The endocrine system, alongside the nervous system and the immune system, is one of the primary control mechanisms in the body. The systems work together to maintain a steady state within the body, ensuring homeostasis. Box 1 defines some of the key terms used when dealing with the endocrine system.

**Main endocrine glands**
The main endocrine glands are:

- Pituitary gland
- Thyroid gland
- Parathyroid glands
- Parts of the pancreas
- Adrenal glands
- Ovaries and testes

Endocrine tissue is also present in many organs that are not normally associated with the endocrine system. For example, the hormone erythropoietin is secreted by endocrine cells in the kidney and affects the production of red blood cells by the bone marrow. Hormones such as gastrin are produced by the cells of the stomach and circulate locally to affect the muscle and exocrine glands of the intestinal tract.

Hormones are released into the bloodstream where they travel through the body but only the cells that have receptors for that particular hormone (target cells) will be affected. The receptors have a particular configuration that fits the hormone; this is the hormone binding site.

The production of hormones is controlled, so that, in the healthy state, there is no over- or underproduction. This regulation is often a ‘self control’ mechanism; if the level of a hormone is increasing, the body will detect this and inhibit further production. The reverse situation is also true: if the level of a hormone is becoming too low, more will then be produced. The same type of control is true for non-hormone systems such as blood glucose or blood calcium. For example, the body detects a rising level of blood glucose, and mechanisms are put in place to ensure the level does not rise above the upper limit of the normal range. It is outside the scope of this article to describe all the functions of the hormones discussed, or all their interactions, but it should be borne in mind that hormones interact and have an effect on each other.

**ABSTRACT**

The endocrine system is one of the primary control mechanisms in the body. This article defines some of the terminology used in describing the endocrine system and describes some examples of hormone systems and how drugs may be used to help manage these.
Nurses often measure blood glucose levels and use these as part of their assessment and care planning. Rather than focusing on the link between blood glucose level and insulin administration, it is worth taking time to consider in more detail the normal mechanism for control of blood glucose in humans, as this would present a more thorough picture of the patient being treated (Box 2).

Blood glucose levels rise and fall between meals. Insulin is produced by the pancreas to prevent the level of blood glucose becoming too high. To prevent the level of blood glucose falling too low, the pancreas produces glucagon. It is vital that glucose is maintained at a level that can be used by cells to produce energy. Other hormones such as adrenaline, cortisol, thyroid hormones and growth hormone can also lead to a rise in blood glucose.

Note that insulin does not just target the muscle cells to enable glucose uptake; there is also an uptake of glucose in liver and fat cells. In addition, as an anabolic hormone, insulin promotes the storage of glucose as glycogen (e.g. in the liver cells), promotes the storage of fat, protein synthesis and reduces the breakdown of fat and protein (Figure 1; Tortora and Grabowski, 2003). If too many sugary foods are eaten at one time, the blood glucose level

**Box 1**

**Basic terminology related to the endocrine system**

**Endocrine**
Endocrine refers to a gland or tissue that secretes a hormone directly into the bloodstream. The hormone is produced by the tissue cells and taken away by the blood capillaries and distributed to the general circulation.

**Exocrine**
Exocrine refers to a gland or tissue that secretes a substance via a duct. Examples are the sebaceous glands (which secrete sebum onto the skin) and the gastric glands (which secrete enzymes into the stomach).

**Hormone**
A chemical messenger secreted by endocrine cells. A hormone will have a particular ‘shape’ to enable it to attach to particular cells elsewhere in the body.

**Target**
The target is the place to which the hormone binds. The hormone’s target organ may be another endocrine gland, in which case its action is to suppress or trigger the production of another hormone. The hormone may enter the general circulation and all organs and tissues may be exposed, but there will only be an effect on the target cells.

**Receptor**
The part of the target cell that has the matching ‘shape’ for the hormone. This is where the hormone will attach and cause its effect.

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**Box 2**

**A consideration of the blood glucose level of a normal, healthy adult**

- The level of glucose in the blood will be relatively low before a meal. It will not fall below a certain set point because the body is equipped with mechanisms to prevent this. For example, the stores of sugar in the liver and muscle (glycogen) can be broken down by the hormone glucagon to release glucose into the bloodstream.

- Eating a meal will enable absorption of glucose into the bloodstream. The blood glucose level will therefore rise and continue to do so while food is being absorbed.

- The glucose circulates in the bloodstream, enters cells, is metabolized, and carbon dioxide and water are produced as waste products. The metabolism of glucose removes it from the blood stream, and the blood glucose level will gradually fall. In the normally healthy adult, the hormone insulin is produced in greater quantities whenever the pancreas senses that the blood glucose level is rising. Insulin has its target on muscle cells (among others). Receptors on these muscle cells connect to insulin molecules and the cells are then able to absorb glucose for metabolism.

- As the level of blood glucose falls (because the glucose is entering the cells) the production of insulin will be reduced.
will rise quickly and the body will eradicate glucose in the urine; the kidney has a limited capacity to reabsorb glucose and prevent its excretion in urine. This is true in normal healthy individuals. If the pancreas is not producing insulin, or is not producing enough insulin, there will be no uptake of glucose and it will remain in the bloodstream. Blood glucose will continue to rise and some glucose will then enter the urine, as the capacity of the kidney to reabsorb the glucose will be exceeded.

**Diabetes mellitus**

In diabetes mellitus, the production of insulin is affected and treatment will be directed at the maintenance of normal blood glucose levels (4–6 mmol/l; Mosby, 2002) although the recommendations for normal levels do vary. At 4–6 mmol/l, no glucose will be detected in the urine. Another important measure of blood glucose is glycosylated haemoglobin (Hb).

Measurement of the fraction HbA1C is an indication of long-term control of blood glucose and a level between 6.5 and 7.5% is recommended (BNF, 2006). This is not a direct measure of the amount of glucose in the blood; instead it gives an indication of how much glucose has combined with the haemoglobin in the erythrocyte over the 120-day average life of the cell. Over the lifespan of the red blood cell, glucose will combine with haemoglobin to form glycosylated haemoglobin (McCance and Huether, 2006). The more glucose there is in the blood, the greater the formation of glycosylated haemoglobin.

A range of insulins is available in cases where normal insulin production is affected severely. The short-acting insulins will work quickly but have a relatively short duration of action; intermediate-acting insulins and long-acting insulins have increasingly longer durations of action. The individual's metabolism does need to be considered. People...
respond differently to the different insulins, and the onset and duration of action may be faster in some and slower in others. Infection, stress, trauma or any additional load on the body could increase the individual’s requirements for insulin. Administering insulin can lead to a severe reduction in blood sugar, i.e. hypoglycaemia (see Box 3 for the signs and symptoms of hypo- and hyperglycaemia).

Although the pancreas is not producing sufficient insulin in diabetes mellitus, insulin treatment is not required in some cases because the pancreas is already producing a small amount of the hormone. Dietary and exercise regimes are prescribed in these cases to try to increase the body’s response to the natural insulin. If these measures are not effective after a trial period, an oral hypoglycaemic agent will be prescribed (BNF, 2006). The sulphonylurea group of hypoglycaemic agents (such as chlorpropamide, glibenclamide) are used if the pancreas is producing some insulin, but not enough, and increase the amount of insulin produced by the beta cells. The biguanides (metformin) work differently; these increase the amount of glucose entering the cells by enabling insulin to bind more easily to the cell, i.e. they partially overcome the problem of insulin resistance.

Control of thyroxine levels
Nurses frequently administer drugs that affect the production of the thyroid gland hormones. The thyroid gland, situated in the neck, manufactures and secretes hormones that control metabolism. The component parts of the hormone are first obtained and held in place during assembly of the hormone. Thyroglobulin (a glycoprotein) is the base in which the amino acid tyrosine is held while iodide is extracted from the blood and attached to the tyrosine. The hormones are tri-iodothyronine ($T_3$) and thyroxine ($T_4$). The hormones can be stored in the thyroid gland attached to thyroglobulin until required. In health, secretion of these hormones is controlled by the pituitary gland and by the hypothalamus (see Figure 2). There is a series of hormones that lead to the production of thyroid hormones, with first the hypothalamus and then the pituitary gland ‘giving instructions’ for the process. As more thyroid hormones are produced, the production of hormones from the hypothalamus and pituitary gland is inhibited, so reducing production by the thyroid gland.

Thyroid hormones affect metabolism, and increasing the amount of these hormones will increase metabolism. This means that cells will ‘burn’ glucose more rapidly and release more heat as a result, the pulse rate will rise and stores of fat and other materials will be broken down. In normal everyday life, the levels of thyroid hormones fluctuate to deal with events that occur, but stay within set boundaries. Thyroid hormones show diurnal variation in the healthy state, with a maximum secretion in the late evening (McCance and Huether, 2006).

If the levels of $T_3$ and $T_4$ become too high, thyrotoxicosis occurs and treatment is required to reduce the levels of the hormones. In the UK the main drug used is carbimazole. This drug interferes with the production of $T_3$ and $T_4$. Existing stores of the hormone may last for 3–4 weeks, so there may not be an immediate effect of treatment.

If thyroid hormone levels drop too low, hypothyroidism occurs. Treatment here is to replace the thyroid hormones, either using a form of $T_4$ (levothyroxine sodium) or $T_3$ (liothyronine sodium).

**Box 3**

**Typical signs and symptoms of hyper- and hypoglycaemia**

For hyperglycaemia, the onset of symptoms tend to be slow and can occur over several weeks. These are

- Thirst
- Polyuria
- Loss of weight
- Tiredness
- Glycosuria
- Ketosis

For hypoglycaemia, the behaviour may be unusual and actions uncoordinated. The onset of symptoms tends to be rapid and signs and symptoms can include

- Anxiety, agitation, aggression
- Lack of concentration
- Loss of memory
- Headache
- Slurred speech
- Sweating
- Pallor
- Dizziness
- Blurred or double vision
- Tremor
- Tachycardia
- Hunger
- Weakness and/or tiredness
- Confusion and/or irritability
- Unconsciousness
The corticosteroids such as prednisolone, cortisol, or hydrocortisone are similar in structure and actions to the hormones released by the adrenal cortex. Anabolic steroids, which have structures and actions based on androgens, are not considered in this article.

**Adrenal glands**

The adrenal glands (suprarenal glands) are small, triangular structures located at the top of both kidneys. They have an inner core (the medulla) of modified nervous tissue and an outer cortex. These two distinct structures arise from different tissues in the embryo. The medulla produces adrenaline.
Cortisol promotes the breakdown of proteins (e.g. muscle proteins) and fats. Glucose can be made from the breakdown products and blood glucose rises to cope with the demands of the cells for energy. Indirectly, cortisol causes the blood vessels to constrict, so blood pressure rises. Activity of white blood cells is reduced, thereby reducing inflammation. Calcium is released more readily from bone.

Adrenaline and noradrenaline whereas the cortex produces other hormones necessary for fluid and electrolyte balance in the body such as cortisone and aldosterone. The adrenal cortex also makes sex hormones but this only becomes important if overproduction is present. Adrenaline and noradrenaline are referred to as hormones in this context because they are chemical messengers secreted directly into the bloodstream but, of course, they also occur as neurotransmitters, when they are secreted by nerve endings at the end of a neuron. Most of the adrenaline in circulation (70%) is produced by the sympathetic nervous system and not by the adrenal glands (McCance and Huether, 2006).
Adrenaline and noradrenaline

In the adrenal medulla, sympathetic nerve fibres attach to the medullary cells. When an electrical impulse is transmitted through these sympathetic fibres, the cells of the adrenal medulla produce adrenaline and noradrenaline in response. More adrenaline is produced than noradrenaline; adrenaline has a stronger effect on the tissues than noradrenaline. The hormones are released into the bloodstream and enter the general circulation. The general effects of these hormones are well known: increased cardiac output (heart rate and stroke volume); diversion of blood to vital organs; reduced gastrointestinal motility and secretions; increase in blood glucose; dilated pupils and dilated airways. The hormones are designed to respond immediately in situations of stress – whether physical, psychological or other. Having the sympathetic nerve fibre in direct contact with the hormone-producing cells increases the speed of response. This immediate effect also occurs if adrenaline is injected.

Cortical hormones

In contrast, the hormones of the adrenal cortex are designed to cope with ongoing stress. In health, the body always produces corticosteroids. As with other hormones, it is the amount produced that varies in relation to the circumstances. Stress will increase the amount of corticosteroids produced. The control of hormone production from the adrenal cortex is very similar to that for the thyroid gland. The hypothalamus secretes corticotrophin-releasing hormone (CRH); this causes the anterior pituitary gland to produce adrenocorticotropic hormone (ACTH), and this, in turn, stimulates the adrenal cortex to produce its hormones, cortisol (and similar substances) and aldosterone. These effects and controls are outlined in Figure 3.

When corticosteroids are given as medication, the blood levels of corticosteroid will rise, which reduces the stimulus on the adrenal cortex to produce its own hormones. As with other tissue, if it is not used, it may atrophy. This is a reminder as to why corticosteroids or other hormone treatments should not be stopped suddenly but instead withdrawn gradually to enable the gland to re-establish itself and normal mechanisms to take over. When corticosteroids are prescribed because the adrenal cortex is not working effectively, the effects of both cortisol and aldosterone will be required. However, where corticosteroids are being used as anti-inflammatory agents, drug choice often aims to maximise the effects of cortisol while minimising the effects of aldosterone, and prednisolone is often preferred. Corticosteroids carry with them the potential for numerous adverse effects based on enhancement of their normal action.
These cells produce the hormone calcitonin and release it into the bloodstream. Osteoclasts are bone cells that refashion bone, removing bone that is not required and releasing calcium into the bloodstream. Calcitonin reduces blood calcium levels by reducing the work of these bone cells so that less calcium enters the bloodstream. This hormone also promotes the uptake of calcium by bone. Calcitonin is given for the treatment of Paget’s disease, for malignancy-associated hypercalcaemia, and for osteoporosis following the menopause. Alternative preparations are also available to prevent or treat osteoporosis. 

By contrast, the parathyroid glands respond to lowered levels of blood calcium by producing and releasing parathormone. This works to increase blood calcium levels by releasing calcium from bone, and reducing the excretion of calcium in the urine. Parathormone also stimulates the kidney to produce vitamin D, which then stimulates absorption of calcium from the diet.

Conclusion

It is clear that hormones work to achieve homeostasis within the body, and this is brought about through a variety of mechanisms. Some rely on control by multiple factors, with the hypothalamus and the pituitary gland playing a major role in controlling and releasing hormones in sequence to control the release of another hormone, such as with the thyroid and adrenal cortical hormones. In other cases, control is achieved through detection of another substance, such as glucose or calcium; as increased levels are detected, hormones are released to bring the level down, and vice versa. From this article it is clear that when administering drugs affecting the endocrine system, the nurse needs to be aware of the complex interactions occurring in the body.