

Thermogenesis

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This is an addition to clarify the thermogenesis process..

Read it if you needed further understanding..

Thermogenesis

Thermogenesis is the process of **heat production** in organisms including humans.

- Thermogenic methods can be classified as one of the following:
- Exercise-associated thermogenesis (**EAT**)
- Non-exercise activity thermogenesis (**NEAT**)
- Diet-induced thermogenesis (**DIT**) or in other words "*thermic effect of food*".

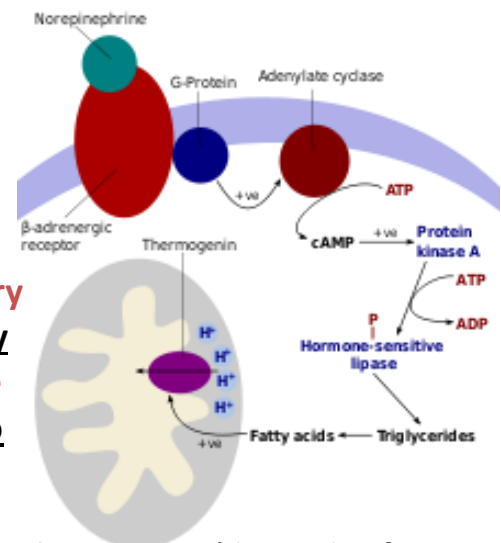
Shivering Thermogenesis:

One method to raise temperature is through shivering. It produces heat because the conversion of the chemical energy of **ATP** into **kinetic energy** causing some of the energy to show up as heat. **It is not 100% efficient**. No real movement is produced in shivering because opposing (antagonistic) muscle pairs are activated at the same time resulting in the shivering.

Non-shivering thermogenesis "our main concern":

Activation cascade of **cells of brown adipose tissue**

Non-shivering thermogenesis usually occurs in brown adipose tissue (brown fat) that is present in human infants. Non-shivering thermogenesis can be **obligatory** or **facultative**. **Obligatory thermogenesis** is the heat production **automatically caused by the metabolic rate**, while **facultative thermogenesis** can be **activated in cold exposure to raise body temperature**.



In this process, substances such as **free fatty acids** (derived from triacylglycerols) remove **purine** (ADP, GDP and others) inhibition of thermogenin (uncoupling protein-1), which causes an influx of **H⁺** into the **matrix of the mitochondria** and **bypasses the ATP synthase** channel. This uncouples **oxidative phosphorylation**, and the energy from the proton motive force is dissipated as heat rather than producing ATP from ADP, which would store chemical energy for the body's use. Thermogenesis can also be produced by **leakage of the sodium-potassium pump** and the **Ca⁺² pump**. Thermogenesis is the simultaneous occurrence of lipogenesis and lipolysis or glycolysis and gluconeogenesis.

The **low** demands of thermogenesis mean that **free fatty acids are been drawn** on lipolysis as the method of energy production.

Uncoupling proteins (UCP): UCPs occur in the inner mitochondrial membrane of mammals, including humans. These proteins create a “proton leak,” and they allow protons to re-enter the mitochondrial matrix without energy being captured as ATP. [Note: Energy is released as heat, and the process is called nonshivering thermogenesis.].

UCP-1, also called thermogenin, is responsible for the activation of fatty acid oxidation and heat production in the brown adipocytes of mammals. Brown fat, unlike the more abundant white fat, uses **almost 90% of its respiratory energy** for thermogenesis in response to cold, at birth, and during arousal in hibernating animals. However, humans have little brown fat (except in the **newborn**), and **UCP-1** does not appear to play a major role in energy balance. Other uncoupling proteins (UCP-2, UCP-3) have been found in humans, but their significance remains unclear.

How it's regulated?

Non-shivering thermogenesis is regulated mainly by **thyroid hormone** and the **sympathetic nervous system**. Some hormones, such as **norepinephrine** and **leptin**, may stimulate thermogenesis by activating the sympathetic nervous system. Rising insulin levels after eating may be responsible for **diet-induced thermogenesis** (thermic effect of food).