GRADE 11A: Biology 3

Physiological regulation in mammals

UNIT 11AB.3
8 hours

About this unit

This unit is the third of eight units on biology for Grade 11 advanced.

The unit is designed to guide your planning and teaching of biology lessons. It provides a link between the standards for science and your lesson plans.

The teaching and learning activities should help you to plan the content and pace of lessons. Adapt the ideas to meet your students' needs. For extension or consolidation activities, look at the scheme of work for Grade 12A and Grade 9.

You can also supplement the activities with appropriate tasks and exercises from your school's textbooks and other resources.

Introduce the unit to students by summarising what they will learn and how this builds on earlier work. Review the unit at the end, drawing out the main learning points, links to other work and real world applications.

Previous learning

To meet the expectations of this unit, students should already know how insulin operates and be able to contrast the hormonal and nervous control systems. They should understand the importance of homeostatic mechanisms and be able to explain temperature and water regulation. They should know the structures and function of nerve cells and about nerve impulses. They should know the importance of the reflex arc and the structure and function of the ear and the eye.

Expectations

By the end of the unit, students know that organisms that can respond to changes in their environment have an increased chance of survival. They understand the principles of homeostasis and negative feedback. They compare and contrast the hormonal and nervous control systems. They describe mammalian thermoregulation and the oestrous cycle.

Students who progress further know about thermoreceptors in the hypothalamus and understand body thermoregulation. They know the causes and effects of heatstroke. They know the structure and function of neurones and how nerve impulses are transmitted. They know the main structures and functions of the brain. They know the main endocrine glands of the human body and their functions. They understand how human blood glucose levels are controlled.

Resources

The main resources needed for this unit are:

- overhead projector (OHP) and prepared transparencies (OHTs)
- video clips about how animals detect danger and human survival in hot and cold conditions
- video recorder and monitor
- round-bottomed flasks
- Internet access

Key vocabulary and technical terms

Students should understand, use and spell correctly:

- *homeostasis*
- *environmental stimuli*
- *internal environment*
- *negative feedback*
- *thermoregulation*
- *hormone*, *TRH*, *TSH*, *thyroxine*, *oestrogen*, *progesterone*, *FSH*, *LH*, *HCG*
- *oestrous cycle (sexual cycle)*, *gonadotrophic*
- *hypothalamus*, *neurotransmitter*
- *dynamic equilibrium*

Standards for the unit

Unit 11AB.3

8 hours	SUPPORTING STANDARDS	CORE STANDARDS Grade 11 standards	EXTENSION STANDARDS
1 hour **Responding to environmental stimuli**	9.10.5 Know the structure and function of the human eye and ear. 9.10.1 Explain the importance of maintaining a constant internal environment.	11A.9.1 Explain the importance to the survival of organisms of being able to respond to environmental stimuli. 11A.9.2 Explain the importance of homeostasis in mammals and describe the process in terms of receptors, effectors and negative feedback.	
1 hour **Homeostasis** **2 hours** **Thermoregulation**	9.10.6 Know how the body controls temperature and water balance.	11A.9.3 Describe thermoregulation in humans and the roles of TRH and TSH.	12A.9.4 Explain the role of thermoreceptors in the hypothalamus in thermoregulation and describe some physiological and behavioural responses of mammals to hot and cold conditions. 12A.9.5 Describe the symptoms of heatstroke and explain why it occurs and how it can be avoided.
2 hours **Oestrous cycle regulation**		11A.9.4 Describe the mammalian oestrous cycle and the roles of oestrogen, progesterone, LH and FSH.	
2 hours **Nervous and hormonal control systems**	9.10.2 Explain the ways in which hormonal control occurs and the effects of insulin. 9.10.3 Know the general structure and functions of the human nervous system, the structure and function of types of nerve cells, and the pathways taken by a nerve impulse in response to a stimulus. 9.10.4 Know the functioning and importance of the reflex arc. 9.10.7 Know the similarities and differences between hormone and nervous control systems.	11A.9.5 Describe the similarities and differences between nervous and hormonal control systems in mammals.	12A.9.6 Describe, compare and contrast the structure and function of sensory, motor and intermediate neurones and know where they are found. 12A.9.7 Explain the function and importance of a reflex arc and differentiate between a simple reflex and a conditioned reflex. 12A.9.8 Explain: the nature of a nerve impulse and the way it is transmitted; resting potential; membrane depolarisation and action potential; refractory period; the passage of sodium and potassium ions. 12A.9.9 Explain the operation of sensory receptors as energy transducers. 12A.9.10 Describe the roles of synapses in the nervous system in determining the direction of nerve impulse transmission and in allowing interconnections of nerve pathways.

8 hours	SUPPORTING STANDARDS	CORE STANDARDS Grade 11 standards		EXTENSION STANDARDS
			12A.9.11	Describe the main structures of the human brain – cerebral hemispheres, cerebellum, medulla oblongata – and their functions. Know that the hypothalamus is the link between the nervous and the endocrine control systems.
			12A.9.12	Know the names, locations and functions of the main endocrine glands of humans.
			12A.9.13	Explain how insulin and glucagon control the blood glucose level and how failure of the system results in diabetes.

Activities

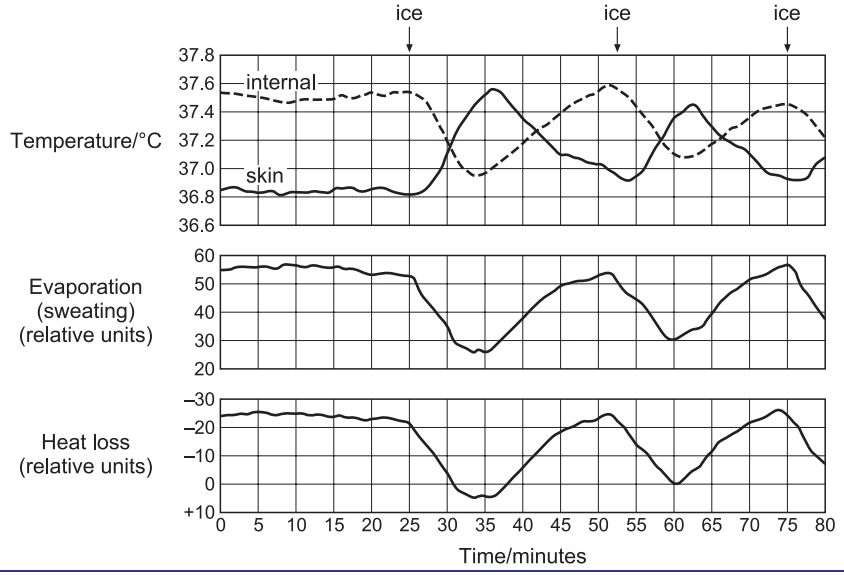
Unit 11AB.3

Objectives	Possible teaching activities	Notes	School resources
1 hour **Responding to environmental stimuli** Explain the importance to the survival of organisms of being able to respond to environmental stimuli.	Introduce this topic by asking students to identify as many environmental stimuli as possible to which mammals are responsive. Expected answers include: light, sound, smell, taste, temperature, pressure, touch, pain, gravity. Ask students the location in the body of the receptors that detect external environmental stimuli. This will identify the main sense organs (eyes, ears, skin, nose and tongue). Ask students why we/mammals are sensitive to these environmental stimuli. Expected answers include 'awareness of the immediate environment'. Now ask why this 'awareness' is important to mammals. Someone should suggest 'increased probability of survival in a changing environment'. Ask students to give examples of how we/mammals increase the chances of survival. Expected answers include: • avoidance of harmful stimuli (e.g. food tasting bad or smelling off); • attraction to other stimuli (e.g. pheromones from female mammals ready for mating); • increasing day length bringing mammals into breeding behaviour at the right time; • predators: finding food by sight, sound, or smell; • prey: avoiding predators by sight, sound or smell.		Use this column to note your own school's resources, e.g. textbooks, worksheets.
	Show students a wildlife video that illustrates a range of ways in which animals detect potential dangers. Ask them to make a note of all the types of stimuli identified and how each impacts on the animal's survival.	**ICT opportunity:** Use of video for illustration.	
	Ask students, in pairs or small groups, to conduct an investigation into taste by blindfolding one subject and asking them to identify food items. This investigation reveals how we often rely on a combination of our senses to identify items.	Enquiry skills 11AB.3.1, 11AB.3.3	
1 hour **Homeostasis** Explain the importance of homeostasis in mammals and describe the process in terms of receptors, effectors and negative feedback.	Introduce the concept of *homeostasis* to students by a brief definition of the principle: 'Homeostasis is the relative constancy of the body's internal environment.' Add historical interest by mentioning the original statement made by the nineteenth-century French physiologist Claude Bernard: 'La fixité du milieu intérieur est la condition de la vie libre.' (The constancy of the internal environment is the condition of the free life.) Ask students why the body's internal environment is likely to change. Make sure they appreciate that the human body is, like all organisms, an open system, since there is an exchange of materials between it and the environment – this will raise the possibility of changes. Examples of factors in the body subject to change are often the easiest illustrations for students to understand. Ask students to suggest internal body factors that are likely to change – they will probably mention temperature, and possibly water and blood sugar too.		

Objectives	Possible teaching activities	Notes	School resources
	Show students an OHT of the fluctuations of Qatar's average monthly temperatures. Briefly outline the changes in the environmental temperatures (e.g. average Qatar summer and winter temperatures) and ask students what the body's normal responses are. Clarify that body temperature does not stay absolutely constant but is allowed to fluctuate above and below a particular value; in other words, homeostasis involves maintaining a *dynamic* equilibrium.	Prepare a suitable OHT. Introduce temperature regulation briefly, but note that this topic is explained in more detail in the section on thermoregulation below.	
	Ask students what they understand by the term *internal environment* of the body. (This usually refers to the tissue fluid surrounding each body cell.)		
	Ask students why maintaining the internal environment within narrow limits is so important to mammals. Their answer should be something like 'it enables mammals to live comfortably in almost any environment and maintain a constant level of activity at all times of the day throughout the year'.		
	The advantages of homeostasis are most easily illustrated by the example of temperature.		
	Ask students to consider two animals, A and B. Animal A has no homeostatic mechanisms and animal B has a range of homeostatic mechanisms. What would be the problems, if any, experienced by animals A and B in a seasonal temperate climate? What differences in behaviour might animal A display compared with animal B?	Animal A may survive the winter by hibernating.	
	Show students an OHT illustrating the homeostatic mechanism in the body and explain the concept of *negative feedback*. Explain the role of the individual components: • receptors or sensors (detect a change in the internal environment); • a regulatory centre (activates effectors); • effectors (reverse the change and bring conditions back to normal again).	Prepare an OHT displaying the general principle of the homeostatic control mechanism with receptors, regulatory centre, effectors and negative feedback.	
	Construct a chart and show students an OHT of a typical mechanical control system using a room thermostat set to a particular temperature. Ask one student to study the scheme and explain it to the class; make sure they refer to negative feedback.	Prepare OHTs of a mechanical control system and a human control system	
	Construct a chart and show students an OHT of a human control system (e.g. regulation of blood pressure). Ask one student to study the scheme and explain it to the class; make sure they refer to negative feedback.		
2 hours **Thermoregulation** Describe thermoregulation in humans and the roles of TRH and TSH.	Show students an OHT of a chart on the regulation of body temperature (*thermoregulation*). Explain the chart. Explain the role of the hypothalamus as the site of the temperature receptors and as the regulatory centre directing the effectors (i.e. blood vessels in the skin, sweat glands, erector pili muscles and thyrotropin releasing hormone (TRH)). Emphasise the process of negative feedback in this example, where the temperature is returned to normal when it fluctuates above and below the relatively stable set point of around 37 °C (36.1 °C to 37.8 °C).	Prepare an OHT of thermoregulation.	
	Show students an OHT diagram of a cross-section of the skin, give each student a copy and then ask them to label the features involved, indicating how each part contributes to the processes in thermoregulation.	Prepare an OHT and student worksheets showing a cross-section of the skin.	
	Ask students, in pairs, to use the Internet, the library or their textbooks to find out how the body loses heat (radiation, conduction, convection and evaporation) or gains heat (radiation, conduction, convection and metabolism). Discuss the heat balance between gain and loss. Ask them to make a table comparing the normal response of the body to over-heating and over-cooling.	**ICT opportunity:** Use of the Internet.	

Objectives	Possible teaching activities	Notes	School resources
	Ask students why involuntary shivering occurs.		
	Ask students to identify the relationship between body temperature and metabolic rate, and to suggest why individuals become less active in warm weather.		
	Use a prepared OHT to explain how metabolism is regulated by the hypothalamus and its production of thyrotropin releasing hormone (TRH), which stimulates thyroid stimulating hormone (TSH) to secrete the hormone thyroxine. (Thyroxine increases the metabolic rate of all the body's cells; heat output is increased by this increase in metabolism.)	Prepare a suitable OHT.	
	Ask students to investigate, in pairs or small groups, the effect of an animal's size on heat loss by comparing the cooling rate of three similar-shaped glass flasks of different sizes that have been filled with warm water.	Use three round-bottomed flasks of different sizes, thermometers and a clock for this investigation.	
	Ask students to investigate the problems of heat balance faced by small babies.	Enquiry skills 11AB.3.1–11AB.3.3	
	Show students a video of human survival in hot and cold conditions. Ask them to research the library or the Internet in order to write an account of how people respond to extreme cold and heat, and survive hypothermia and heat exhaustion.	**ICT opportunities:** Use of video for illustration; use of the Internet.	
	Ask students to work in small groups to write a play about human survival in hot or cold conditions.		
2 hours **Oestrous cycle regulation** Describe the mammalian oestrous cycle and the roles of oestrogen, progesterone, LH and FSH.	Introduce this topic by telling students that the female mammal's reproductive physiology is a carefully synchronised series of events. The events occur in a cycle called the *sexual cycle* or *oestrous cycle.*		
	Ask students to use the library or the Internet to find out about the timing of reproductive behaviour in mammals. Get them to discuss the involvement of breeding seasons for some mammals and the differences in oestrous cycles between mammals.	**ICT opportunity:** Use of the Internet.	
	Show students an OHT diagram summarising the events of the human menstrual cycle: the cycle begins with the menstrual flow (menstruation), ovulation occurs on day 14, and if no fertilisation takes place the uterine lining breaks down again on day 28. The control of the cycle is regulated by hormones to ensure that the production of the ovum is synchronised with the readiness of the uterine lining to receive it, should it be fertilised. The set pattern of events is regulated by hormones from the pituitary gland and the ovaries. The control process is an excellent example of hormone interaction, with the production of one hormone leading to the stimulation or inhibition of another.	Prepare an OHT showing the human menstrual cycle.	
	Ask students to examine an OHT graph showing the fluctuating levels of the pituitary hormones (follicle-stimulating hormone (FSH) and luteinising hormone (LH) – also known as the gonadotrophic hormones) and the ovarian hormones (oestrogen and progesterone) during the oestrous cycle. Explain the sequence of events in the cycle.	Prepare a suitable OHT.	
	Give students a task sheet that outlines all the events of the oestrous cycle with key words missing; ask students to add the missing words.	Prepare task sheets.	
	Provide pairs of students with a series of cards, each containing a statement about an event in the oestrous cycle (e.g. 'the anterior pituitary gland starts to secrete FSH (follicle-stimulating hormone)', or 'the uterine lining becomes more vascularised'). Ask students to arrange these statements in the correct order. Alternatively, give students an A3-size graph summarising the events of the human menstrual cycle and ask them to place the cards on the relevant place on the graph.	Prepare suitable sets of cards.	

Objectives	Possible teaching activities	Notes	School resources
	Ask students to study and interpret data on the levels of hormones in the bloodstream of women over a monthly cycle and compare this with the levels of the same hormones in the bloodstream of pregnant women. Ask students to find out how a home pregnancy test works (the test detects another hormone present in pregnancy – human chorionic gonadotrophin (HCG) – which is secreted by the placenta and found in the urine). Ask students to use the library and the Internet to find out about the hormonal action of the female contraceptive pill. Ask students to use the library and the Internet to complete a table on birth control methods or contraception, such as sterilisation, prevention of ovulation, prevention of implantation, barriers that prevent sperm reaching an egg and natural methods. Tell them to give examples or outline details of each method's action, its advantages and its disadvantages.	Provide data for students. **ICT opportunity:** Use of the Internet.	
2 hours **Nervous and hormonal control systems** Describe the similarities and differences between nervous and hormonal control systems in mammals.	Introduce this topic by asking students to explain how the body's internal environment is kept constant. The recognition of the two coordinating systems – the nervous system and the endocrine (hormonal) system – will quickly be established. Ask students to work in pairs and provide each pair with a series of statements about the nervous and hormonal systems on cards. Ask them to sort the cards into sets of properties that are unique to each system and properties that are common to both systems. Discuss the results together as a class. Explain the similarities of both systems: • both involve the transmission of messages that are originated by stimuli and which produce responses; • both involve chemical secretion (neurotransmitters or hormones); • the hormone adrenaline is almost identical to the neurotransmitter substance noradrenaline from the sympathetic nervous system so has similar effects on the body's organs; • there is close cooperation between them with the hypothalamus acting to manage many of the hormone secretions of the pituitary gland. Explain the differences between the two systems: • the nature of the message – an action potential along a nerve fibre compared with a chemical messenger conveyed through the circulatory system; • speed of conduction of nerve impulses compared with hormones; • speed of response produced; • localised responses of nervous system compared with often widespread responses of hormones; • effector organs (e.g. muscles) are connected by nerves to the nervous system whereas target organs for hormones are only connected by the bloodstream; • short-lived responses in nervous system compared with often long-term responses of hormones; • nervous system involves irregular bursts of nerve impulses whereas hormones are often produced continuously at a steady trickle (e.g. growth hormone).	Prepare suitable sets of cards.	

	Examples of assessment tasks and questions	Notes	School resources
Assessment Set up activities that allow students to demonstrate what they have learned in this unit. The activities can be provided informally or formally during and at the end of the unit, or for homework. They can be selected from the teaching activities or can be new experiences. Choose tasks and questions from the examples to incorporate in the activities.	*Explain the role of negative feedback in homeostasis by reference to the regulation of body temperature.*		
	Produce a table comparing the similarities and differences between the nervous system and the endocrine system.		
	Examine the following graphs; the top graph shows the variations in internal temperature (temperature of the hypothalamus) and skin temperature when the individual is given iced drinks at the intervals indicated; the middle graph shows evaporation through sweating over the same time period; the bottom graph shows heat lost by evaporation (sweating) over the same time period. Explain what the graphs show.  	
	Examine the graph of the hormones involved in the regulation of the oestrous cycle. Explain the control of the oestrous cycle.	Provide students with a suitable graph.	