Thirst

WEEK 9, LECTURE 2

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Let's continue our discussion of internal regulation by moving on to another body process – thirst – which in this class we're referring to as the desire to drink fluids (as opposed to any other definitions you might know).

Thirst

Water constitutes 70 percent of the mammalian body

Water in the body must be regulated within narrow limits

- Sufficient fluid is needed in circulatory system

The concentrations of different chemicals in water determines the rate of all chemical reactions in the body

As you probably know from reading the lids of Snapple bottles or going to children’s museums, mammalian bodies consist of nearly 70% water. This is a large amount, but it’s also a highly optimal amount for mammals – water is needed for many bodily processes, and the set point here varies within incredibly narrow limits. Too much or too little water can be extremely dangerous.

As I mentioned, we need a lot of water in order to regulate normal body functions. For example, the circulatory system needs water to help pump and distribute blood throughout the body. The chemicals contained in water also dictate the rate of different chemical reactions in the body. So if we didn’t have sufficient water, processes like neurotransmission would not be possible.

Mechanisms of Water Regulation

Human mechanisms of water regulation vary depending on circumstances

Water levels can be maintained by…

- Excreting dilute urine (gets rid of excess water)
- Decreasing sweat (retains water)

Most often, water regulation is accomplished by drinking more water than we need and excreting the rest

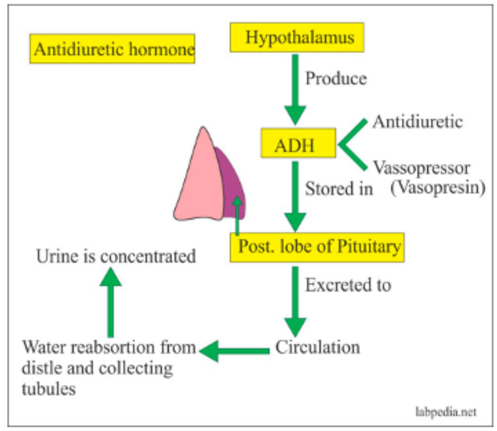
There's a lot of variance in how different species maintain water levels, and even within humans this can vary widely depending on different environmental circumstances. Generally speaking, though, water levels are maintained by two processes, which you can read about above.

The easiest way to regulate this is to consume an excess of water and excrete the rest.

Mechanisms of Water Regulation: Vasopressin

Vasopressin is a hormone released by the posterior pituitary gland

- Also known as an **antidiuretic hormone (ADH)**
- Raises blood pressure by constricting blood vessels
- Helps to compensate for decreased water volume
- Enables the kidneys to reabsorb water and excrete highly concentrated urine



Our pituitary glands release a hormone called vasopressin (also known as "antidiuretic hormone"), which helps our bodies conserve water when it's scarce, but also when we're unable to consume water, like when we're asleep. You can read about how it functions in the slide above.

The diagram here is meant to help you, not hurt you. Start at the "hypothalamus" and work your way down. You can see the role of vasopressin, and how it eventually enables water to be reabsorbed from the kidneys. This is an incredibly efficient process, as it ensures that all necessary water is absorbed. The result is highly concentrated urine – it's highly concentrated because it *only* contains the most unnecessary amounts of water and other waste products.

Types of Thirst

Two different kinds of thirst…

- **Osmotic thirst**: results from eating salty foods
- **Hypovolemic thirst**: a thirst resulting from loss of fluids due to bleeding or sweating

Fixed concentration of solutes in the body is a set point

- 0.15 M (molar) in mammals

There are actually two different types of thirst, although we experience them as *generally* the same motivational feeling (there are subtle differences, which we'll discuss here). You can read very general descriptions of these two types of thirst above.

We have a set point for the amount of solutes in the body. Solutes are molecules of any particle that are present in a given solution. In mammals, this set point is at .15 molar, meaning that there are .15 particles or solutes per unit of liquid. If we deviate from this set point, mechanisms like thirst kick in to return to it.

Osmotic Pressure

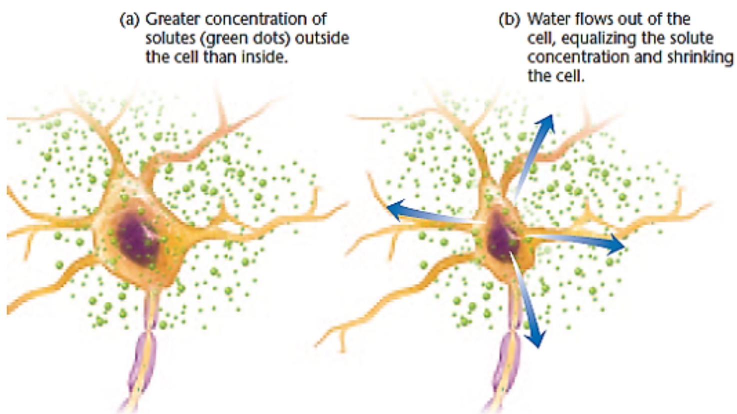
Solutes inside and outside a cell create osmotic pressure

- Water flows across a semi-permeable membrane from an area of low solute concentration (comparatively low molarity) to an area of high solute concentration (comparatively high molarity)
- Occurs when solutes are more concentrated on one side of the membrane
- Helps even out the molarity

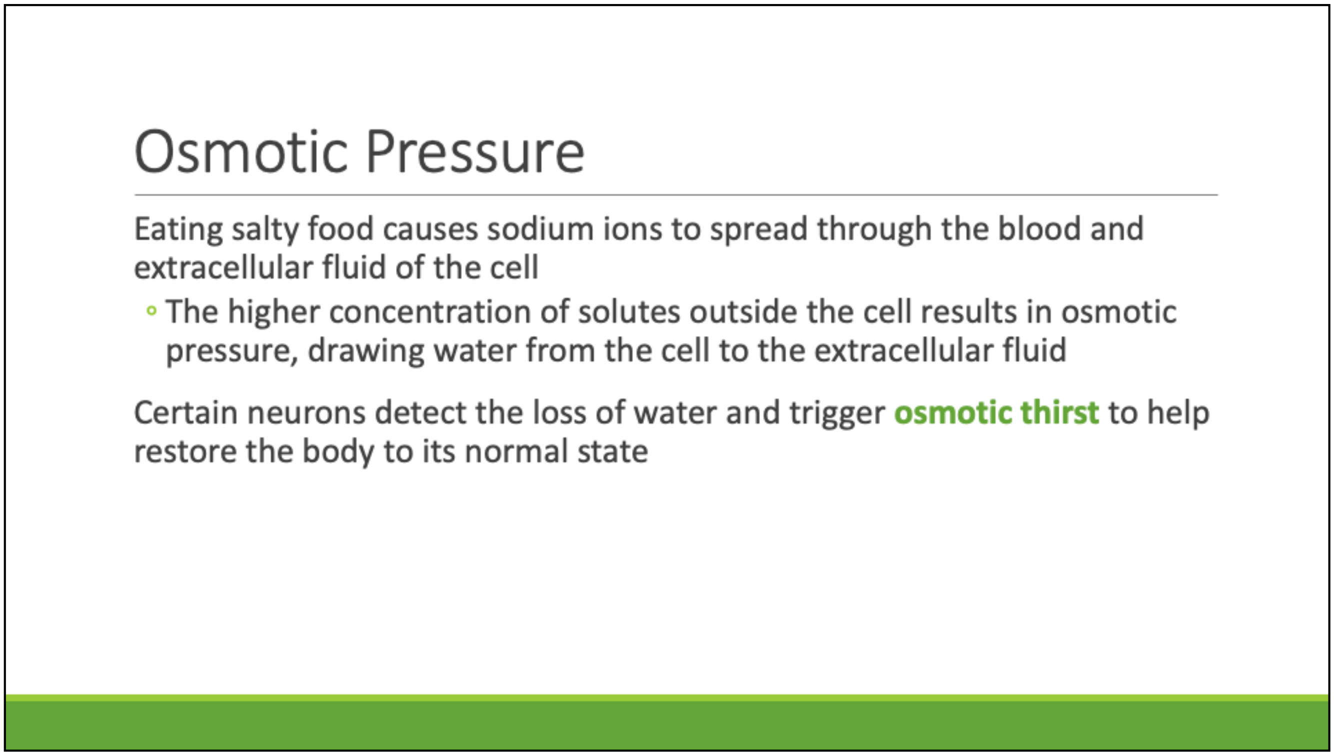
One such mechanism for returning to this set point is something called osmotic pressure, which you can read about above.

Basically, when there are more solutes on one side of the membrane, it means that the molarity is higher on that side compared to the other. Water will tend to flow *towards* the side with *more* solutes in order to *even out the molarity*. This should sound somewhat familiar – recall the process of diffusion from our lecture on neurotransmission. This is a similar – though not identical – process, and I'll leave it to you to think about how they are similar and different from one another.

The Consequence of a Difference in Osmotic Pressure



This how this process might look at the neuronal level. You have more solutes (indicated here by the green particles) on the outside of the cell, and water will want to flow outside to equalize the molarity inside and outside the cell. The result is that the cell itself will shrink, because it loses water.

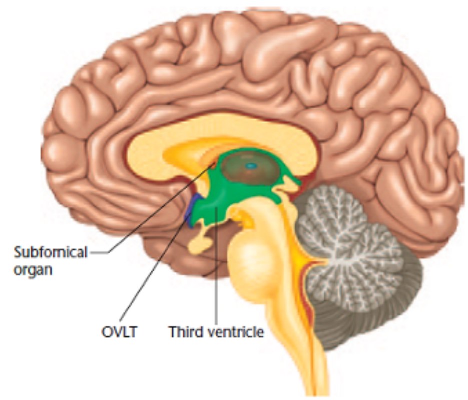


As you might've guessed, osmotic pressure can lead to osmotic thirst. You can read about this process more in the slide above.

Detecting Osmotic Pressure

The brain detects osmotic pressure from…

- Receptors around the third ventricle
- The **OVLT (organum vasculosum laminae terminalis)** and the **subfornical organ (SFO)** detect osmotic pressure and sodium content of the blood
- Receptors in the periphery, including the stomach and digestive tract



The brain doesn't detect the change in osmotic pressure from *everywhere* – there are specific parts of the brain and body that send these signals.

For example, there is an area around the third ventricle in which the blood-brain barrier is very weak; this area can easily monitor the concentration of fluids in the bloodstream, and report to other areas of the brain like the hypothalamus (which controls the sensation of thirst).

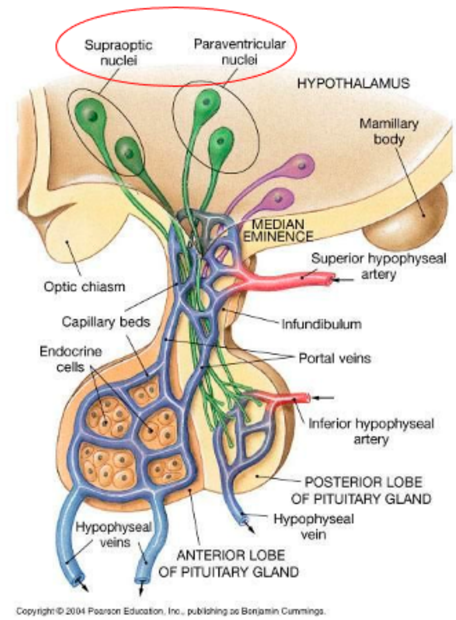
There are also these other brain areas: the OVLT and SFO (subfornical organ), which help detect osmotic pressure – as well as areas in the periphery like the digestive tract. The book goes over these in much more detail, and I suggest you read up on this section for the next exam.

OVLT, SFO (and other) Receptors

Receptors in the OVLT, SFO, stomach, and elsewhere relay information to two areas of the hypothalamus…

- **Supraoptic nucleus**
- **Paraventricular nucleus**
  - Both control the rate at which the posterior pituitary releases vasopressin

Receptors also relay information to the **lateral preoptic area**, which controls drinking behavior



Receptors from these different brain and peripheral areas relay information to two main areas of the hypothalamus: the supraoptic nucleus, and the paraventricular nucleus. Both structures control the rate of release of vasopressin. This diagram shows a little more detail than what we're talking about, but you can focus on the relevant areas (circled in red) to see where they're located within the hypothalamus. And you can see that both structures have a direct connection to the posterior pituitary.

These receptors also communicate with the lateral preoptic area, which controls the behavior of drinking itself.

Osmotic Thirst

When osmotic thirst is triggered, water that you drink must be absorbed through the digestive system…

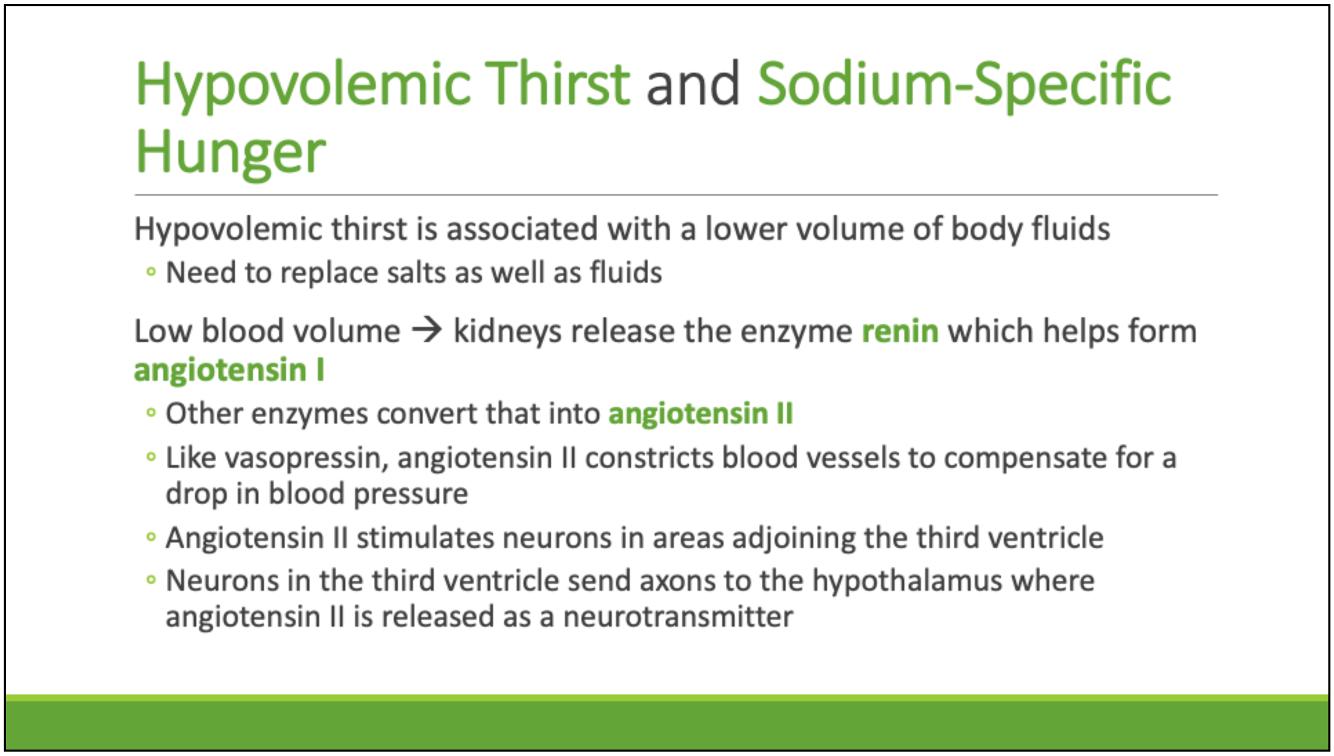
- Delivered by the blood to the brain
- Process takes about 15 minutes

To inhibit thirst, the body monitors swallowing and detects the distension of the stomach and intestines

What happens once osmotic thirst is triggered? Read through the first three points above.

These are largely allostatic processes – if you eat something salty, for example, your body will anticipate the change in osmotic pressure and motivate you to drink something (hopefully water) before the change in pressure actually occurs. Similarly, we often get thirsty (for something to drink) right before bed, and this motivational state is your body anticipating not being able to drink for an extended period of time.

Now, what stops us from continuing to drink once we start? The body actually monitors how much the stomach and intestines distend, or exert pressure, which increases as more water enters these areas.



So that's osmotic thirst. Let's shift gears a little now and talk about the other type of thirst – hypovolemic thirst. Whereas osmotic thirst is associated with the concentration of solutes in the body, hypovolemic thirst is more concerned with the volume of fluids in the body (although it also helps replace salts).

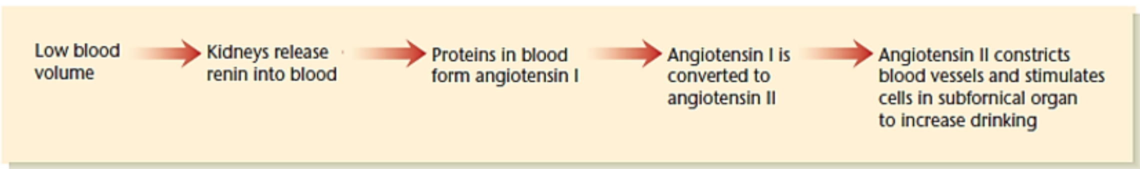
How does this process actually work? You can read about it more above.

Hypovolemic Thirst and Sodium-Specific Hunger

Thirst is associated with a lower volume of body fluids

Low blood volume → kidneys release the enzyme **renin** which helps form **angiotensin I**

- Other enzymes convert that into **angiotensin II**



This is just a flow chart to help you when you're studying; it essentially outlines the process I just described.

Hypovolemic Thirst and Sodium-Specific Hunger

Animals with osmotic thirst have a preference for pure water

Animals with hypovolemic thirst have a preference for slightly salty water
- Pure water dilutes body fluids and changes osmotic pressure

Sodium-specific hunger → strong craving for salty foods
- **Aldosterone** (a hormone produced by the adrenal glands), increases retention of salt and alters taste system to make salty foods more desirable

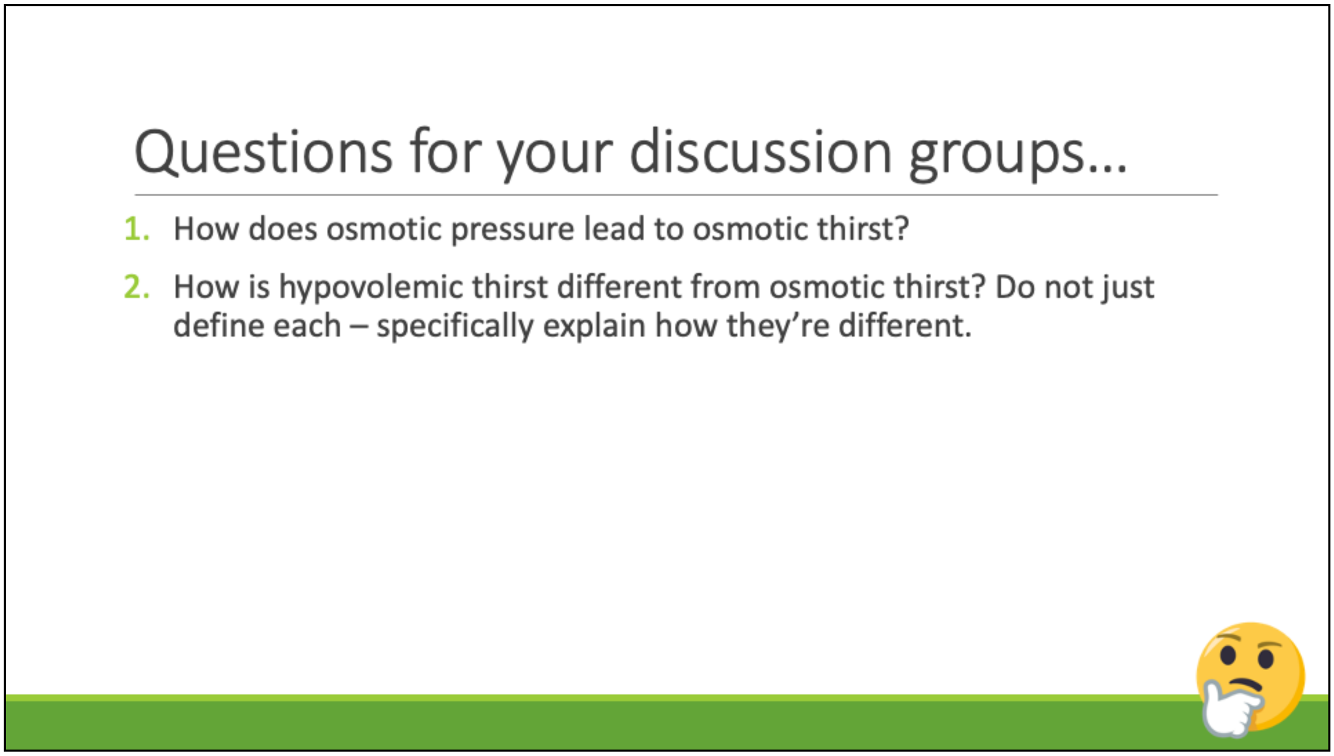
[read through the first three points above]

This process of regulating sodium levels also translates to hunger. Mammals have a process called sodium-specific hunger, which induces a strong craving for salty foods. This is all controlled by a hormone called aldosterone, which makes salty foods more rewarding and also increases the retention of salt.

Comparison of Osmotic and Hypovolemic Thirst

Type of Thirst	Caused by	Best Relieved by	Receptor Location
Osmotic	High solute concentration outside cells	Pure water	OVLT, subfornical organ, and digestive tract
Hypovolemic	Low blood Volume	Water containing solutes, near 0.15M	Kidneys and blood vessels

To finish up, this is just a handy chart laying out the differences in the two types of thirst. You'll need to know these two processes in much more detail, but I feel like this provides a good summary of the main points of each.



Okay, here's two questions for your discussion group. I'll see you in the next lecture, which is on hunger!