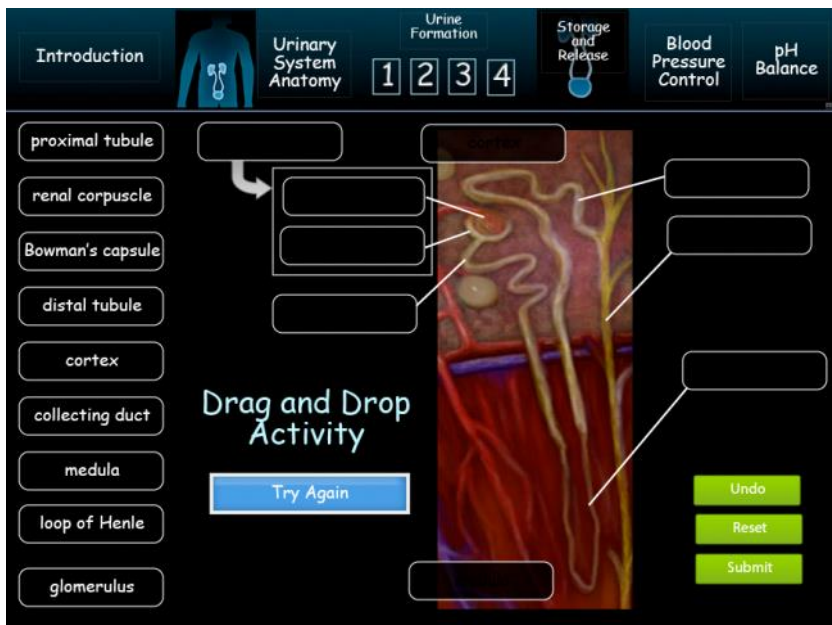
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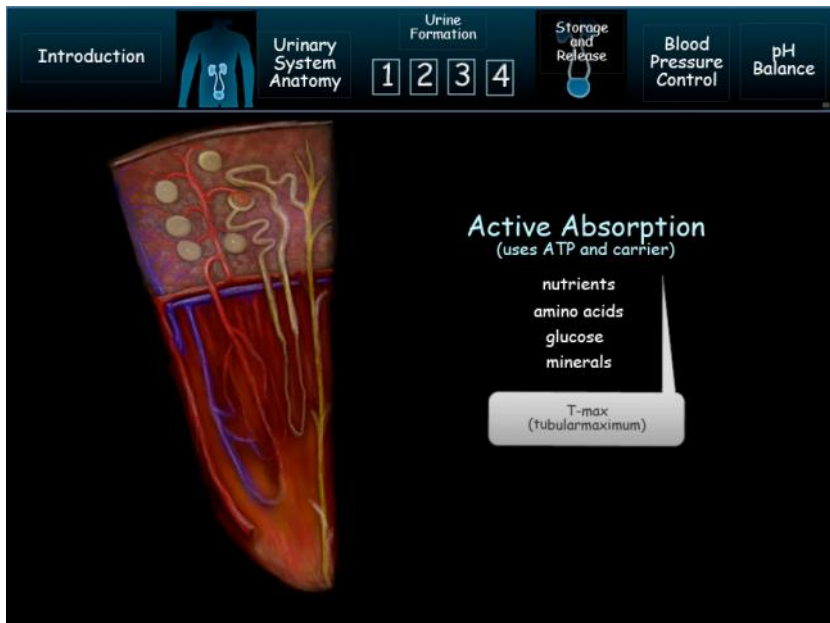
The walls of the nephron tubules are very thin. The one nearest the Bowman capsule is the proximal tubule. It is made up of simple cuboidal epithelium because there must be room for cellular machinery to facilitate reabsorption. The cells have a brush border to increase surface area much like the intestines have villi. This increases the rate of reabsorption.

Most of the reabsorption happens in the proximal tubule: 65% of the water and virtually 100% of the glucose will be able to be returned to the peritubular capillaries from this structure.

The loops of Henle is made up of simple squamous cells. It leads to the distal tubule and the collecting ducts. When the filtrate enters the collecting tube then it is officially urine.



There are two types of reabsorption, active and passive.



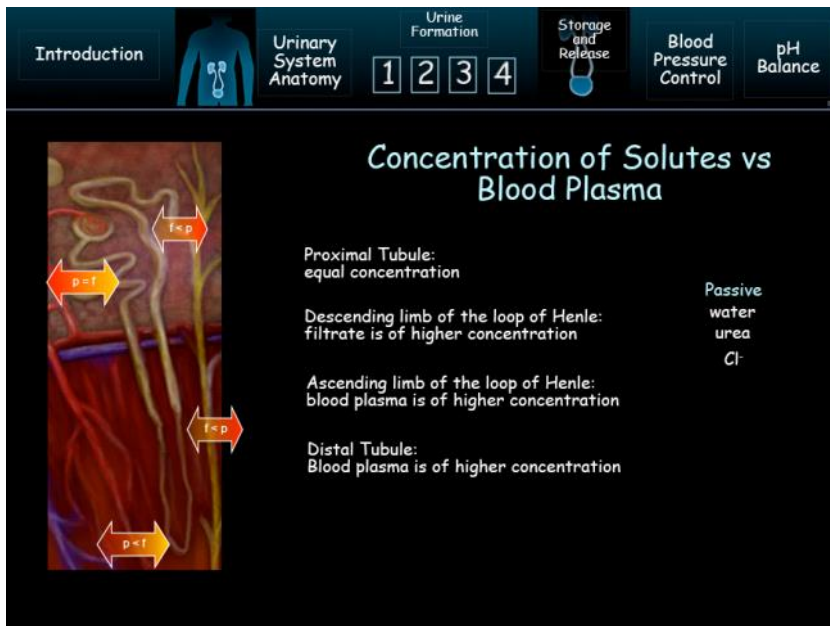
The materials that must be actively absorbed are nutrients, minerals amino acids, and glucose. These will not normally pass through the membranes of the nephron. To move these materials back into the blood supply, energy in the form of ATP must be expended and carriers must be used.

Tubular Maximum (T-max) is the maximum rate of reabsorption by active transport through the nephron tubules. This limit occurs because there are a finite number of carriers taking the materials out of the filtrate. The carrier quantity is calibrated to what the body needs. If you need a lot of a substance, more carriers will be there to perform the job of getting the substance back in to the blood supply. If you need only a little, then only a few carriers for that substance will be provided. You hit the T-max when all the carriers are busy and some of the material then passes on to become urine without being reabsorbed.

Sodium is usually in urine since we take in so much of it that we are usually at T-max. If glucose levels are too high, you will spill glucose into urine because it is at T-max.

The glomerulus isn't supposed to let proteins get through, but if any proteins did slip through the filtration step, they will be returned to the blood supply through pinocytosis.

Next, let's look at passive absorption ...



- Substances that are passively absorbed move freely through the membranes because of differences in concentration.

The proximal tubule will have internal and external concentrations that are about equal.



The descending limb of the loop of Henle will have filtrate that is of higher concentration than the fluids of the blood plasma.

The ascending limb will have much of the filtrate's substances removed, so the blood plasma now will have a higher concentration.

The distal tubule will also be an area where the blood plasma will be more concentrated than the filtrate.

Some of the substances that will passively absorbed are water, urea, and Chlorine ions.

- Step 3 - Secretion


Introduction  Urinary System Anatomy **1** **2** **3** **4**  Storage and Release **Blood Pressure Control** **pH Balance**

Urine Formation - Step 3: Secretion

What: mostly potassium ions and hydrogen ions.
Where: distal tubule



Waste product which made it back into the peritubular capillaries are secreted back into the nephron.

It's like putting something back in to the drawer, but then deciding, "Nah, I will put it back in trash again after all."



Some chemicals that have passed back in to the blood we don't want there. They must be secreted back into the nephron.

The desk drawer analogy helps us understand this. After adding things back in to the desk drawer you may decide you don't want something after all and put it back in the junk pile to be thrown away. You secrete it back to the junk pile.

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Urine Formation - Step 4: Reabsorption of Water


Always permeable to water:
proximal tubule
descending limb of the loop of Henle

Never permeable to water:
ascending limb of the loop of Henle

Sometimes permeable to water:
permeability responds to the levels of ADH (comes from the hypothalamus)
distal tube
collecting duct

electrolytes: Na, K, Cl ions

cortex/medulla concentration gradient
4x
vasa recta



Step 4 is the reabsorption of water.

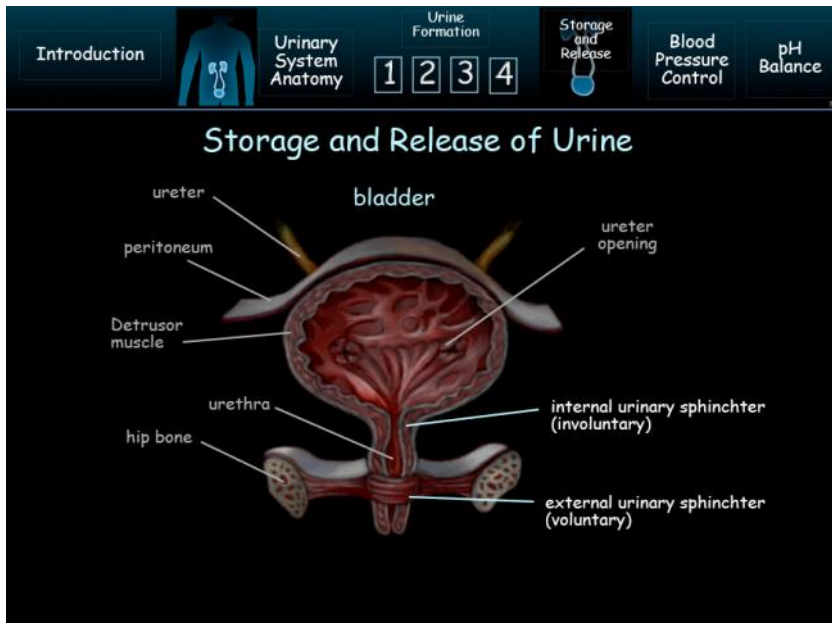
Step 4 is water Reabsorption. Some sections of the nephron are permeable and others impermeable to water. These variations of permeability are essential to the control of water levels that return to the blood.

In the distal tubule and the descending loop of Henle, the membranes are permeable to water. The interstitial fluid in the kidneys here reach up to 4x more concentrated than in the rest of the body as you move toward the tip of the loop. This efficiently pulls water out of the tubule and loop and in to the medulla. The vasa recta capillary in the medulla then reabsorbs it.

Ascending limb of the loop of Henle is impermeable to water. Its job is to actively moves electrolytes back in to the blood flow.

The distal tubule and collecting duct vary their permeability based on ADH levels. ADH is produced in the hypothalamus in response to cell shrinkage. If the cells shrink it is because the concentration in the blood plasma is too high so the water in the cells moves out toward the higher concentration. This cell shrinkage can damage the cell. It will be important to get more water into the plasma to reduce concentration there. The reverse can be the case as well and the lack of ADH will slow the amount of water that continues to be absorbed in the distal tubule and collecting duct.

Transitional Squamous epithelium line the bladder = stretch without tearing. Size of thumb when empty.

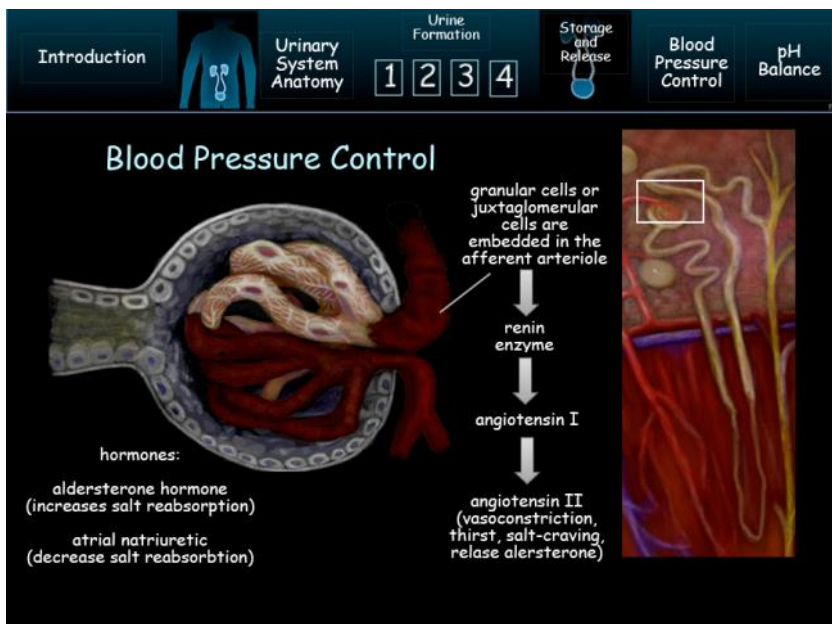


Notice that there are two sphincters. One is involuntary and the other voluntary.

Babies - automatic system When we are babies, a full bladder results in an impulse to spinal column which then signals the internal sphincter to relax and allow urine to flow.

Myelination of the nervous system so the spinal column can send a signal to the cerebral cortex will begin giving us control of the voluntary valve called the external urinary sphincter. Before the myelination, it opens with the other sphincter automatically.

As we age we lose our nervous system control and the system reverts back to like it is when we are a baby. This is called incontinence.



When we listed the 7 functions of the urinary system, number 4 was blood pressure control. This is because the kidneys can regulate how much water is in the blood. The more water there is the higher the blood pressure. You cannot just add water to the blood supply though. If concentration doesn't stay balanced in the plasma diffusion and osmosis will get messed up, so with the water, you must also increase the solutes in the blood along with it.

The afferent arteriole has juxtaglomerular cell also called granular cells. These detect the blood sodium levels and blood pressure.

Drop in either they release renin. Renin is an enzyme that will activate angiotensinogen in the liver. (-ogen means precursor, -angio means blood vessel, -tensin means pressure)

When the above two interact a peptide called angiotensin I is produced

Angiotensin II -

1. Increases vasoconstriction powerfully
2. Makes you thirsty
3. Makes you want salt
4. Released aldosterone which increases sodium reabsorption

More salt will cause more water to be retained and increases pressure.

When volume is high, it stretches the atria which triggers natriuretic hormone release. This hormone inhibits the nephrons from re-absorbing sodium which lowers water levels bringing blood pressure down.

The last function we will discuss is pH control. Normal pH ranges from 7.35 to 7.45. That is a pretty narrow range to have to keep things in.

Introduction **Urinary System Anatomy** Urine Formation Storage and Release Blood Pressure Control **pH Balance**

1 2 3 4

pH Balance

Normal: 7.35 to 7.45

← acidosis (too acidic) alkalosis (too alkaline) →

↑ speed

↓ effectiveness

Buffer systems
 A mixture of a weak acid and a weak base which resists changes in pH.
 3 buffers: bicarbonate, phosphate, protein

Ventilation depth and speed in the lungs

H⁺ secretion in the kidney

This would be the pH of the blood, not cells. Cells are a bit more acidic inside because of the carbon dioxide being produced.

Notice it isn't even to 7.0 on the pH scale which is considered neutral - neutral will not allow life to continue

If the blood becomes too acidic, acidosis occurs. This will decrease of nervous system action leading to coma and death

Alkalosis is when blood pH drops below normal. It results in over excitement of the nervous system leading to convulsions

pH changers:

Vomiting leads to alkalosis

Diarrhea leads to acidosis

Kidney disfunction

The typical western diet is high in acid, so it is easier to slip into acidosis than alkalosis.

How does we control pH:

Buffer system (least efficient, but quick). It includes buffers such as bicarbonate, phosphate, and there are a few proteins that help too.

Respiratory system (slower, more effective)

Kidney secretion of hydrogen ion (more = acidic) .(most effective, slowest) lowers the pH of the blood and raises the pH of the urine.

Introduction **Urinary System Anatomy** Urine Formation Storage and Release Blood Pressure Control **pH Balance**

1 2 3 4

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