Biology Summer work 2022

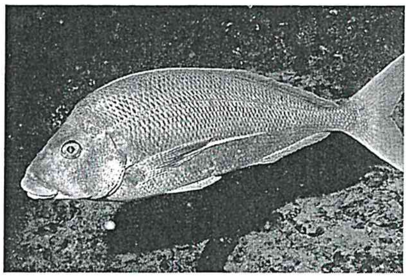
1. Prepare for your September assessment – instructions were sent via email early July.
2. Complete and self-assess the Biozone pages within this pack.
3. Construct and interpret a Kite diagram based upon sand dune data collected 8/7/22 (all instructions with the task). Please collect graph paper for this.
4. Complete the Educake tests to review GCSE studies on topics we will be covering in September. Please ensure you have your correct username before the end of term.

In September please be prepared for your assessment during your first lesson back. Please also bring along your completed Biozone work and Kite diagram.

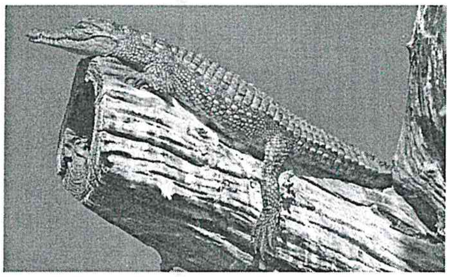
6 Endothermy vs Ectothermy

Key Idea: Ectotherms depend on heat from the environment whereas endotherms generate heat through metabolic activity. Both endotherms and ectotherms may thermoregulate to maintain an optimum temperature for functioning.

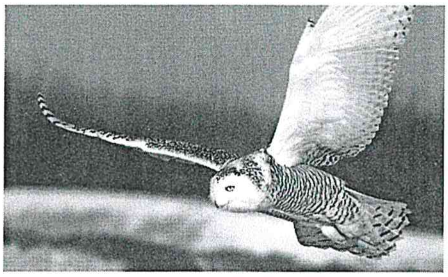
Animals are classified into two broad groups based on the source of their body heat. **Ectotherms** depend on the environment for their heat energy (e.g. heat from the sun) whereas **endotherms** generate most of their body heat from internal metabolic processes. All endotherms and many ectotherms **thermoregulate** (control body temperature) in order to maintain an optimum temperature for the functioning of their metabolic pathways. Ectotherms rely on behavioural mechanisms to do this, whereas in endotherms both behavioural and physiological responses are involved.



Most fish and all amphibians are ectothermic. Unlike many reptiles, they do not thermoregulate, so their body temperature fluctuates with the environment (they are poikilothermic) and they are usually restricted to thermally stable environments.



Reptiles, such as snakes, lizards, and crocodiles, depend on environmental sources of heat energy and regulate body temperature using behaviour. They bask and use body positioning to raise their body temperature for activity. Some larger reptiles maintain a relatively elevated body temperature for a lot of the time.

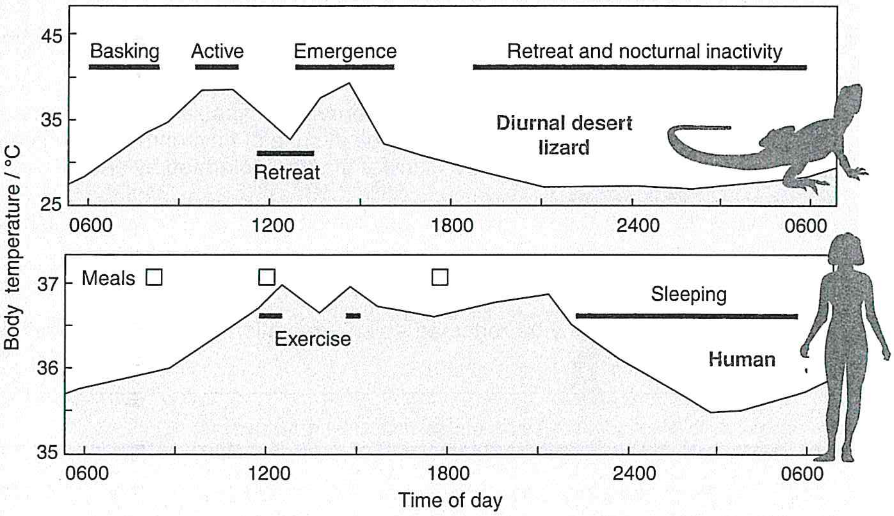


Birds and mammals achieve a high body temperature through metabolic activity and reduction of heat exchanges. They can function independently of the environmental temperature (within the species-specific tolerance range) and maintain high metabolic rates. Their body temperature remains stable (they are homeothermic).

Daily temperature variations in ectotherms and endotherms

Ectotherm: Diurnal lizard
Body temperature is regulated by behaviour so that it does not rise above 40°C. Basking increases heat uptake from the sun. Activity occurs when body temperature is high. Underground burrows are used for retreat.

Endotherm: Human
Body temperature fluctuates within narrow limits over a 24 hour period. Exercise and eating increase body temperature for a short time. Body temperature falls during rest and is partly controlled by an internal rhythm.



1. Distinguish between ectotherms and endotherms in terms of their sources of body heat: ______________________

____

____

2. The diagrams above show daily temperature variations in an ectotherm and an endotherm.

(a) Which animal has the largest temperature variation? ______________________

(b) How does the lizard regulate its body temperature? ______________________

____

____

(c) Describe the effect of eating and exercise on the temperature in humans: ______________________

____

(d) What effect does sleeping have on human body temperature? ______________________

____

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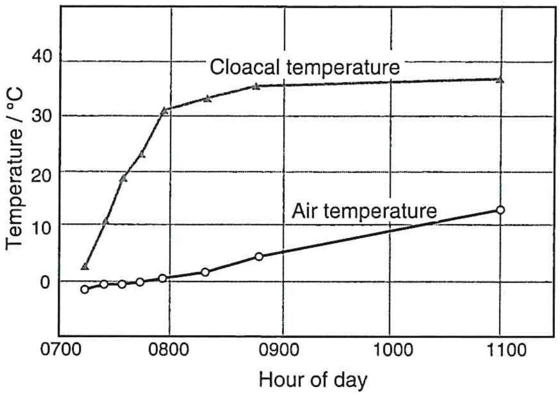
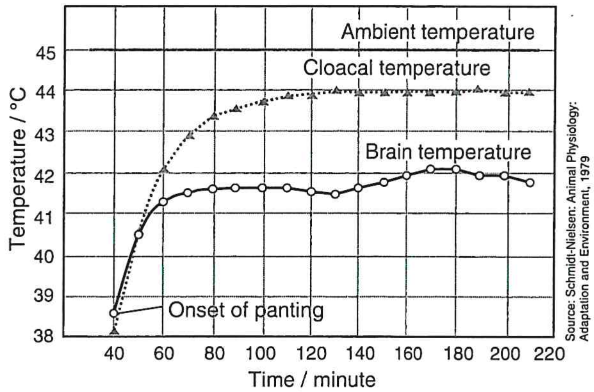
The Peruvian mountain lizard (*Liolaemus*) emerges in the morning when the air temperature is below freezing. By exposing itself to the sun, it rapidly heats up to a body temperature that enables it to be fully active. Once warm, the lizard maintains its preferred body temperature of around 35°C by changing posture and orientation to the sun and thereby controlling the amount of heat energy absorbed.

When the desert lizard, the chuckawalla (*Sauromalus*) is moved from 15°C to 45°C, cloacal and brain temperatures increase rapidly. At ~41°C, these temperatures diverge and the brain stays at ~2°C below the cloacal temperature* and 3°C below air temperature. The chuckawalla achieves this by panting. Its carotid arteries supplying the brain run close to the surface of the pharynx and heat is lost there by evaporative cooling.

*Cloacal temperature measures deep body temperature through the cloaca (equivalent to rectal temperature in mammals)





3. As illustrated in the examples above, ectotherms are capable of achieving and maintaining high, relatively constant body temperatures for relatively long periods in spite of environmental fluctuations. However, they also tolerate marked declines in body temperature to levels lower than are tolerated by endotherms.

   (a) What is the advantage of allowing body temperature to fall when ambient temperature drops? ____________________

   (b) Why might ectothermy be regarded as an adaptation to low or variable food supplies? ____________________

4. (a) In the examples above, the increase in body temperature is very rapid. Why is this important for an ectotherm?

   ____

   (b) What is the purpose of 'panting' in the chuckawalla? ____________________

5. (a) In the generalised graph right, identify the optimum temperature range for an endotherm:

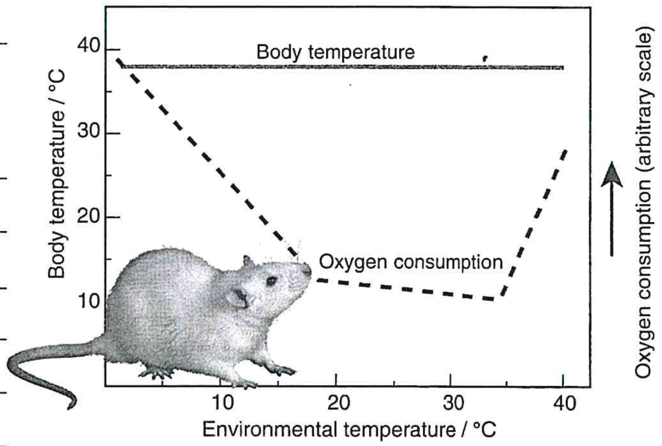
   ____

   (b) Describe the energetic costs of thermoregulation (as measured by oxygen consumption) in an endotherm:

   ____

   (c) Explain why this is the case: ____________________

Body temperature and oxygen consumption in an endotherm at different ambient temperatures



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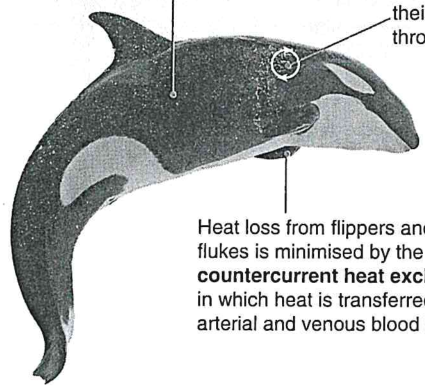
7 Mechanisms of Thermoregulation

Key Idea: Animals thermoregulate by regulating exchanges with the environment and by generating heat from metabolism. To maintain a constant temperature, animals must balance heat losses and gains. Heat exchanges with the environment occur via **conduction** (direct heat transfer), **radiation** (indirect heat transfer), and **evaporation**. Animals employ a range of structural, behavioural, and physiological mechanisms to maintain a body temperature that is optimum for functioning.

Water has a much greater capacity than air to transfer heat away from organisms, so aquatic mammals have heavily insulated surfaces of vascularised fat called blubber (up to 60% of body thickness). Blood is diverted to the outside of the blubber if heat needs to be lost.

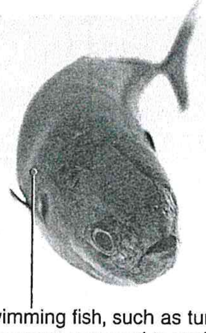


Mammals generate their body heat through metabolism.

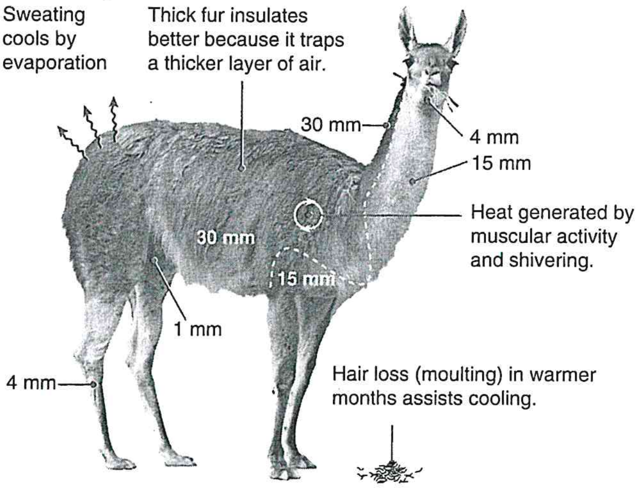
Heat loss from flippers and tail flukes is minimised by the use of **countercurrent heat exchangers** in which heat is transferred between arterial and venous blood flows.

Temperature regulation mechanisms in water

- Heat generation from metabolic activity
- Insulation layer of blubber
- Changes in circulation patterns when swimming
- Large body size
- Heat exchange systems in limbs or high activity muscle



In fast swimming fish, such as tuna, heat exchangers are used to maintain muscle temperatures up to 14°C above the water temperature.



Sweating cools by evaporation

Thick fur insulates better because it traps a thicker layer of air.

Heat generated by muscular activity and shivering.

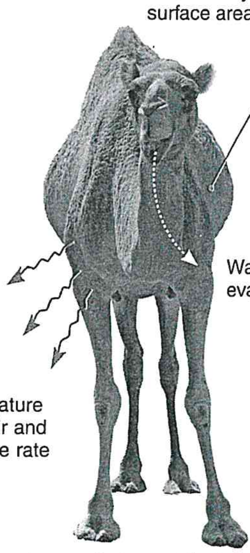
Hair loss (moulting) in warmer months assists cooling.

For most mammals, the thickness of the fur or hair varies around the body (as indicated above). Thermoregulation is assisted by adopting body positions that expose or cover areas of thin fur (the figures above are for the llama-like guanaco).

Temperature regulation mechanisms in air

- Behaviour or habitat choice
- Heat generation from metabolic activity, including shivering.
- Insulation (fat, fur, feathers)
- Circulatory changes including constriction and dilation of blood vessels
- Large body size
- Sweating and panting
- Tolerance of fluctuation in body temperature

Large body size reduces heat loss by lowering the surface area to volume ratio.



Water is lost in evaporative cooling

The greater the temperature gradient between the air and the body, the greater the rate of heat gain (or loss).

Animals adapted to temperature extremes (hot or cold) often tolerate large fluctuations in their body temperature. In well watered camels, body temperature fluctuates less than 2°C, but when they are deprived of water, the body temperature may fluctuate up to 7°C (34°C to 41°C) over a 24 hour period. By allowing their body temperature to rise, heat gain is reduced and the animal conserves water and energy.

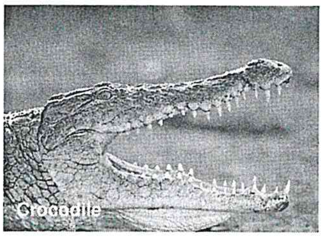
Panting to lose accumulated heat is important in dogs, which have sweat glands only on the pads of their feet.

Circulation changes slow heat loss in water and speed heat gain when basking on land in marine iguanas.

Thick blubber and large body size in seals and other marine mammals provide an effective insulation.

Mammals and birds in cold climates, like the musk oxen above, cluster together to retain body heat.

Behaviours to reduce heat uptake via conduction, e.g. standing on two legs, are important in desert lizards.



Gaping is a behavioural mechanism in large ectotherms to protect the brain from overheating.

Hair, fur, wool, or feathers trap air next to the skin. The air layer slows the loss and gain of heat.

Most mammals can sweat to cool down. Heat is lost when sweat evaporates from the body surface.

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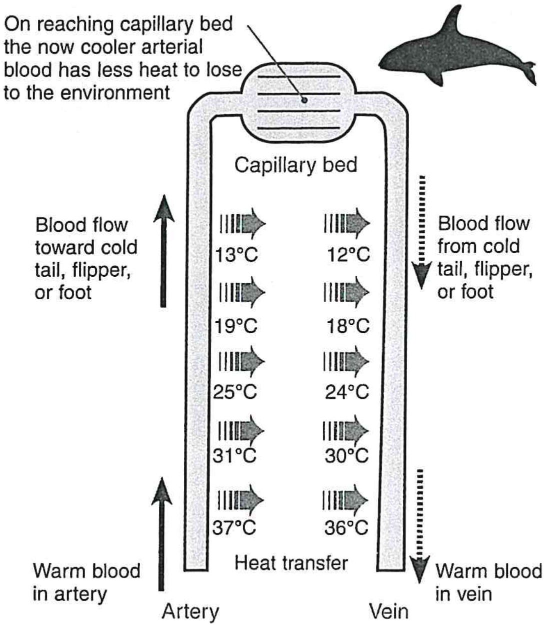

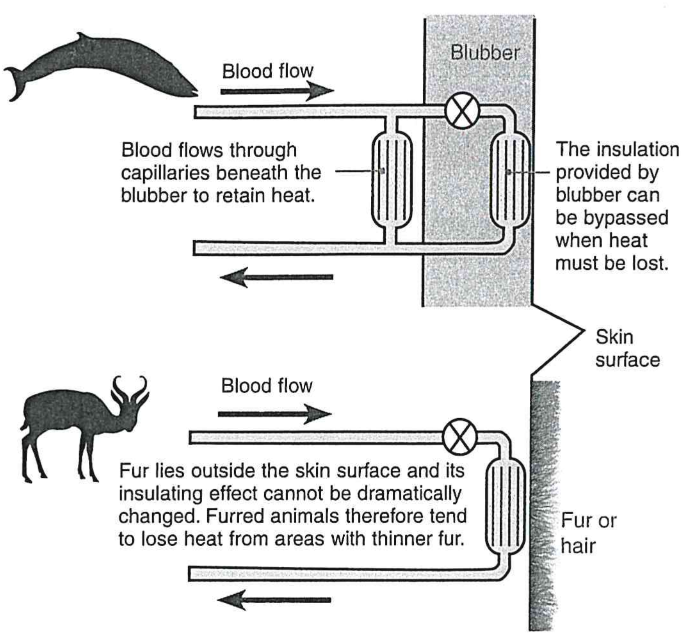

Countercurrent heat exchange systems occur in both aquatic and terrestrial animals as an adaptation to maintaining a stable core temperature. In the flippers and fins of whales and dolphins, and the legs of aquatic birds, they minimise heat loss. In some terrestrial animals adapted to hot climates, the heat exchangers works in the opposite way to prevent the brain from overheating: venous blood cools the arterial blood before it supplies the brain.

Control of blood flow: The blubber in marine mammals provides good insulation against heat loss but presents a problem in warmer waters or during exertion when a lot of metabolic heat is generated. In these situations, blood flows through the blubber to the skin surface where excess heat is dissipated. Cold adapted land mammals have insulation outside the skin and have thinly covered areas on the face and feet, where heat can be lost during exertion.

1. Classify each of the following thermoregulatory mechanisms as primarily structural, physiological, or behavioural:
   (a) Panting in mammals: ______
   (b) Sweating in mammals: ______
   (c) Constriction and dilation of surface blood vessels: ______
   (d) Stilting (raising the body up off the surface) in lizards: ______
   (e) Thick fur, hair, feathers, or blubber: ______
2. (a) How does thick hair or fur assist in thermoregulation in mammals? ______
   (b) Why is fur/hair thickness variable over different regions of a mammal's body? ______
   (c) How would you expect fur thickness to vary between related mammal species at high and low altitude? ______
   (d) How do marine mammals compensate for lack of thick hair or fur? ______
3. Explain how a marine mammal regulates its body temperature when moving from colder to warmer waters: ______
4. Explain how countercurrent heat exchangers help retain body heat in marine mammals: ______

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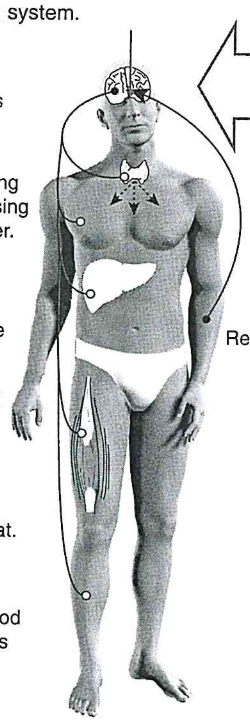
8 Thermoregulation in Humans

Key Idea: In humans, the temperature regulation centre is in the hypothalamus. Thermoregulation relies on negative feedback mechanisms and involves several body systems.

In humans, the temperature regulation centre of the body is in the hypothalamus. It has a 'set point' temperature of 36.7°C. The hypothalamus responds directly to changes in core temperature and to nerve impulses from peripheral temperature receptors in the skin. It then coordinates nervous and hormonal responses to counteract the changes and restore normal body temperature. Like a thermostat, the hypothalamus detects a return to normal temperature and the corrective mechanisms are switched off (negative feedback).

Counteracting heat loss

Heat promoting centre in the hypothalamus monitors fall in skin or core temperature below 35.8°C and coordinates responses that generate and conserve heat. These responses are mediated primarily through the **sympathetic nerves** of the autonomic nervous system.



Thyroxine increases metabolic rate.

Erector muscles of hairs contract, raising the hairs and increasing the insulating air layer.

Under conditions of extreme cold, the hormones adrenaline and thyroxine increase the energy releasing (exergonic) activity of the liver.

Muscular activity, including **shivering** produces internal heat.

Vasoconstriction: Blood vessels to the skin constrict and blood flow to skin decreases keeping warm blood near the core.

Factors causing heat loss

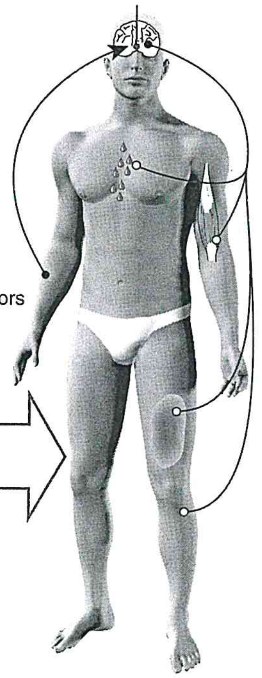
- Wind chill factor accelerates heat loss through conduction.
- Heat loss due to temperature difference between the body and the environment.
- The rate of heat loss from the body is increased by being wet, by inactivity, dehydration, inadequate clothing, or shock.

Factors causing heat gain

- Gain of heat directly from the environment through radiation and conduction.
- Excessive fat deposits make it harder to lose the heat that is generated through activity.
- Heavy exercise, especially with excessive clothing.

Counteracting heat gain

Heat losing centre in the hypothalamus monitors any rise in skin or core temperature above 37.5°C and coordinates responses that increase heat loss. These responses are mediated primarily through the **parasympathetic nerves** of the autonomic nervous system.



Sweating increases, cooling by evaporation.

Muscle tone and metabolic rate decrease, reducing the body's heat output.

Vasodilation: Blood vessels to the skin dilate. Warm blood from the body core is transported to the skin, and heat is lost from the skin surface.

Erector muscles of hairs relax, flattening the hairs to decrease the insulating air layer.

1. Describe two mechanisms by which body temperature could be reduced after intensive activity (e.g. hard exercise):

   (a) ______________________________

   (b) ______________________________

2. Describe the role of the following in regulating internal body temperature:

   (a) The hypothalamus: ______________________________

   (b) The skin: ______________________________

   (c) Nervous input to effectors: ______________________________

   (d) Hormones: ______________________________

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Skin section


Cross section through the skin of the scalp

EII

Blood vessels in the dermis dilate or constrict to promote or restrict heat loss.

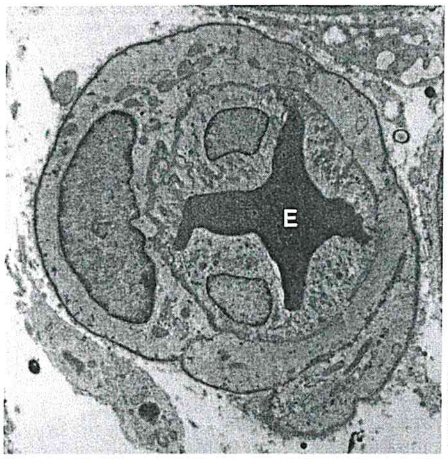
Hairs raised or lowered to increase or decrease the thickness of the insulating air layer between the skin and the environment.

Sweat glands produce sweat, which cools through evaporation.

Fat in the sub-dermal layers insulates the organs against heat loss.

Thermoreceptors in the dermis are free nerve endings, which respond to changes in skin temperature and send that information to the hypothalamus. Hot thermoreceptors detect an increase in skin temperature above 37.5°C and cold thermoreceptors detect a fall below 35.8°C.

Regulating blood flow to the skin



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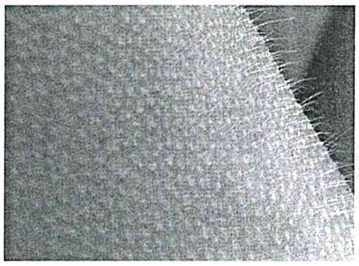
Constriction of a small blood vessel. An erythrocyte (E) (red blood cell) is in the centre of the vessel.

To regulate heat loss or gain from the skin, the blood vessels beneath the surface constrict (**vasoconstriction**) to reduce blood flow or dilate (**vasodilation**) to increase blood flow. When blood vessels are fully constricted there may be as much as a 10°C temperature gradient from the outer to inner layers of the skin. Extremities such the hands and feet have additional vascular controls which can reduce blood flow to them in times of severe cooling.

The hair erector muscles, sweat glands, and blood vessels are the effectors for mediating a response to information from thermoreceptors. Temperature regulation by the skin involves **negative feedback** because the output is fed back to the skin receptors and becomes part of a new stimulus-response cycle.

Left photograph shows vasodilation and sweating in response high temperature or exertion.
Right photograph shows vasoconstriction and goosebumps in response low temperature or inactivity.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3. (a) What is the purpose of sweating and how does it achieve its effect?

   (b) Why does a dab of methanol or ethanol on the skin feels cold, even if the liquid is at room temperature?

4. Describe the feedback system that regulates body temperature:

5. How do the blood vessels help to regulate the amount of heat lost from the skin and body?

6. (a) What is the role of subcutaneous fat in temperature regulation in humans:

   (b) Why do excessive deposits of fat tend to lead to overheating during exercise?

1. Homeostasis (page 5)

1. Homeostasis is the relatively constant internal state of an organism, even when the external environment is changing.
2. (a) Detects a change in the environment and sends a message (electrical impulse) to the control centre.
   (b) Receives messages send from the receptor, processes the sensory input and coordinates an appropriate response by sending a message to an effector.
   (c) Responds to the message from the control centre and brings about the appropriate response, e.g. muscle contraction or secretion from a gland.

2. Maintaining Homeostasis (page 6)

1. Two mechanisms operating to restore homeostasis after infection (a and b any two of):
   - Immune system response with the production of antibodies against the antigens of the pathogen (humoral response).
   - Immune system response with the production of T cells which recognise the antigens of the pathogen and destroy them directly (cell-mediated response).
   - Local inflammatory response (redness, pain, swelling, heat) at the site of infection.
   - Fever (widespread increase in body temperature).
   - The production of antimicrobial substances such as interferon and interleukin-1.
   - Phagocytosis of pathogen by white blood cells.

   All the above aim to destroy the pathogen and/or its toxins and assist a return to homeostasis.
2. Two mechanisms by which responses to stimuli are brought about and coordinated (a and b in any order):
   (a) Hormonal response to stimuli: endocrine glands respond to a stimulus (e.g. a nerve impulse or another hormone or metabolite) by producing hormones which bring about an appropriate physiological response.
   (b) Nervous response to stimuli: direct stimulation of nerves from a sensory receptor causes a reaction to the stimulus. This may be a response requiring interpretation of the message by the brain or it may be a reflex.
3. Two ways in which water and ion balance are maintained, and the organs and hormones involved:
   (a) Water and ions are taken in with food and drink, helping to replace that lost through urine, faeces, and sweat. The digestive organs and digestive hormones are all involved in digestion and absorption processes.
   (b) The kidneys are the primary regulator of fluid and ions. When large quantities of fluid must be excreted, the kidney produces large amounts of dilute urine. When water must be conserved, small amounts of concentrated urine are produced. ADH (antidiuretic hormone) causes more water to be reabsorbed from the kidney (concentrating the urine). ADH secretion increases when blood volume is low. Essential ions (and glucose) are retained by active reabsorption from the kidney tubules. Another hormone, aldosterone from the adrenal glands, increases the absorption of Na^+ ions.
4. Two ways in which the body regulates its respiratory gases during exercise:
   (a) Increasing the rate of breathing. This increases both the rate of oxygen entering the lungs and the rate at which CO_2 leaves. It also increases the rate of loading and unloading of oxygen and CO_2 into and out of the blood.
   (b) Increasing the heart rate. This increases blood flow, which facilitates the loading and unloading of oxygen and CO_2 into and out of the blood. It also increases the speed of delivery of oxygen to working tissues (e.g. muscles) and speeds up the removal of CO_2 and other products of metabolism.

3. Cell Signalling (page 8)

1. (a) **Endocrine signalling** involves a hormone being carried in the blood between the endocrine gland/organ where it is produced to target cells.
   (b) **Paracrine signalling** involves cell signalling molecules being released to act on target cells in the immediate vicinity, e.g. at synapses or between cells during development.
   (c) **Autocrine signalling** involves cells producing and reacting to their own signals (e.g. growth factors from T cells stimulate production of more T cells).
2. The three signalling types all have in common some kind of chemical messenger or signal molecule (ligand) and a receptor molecule (on the target cells, which may or may not be on the cell producing the signal).

4. Negative Feedback (page 9)

1. Negative feedback mechanisms are self-correcting (the response counteracts changes away from a set point) so that fluctuations are reduced. This stabilises physiological systems against excessive change and maintains a steady state.
2. (a) A: Eating or food entering the stomach.
   B: Emptying of stomach contents.
   (b) The smooth muscles in the stomach wall.
   (c) An empty stomach.

5. Positive Feedback (page 10)

1. (a) Positive feedback has a role in amplifying a physiological process to bring about a particular response. Examples include (1) elevation in body temperature (fever) to accelerate protective immune responses, (2) positive feedback between oestrogen and LH to leading to an LH surge and ovulation, (3) positive feedback between oxytocin and uterine contractions: oxytocin causes uterine contraction and stretching of the cervix, which causes more release of oxytocin and so on until the delivery of the infant, (4) positive feedback in fruit ripening where ethylene accelerates ripening of nearby fruit.
   (b) Positive feedback is inherently unstable because it causes an escalation in the physiological response, pushing it outside the tolerable physiological range. Compare this with negative feedback, which is self correcting and causes the system to return to the steady state.
   (c) Positive feedback loops are normally ended by a resolution of situation causing the initial stimulation. For example, the positive feedback loop between oestrogen and LH leading to ovulation is initiated by high oestrogen levels and ended when these fall quickly after ovulation, prompting a resumption of negative feedback mechanisms. In childbirth, once the infant is delivered, the stretching of the cervix ceases and so too does the stimulation for more oxytocin release.
   (d) When positive feedback continues unchecked, it can lead to physiological collapse. One example includes unresolved fever. If an infection is not brought under control (e.g. by the body's immune system mechanisms or medical intervention), body temperature will continue to rise and can lead to seizures, neurological damage, and death.

6. Endothermy vs Ectothermy (page 11)

1. Ectotherms depend on the environment for their heat. Endotherms generate heat from their internal metabolism.
2. (a) The lizard (ectotherm)
   (b) By basking in the sun (to heat up) and retreating to shade (to cool down).
   (c) Eating and exercise cause a rise in body temperature.
   (d) Sleeping generally causes the reduction of body temperature.
3. (a) Allowing body temperature to fall saves energy because the animal does not have to maintain body temperature against environmental variation.
   (b) Ectothermy saves energy because ectotherms are not physiologically committed to maintaining a high metabolic rate. Lower metabolic rates are advantageous when food supplies are low (less energy is required for maintenance).
4. (a) Raising body temperature quickly is important as it allows activity, e.g. for hunting or escaping danger. It also increases the rate and efficiency of metabolic processes

such as digestion.
(b) Panting causes evaporative cooling and helps to keep the temperature of the brain lower than the rest of the body.

5. (a) Optimum temperature range for an endotherm is from 18° or 19°C to 36°C. Between these temperatures, oxygen consumption, and therefore energy expenditure, is lowest.
(b) Below 15°C more energy is required to maintain body temperature against heat loss. Above 35°C, more energy is used to dissipate excess heat.
(c) Warming the body, e.g. by shivering, requires muscle movement. Panting requires muscle movement. Cooling by sweating uses cellular energy because secretion (of sweat) is an active process.

7. Mechanisms of Thermoregulation (page 13)

1. (a) Behavioural
(b) Physiological
(c) Physiological
(d) Behavioural
(e) Structural

2. (a) Thick hair reduces heat loss by trapping an insulating layer of air between the animal and the cooler environment. The insulating layer of hair also reduces heat gain from the environment.
(b) Different fur thicknesses allow an animal to expose or cover thinner areas to allow for greater of lower heat loss depending on needs.
(c) Related species at low altitude could be expected to have less thick and less dense fur covering than animals at high altitude.
(d) They have thick blubber and are usually large.

3. In warmer waters, blood is allowed to flow above the blubber layer, letting heat dissipate into the water.

4. Use of countercurrent heat exchange in marine mammals means most of the heat in the blood moving towards the skin of the extremity is transferred to the blood moving away from the skin of the extremity before the blood reaches the coldest part of the body. Therefore the blood is already cooler by the time it reaches the coldest part of the body and no heat is lost to the environment and the blood is warmed again before returning to the body's core.

8. Thermoregulation (page 15)

1. Body temperature reduced by ((a) and (b) any two of):
• Sweating (cooling by evaporation) • Reducing activity (reduces metabolic rate) • Behavioural mechanisms such as removing clothing or seeking shade • Increasing blood flow to skin (leads to increased radiation from the skin surface).

2. (a) Hypothalamus: Monitors temperature changes in the body and coordinates appropriate responses to counteract the changes.
(b) Skin: Detects changes in skin temperature and relays the information to the hypothalamus. In response to input from the hypothalamus, muscles and capillaries in the skin act as effectors to bring about an appropriate thermoregulatory response.
(c) Nervous input to effectors (from hypothalamus): Brings about (through stimulation of muscles) an appropriate thermoregulatory response (e.g. raising hairs, constricting blood vessels).
(d) Hormones: Mediate a change in metabolic rate through their general action on body cells (adrenaline and thyroxine increase metabolic rate).

3. (a) Sweating cools the body by using heat energy transported from the body's core to the skin to evaporate the sweat.
(b) Methanol and ethanol both have very low temperatures of vaporisation. They feel cold because they absorb heat energy easily and vaporise quickly, rapidly removing heat energy from the skin.

4. Sensory receptors in the skin detect changes in temperature and send signals to the hypothalamus which initiates responses to counteract the changes. Restoration of the normal body temperature leads to reduced sensory output and the responses are switched off (negative feedback).

5. Blood vessels can constrict (reduce blood flow) or dilate (increase blood flow) to regulate the amount of blood flowing from the body to the skin and back. This regulates temperature by regulating the amount of heat moving from the body's core to the skin's surface where heat is lost.

6. (a) Subcutaneous fat helps to insulate the body and reduce heat loss to the environment.
(b) Excessive fat does not allow heat to be dissipated easily, making the body more likely to overheat during exercise.

9. Chapter Review (page 17)

No model answer. Summary is the student's own.

10. Key Terms: Did You Get It?(page 18)

1. ectotherm (I), effector (D), endocrine signalling (C), endotherm (L), homeostasis (A), negative feedback (F), paracrine signalling (E), positive feedback (J), receptor (H), response (B), stimulus (K), thermoregulation (G).

2. A: Type of mechanism: Positive feedback
Mode of action: Escalation (increase) of the physiological response away from the steady state condition. Once the outcome is achieved, the positive feedback ends.
Biological example: Fruit ripening, fever, labour, blood clotting.

B: Type of mechanism: Negative feedback
Mode of action: Has a stabilising effect, maintains a steady state by counteracting variations from the normal set point.
Biological example: Regulation of body temperature, blood glucose, and blood pressure.

11. Waste Products in Humans (page 20)

1. Excretion enables the toxic by-products of metabolism (CO_2, nitrogenous wastes, excess ions) as well as drugs and poisons to be removed before they can disrupt functioning of organ systems.

2. **Carbon dioxide**: Origin: All metabolising cells.
Organ of excretion: Lungs.
Water: Origin: All metabolising cells.
Organs of excretion: Lungs, kidneys, gut, skin.
Bile pigments: Origin: Breakdown of haemoglobin in liver.
Organ of excretion: Gut. The breakdown product passes out in the faeces.
Urea: Origin: Produced in the liver from ammonia (resulting after breakdown of amino and nucleic acids). Organs of excretion: Kidneys, skin.
Ions: Origin: General result of cellular metabolism. Organs of excretion: Kidneys, skin, gut.
Hormones: Origin: Endocrine organs, sometimes ingested (synthetic hormones and anti-inflammatories). Organs of excretion: Kidneys, skin.
Poisons: Origin: Ingested or inhaled from external sources.
Organs of excretion: Kidneys.
Drugs: Origin: Ingested or inhaled from external sources.
Organs of excretion: Kidneys.

3. The liver produces urea from ammonia (urea cycle) and bile pigments from the breakdown of haemoglobin.

4. – Problems with fluid retention: oedema and retention of fluids containing toxins and waste products.
– Problems with salt retention leading to hypertension and heart problems as the heart works harder to move the blood through constricted vessels.
– Problems with the retention of ions other than sodium leading to the toxic effects of high ion levels.
– Poisoning of the body with its own metabolic wastes eventually leads to coma and death.

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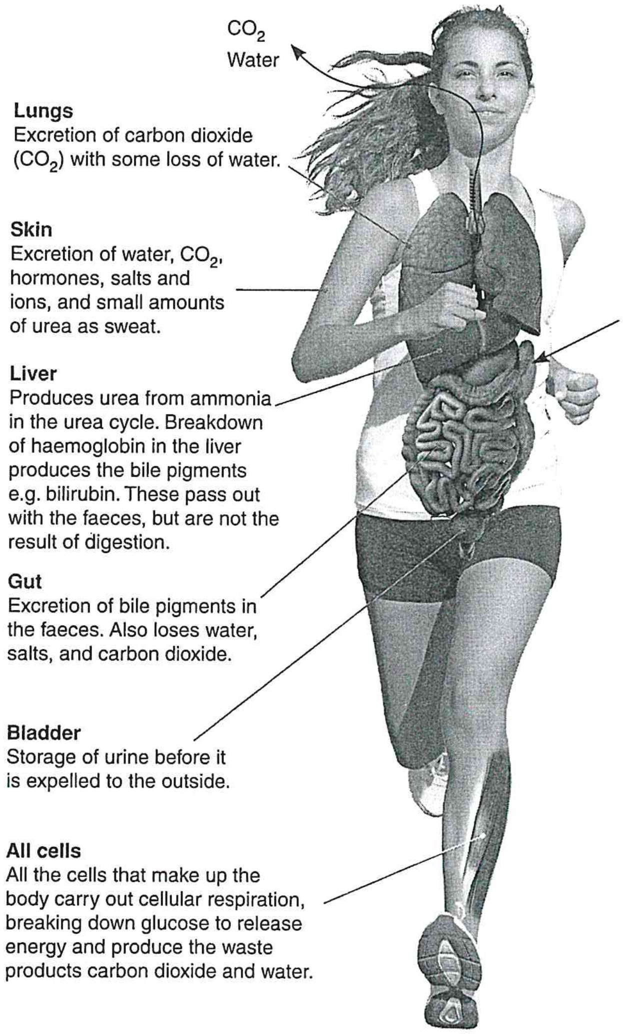
11 Waste Products in Humans

Key Idea: Metabolism produces a number of waste products that must be excreted from the body. Excretion is primarily the job of the kidneys although other organs also play a role. **Excretion** refers to the elimination from the body of the waste products of metabolism. It should not be confused with the elimination or egestion of undigested and unabsorbed food material from the gut. In mammals, a number of organs are involved in excretion, primarily the kidneys, which produce urine, but also the liver, lungs, and skin. The liver is particularly important in processing wastes, particularly in detoxifying poisons, breakdown of haemoglobin, and forming **urea** from ammonia. Note that the breakdown products of haemoglobin are excreted in bile and pass out with the faeces, but they are not the result of digestion.



Excretion in humans

In mammals, the kidneys are the main organs of excretion, although the liver, skin, and lungs are also important. As well as ridding the body of nitrogenous wastes, the kidneys also regulate pH and excrete many toxins that are taken in from the environment. Many toxic substances, such as alcohol, are rendered harmless by detoxification in the liver, but the kidneys can also eliminate some by actively secreting them into the urine.

Substance	Origin*	Organ(s) of excretion
Carbon dioxide		
Water		
Bile pigments		
Urea		
Ions (K^+, HCO_3^-, H^+)		
Hormones		
Poisons		
Drugs		

*Origin refers to from where in the body each substance originates

1. Explain the need for excretion: ______________________________

2. Complete the table above summarising the origin of excretory products and the main organ(s) of excretion for each.

3. What is the role of the liver in excretion, even though it is not primarily an excretory organ? ______________________________

4. Based on the information on this page, predict the effects of kidney failure: ______________________________

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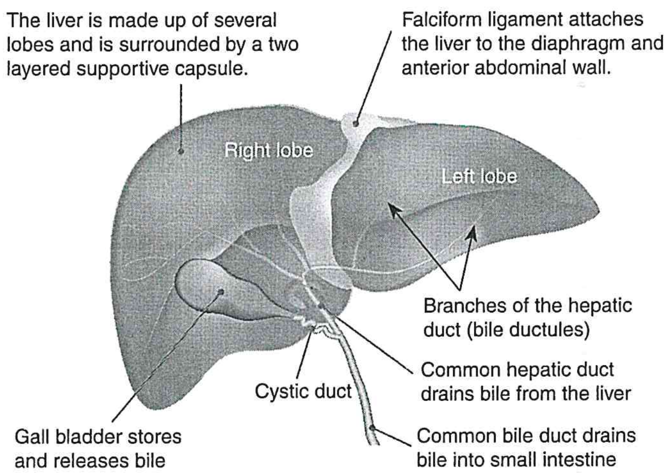
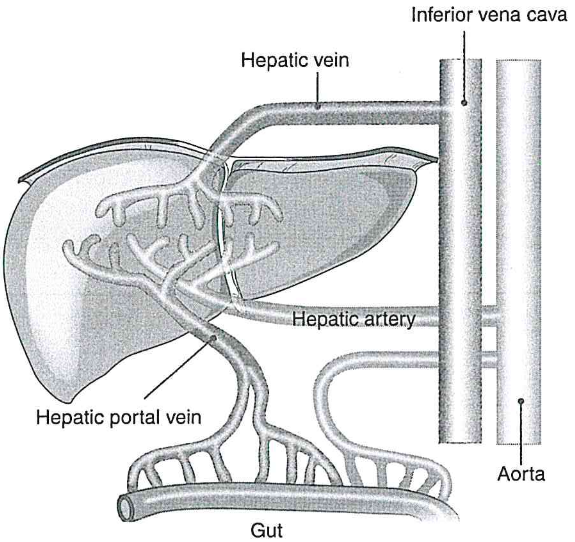
12 The Structure and Role of the Liver

Key Idea: The liver has both homeostatic and digestive functions. It receives a double blood supply and has a simple internal structure, made up of repeating units called lobules. The liver the largest homeostatic organ. It is located just below the diaphragm and makes up 3-5% of body weight. It performs a vast number of functions including production of bile, storage and processing of nutrients, and detoxification of poisons and metabolic wastes. The liver receives a dual blood supply from the hepatic portal vein and hepatic arteries, and up to 20% of the total blood volume flows through it at any one time. This rich vascularisation makes it the central organ for regulating activities associated with the blood and circulatory system. In spite of its many functions, the liver tissue and the hepatocytes (liver cells) themselves are structurally relatively simple. Features of liver structure and function are outlined below.

The gross structure of the liver

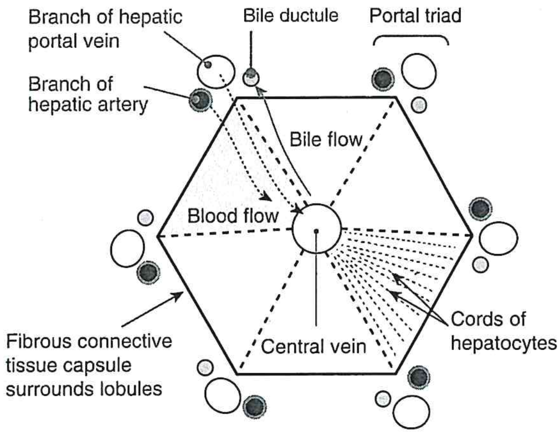




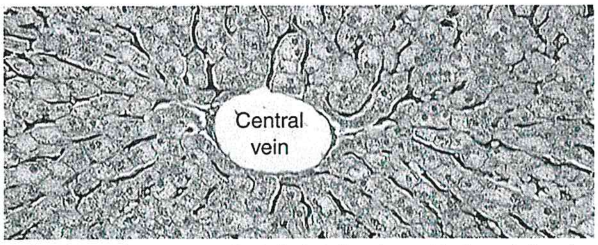
The liver has a double blood supply. The hepatic portal vein brings nutrient-rich blood from the gut, and the hepatic artery branches from the aorta to supply the liver with oxygen-rich blood. The hepatic vein drains the liver to return blood to heart via the vena cava. Branches of the hepatic artery, hepatic portal vein, and hepatic duct form the portal triads surrounding each functional unit (lobule) of the liver (right).

Homeostatic roles of the liver

- Hepatocytes secrete bile, which emulsifies fats in digestion.
- Metabolises amino acids, fats, and carbohydrates.
- Synthesises glucose from non-carbohydrate sources.
- Stores iron, copper, and some vitamins (A, D, E, K, B_{12}).
- Synthesises cholesterol from acetyl coenzyme A.
- Converts unwanted amino acids to urea (ornithine cycle).
- Manufactures heparin and plasma proteins (e.g. albumin).
- Detoxifies poisons or turns them into less harmful forms.
- Some liver cells phagocytose worn-out blood cells.



Liver tissue comprises many roughly hexagonal units called **lobules**. Cords of hepatocytes radiate from a central vein. Portal triads are arranged around the lobule boundary. Blood flows in sinusoids between the cords of hepatocytes towards the central vein. Bile flows in the opposite direction to the bile ductules.



This photo shows part of a lobule. The sinusoids (specialised capillaries) are the dark spaces between the rows of hepatocytes.

1. What cells produce bile? ______________________________

2. (a) State one vascular function of the liver: ______________________________

   (b) State one metabolic function of the liver: ______________________________

   (c) State one digestive function of the liver: ______________________________

   (d) State one excretory function of the liver: ______________________________

   (e) State one storage function of the liver: ______________________________

3. What is the basic functional unit of the liver? ______________________________

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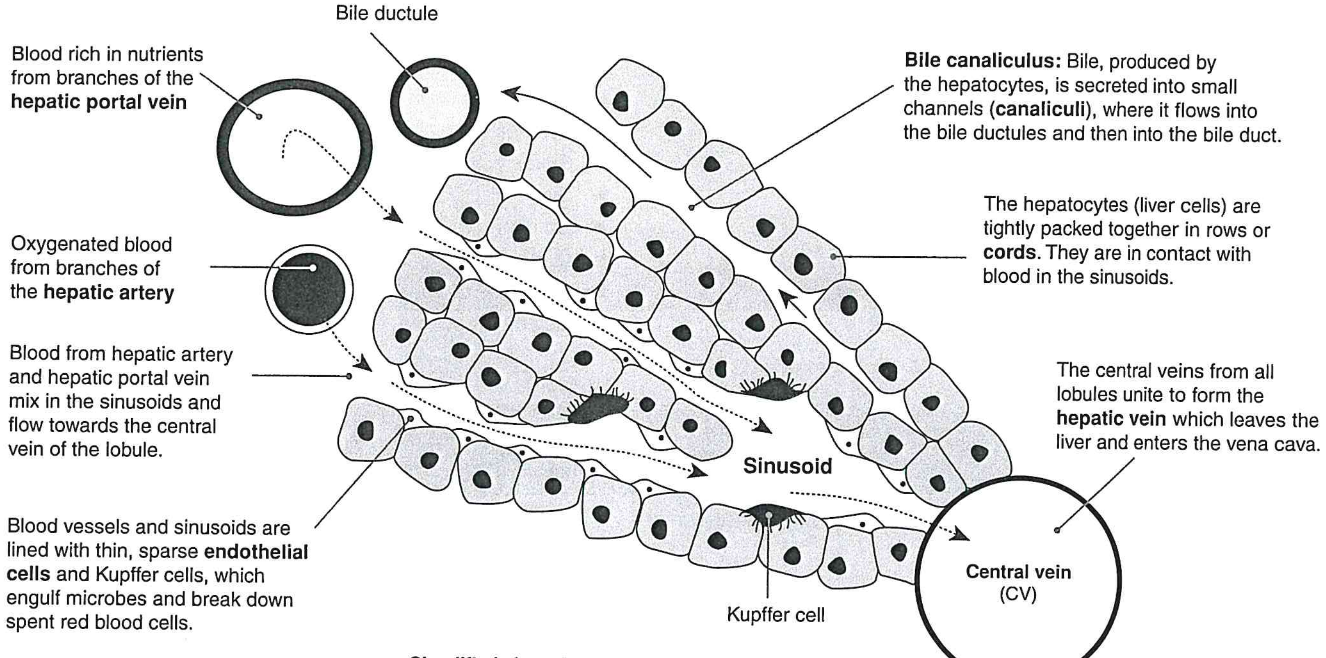
13 The Histology of the Liver

Key Idea: Liver lobules are made up of mostly of hepatocytes. These receive blood via sinusoids, which transport blood from the hepatic portal vein and hepatic artery to the central vein. The functional repeating unit of the liver is the **lobule**, which is made up of tightly packed rows (cords) of liver cells radiating from a central vein and surrounded by small blood vessels called sinusoids. Branches of the hepatic artery and the hepatic portal vein supply the lobules. This highly vascular structure is a reflection of the liver's important role as dynamic blood reservoir, able to both store and release blood as required. More than half of the 10-20% of the total blood volume normally in the liver resides in the sinusoids. Sinusoids are similar to capillaries but have a more porous endothelium. The increased permeability of the sinusoids allows small and medium-sized proteins, such as albumin, to readily enter and leave the bloodstream.



Simplified view of part of a liver lobule to show the direction of blood and bile flow

1. State the two sources of blood supply to the liver, describing the primary physiological purpose of each supply:

   (a) Supply 1: ______________________ Purpose: ______________________

   (b) Supply 2: ______________________ Purpose: ______________________

2. Briefly describe the role of the following structures in liver tissue:

   (a) Bile canaliculi: ______________________

   (b) Phagocytic Kupffer cells: ______________________

   (c) Central vein: ______________________

   (d) Sinusoids: ______________________

3. Explain the significance of the venous supply to the liver through the hepatic portal system: ______________________

4. Describe how the histology of the liver contributes to its considerable ability to serve as a blood storage organ:

5. Explain the significance of the leaky endothelium of the sinusoids: ______________________

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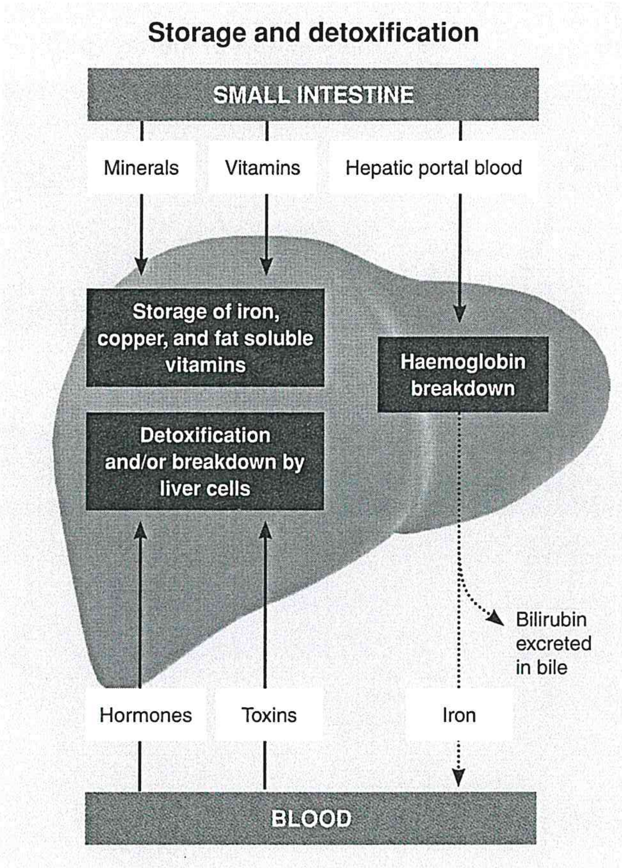
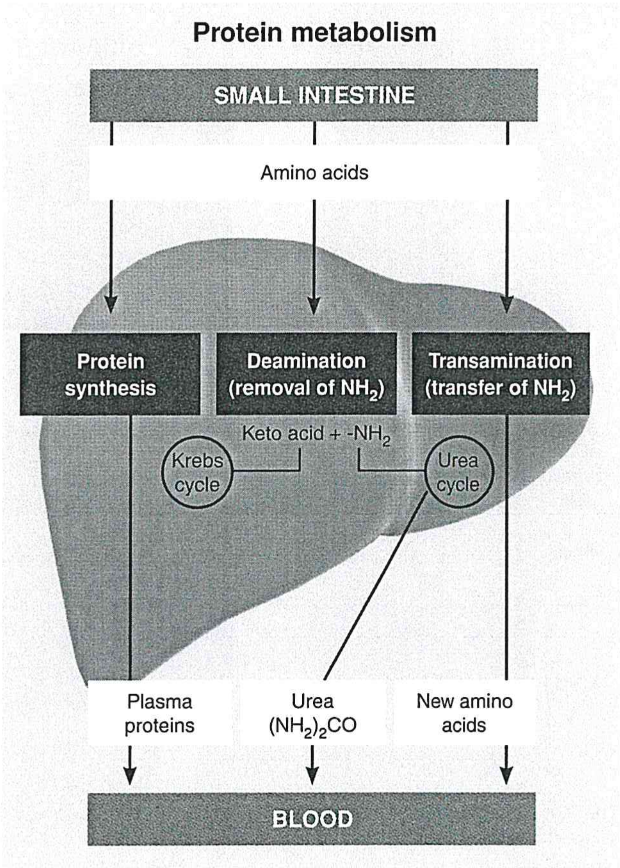
14 The Liver's Role in Protein Metabolism

Key Idea: The liver has a crucial role in the metabolism of proteins and the storage and detoxification of hormones and ingested or absorbed poisons (including alcohol).

The most critical aspects of protein metabolism occurring in the liver are deamination and transamination of amino acids, removal of ammonia from the body by synthesis of urea, and synthesis of non-essential amino acids. Hepatocytes are responsible for synthesis of most of the plasma proteins, including albumins, globulins, and blood clotting proteins. Urea formation via the ornithine cycle occurs primarily in the liver. The urea is formed from ammonia and carbon dioxide by condensation with the amino acid ornithine, which is recycled through a series of enzyme-controlled steps. Urea is transported in the blood to the kidneys and excreted.





1. Describe three aspects of protein metabolism in the liver:

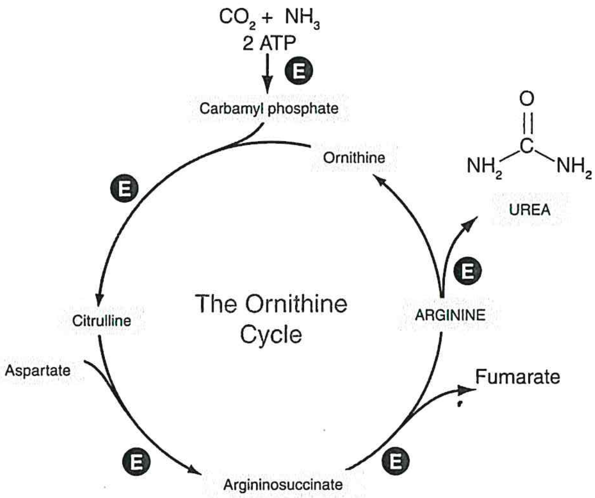
   (a) ____

   (b) ____

   (c) ____

2. Identify the waste products arising from deamination of amino acids and describe their fate:

3. An X-linked disorder of the ornithine cycle results in sufferers lacking the enzyme to convert ornithine to citrulline. Suggest what the symptoms and the prognosis might be:



Ammonia (NH_3), the product of protein metabolism, is toxic in even small amounts and must be removed. It is converted to the less toxic urea via the ornithine cycle and is excreted from the body by the kidneys. The liver contains a system of carrier molecules and enzymes (**E**) which quickly convert the ammonia (and CO_2) into urea. One turn of the cycle consumes two molecules of ammonia (one comes from aspartate) and one molecule of CO_2, creates one molecule of urea, and regenerates a molecule of ornithine.

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12. The Structure and Role of the Liver (page 21)

1. Hepatocytes
2. (a) Vascular functions (one of):
   Manufactures heparin and blood proteins.
   Acts as a reservoir of blood, being able to store and release blood as required to maintain blood volume.
   (b) Metabolic functions (one of):
   Central to the metabolism of amino acids (e.g. deamination), fats (gluconeogenesis), and carbohydrates (e.g. glycogenolysis, glycogenesis). Synthesises cholesterol.
   Stores minerals and vitamins.
   Detoxifies poisons.
   (c) Digestive function: Secretes biles for the emulsification of fats.
   (d) Excretory functions (one of):
   Produces urea from amino acids for excretion of nitrogen
   Excretes hormones
   Metabolises haemoglobin which is excreted in the bile.
   (e) Storage functions (one of):
   Stores blood
   Stores iron, copper, and vitamins (A, D, E, K, B_{12}).
3. The lobule

13. The Histology of the Liver (page 22)

1. (a) **Supply 1**: Branches of the hepatic artery. **Purpose**: Supply of oxygen and nutrients to the liver tissue.
   (b) **Supply 2**: Hepatic portal vein. **Purpose**: Brings nutrient-rich blood to the liver for processing by the liver cells.
2. (a) **Bile canaliculi**: Carry the bile (secreted by the hepatocytes) to the bile ductules where it then flows into the bile duct.
   (b) **Phagocytic Kupffer cells**: Engulf microbes and break down spent red blood cells.
   (c) **Central vein**: Carries blood (mix of hepatic portal and arterial blood) that has passed through the liver lobule to the hepatic vein (which exits the liver).
   (d) **Sinusoids**: Blood spaces that carry the mix of hepatic portal and arterial blood through the lobules, for processing, and supply of oxygen and nutrients.
3. Venous supply through the hepatic portal system provides a supply of nutrient-rich blood from the gut directly to the liver for processing.
4. The liver is richly vascularised with a system of capillary-like sinusoids ramifying throughout. At any one time, more than half of the 10-20% of liver's volume is in the sinusoids.
5. Sinusoids are leakier than capillaries so small and medium sized proteins can easily leave and enter the blood. This facilitates exchanges between the blood and the hepatocytes.

14. The Liver's Role in Protein Metabolism (page 23)

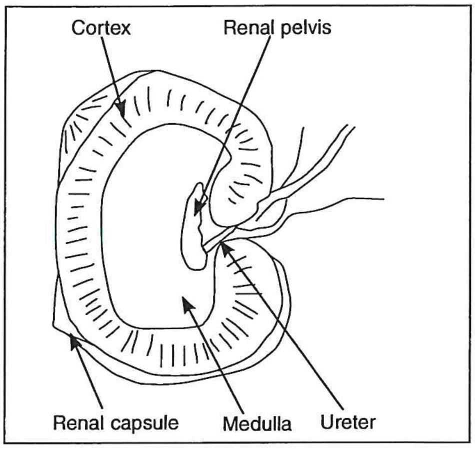
1. Aspects of protein metabolism (a-c in any order):
   (a) Transamination of amino acids to create new, non-essential amino acids.
   (b) Deamination of excess amino acids and production of urea in the urea cycle.
   (c) Synthesis of plasma proteins.
2. Deamination produces keto acids and an amino group. The keto acids feed into the Krebs cycle and are oxidised to yield ATP. NH_2 is converted to ammonia (toxic) and joins with CO_2 and enters the ornithine cycle to produce urea.
3. Symptoms would be a build up of ammonia in the tissues and, unless addressed by management of diet to minimise protein content, it would be fatal.

15. The Urinary System (page 24)

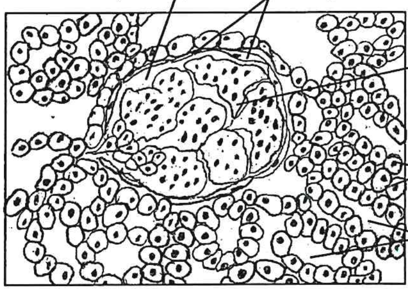
1. (a) Kidney: produces urine and regulates blood volume.
   (b) Ureters: convey urine to the bladder
   (c) Bladder: stores urine
   (d) Urethra: conveys urine to the outside
   (e) Renal artery: carries blood from aorta to kidney. Supplies the kidney with blood carrying oxygen and urea.
   (f) Renal vein: carries blood from kidney to vena cava. Returns blood from the kidney to the venous circulation.
   (g) Renal capsule: covers the kidney and protects it against trauma and infection.
2. 99.4%
3. (a) A nephron is the selective filtering element in the kidney. It is the functional unit of the kidney.
   (b) The nephron produces a filtrate from the blood, modifies the filtrate and produces the final excretory fluid (urine).
4. (a) Transitional epithelium is found in the bladder.
   (b) It means the walls of the bladder can be stretched without the outer cells breaking apart from one another.
5. The sphincter allows the voluntary voiding of urine (urination or micturition).

16. Drawing the Kidney (page 26)

Task 1: Student's own drawing.



Task 2: Student's own drawing. Points to note:
- Cells should be drawn with unbroken lines and not overlapping.
- Cell borders may sometimes be inferred from the positions of the nuclei.
- Structures to label include tubule lumen, cuboidal cells lining tubules, Bowman's capsule, squamous epithelium lining capsule, lumen of capsule.



17. The Physiology of the Kidney (page 27).

1. The high blood pressure is needed for ultrafiltration, i.e. to force small molecules such as water, glucose, amino acids, sodium chloride and urea through the capillaries of the glomerulus and the basement membrane and epithelium of Bowman's capsule.
2. (a) Glomerular filtration: Produces an initial filtrate of the blood that is similar in composition to blood and can be modified to produce the final urine.
   (b) Active secretion: Secretion allows the body to get rid of unwanted substances into the urine.
   Explanatory detail: Active secretion of chloride in the ascending limb (with sodium following passively) contributes to the maintenance of the salt gradient in the extracellular fluid (this gradient allows water to be

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Year 12 Summer Work 2022 – Kite Diagrams

Data Sets from Botany Bay Field Trip Required

1. Species distribution along the sand dune transect

Links to help:

How to Make a Kite Graph Video

https://www.youtube.com/watch?v=_yKtAHhTF50

How to Draw a Kite Diagram

https://slidetodoc.com/kite-diagrams-kite-diagrams-are-a-visual-picture/

Khan Academy Ecological Succession

https://tinyurl.com/s5aett6v

Sand Dunes Succession

https://www.biology-fieldwork.org/a-level/succession/sand-dunes/

Activity - Kite Diagrams

A kite diagram can be used to compare the distribution of different species along a transect.

Watch the video linked above. Draw one kite diagram to show the distribution of different species (plants) along the sand dune transect

Guidance:

- You must hand-draw your kite diagram using graph paper, a pencil and a ruler
- You must include a table showing the original data used
- You must include a scale showing how many organisms each box represents. If you have a particularly large number of organisms for one species in your data you may need to draw separate kite diagrams with different scales
- Include a clear and descriptive title and axis labels
- Plan your diagram carefully to ensure your 'kites' will not overlap
- Write a paragraph summarising what your kite diagram shows. Link this to the change in the following abiotic factors as you move along the transect –salinity, soil stability, mineral content, water content