# Homeostasis Notes

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**Homeostasis**: the maintenance of a constant internal environment.

**What kind of environment are we trying to keep the same inside the body?** We are trying to keep the temperature of the body the same (mostly) and we're also trying to make sure that our blood has the correct concentration of water and glucose.

First let's look at how the body regulates its temperature, this process is called thermoregulation.

**Thermoregulation:** is the process by which animals maintain an internal temperature that is the optimum for their enzymes to function. In humans this is 37 $^{o}$C.

Warm blooded animals are called **endotherms**. These are animals that produce their own heat from respiration.

Cold blooded animals are called **ectotherms**. These are animals that gain their heat from the environment.

Before we go into thermoregulation in detail let's mention the hypothalamus and explain what it does.

**The Hypothalamus:** the region of the brain that regulates the temperature of the body as well as regulating the water concentration of the blood. So, the hypothalamus acts like the homeostasis control centre.

**What can happen to the body when its temperature is too low?**

1. The hypothalamus detects the change.
2. **Shivering** – this increases the amount of muscle contractions occurring. This increases body temperature as more respiration is required to power the contractions. Respiration is an exothermic process.
3. **Vasoconstriction** – arterioles supplying the capillaries near the surface of the skin constrict, reducing blood flow. Therefore, **less** heat is lost via radiation.
4. **Piloerection** – is the raising of the hairs in the skin. This causes a layer of insulating air to be trapped close to the surface of the skin. Reducing heat loss via convection. Don't say that hairs stand up as this implies they have legs.
5. These responses bring the body's temperature back to normal.

**What can happen to the body when it's temperature is too high?**

1. The hypothalamus again detects the change.
2. **Sweating** – sweat glands in the skin release more sweat onto the surface of the skin. The sweat evaporates, transferring heat energy from the skin to the environment.
3. **Vasodilation** – arterioles supplying the capillaries near the surface of the skin dilate, increasing blood flow. Therefore, **more** heat is lost via radiation.
4. **Hairs lie flat** – the hair follicles in the skin lie flat. This prevents a layer of insulating air being trapped close to the surface of the skin. Increasing heat loss via convection.
5. These responses bring the body's temperature back to normal.

## Importance of Thermoregulation

**Exam note**: this is a very popular type of question as it's a way of bringing in questions on enzymes into paper 2.

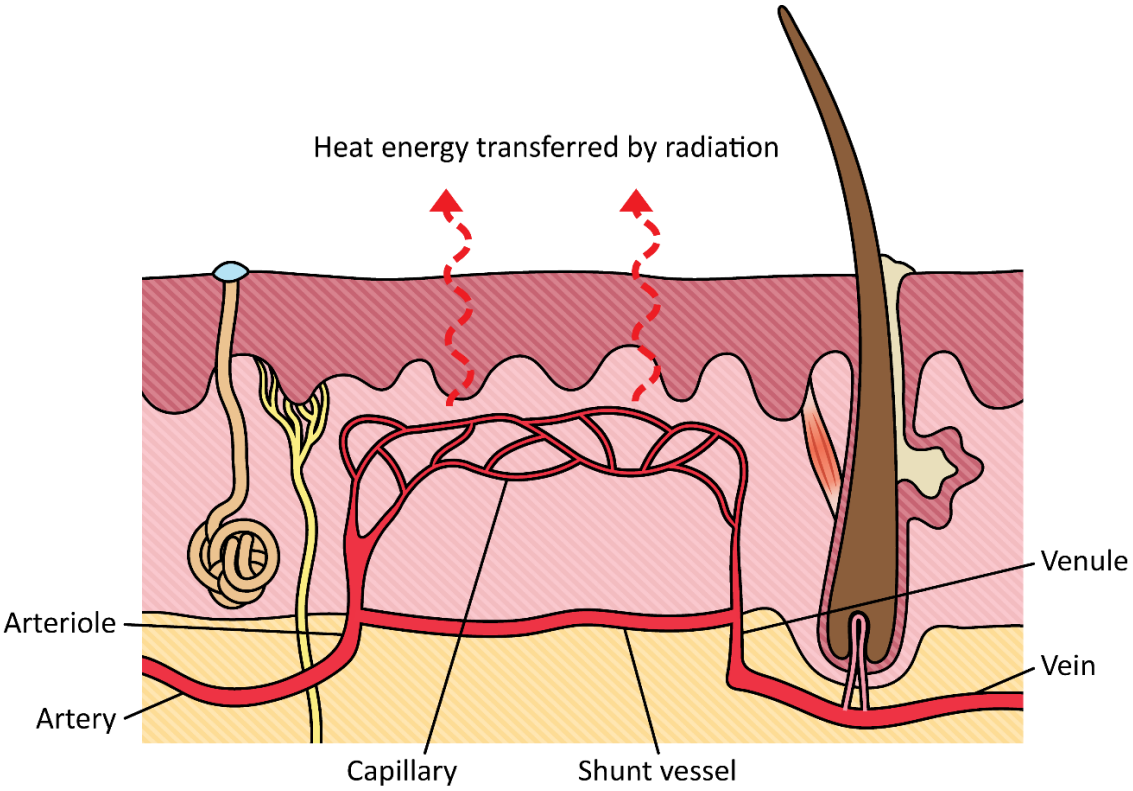
As mentioned previously thermoregulation is important to ensure that the animals' enzymes are working at their optimum temperature. In humans this is 37$^{o}$C, this temperature ensures that enzymes are able to catalyse reactions at their fastest rate. Thereby ensuring a high rate of reaction.

If the temperature in the organism is too high for too long than the enzymes can be denatured.

If an enzyme is denatured this means that the enzymes active site changes shape, this means that the substrate can no longer bind to the active site. As the two must be complementary (the same shape). Therefore, there can be no **enzyme substrate complexes** and no products will form.

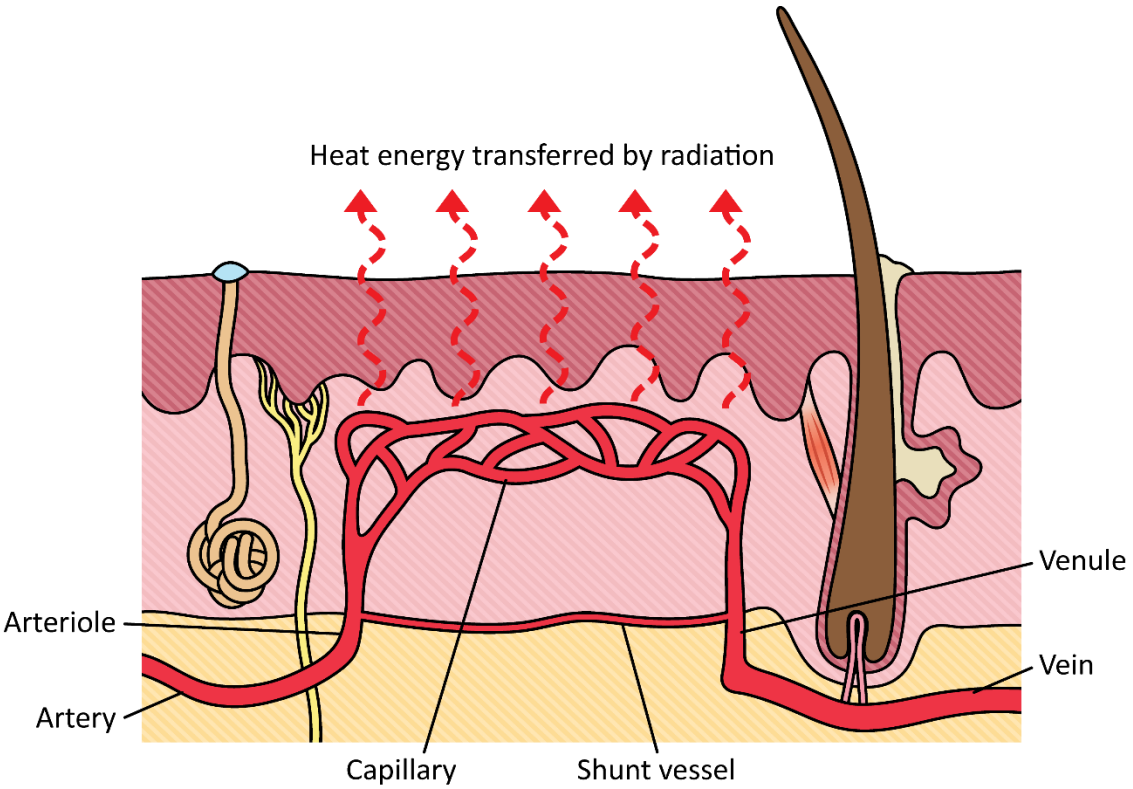
## Vasoconstriction

The figure below shows vasoconstriction occurring in a section of skin. We see that **less** blood is flowing close to the surface of the skin. So, **less** heat is lost via radiation.




## Vasodilation

The figure below shows vasodilation occurring in a section of skin. We see that **more** blood is flowing close to the surface of the skin. So, **more** heat is lost via radiation.



## Osmoregulation

**Osmoregulation**: the regulation of the concentration of water in an organism.

**Osmosis:** the movement of water from an area of high water concentration to an area of low water concentration down its concentration gradient through a partially permeable membrane.

**What happens when there is too little water in the blood?**

1. The hypothalamus detects the change.
2. The hypothalamus causes the pituitary gland to produce **more** antidiuretic hormone (ADH).
3. ADH travels to the kidneys via the blood stream. It then causes the collecting duct of the kidney nephron to become **more** permeable to water.
4. Therefore **more** water is reabsorbed back into the blood and **less** is lost as urine.
5. This brings the blood water concentration back to normal.

**What happens when there is too much water in the blood?**

1. The hypothalamus again detects the change.
2. The hypothalamus causes the pituitary gland to produce **less** antidiuretic hormone (ADH).
3. As there is now less ADH in the bloodstream, this then causes the collecting duct of the kidney nephron to become **less** permeable to water.
4. Therefore **less** water is reabsorbed back into the blood and **more** is lost as urine.
5. This brings the blood water concentration back to normal.

**Exam note:** You have probably noticed that there are really only **four words** different between the two paragraphs 😊. This makes osmoregulation quite nice and easy to learn. If it were to come up as a 4, 5 or 6 mark question you would probably (depending on the question) need to describe what happens when there is too little **and** too much water. Make sure you read the question carefully, we can't say that enough.

## Glucoregulation

When an animal eats more food than it needs the body stores the excess glucose as glycogen in the liver and muscle cells. Glycogen is a polymer made of many glucose molecules. Glucose is the fuel of all body cells, used to make ATP in respiration.

**Glucoregulation**: is the regulation of the body's blood glucose concentration.

Glucoregulation uses the hormones **insulin** and **glucagon** to regulate the body's blood glucose concentration.

**Insulin**: a hormone produced by the pancreas. It causes the cells of the liver and muscles to take in excess glucose and store it as glycogen

**Glucagon**: a hormone produced by the pancreas. It causes the cells of the liver and muscles to break down glycogen and release it into the blood as glucose.

What happens when there is **too little glucose** in the blood?

1. The pancreas detects the change.
2. The **pancreas** produces **more glucagon** and releases it into the blood.
3. This causes cells of the liver and muscles to break down stored glycogen and release it into the blood as glucose.
4. This increases the blood glucose concentration back to normal.

What happens when there is **too much glucose** in the blood?

1. The pancreas detects the change.
2. The **pancreas** produces **more insulin** and releases it into the blood.
3. This causes cells of the liver and muscles to take in excess glucose and store it as glycogen.
4. This decreases the blood glucose concentration back to normal levels.

# Diabetes

We've just looked at how the body regulates the concentration of glucose in the blood. But what happens when the body can't regulate the amount of glucose in the blood? Well… when this happens, and it does, we call it diabetes.

**Diabetes**: is a non-communicable condition where the body cannot regulate its blood glucose concentration. If diabetes is left untreated, blood glucose levels can rise to dangerously high levels.

There are two types of diabetes, these are Type 1 and Type 2 diabetes. What do we need to know about each type?

Well… we need to know what each type is, what causes each and how each is treated . Let's get straight into them.

**What is type 1 diabetes?** It's a condition where **the pancreas fails to produce enough (or any) insulin**.
In type 1 diabetes blood glucose levels can rise very high after eating carbohydrates because the glucose is not converted into glycogen.

**What causes type 1 diabetes?** It's caused by the pancreas failing to produce insulin.

**How is type 1 diabetes treated?** It is treated with insulin injections (usually taken just before meals) to manually bring blood glucose levels down. People with Type 1 also need to carefully monitor their diet and exercise.

**What is type 2 diabetes?** It's a condition where the person's body cells become **resistant to insulin**. The pancreas is still making insulin of course, but the liver and muscle cells no longer respond to it.

**What causes type 2 diabetes?** It's caused by the cells of the liver and muscles being exposed to high levels of insulin on a regular basis. This causes the cells to literally get sick of seeing insulin all of the time so they become resistant to it. They simply stop responding to it.

**Are there other factors in developing type 2 diabetes?** Yes, genetics and age play a part, but there is a very strong correlation between Type 2 diabetes and **obesity** (having a high BMI or a high waist-to-hip ratio).

**How is type 2 diabetes treated?** It is treated by having a carefully controlled diet (**carbohydrate-controlled diet)** and taking regular exercise.