Hormones and regulation of blood glucose

The regulation of blood glucose is an example of how different hormones interact in achieving **homeostasis**. However, let us first look at what hormones are and how they work.

Hormones

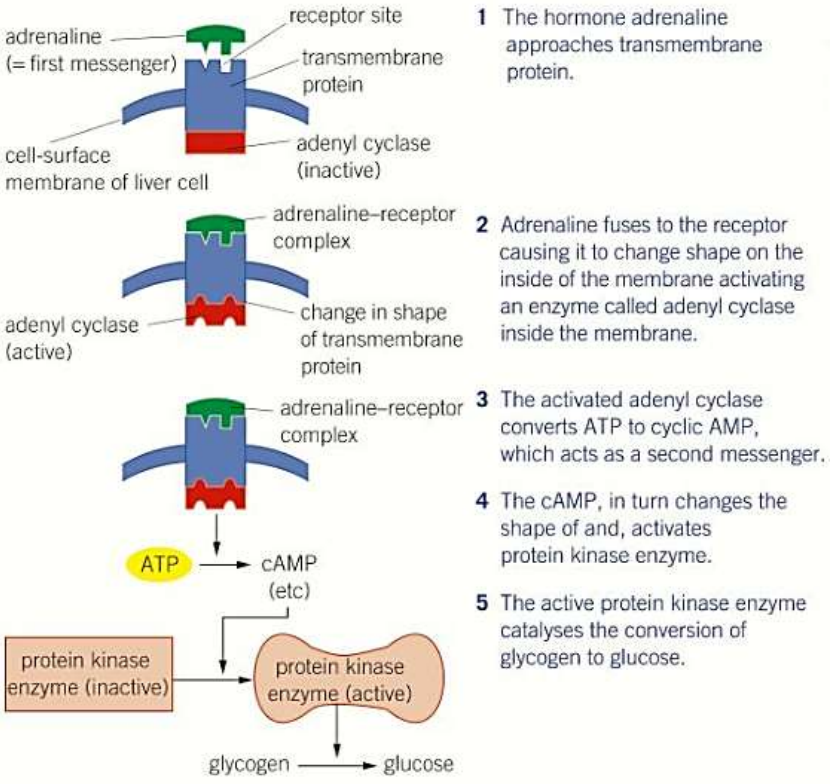
long	plasma	endocrine	blood	target	receptors	hormone

Hormones are produced by _____ glands. These secrete the hormone directly into the _____.

They travel in the blood _____ until they arrive at their _____ cell. These have protein _____ on their cell surfaces that are complementary to the _____.

Hormones can be effective in very low concentrations, but often have widespread and _____ lasting effects.

Hormones function in two main ways. One mechanism is known as the **second messenger model**. This mechanism is used by two hormones involved in the regulation of blood glucose, namely adrenaline and glucagon. The second messenger model works at follows:

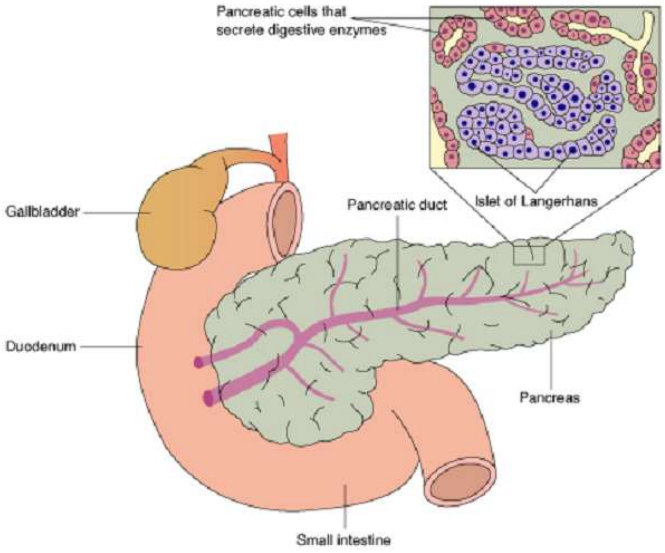


- **Adrenaline** binds to a **transmembrane protein receptor** within the cell-surface membrane of a liver cell.
- The binding of the adrenaline causes the protein to **change shape** on the inside of the membrane.
- This change of protein shape leads to the **activation** of an enzyme called **adenyl cyclase.** The activated adenyl cyclase converts **ATP to cyclic AMP (cAMP).**
- The cAMP acts as a **second messenger** that binds to protein **kinase enzyme,** changing its shape and therefore activating it.
- The active protein kinase enzyme catalyses the conversion of **glycogen to glucose** which moves out of the liver cells **facilitated diffusion** and into the blood, through channel proteins.

This is called **cascade amplification.** Here one adrenaline molecules produces many cyclic AMPs (cAMPs). In turn each cAMP produces many glucose molecules. I.e. it is amplified.

The role of the pancreas in regulating blood glucose

The pancreas is a large, pale-coloured gland that is situated in the supper abdomen behind the stomach.



The pancreas is both-

- an **exocrine gland**, releasing enzymes into the pancreatic duct.
- an **endocrine gland** secreting hormones from the islets of Langerhans directly into the blood. **Which hormones?**

When examined microscopically, the pancreas is made up largely of the cells that produce digestive enzymes. Scattered throughout these cells are groups of hormone-producing cells known as **islets of Langerhans**. The cells of the islets of Langerhans are of two types:

- α cells –
- β cells -

- Gluco/glyco = glucose
- Glycogen = glycogen (!)
- Neo = new
- Lysis = splitting
- Genesis = birth/origin

Therefore:

- Glycogen – o – lysis = splitting of glycogen
- Gluco-neo-genesis = formation of new glucose

The role of the liver in regulating blood glucose

The liver is located immediately below the diaphragm, has a mass of up to 1.5 kg and is made up of cells called hepatocytes. It serves a large variety of roles including regulating blood glucose concentration. While the pancreas produces the hormones insulin and glucagon, it is in the liver where they have their effects. There are three important processes associated with regulating blood sugar which take place in the liver.

- **Glycogenesis** is the conversion of glucose into glycogen. When blood glucose concentration is higher than normal the liver removes glucose from the blood and converts it to glycogen. It can store 75–100 g of glycogen, which is sufficient to maintain a human's blood glucose concentration for about 12 hours when at rest, in the absence of other sources.
- **Glycogenolysis** is the breakdown of glycogen to glucose. When blood glucose concentration is lower than normal, the liver can convert stored glycogen back into glucose which diffuses into the blood to restore the normal blood glucose concentration.
- **Gluconeogenesis** is the production of glucose from sources other than carbohydrate. When its supply of glycogen is exhausted, the liver can produce glucose from non-carbohydrate sources such as glycerol and amino acids.

Why do we need glucose?

Why do we need to control blood glucose levels?

Blood glucose and variations in its level

The normal level of blood glucose is between 82-110mg/dL. Blood glucose comes from three sources:

Where are high levels of glucose detected?

The cell:

The group of cells:

The organ where these cells are found:

Where is insulin released from and how does it find its target cells? What does it do to the target cells?

Control of blood glucose

How does insulin lower blood glucose?

What is glucagon? Where is glucagon released from? What does glucagon do?

Where are reduced levels of glucose detected?

The cell:

The group of cells:

The organ where these cells are found:

Define the following;

Gluconeogenesis –

Glycogenolysis –

Glycogenesis –

Hormone interaction in regulating blood glucose

The two hormones insulin and glucagon act in opposite directions. Insulin lowers the blood glucose level, whereas glucagon increases it. The two hormones are said to act antagonistically. The system is self-regulating in that it is the level of glucose in the blood that determines the quantity of insulin and glucagon produced. In this way the interaction of these two hormones allows highly sensitive control of the blood glucose level. The level of glucose is not, however, constant, but fluctuates around a set point. This is because of the way negative feedback mechanisms work. Only when the blood glucose level falls below the set point is insulin secretion reduced (negative feedback), leading to a rise in blood glucose. In the same way, only when the level exceeds the set point is glucagon secretion reduced (negative feedback), causing a fall in the blood glucose level.

The control of blood glucose level is summarised in Figure 3.

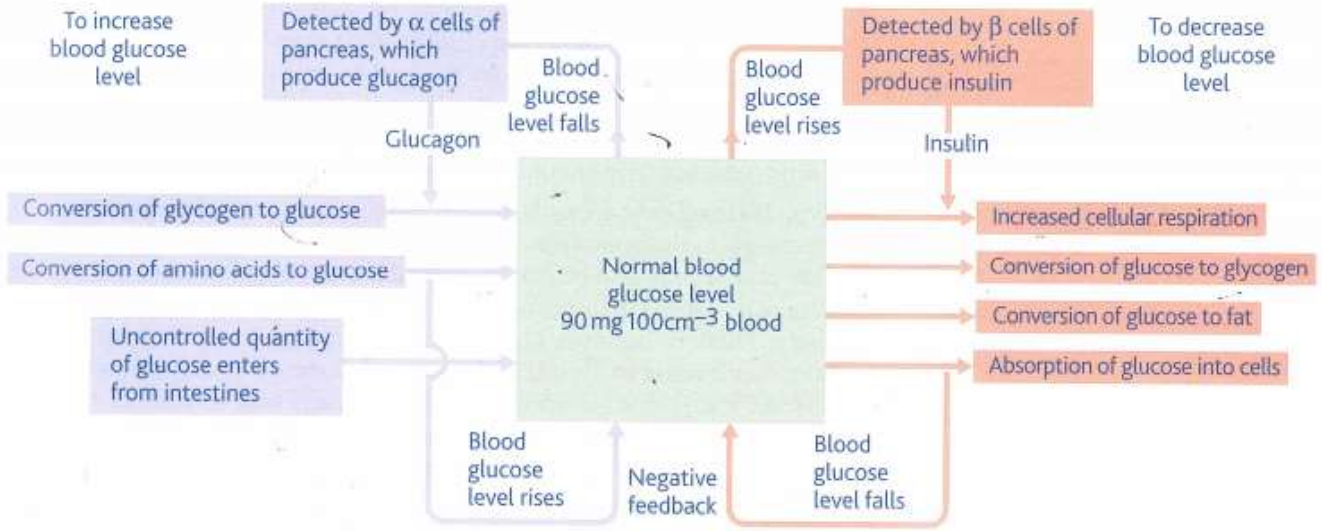


Figure 3 *Summary of regulation of blood glucose*

Summary questions

In the following passage, state the most suitable word to replace the numbers in brackets.

The chemical energy in glucose is released by cells during the process known as (1). It is therefore important that the blood glucose level is maintained at a constant level because if it falls too low cells are deprived of energy, and (2) cells are especially sensitive in this respect. If it gets too high (3) problems occur that may cause dehydration. Blood glucose is formed directly from (4) in the diet or from the breakdown of (5), which is stored in the cells of the liver and (6). The liver can also increase blood glucose levels by making glucose from other sources, such as glycerol and (7), in a process known as (8). Blood glucose is used up when it is absorbed into cells, converted into fat or (9) for storage, or used up during (10) by cells. In order to maintain a constant level of blood glucose the pancreas produces two hormones from clusters of cells within it called (11). The β cells produce the hormone (12), which causes the blood glucose level to fall. The α cells produce the hormone (13), which has the opposite effect. Another hormone, called (14), can also raise blood glucose levels.