



CHAPTER 13

COORDINATION AND THE ENDOCRINE SYSTEM

The **endocrine system**, in conjunction with the nervous system, coordinates many bodily functions. It monitors body processes and produces hormones to regulate them.

The endocrine system is made up of all your hormone-secreting glands. **Hormones** are chemical messages that are carried to all parts of the body by the blood. They influence many organs, regulating the rates of body processes such as digestion, circulation, respiration, and excretion. They control body growth and sexual maturing. Our emotions and sexual desire are also heavily influenced by hormones. In fact, it is not always clear whether hormones are causing our emotions, or our emotions are causing hormones to be released.

The Endocrine System vs. the Nervous System

The endocrine and nervous systems are very closely related. Hormones influence the nervous system and the nervous system influences the glands. In fact, in some cases, scientists are not sure which is influencing which.

These two systems work together to coordinate bodily activities. However, they work in different ways. While the nervous system communication is based on *electrical* messages carried by *nerves*, the endocrine system sends *chemical* messages— the hormones— that are carried by the *blood*.

Which do you think goes faster— an electrical message or a chemical message? Consider the following classroom analogy.

Your nervous system is like the electrical wiring in your classroom. If you turn on the light switch, electricity immediately flows through the wire to the light bulb. A small fraction of a second after you flip the switch, the light is on. Just as quickly you can turn it off. In the same way, your nervous system can send an electrical message along the nerves to your hand to grab a pen— and just as quickly you can drop it.

Also, these electrical messages are very controlled. The electricity goes only to the light bulb, the neural message goes only to one particular muscle tissue. When you turn on the light switch in your classroom, the light would never go on in the next room instead. When you decide to wiggle your toe, you never wiggle your finger instead by mistake.

Your endocrine system, on the other hand, is more like opening a bottle of perfume in the corner of the classroom. Slowly, the perfume will evaporate and diffuse through the room. If you close the bottle, will the smell suddenly disappear? No. The smell will very gradually diffuse out of the room. Your glands are like the perfume bottle and the hormones they secrete are like the perfume. When a gland "opens" and secretes chemical hormones, both the blood and simple diffusion spread the hormones through the body. Even after a gland stops secreting a hormone, the body takes time to break down the hormones that have already been released.

Also, diffusion carries the perfume all over the room— you cannot keep it in just one corner. In the same way, the blood carries hormones to all parts of the body. They cannot be sent to just one particular part.

The nervous system sends very fast, tightly controlled messages; the endocrine system sends slower messages that cannot be directed or suddenly "turned off". Thus, the nervous system coordinates "fast" things such as movement and the endocrine system coordinates slower, longer-term changes such as metabolic rate, growth, and emotional states.

Summary of differences between the nervous and endocrine systems

Nervous System	Endocrine System
electrical messages	chemical messages
messages carried by nerves	messages carried by blood
faster	slower
directed travel to exact spots in the body	spreads to whole body, direction not controlled
stops and starts at will	longer-lasting effect
coordinates body movement	coordinates body processes

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THE HUMAN ENDOCRINE SYSTEM

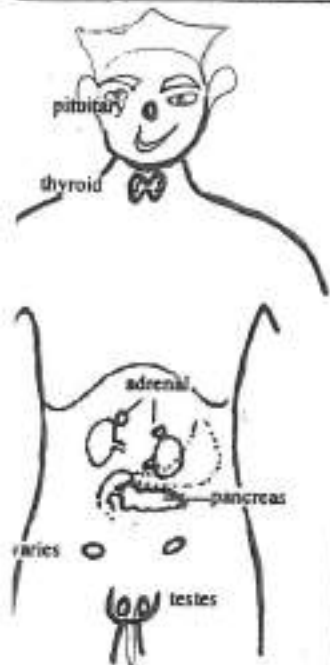
The endocrine system is made up of glands and the hormones they secrete into the bloodstream.

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The Glands and Hormones

The Endocrine System

Gland	Hormone(s) it secretes	Function
pituitary	secretes many hormones including TSH- thyroid stimulating hormone	"master gland" - controls all the other glands. TSH causes the thyroid to secrete more thyroxine
thyroid	thyroxine	regulates metabolic rate- speed of digestion, cellular respiration, etc.
pancreas	insulin	tells liver to change glucose to glycogen
	glucagon	tells liver to change glycogen to glucose
adrenal	adrenalin	prepares body for activity in danger or excitement <i>eg. raises breathing and heart rates</i>
ovaries (female)	oestrogen and progesterone	cause ovulation, menstruation, and female sex characteristics <i>eg. breast and hip development</i>
testes (male)	testosterone	causes sperm formation and male sex characteristics <i>eg. facial hair, deepening of the voice</i>



These are just the main glands in your body. You have many others, including some in your liver, brain, and kidneys.

The Pituitary Gland

The **pituitary gland**, in the centre of the brain, releases many different kinds of hormones which influence all the other glands. For this reason, it is sometimes called the *master gland*. Regulating body growth is one of many important functions of the pituitary. One of the hormones it releases is TSH, which causes the thyroid gland to make more thyroxine.

The Thyroid Gland

Thyroxine, the hormone secreted by the **thyroid gland**, raises your base-level metabolic rate. With more thyroxine in the blood, the cells burn up food faster in the respiration reaction. If there is less thyroxine, the cells use up glucose more slowly.

Have you ever noticed how some people stay thin no matter how much they eat, while others grow fat even though they eat very little? This is usually due to a difference in basic metabolic rate.

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The thin people's thyroid glands secrete more thyroxine than most other people's glands; the glands of the fat people secrete less. Usually, the thin people have high energy levels since their cells are burning up so much glucose. The people with underactive thyroids may suffer an energy shortage and become dangerously overweight because the body is not burning food as fast as it should; their metabolic rate is too low.

As people age, their thyroid glands release less thyroxine, especially in women. This is why you often see middle-aged people gaining weight. To maintain their weight, they have to eat much less food than they used to. Their bodies are using food more slowly than they did before because the thyroxine level in their blood has dropped.

The Pancreas

Most of the pancreas is devoted to making digestive enzymes.

Diabetics have trouble regulating blood sugar content due to a shortage of insulin. Sugar levels that are too high cause drunk-like delirium that can kill if insulin is not injected.

Sometimes patients inject too much insulin, leading to the opposite problem of sugar levels that are too low. This leads to body shakes and eventually death if the cells are starved of glucose for too long.

See Chapter 25 for what to do in diabetic emergencies.

Some parts of the pancreas release hormones that regulate blood sugar content. If there is too much sugar in the blood, such as after eating a few lollies for example, which hormone will the pancreas secrete in order to keep homeostasis?

When the level of sugar in the blood is too high, the pancreas releases the hormone **insulin**. Insulin tells the liver to convert sugar to glycogen, which will then be stored in the liver. If blood sugar level drops too low, then the pancreas secretes **glucagon**. This hormone tells the liver to break glycogen down into glucose.

By monitoring the level of sugar in the blood and releasing insulin or glucagon as needed, the endocrine system keeps blood sugar level stable. As you may have seen in diabetics, blood sugar levels that are either too high or too low are dangerous.

The Adrenal Glands

In any dangerous situation, you have two options—fighting or fleeing. Both require a burst of activity from your muscles. **Adrenal glands** secrete a hormone which prepares you for a "fight or flight" reaction in a dangerous situation. The adrenal glands are also active when you feel excited or nervous. The hormone they secrete, **adrenalin**, prepares you for action by raising your breathing and heart rates to increase blood supply to your muscles.

You've felt the effects of adrenalin whenever you have been scared or very nervous. If you have ever been in a dangerous situation, like a car accident or rock climbing, you probably feel shaky and light-headed afterwards. This is the left-over effect of adrenalin.

There are true stories of adrenalin giving "super-human" strength to people in need, for example, mothers who lift



single-handedly lifted up a car to save their child trapped underneath and men who have moved multi-ton concrete slabs to release an earthquake victim. Adrenalin causes the body to supply so much oxygen and glucose to muscles that this kind of unbelievable strength becomes possible in emergency situations. However, the body cannot keep up this supply for long, and the person is left feeling very weak and shaky once the threat has receded.

The Ovaries (in women only)

Oestrogen and progesterone, produced by women's ovaries, cause the female characteristics to develop at puberty, changing girls into women. They cause ovulation, menstruation, and secondary sex characteristics like breasts and hips and hair growth under the arms and in the genital area. These hormones also produce changes in a woman's body during pregnancy.

Women also produce testosterone, but oestrogen is "stronger" and masks its effects.

Oestrogen production lessens as women age, sometimes allowing the testosterone to "show through" in the form of a little more facial hair. Also, ovulation and menstruation become less and less frequent and then eventually stop completely.

The Testes (in men only)

Testosterone, produced by men's testes, causes all of the male characteristics to develop at puberty, changing boys into men. These characteristics include sperm production, widening chest and shoulders, muscle build-up, voice deepening, "wet dreams", and hair growth on face, chest, underarms, and in the genital area.

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HORMONES AND HOMEOSTASIS

Hormones are powerful things. Too much or too little of an hormone can change your entire appearance or personality. For example, people who cannot produce enough thyroxine become enormously fat and feel very lazy. Men injected with oestrogen develop breasts, a higher voice, and cannot get an erection. An injection of adrenalin makes people almost wild with activity and excitement.

Dwarfism is a genetic disorder where a person does not grow to be more than one metre tall.

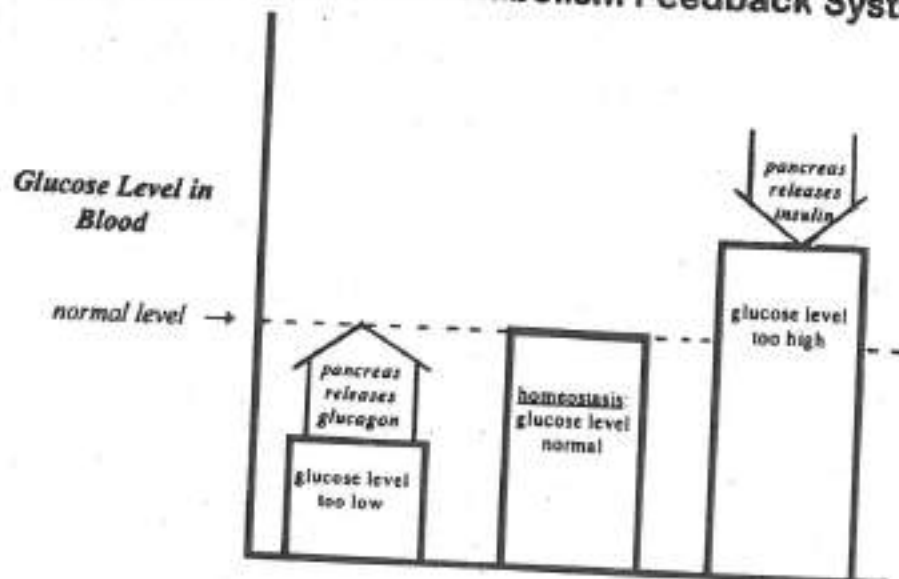
Many illegal drugs, such as cocaine and perhaps marijuana affect the user's hormone balance. Also, several genetic diseases are related to hormone problems, including diabetes and dwarfism.

Feedback Systems

Too much or too little of any hormone can have serious health consequences. Normally, hormone secretion is tightly regulated to keep homeostasis. Most glands "know" when and how much hormone to secrete by a feedback system. In a feedback system, glands sense a change in internal conditions and use that information to "decide" whether or not to release hormones.

Feedback systems are best understood by thinking about specific examples. Study the two examples of feedback systems given below.

Example 1 Glucose Metabolism Feedback System



insulin
many glucose molecules → glycogen

If glucose levels are too high in the blood, the pancreas is stimulated to secrete insulin. Insulin reduces glucose concentration in the blood by telling the liver to change glucose to glycogen.



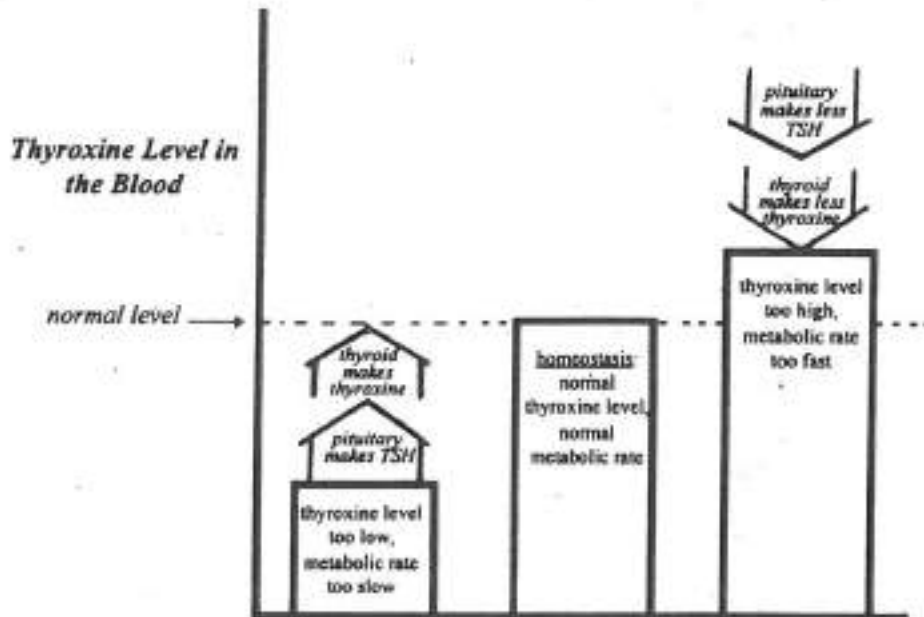
glucagon
gen → many glucose molecules

If blood glucose levels drop too low, the pancreas makes glucagon, which tells the liver to break down glycogen back into glucose. If the level is normal, then the pancreas doesn't secrete either hormone. This helps to keep the supply of glucose to cells constant.

Example 2 Thyroxine Production Feedback System

The pituitary gland can sense the thyroxine concentration in the blood. If the thyroxine concentration becomes too high, then the pituitary stops making TSH. Without TSH to stimulate it, the thyroid gland stops making thyroxine.

When the thyroxine concentration drops below normal, the pituitary gland makes more TSH, which forces the thyroid gland to make more thyroxine.



With the pituitary gland monitoring the thyroxine level and then secreting TSH as needed, thyroxine is kept at appropriate levels at all times. This ensures a stable metabolic rate.

Feedback systems may look a bit complicated, but they make sense if you spend some time thinking about them. Don't look at the whole thing at once. Think of them step by step, asking yourself, "What will happen if the level of _____ goes up in the blood? And what if the level of _____ drops below the normal level?"

Feedback systems are part of the thousands of ways the body keeps homeostasis, regardless of changes outside of the body.

Vocabulary list

endocrine system	thyroid gland	glucagon	progesterone
hormones	thyroxine	adrenal gland	testosterone
pituitary gland	pancreas	adrenalin	feedback system
TSH	insulin	oestrogen	

Review exercises

- Why do we need an endocrine system? *To coordinate our body processes*
- Describe four differences between the nervous and endocrine systems.
- Would your body use your nervous or your endocrine system to coordinate in each of the following situations? Explain your choice.
 - kicking a soccer ball
 - growing two centimetres taller
 - regulating the amount of water reabsorbed by the kidneys
 - walking
 - puberty
- A diabetic person injected too much insulin by mistake and his body is beginning to shake. What is the problem, and what should you do to solve it?
- Your mean older brother jumps out from behind a doorway to scare you. Your pulse rate rises. What in your body has caused your heart to beat faster?
- Why are feedback systems important?
- Study the diagram of a feedback system on the right.
 - When the level of water in the body is too high, what happens to the amount of hormone released?
 - When the water level is too low, then what happens?
 - Finish the following sentence:
To increase the retention of water, the body will...
 - If you drink 4 litres of water, what will happen to the amount of this hormone released in your body?
- Name the hormone that might be causing each of the following changes in the body:
 - muscle development
 - high metabolism
 - blood sugar content too low
 - increased breathing rate

