Temperature Regulation

Your body tries to maintain a body temperature of 98.6°F (37°C). Your body has two main ways of handling temperature changes that can occur. If you become too hot, your body triggers the sweat glands. If you become too cold, your body triggers your muscles to shiver.

Sweating

You are about to do something really big -- maybe a job interview, a presentation, a first date or a big football or basketball game -- and you notice that your palms and underarms are sweating. Perhaps, you've just completed an aerobic workout and your whole body is drenched in sweat. How can such different activities have the same effect on your body? What is sweat and why do we make it?

Perspiration, or sweat, is your body’s way of cooling itself, whether that extra heat comes from hardworking muscles or from over-stimulated nerves. In this article, we will examine your body's sweat glands, how sweat is made and what it does. You will learn that there is difference between the sweat on your palms and the sweat in your armpits and why your skin tastes salty after a workout!

The Sweat Gland

The average person has 2.6 million sweat glands in their skin! Sweat glands are distributed over the entire body -- except for the lips. The sweat gland is in the layer of skin called the dermis along with nerve endings, hair follicles and so on. Figure 1 illustrates what’s going on:
Basically, the sweat gland is a long, coiled, hollow tube. The coiled part in the dermis is where sweat is produced, and the long portion is a duct that connects the gland to the opening or pore on the skin's outer surface. Nerve cells from the sympathetic nervous system connect to the sweat glands. There are two types of sweat glands:

- **Eccrine** - the most numerous type that are found all over the body, particularly on the palms of the hands, soles of the feet and forehead. They are smaller and are active at birth. The sweat coming out of an eccrine gland does not have proteins or fatty acids.

- **Apocrine** - mostly confined to the armpits. They typically end in hair follicles rather than pores. Apocrine glands are larger, become active during puberty, and the sweat contains proteins and fatty acids.

### How Sweat is Made

We are constantly sweating, even though we may not notice it. Sweating is your body’s major way of getting rid of excess body heat, which is produced by metabolism or working muscles. The amount of sweat produced depends upon our states of emotion and physical activity. Sweat can be made in response to nerve stimulation, hot air temperature, and/or exercise. First, let's concentrate on how sweat is made in an eccrine sweat gland.

When the sweat gland is stimulated, the cells secrete a fluid that is similar to plasma -- it is mostly water and it has high concentrations of sodium and chloride and a low concentration of potassium. The source of this fluid is the spaces between the cells which get the fluid from the blood vessels in the dermis. This fluid travels from the coiled portion up through the straight duct. What happens in the straight duct depends upon the rate of sweat production or flow.

Sweat is produced in apocrine sweat glands in the same way. However, the sweat from apocrine glands also contains proteins and fatty acids, which make it thicker and give it a milkier or yellowish color. This is why underarm stains in clothing appear yellowish. Sweat itself has no odor, but when bacteria on the skin and hair metabolize the proteins and fatty acids, they produce an unpleasant odor. This is why deodorants and antiperspirants are applied to the underarms instead of the whole body.
The maximum volume of sweat that a person who is not adapted to a hot climate can produce is about one liter per hour. Amazingly, if you move to a hot climate such as the American desert southwest or the tropics, your ability to produce sweat will increase to about two to three liters per hour within about six weeks! This appears to be the maximum amount that you can produce.

**Cooling Down**
When sweat evaporates from the surface of your skin, it removes excess heat and cools you. Typically, all of the sweat does not evaporate, but rather runs off your skin. In addition, not all heat energy produced by the body is lost through sweat. Some is directly radiated from the skin to the air and some is lost through respiratory surfaces of the lungs.

A major factor that influences the rate of evaporation is the relative humidity of the air around you. If the air is humid, then it already has water vapor in it, probably near saturation, and cannot take any more. Therefore, sweat does not evaporate and cool your body as efficiently as when the air is dry.

Finally, when the water in the sweat evaporates, it leaves the salts (sodium, chloride and potassium) behind on your skin, which is why your skin tastes salty. The loss of excessive amounts of salt and water from your body can quickly dehydrate you, which can lead to circulatory problems, kidney failure and heat stroke. So, it is important to drink plenty of fluids when you exercise or are outside in high temperatures. Sports drinks contain some salts to replace those lost in the sweat.

**Nervous or Scared?**
As we mentioned, sweating responds to your emotional state. So when you are nervous, anxious or afraid, there is an increase in sympathetic nerve activity in your body as well as an increase in epinephrine secretion from your adrenal gland. These substances act on your sweat glands, particularly those on the palms of your hand and your armpits, to make sweat. Thus, you feel a "cold" sweat.
Temperature Regulation

Shivering

You've been floating along in the cool water of the lake for a while, and even though you were hot before you dove in, you feel your legs start to shake. You get out and wrap yourself in your towel, and your teeth start chattering. What's going on? You're probably shivering.

Nerves Know

When your body temperature gets too low, sensory neurons send a signal to your brain. Shivers are reflexes which are things your body does automatically to keep you safe and healthy. Reflexes are controlled by your nervous system, which is made up of your brain, your spinal cord, and lots of little nerves that stretch out all over your body. Nerves are like little strings or wires that carry information.

What kind of information? Well, your nerves sense that the cool water of the lake has lowered your body temperature. Your body needs to stay at a toasty 98.6° Fahrenheit (37° Celsius) for you to be safe and comfortable. The nerves send signals saying, "I'm cold! Warm me up!"

Muscles in Action

That's when things really start to get interesting. The signals go to your brain (telling you to wrap in the towel) and to your spinal cord, which sends a message to other nerves all over your body. What happens next? Your skeletal muscles tighten and loosen really fast. This movement creates heat and helps to bring your body temperature up. Once you get all snug and cozy in your towel and your body warms back up, your brain and nerves tell your muscles to stop shivering.

There are other times when you might shiver, too. Sometimes you'll shiver when you're excited or afraid. When you feel these things, your brain and nerves send out messages through your body that cause your muscles to get excited, so you shiver.

Great Goosebumps!

You might notice that when you shiver, tiny bumps form all over your skin. Goosebumps happen because your skin is covered with hair. When the muscles that are attached to each hair get tight, they pull the hair and your skin up into the air. We call them goosebumps because they look like the skin of a goose or a chicken. So don't be a silly goose the next time you get the goosebumps after swimming. Towel off and put on some dry clothes to warm yourself up!
Sweating

**Directions:** Just like animals react to their changing environment by going into hibernation to maintain homeostasis, humans maintain homeostasis by sweating when we are overheated.

This is an important day for Josh. He is going to compete in the track state final for the 100 m dash. Right now, Josh is inside a locker room getting dressed and feels very comfortable. It’s time for Josh to compete and he starts feeling a little overwhelmed. It’s 95°F outside, Josh is now face to face with his competition and he’s seconds away from the race of his life. The gun is shot, and Josh takes off. What seemed like a life time, took less than 10 seconds, and Josh is now the state champ! Josh is so overcome with joy and SWEAT! Josh is drenched in sweat and it won’t stop. Josh realizes that this is a normal process. Whenever Josh runs, his body becomes overheated and his body temperature will rise above its average temperature. In order for the body to maintain its average temperature, it must somehow cool itself off – by sweating. When someone sweats, the sweat evaporates from the surface of the skin, removing excess heat and cooling the body off. When the body gets cooled off, your body stays in balance or in homeostasis.

PLACE THE EVENTS IN THE CORRECT ORDER BY USING NUMBERS 1-6

1. _______The body returns to its balance or homeostasis
2. _______Josh won the state championship and is drenched in sweat
3. _______Josh’s body is overheated
4. _______The sweat evaporates from the skin
5. _______Excess heat is removed and cooling of the body begins
6. _______The temperature outside is 95°F before the race
7 A basketball player helps maintain stable body temperature during the game by perspiring. The sweat helps cool his body by evaporating. What is this an example of?
A mitosis
B homeostasis
C respiration
D digestion

8 The skin helps regulate body temperature by allowing excess heat to escape from the body. It does this by producing sweat. If your body lost the ability to sweat, what could happen to you if you competed at a track meet?
A nothing
B you would start to shiver
C you would overheat
D you could win the races easier

One way your body responds to a cold environment is by shivering.

9 Which two body systems are involved here to maintain body temperature? ____________

10 How does shivering help to maintain body temperature? ________________