Homeostatic control of blood glucose levels essay sample

Literature, Russian Literature

Glucose is an essential substance in the body as it the primary source of energy for all biological functions and is indeed the only form of energy which can be used by the brain and central nervous system. The ideal level of blood glucose is 80 – 90mg of glucose per 100mls of blood. However this level is not static – it oscillates due to changes in the body which are brought about by actions such as eating a meal, exercising, or not eating for long periods. If blood glucose levels drop or rise dramatically there may be serious consequences such as hypo- or hyperglycaemia which can both cause death.

Thus it is necessary for blood glucose levels to be regulated and this is achieved through homeostasis. To work effectively homeostasis requires an effective receptor to detect variations from the norm and a negative feedback system where antagonistic processes work to redress any variations as they occur. By examining the mechanisms of the homeostatic control of blood glucose levels it should be possible to explore the consequences of a breakdown of this part of the endocrine system. Essentially, blood glucose levels are controlled by the pancreas.

It is in this organ that areas of cells called the Islets of Langerhans exist, which consist of alpha cells and beta cells. These cells monitor blood glucose and secrete the hormones glucagon and insulin respectively. Glucagon and insulin regulate blood glucose levels through their antagonistic and opposite effects in a system of negative feedback. The most important effects of insulin work to lower blood glucose levels, which may be too high following a large, carbohydrate heavy meal for example and are as follows.

Blood glucose levels are reduced by the liver and muscle cells being stimulated to take up more glucose and convert it to glycogen which is insoluble; the production of glucose from protein and fats (gluconeogenesis) is reduced; cell membranes increase in their permeability to glucose, therefore more glucose is taken out of the blood and into the cells (increasing respiration). The level of blood glucose is constantly monitored by the beta cells.

As the effects of insulin bring down the blood glucose level the cells secrete less and less of the hormone in accordance with the falling level of blood glucose – this continues until levels return to normal. The corresponding effect of this antagonistic mechanism occurs when blood glucose level have fallen too low – this is detected in the Islets of Langerhans by the alpha cells which are stimulated to produce glucagon. This hormone acts in two main ways to raise blood glucose concentration back to normal levels.

Firstly, it stimulates the process of glycogenolysis whereby the liver and muscle cells convert glycogen into glucose to be discharged into the blood. In addition, it increases gluconeogenesis so that more glucose is synthesised from protein and fat sources. However if glucagon is allowed to encourage the production of glucose unchecked, the liver will begin to produce ketones which dangerously disrupt the acid/base balance in the body. The two antagonistic processes described above combine to homeostatically regulate and maintain blood glucose at an appropriate level – their actions are summarised in the diagram below.

Although insulin and glucagon are the hormones that have the greatest effect on blood glucose other hormones also play a part. Somatotrophin, adrenaline and corticosteroids all work in conjunction with glucagon to counteract low blood glucose levels. In some people these essential control mechanisms are inactive and this results in a condition known as diabetes mellitus, of which there are around 700 000 diagnosed cases in the UK. The disease can be classed as either Type 1 (insulin dependent) or Type 2 (non-insulin dependent) diabetes, both of which have different characteristics and causes.

Type 1 occurs when the insulin producing beta cells are attacked by the body's immune system because it perceives them as foreign. The causes of this autoimmune response are not entirely clear, but it is believed to be a combination of genetic susceptibility and a virus which only has this effect on those who are genetically vulnerable. This is a serious type of diabetes which develops quickly and mainly occurs in people under 35 (accounting for approximately 10% of diabetes cases).

As the sufferer doesn't produce insulin, blood glucose is periodically monitored and regular injections of the hormone are required to avoid blood glucose levels spiralling out of control – this would result in coma followed by death. In contrast Type 2 diabetes tends to develop more slowly and is most common in people over 40. The main causes are defects in the beta cells (so insulin production is decreased) and insulin resistance, whereby insulin is no longer able to stimulate the absorption of glucose by cells.

This form of the disease is more strongly predicted by genetics than Type 1 and there is believed to be a link between Type 2 and obesity. For this reason one of the main steps against Type 2 is to lose weight in combination with improved diet and medication (to stimulate insulin production in the pancreas) – it is rare for insulin injections to be required. Many symptoms are common to both types of disease. With no control over glucose levels they may rise to 200mgs/100mls blood. As the kidneys reach saturation point and become unable to reabsorb any more excess glucose it is excreted in the urine, known as glucosuria.

Due to osmosis the glucose takes a lot of water with it so the volume of urine is abnormally large and this results in the diabetic also being dehydrated and always thirsty. As cells are forced to metabolise fats and proteins for energy in the absence of glucose, ketones are produced which give the sufferer breath which smells of acetone. As mentioned earlier, the disruption of the body’s acid balance as a result of ketone production is the main cause of coma and death in Type 1 diabetics. Again, due to the metabolism of fats diabetes will also manifest itself as weight loss, especially in Type 1 cases.

In the long term both types have potential to cause heart disease, kidney and nerve damage, stroke and blindness if not managed well. As stated above both types are currently treated through a healthy diet combined with medication, but there are other treatment prospects to consider in the future such as Islet Cell Transplantation. Perhaps the most interesting is the work by the US Department of Energy on an artificial pancreas which if developed could free diabetics from the rigours of current treatments and ensure accurate control of blood glucose at all times.