HUMAN BIOLOGY

UNIT 3

Endocrine System

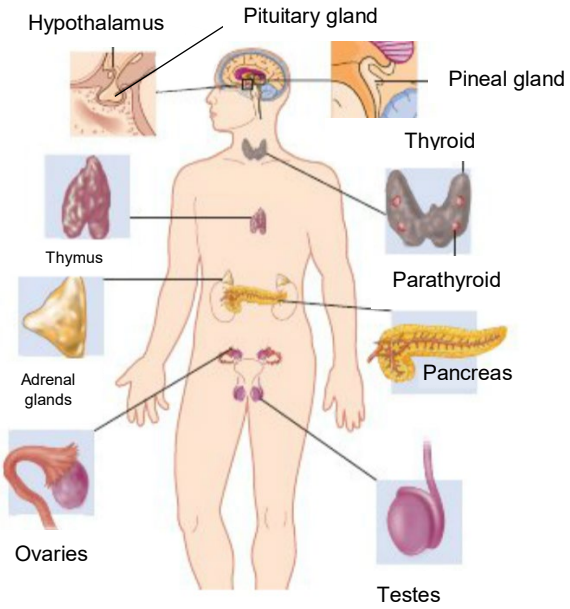
the hypothalamus, pituitary, thyroid, parathyroid, pancreas, thymus, gonads, pineal and adrenal glands, are endocrine glands found in the human body

Glands

- Endocrine and exocrine glands

Exocrine glands: secrete into a duct that carries the secretion to the body surface or to a body cavity e.g. sweat glands, salivary glands

Endocrine (ductless) gland: secrete hormones into the surrounding extracellular fluid, which passes into the capillaries to be transported by the blood e.g. thyroid gland, pituitary gland



hormones secreted from the hypothalamus, pituitary, thyroid, parathyroid, pancreas and adrenal glands are involved in homeostasis by affecting specific target organs

Endocrine glands

- Hypothalamus
  - Located at the base of the brain
  - Functions are carried out through the pituitary gland
- Pituitary lies just under the hypothalamus and is joined to it by the infundibulum
- Pituitary consists of anterior (front) and posterior (back) lobes – function separately

Anterior Pituitary Gland

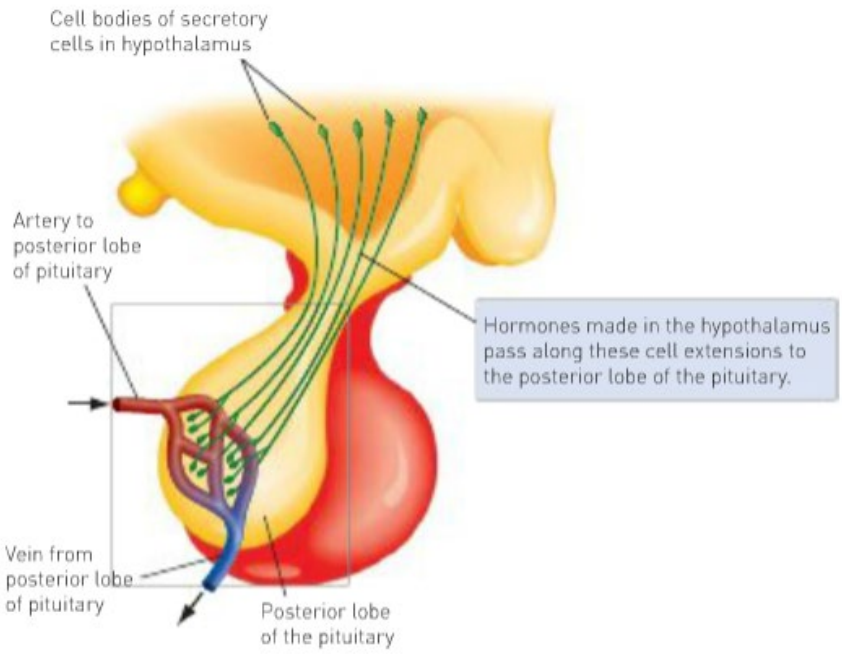
- Has no nerves connecting it to the hypothalamus but is connected to it by a complex network of blood vessels.

Posterior Pituitary Gland

- Is connected to the hypothalamus by nerve fibres with nerve cells bodies in the hypothalamus
- The fibres pass through the infundibulum.
- Not a ‘true’ gland as it does not secrete anything.
- Release is stimulated by nerve contraction

Hormone	Target Organ	Main Effects
Anterior Pituitary Gland		
Follicle-stimulating hormone (FSH)	Ovaries (females) Testes (males)	Growth of ovarian follicles Production of sperm
Luteinising hormone (LH)	Ovaries (females) Testes (males)	Ovulation and formation of the corpus luteum Stimulates interstitial cells of testes to secrete testosterone
Growth Hormone (GH)	All body cells	Growth and increase rate of protein synthesis
Thyroid-stimulating hormone (TSH)	Thyroid gland	Acts on the thyroid to stimulate release of hormones from thyroid
Adrenocorticotrophic hormone (ACTH)	Adrenal cortex	Acts on the adrenal cortex to stimulate the realise of hormones from the adrenal cortex
Prolactin	Mammary glands	Milk production
Posterior Pituitary Gland		
Oxytocin	Uterus Mammary glands	Contraction of uterus during childbirth Release of milk
Antidiuretic hormone (ADH)	Kidney tubules	Increase the permeability of the distal convoluted tubule to reabsorb water

The secretions of the pituitary gland are controlled by the hypothalamus through transport of hormones, either via nerve cells or the vascular link between them.

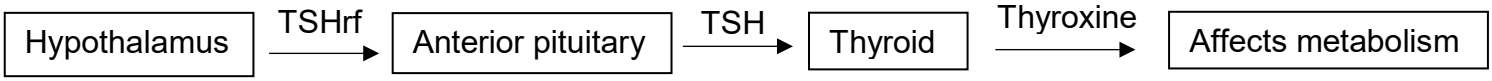


Pineal Gland

- Found inside the brain
- Secretes melatonin
    - Regulates sleep patterns

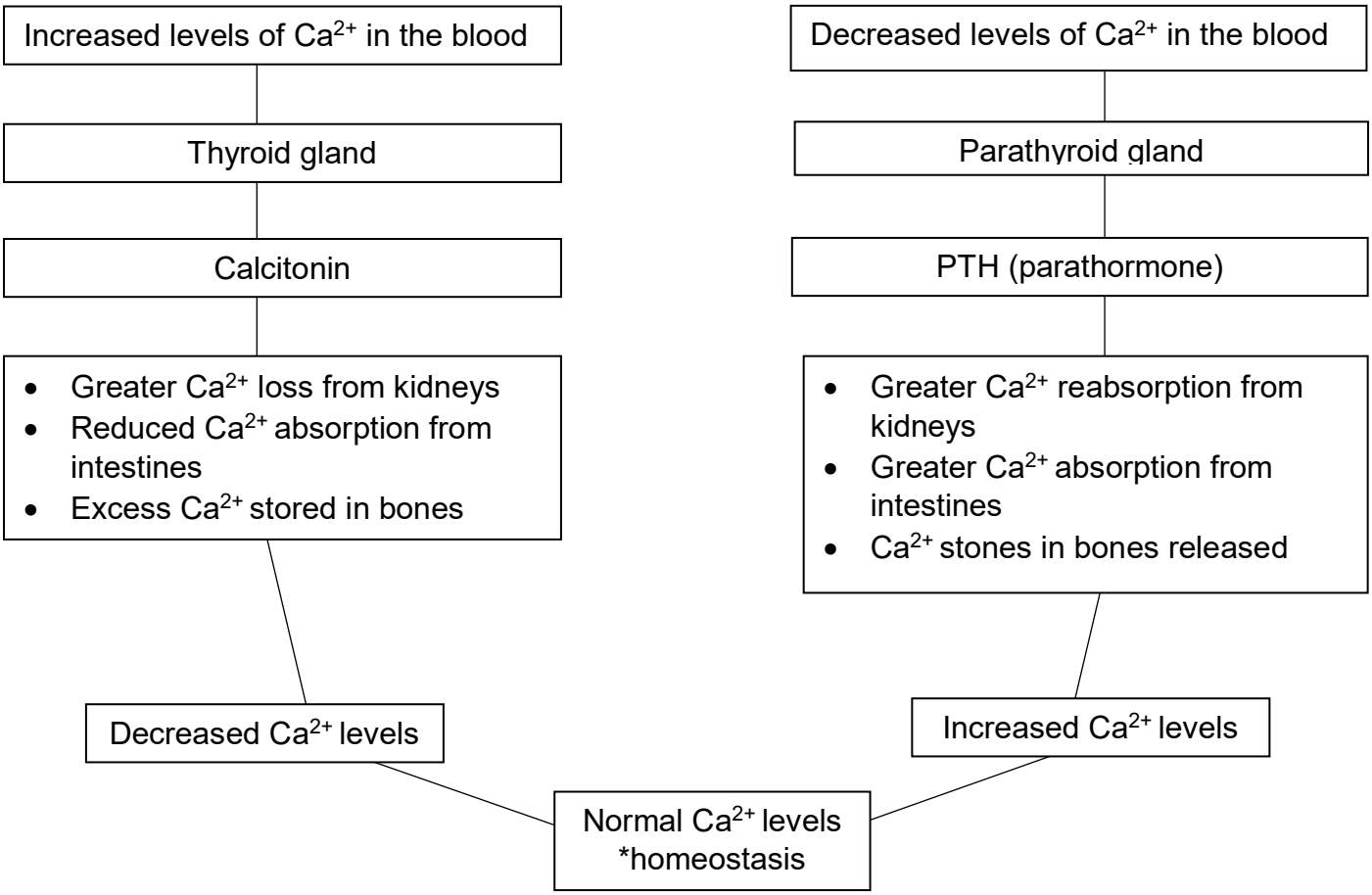
Thyroid

- Just below larynx, two lobes surrounding trachea
- Releases thyroxine
    - Controls body metabolism by regulating both catabolic and anabolic reactions
    - Brings about release of energy and maintains body temperature



Parathyroid Glands

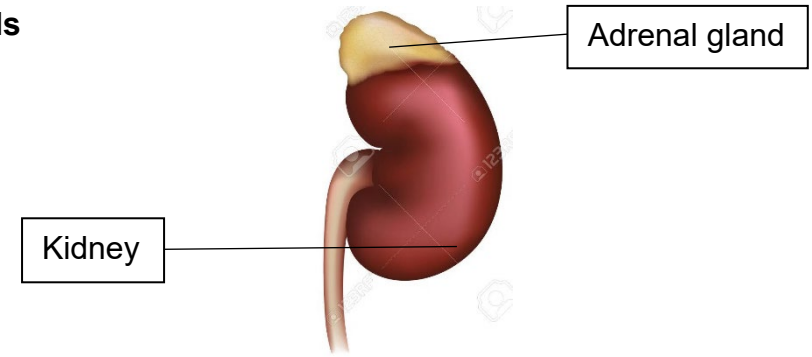
- Four pea-sized glands embedded at the back of the two lobes of the thyroid gland
- Parathormone (PTH) controls level of calcium in the blood



Thymus

- Above the heart behind the sternum
- Decrease in size after puberty
- Thymosins influence the maturation of T-lymphocytes (disease response)

Adrenal Glands



- Two glands, one just above each kidney
- Each gland has an adrenal medulla (inner portion) and an adrenal cortex (outer portion)

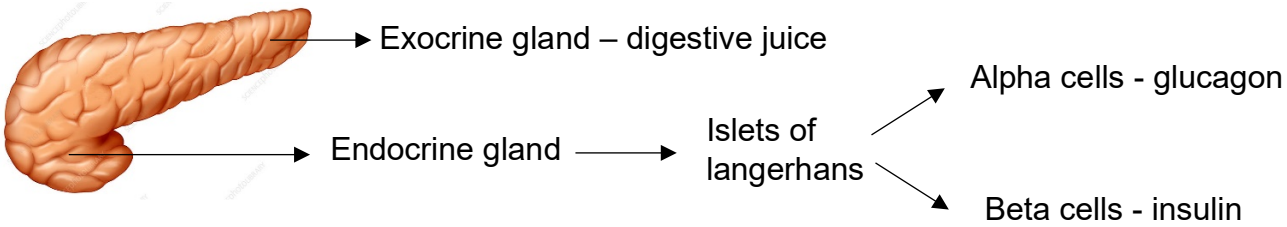
Adrenal Medulla

- Adrenaline (epinephrine) is similar to the effect of the sympathetic division of the autonomic nervous system (fight or flight response)
- Noradrenaline (norepinephrine) is similar to adrenaline but is particular to the heart rate and force of the heartbeat

Adrenal Cortex

- Produces >20 hormones called corticosteroids
- Aldosterone acts on the kidney to reduce the amount of sodium and increase amount of potassium in the urine
- Cortisol promotes normal metabolism, helps the body withstand stress and helps repair of damaged tissue

Pancreas



- Endocrine and exocrine gland
- Clusters of cells called islets of Langerhans
- Islets contain two types of cells
    - Alpha cells
      Glucagon: increases blood glucose levels
      Promoting the breakdown of glycogen to glucose in the liver (glycogenolysis)
      Breaking down fat in the liver and adipose tissue to convert it to glucose (gluconeogenesis)
    - Beta Cells
      Insulin: decreases blood glucose levels
      Promoting uptake of glucose from the blood by body cells
      Liver converting glucose to glycogen (glycogenesis)
      Formation of glycogen from glucose in skeletal muscle.

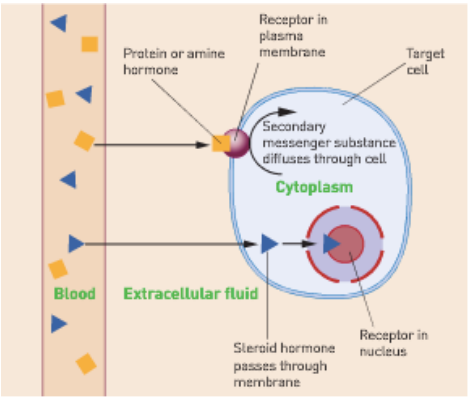
Hormone Summary

Gland	Hormone	Production site	Target Cells	Effect
Anterior Pituitary Gland	Follicle-Stimulating Hormone (FSH)	APG	Ovaries, testes	Growth of ovarian follicle, production of sperm
	Luteinising Hormone (LH)	APG	Ovaries, testes	Ovulation and corpus luteum, secretion of testosterone
	Growth Hormone (GH)	APG	All body cells	Growth, increase rate of protein synthesis
	Thyroid-Stimulating Hormone (TSH)	APG	Thyroid gland	Secretion of hormones from thyroid
	Adrenocorticotrophic Hormone (ACTH)	APG	Adrenal cortex	Secretion of hormones from adrenal cortex
	Prolactin	APG	Mammary glands	Milk production
Posterior Pituitary Gland	Oxytocin	Hypothalamus	Uterus and mammary glands	Contraction of uterus during childbirth, release of milk
	Anti-diuretic Hormone (ADH)	Hypothalamus	Kidney tubules	Increase permeability of DCT and collecting duct to reabsorb water
Thyroid	Thyroxine (T3 and T4)	Most cells	Most cells	Increase metabolism and therefore oxygen consumption and heat production
Para-thyroids	Parathormone (PTH)	Parathyroid	Bones, kidney, blood, intestines	Increase Calcium levels
	Calcitonin	Parathyroid	“ ‘	Decrease Calcium levels
Adrenal Glands	Aldosterone	Adrenal Cortex	Kidney	Increase reabsorption of sodium ions and decrease reabsorption of potassium ions
	Cortisol	Adrenal Cortex	Most cells	Promotes normal metabolism, withstand stress, replace damaged tissue
	Adrenaline (epinephrine)	Adrenal medulla	Most cells	Reinforces the effect of sympathetic nervous system (fight or flight)
	Noradrenaline (norepinephrine)	Adrenal medulla	Most cells	“ “
Pancreas	Glucagon	Alpha cells	Most cells	Decrease glucose absorption therefore increasing BGL
	Insulin	Beta cells	Most cells	Increase glucose absorption therefore decreasing BGL

hormones can be lipid-soluble and able to cross cell membranes to bind with and activate intracellular receptors or, water-soluble and able to bind with and activate receptors on cell membranes, and require secondary messengers to affect cell functioning

Types of hormones

- Hormones do not start reactions, but they regulate reactions
- Hormones are required in minute quantities
- Hormones from animals can be transferred
- Hormones cannot be stored, they have an expiry date – in our body the liver catabolises them
- May be proteins, steroids or amines
- Proteins and amines attach to a receptor molecule on the membrane of the target cell
    - Causes a secondary messenger substance to diffuse through the cell and activate particular enzymes
- Steroid hormones work by entering target cells and combining with a receptor inside the cell
    - Activates the genes controlling the production of particular proteins



Enzyme Amplification

- One hormone molecule can manufacture or activate thousands of enzyme molecules
- Hormone triggers a cascading effect called enzyme amplification
- A very small stimulus can cause a very large effect

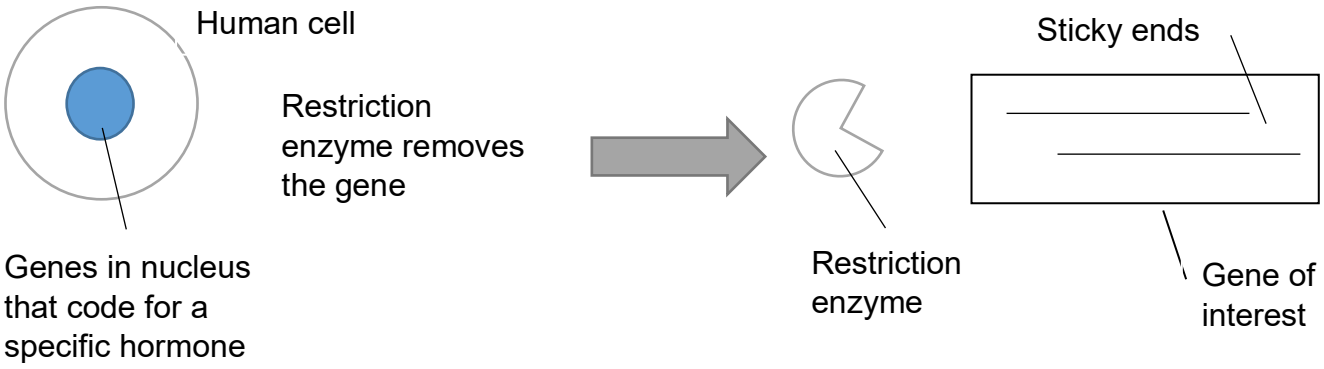
Synthesising Human Proteins

synthetic hormones may be developed to control or treat endocrine dysfunction, including diabetes mellitus, hypothyroidism and hyperthyroidism, to improve the quality of life for individuals

hormones and vaccines are developed using recombinant DNA and associated biotechnological techniques

- Done using recombinant DNA technology
- Synthesis of human insulin using recombinant DNA technology:

Step 1



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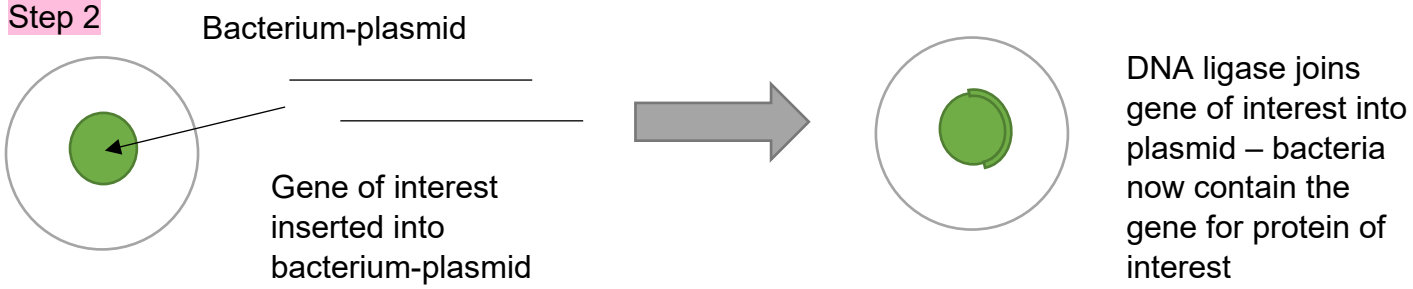

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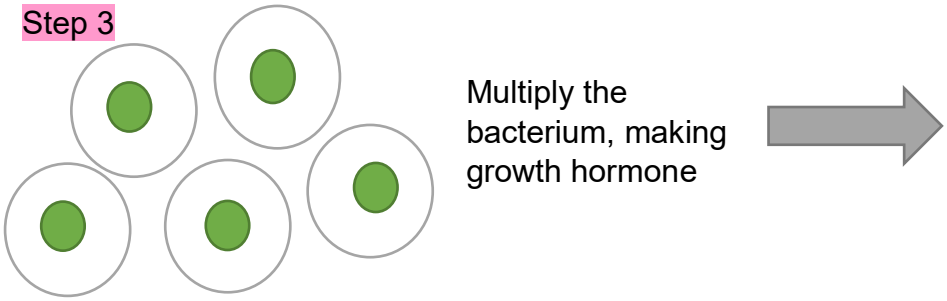


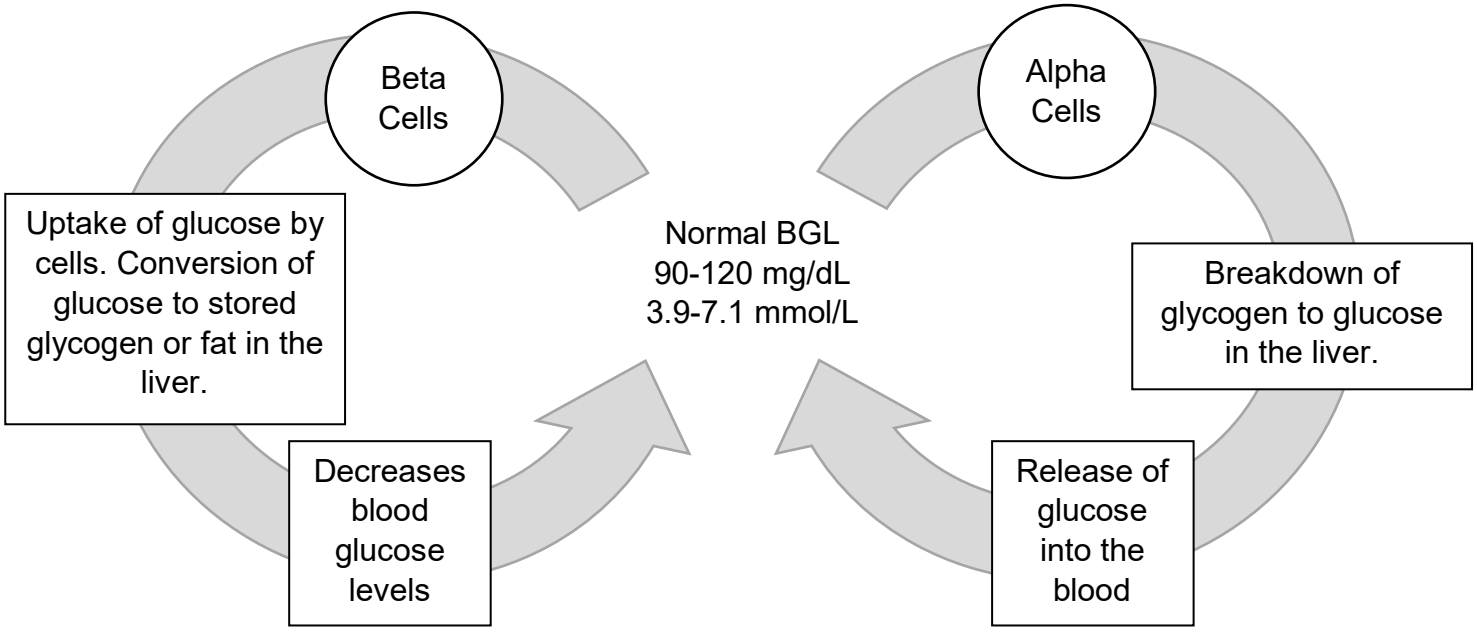
	Type 1 Diabetes	Type 2 Diabetes
Cause	• Deficiency of insulin • Lack of insulin production (beta cells destroyed in autoimmune reaction)	• Insulin receptors are resistant to the hormone – cell becomes impermeable to glucose • Cells can't uptake glucose
Symptoms	• Severe • Hyperglycaemia • Glucose in urine • Increased urine production • Excessive thirst and hunger • Weight loss • Ketosis	• Increased appetite (overeating may contribute to existing obesity problem) • Urine production increases • Glucose in urine • Muscle weakness, fatigue • Frequent infections, poor wound healing

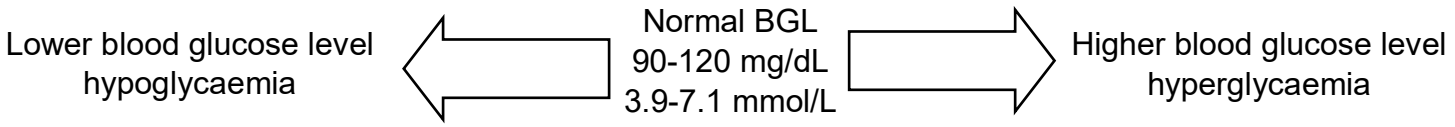
Treatment	**Present:** • Regular insulin injections • BGL monitoring **New:** • Cell therapy (transplant of beta cells) **Future:** • Gene therapy (gene for insulin inserted into diabetic's cell)	• Regularly check blood glucose level • Manage diet to reduce fluctuations in blood glucose level • Reduce weight (exercise, diet) • Reduce blood pressure • Take anti-diabetic drugs • Insulin therapy

	Hyperthyroidism	Hypothyroidism
Cause	Too much thyroxine	Too little thyroxine
Symptoms	• Weight loss • Appetite change • Muscle weakness • Grave's disease (the eye thing)	• Slow metabolism • Weight gain • Swelling • Enlarged thyroid gland (goiter)
Treatment	• Radioactive iodine	• Synthetic thyroxine (levothyroxine) • Increased iodine intake

Control of Blood Glucose Levels

- Glucagon and Insulin mediate the regulation of blood glucose levels
- Negative feedback loops
- Glucagon – increase blood glucose levels, synthesis of glucose from amino acids
- Insulin – decrease blood glucose levels, synthesis of glycogen and cellular uptake of glucose
- When food is unavailable for long periods of time

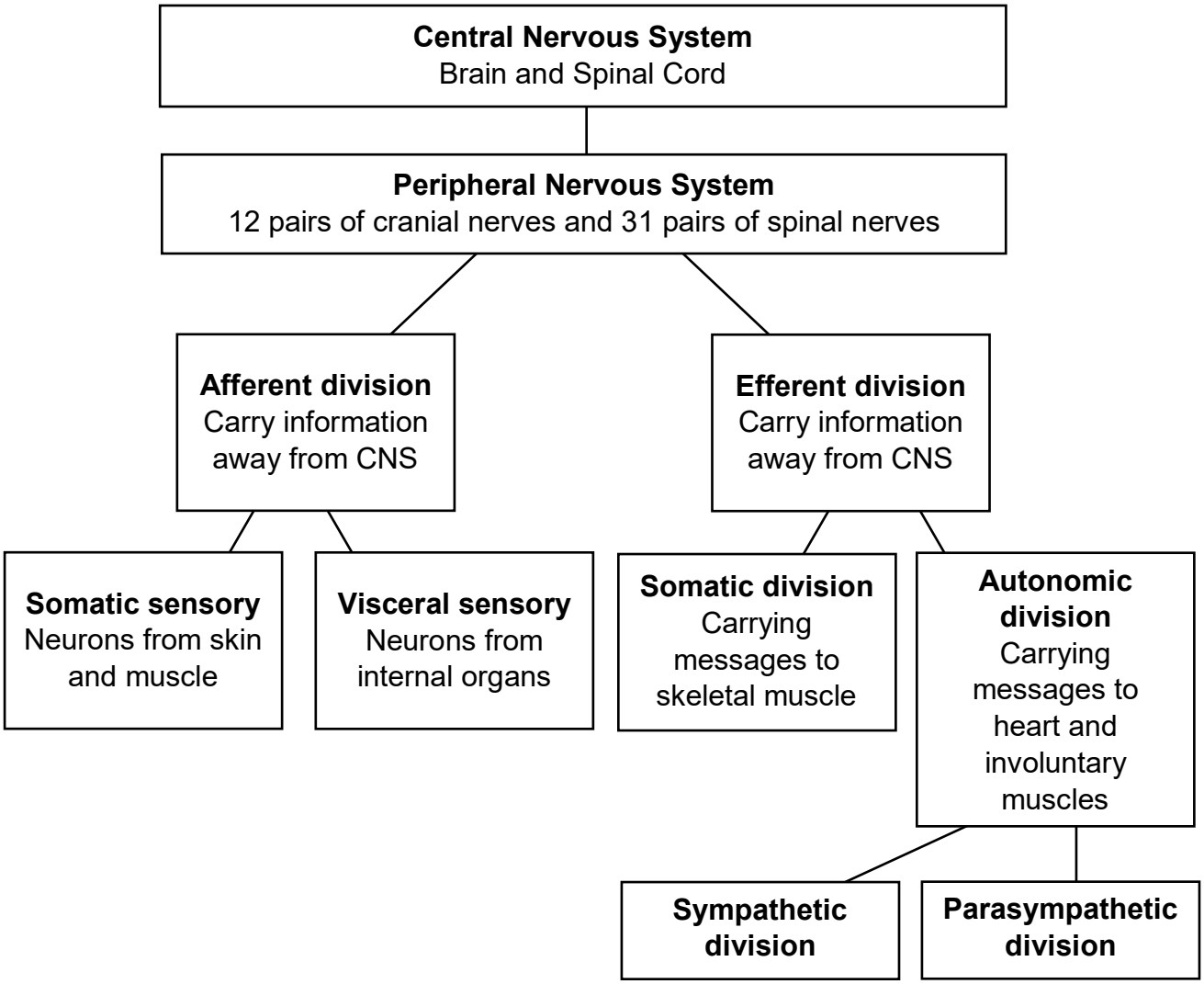




Nervous System

structure and function of the divisions of the nervous system can be observed and compared at different levels in detecting and responding to the changes in the internal and external environments including:
- *central-peripheral*
- *afferent-efferent*
- *autonomic-somatic*
- *sympathetic-parasympathetic*

- Communication network and control centre of the body
- Maintains homeostasis
- Two main parts
  - Central Nervous System (CNS) consists of brain and spinal cord
  - Peripheral Nervous System (PNS) is the nerves that connect the CNS with the receptors, muscles and glands



Neurons

Term	Definition
Neuron	Single nerve cell
Nerve-fibre	Extension of the cell, usually an axon
Synapse	Junction between the branches of two neurons. Is a gap, the signal is carried across the gap by a neurotransmitter
Neuromuscular junction	Axon terminal joins a muscular fibre

Types of Neurons

Type of Neuron	Diagram	Purpose
Multipolar Motor neuron, efferent neuron		• Takes impulses away from the CNS • EFFerent for f off
Bipolar Sensory neuron, afferent neuron		• Takes impulses into the CNS
Unipolar Sensory neuron, afferent neuron		• Takes impulses into the CNS

Transmission of Impulses

transmission of nerve impulses is via electro-chemical changes that occur at the generation of the impulse, the propagation of the impulse along the nerve fibre, and the transfer of the impulse across the synapse

Transmission of Nerve Impulses Across an Unmyelinated Neuron

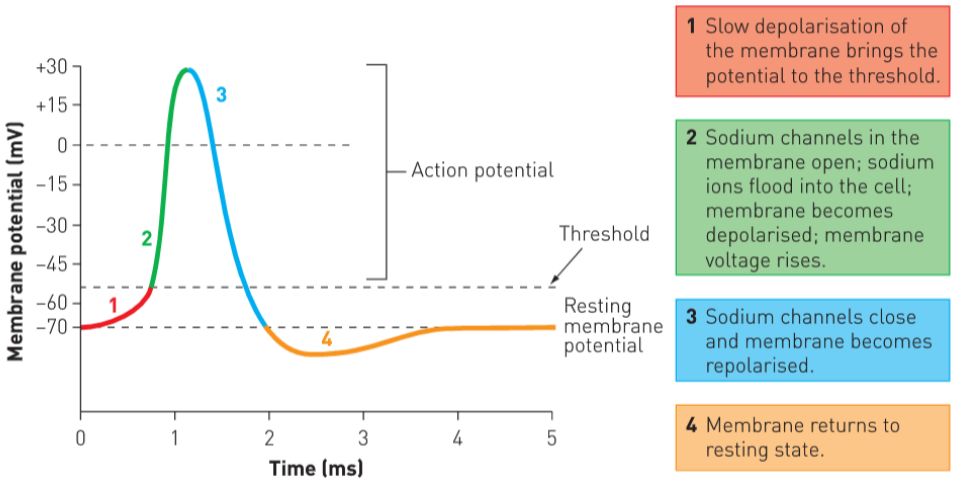
Resting Potential

- Normal state, not stimulated
- Inside of membrane is negative compared to outside which is positive
- Difference is called resting potential
- Resting potential is -70mV
- Difference in concentration of ions (K^+, Na^+, Cl^-) maintained by the active transport of ions using carrier-mediated transport (pumps)
- Sodium-potassium ion pump
- These pumps move $3Na^+$ out of the cell for every $2K^+$ ions into the cell
- Requires ATP

Action Potential

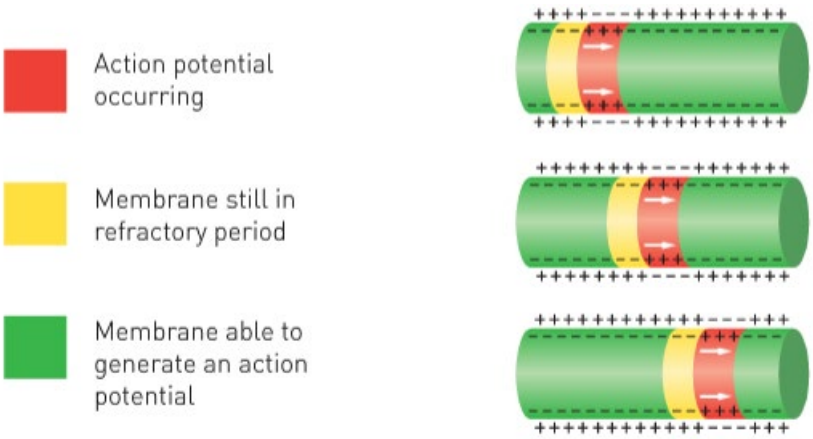
- When the membrane receives stimulation, the negative charge inside the membrane becomes positively charged
- As a result of action potential, the membrane is depolarised
- In order for the neuron to be stimulated, it has to be above the threshold -55mV
- Caused by an influx of Na^+
- ALL or NOTHING response – it either happens or it doesn't
- Na^+ gates open rapidly, influx of Na^+ by diffusion
- Depolarises the membrane
- K+ gates take longer to open but eventually do

- At about 30mV the Na^+ entering are equal to K^+ leaving, no net movement with Na^+ gates shut and the K^+ gates open the membrane begins repolarising
- Does overshoot called hyperpolarisation



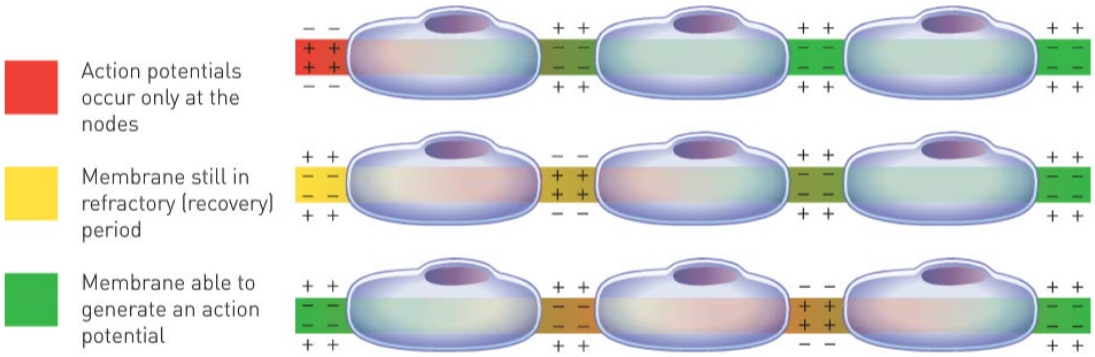
Refractory Period

- After an action potential, K^+ ions quickly restore to resting potential
- Na^+ diffusion into the cell is prevented in that region
- During the 1ms afterward no action potentials can be generated
- Therefore an action potential can only travel in one direction



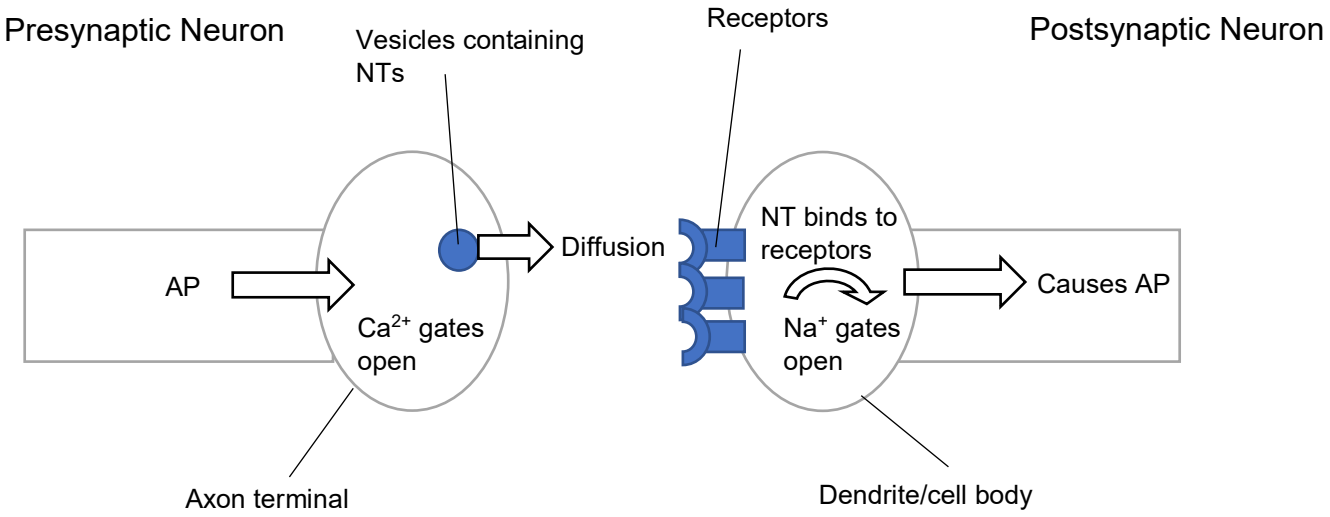
Transmission of Nerve Impulses Across a Myelinated Neuron

- Called saltatory conduction
- Action potential moves from one node of ranvier to the next
- Moves 140m/s



Transmission across a synapse

- In a synapse there is no membrane
- Neurotransmitters diffuse across gap and attach to receptors
- Over 100 neurotransmitters (NTs)
    - Acetylcholine
    - Adrenaline and Noradrenaline
    - Dopamine
- Only occurs from axon terminals to dendrite/cell body



Excitatory	Inhibitory

• Increase stimulation of transmission at synapse
  ○ Acetylcholine (Ach)
  ○ Adrenaline
  ○ Noradrenaline
• Nerve agents (organophosphate) stops enzyme (denatures the enzyme) from breaking down Ach
• Causes constant muscle contraction i.e. seizures, difficulty breathing, loss of control, urination and defaecation, spasms and pain, death
	• Increase depression of transmission at synapse
	  ○ Snake venom
	  ○ Spider venom
	• Snake venom inhibits Ach from binding to receptors, muscle contraction does not occur
	• Causes paralysis

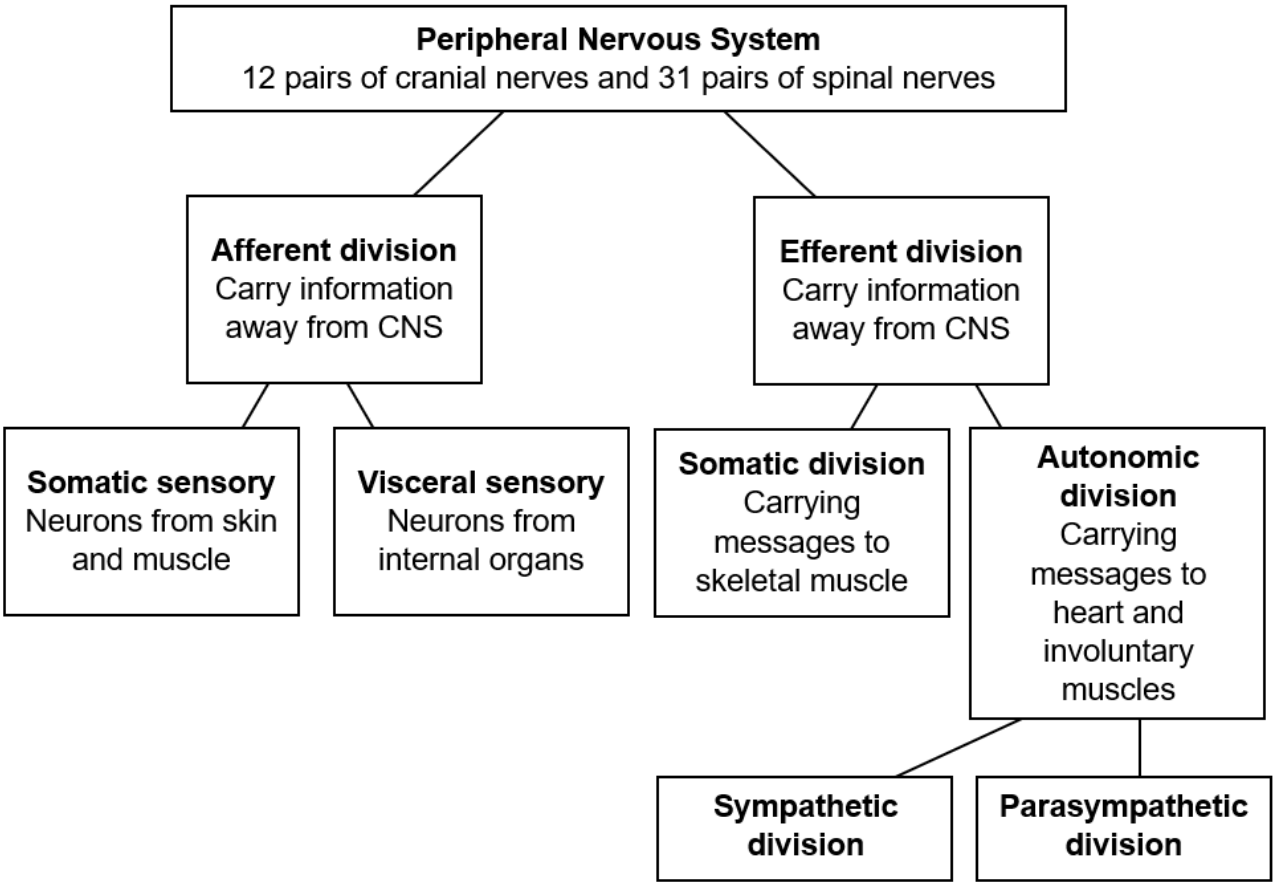
Divisions of the Nervous System

Peripheral Nervous System (PNS)

- Consists of nerve fibres which carry information to and from the CNS
- Consists of groups of nerve cell bodies called ganglia
- Nerve fibres are arranged into nerves which arise from brain and spinal cord
- 12 pairs of cranial nerves (brain)
    - Optic nerve, auditory nerve
    - Usually missed nerves being able to carry information to the brain (sensory fibres) and those that carry impulses away from the brain (motor fibres)
    - A few cranial nerves carry only sensory or motor impulses
- 31 pairs of spinal nerves (spinal cord)

Spinal nerves

- 8 pairs of cervical spinal nerves
- 12 pairs thoracic spinal nerves
- 5 pairs of lumbar spinal nerves
- 1 pair of coccyx spinal nerve



Afferent division of the PNS

- Carries impulses from sensory receptors to the CNS (away from CNS)
- Afferent nerve cell can be: somatic sensory and visceral sensory
    - Somatic: receptors in skin, around muscles and joints
    - Visceral: receptors in internal organs

Efferent division of the PNS

- Carries impulses away from the CNS
- Somatic division takes impulses from the CNS to skeletal muscles
- Autonomic division divided into sympathetic and parasympathetic divisions

Autonomic Division

- ANS responsible for our internal environment by controlling homeostatic mechanisms without conscious control
    - Heart rate, blood pressure, temperature, digestion, pupil size, airflow, defaecation and urination
- Carries messages away from the CNS
- Two types of neurons
    - First cell body in grey matter of CNS
    - Second has cell body in ganglion
- Is divided into Sympathetic and Parasympathetic divisions
- Parasympathetic: Tends to control homeostatic mechanisms
    - **Rest and digest**
- Sympathetic: Takes control during strenuous physical activity
    - **Fight or flight** – stimulated by fear, anger, competition or stress
    - Rate and force of heart beat and blood pressure, dilate blood vessels, non-essential organ blood flow restricted, dilated airways and increase depth of breathing, blood glucose level increase, sweat secretion increase, Adrenal Medullae release adrenaline and noradrenaline

Receptors

different receptors detect changes in the internal and external environments, including thermoreceptors, osmoreceptors, chemoreceptors and receptors for touch and pain

Type of Receptor	Stimulus	Location
Thermoreceptor	Temperature	Skin, hypothalamus
Nocireceptors/ mechanoreceptors	Intense stretch or strain, damage or threat of damage	Skin
Baronoceptors	Pressure in blood vessels	Aortic and carotid bodies
Osmoreceptors	Osmolarity: concentration of substances dissolved in the water of blood plasma	Hypothalamus
Proprioceptors	Sense of position	Inner ear, muscles, tendons, joints
Stretch receptors	Relative position	Muscles
Chemoreceptors	Presence of chemicals	Aortic and carotid bodies
Pain receptors	Pain, damage or threat of damage	Skin
Hair root plexus	Movement of hair	Hair follicles (skin)

Central Nervous System

the parts of the central nervous system, including the brain (cerebrum, cerebellum, medulla oblongata, hypothalamus, corpus callosum) and spinal cord, have specific roles in the co-ordination of body functions and are protected by the meninges and cerebro-spinal fluid

- Consists of the brain and spinal cord
- Control centre of the nervous system

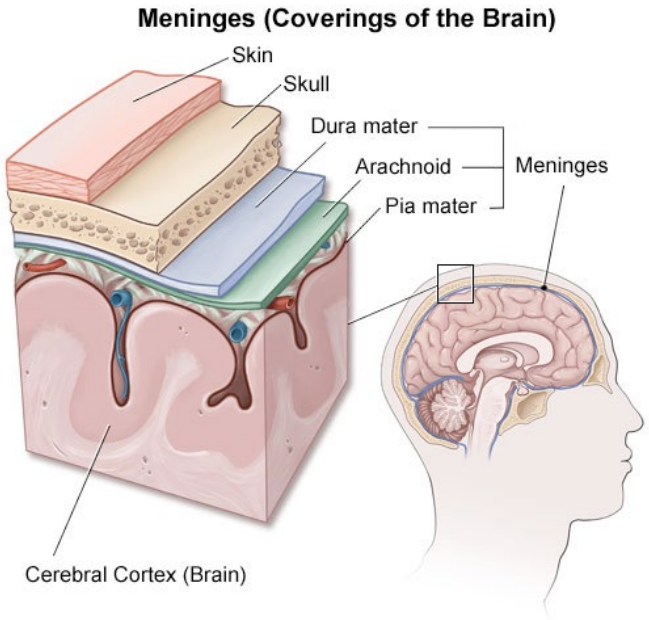
Protection of the CNS

1. Bone

- Cranium protects the brain
- Spinal cord protected by vertebrae
    - Runs through vertebral canal

2. Meninges

- Three layers of connective tissue forming membranes that cover the surface of the brain and spinal cord



Pia Mater	**Arachnoid**	**Dura Mater**
Inner layer	Middle layer	Outer layer
Delicate, has blood vessels	Loose mesh of fibres	Tough and fibrous

3. Cerebrospinal Fluid

- Clear, watery fluid that occupies space between middle and inner meninges, cavities in the brain and centre of spinal cord
- Contains water, cells, glucose, urea and salts

PST

Protection: shock absorber to cushion blows/shocks
Support: Brain suspended in cranium and floats in fluid
Transport: Takes nutrients to and wastes away from the cells of the brain and spinal cord

Brain

Corpus Callosum
- Wide band of nerve fibres
- Lies underneath the cerebrum
- Nerves cross from 1 hemisphere to the other
- Allows communication between hemispheres

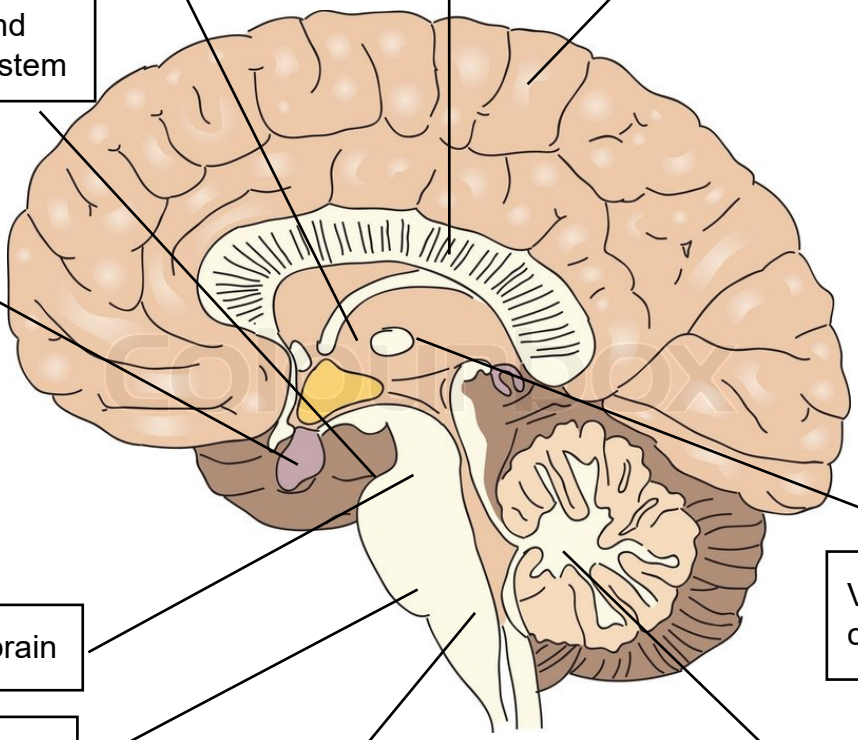
Cerebrum
- Highly folded = large surface area
- Fissure: longitudinal fissure that separates brain into two hemispheres
- Fissures and sulci divide brain into four hemispheres
- Frontal, parietal, occipital and temporal lobes
- Voluntary movement

Diencephalon

Thalamus

Hypothalamus
- HR, BP, digestive juices, alimentary canal, diameter of pupils
- Body temp., food+water intake
- Hormones and endocrine system

Pituitary gland



Ventricle and cerebrospinal fluid

Brain stem

Midbrain

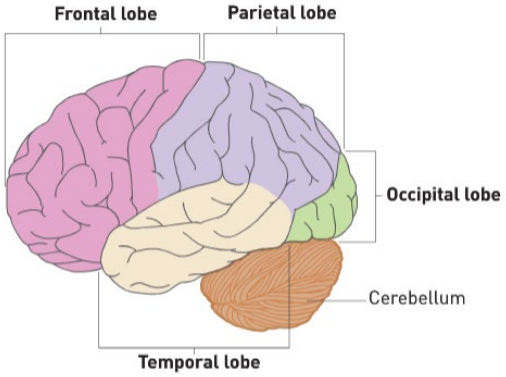
Pons

Medulla Oblongata
- Continuation of spinal cord
- Automatically adjusts body functions as it contains the cardiac, respiratory and vasomotor centres
- All functions under the influence of the hypothalamus

Cerebellum
- Second largest part of brain
- Surface folded into a series of parallel ridges
- Control of posture and balance; information received from inner ear and stretch receptors in skeletal muscles
- Fine coordination of muscle movement
- White matter inside, grey matter outside

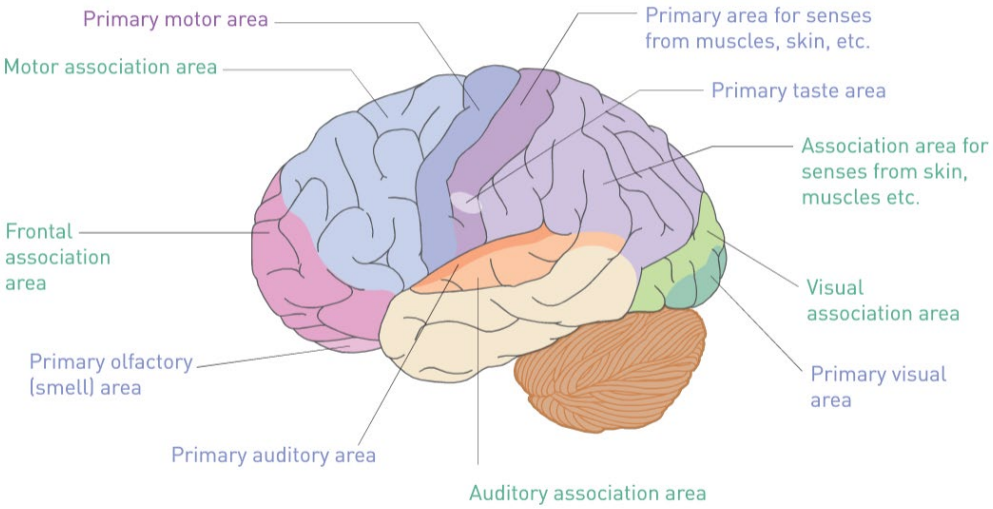
Cerebrum

- Rounded ridges – convolutions (gyri) separated by either shallow downfolds (sulci) or deep down folds (fissures)
- Four lobes



- 3 different areas: sensory, motor, association

Sensory areas	**Motor areas**	**Association areas**
Receive and process nerve impulses from the senses	Send impulses to muscles, especially voluntary	Interpret information from sense and make it useful



Control of Movement

Cerebrum	Cerebellum
• Intention to contract muscles begins in the motor association area • Plans the behaviour and makes up the sequence and intensity of the muscle contractions required • Program sent to the primary motor area • Nerve impulses sent to muscles • Upper motor neurons carry impulses to appropriate level of spinal cord (neurons cross over) • Lower motor neuron carry impulses to the muscles	• Achieves smooth and coordinated movement and maintains pressure and muscle tone during movement by integrating movement from: ○ Cerebrum: position of body ○ Semi-circular canals (inner ear): movements of the head ○ Saccule and utricle (inner ear): position of the head ○ Eyes: observe body's position in space ○ Pressure receptors in skin: relative amount of pressure on parts of body ○ Stretch receptors in muscles and joints: body movement and joint position

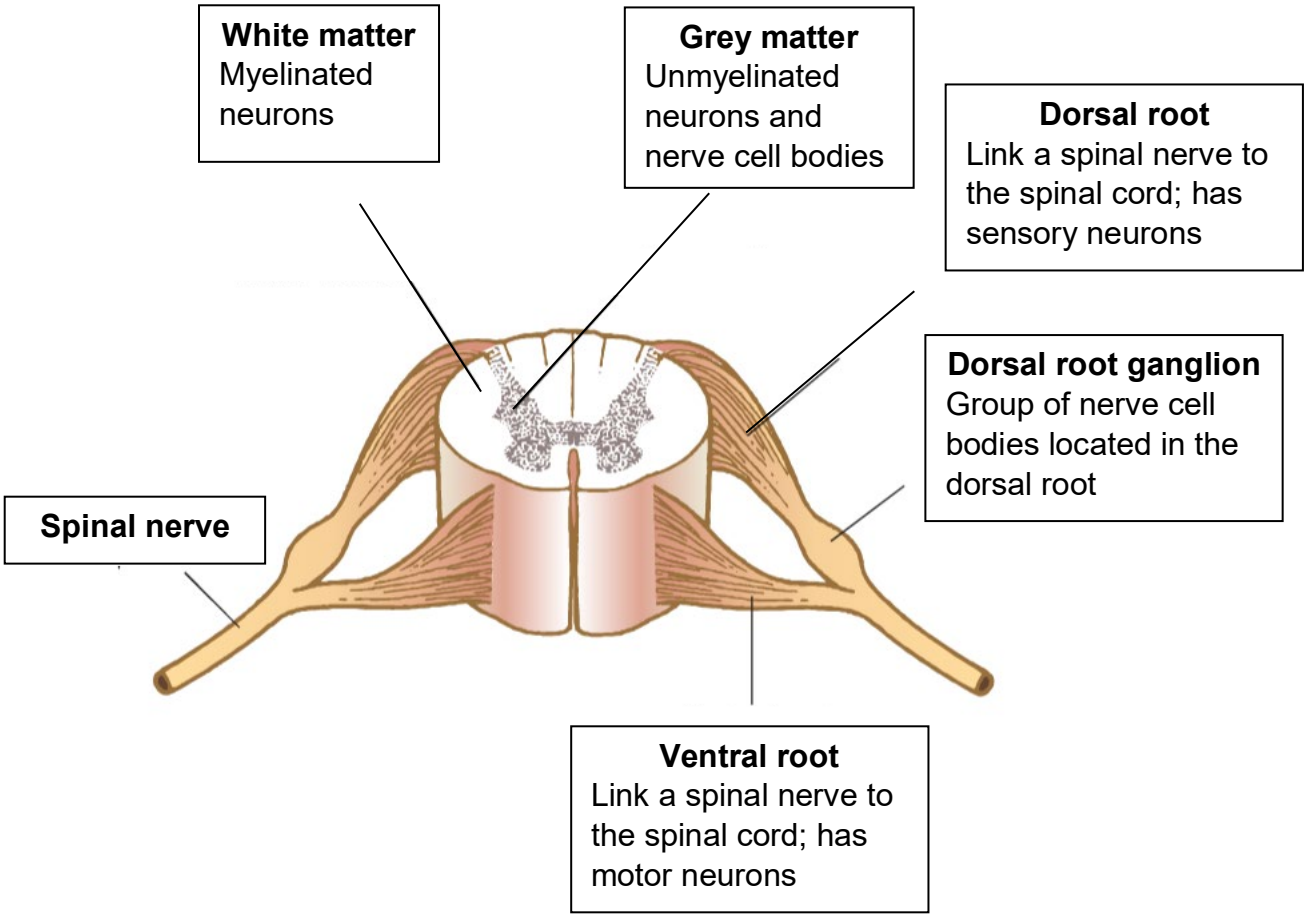
Explain how the cerebrum and cerebellum initiate and control movement of skeletal muscle. (4 marks)

- Cerebrum initiates movement through the motor association area which initiates the primary motor area. The primary motor area sends an action potential via upper motor neurons to the spinal cord. This action potential affects the lower motor neuron and the action potential reaches the neuromuscular junction and muscle contraction occurs
- Cerebellum controls fine coordination of muscle movement through information received from sensory receptors of the ear and stretch receptors in skeletal muscle

Reflex Arcs

the reflex arc comprises of specially structured neurons, including sensory, interneuron and motor neurons, to transmit information from the receptor to the effector to respond rapidly to stimuli

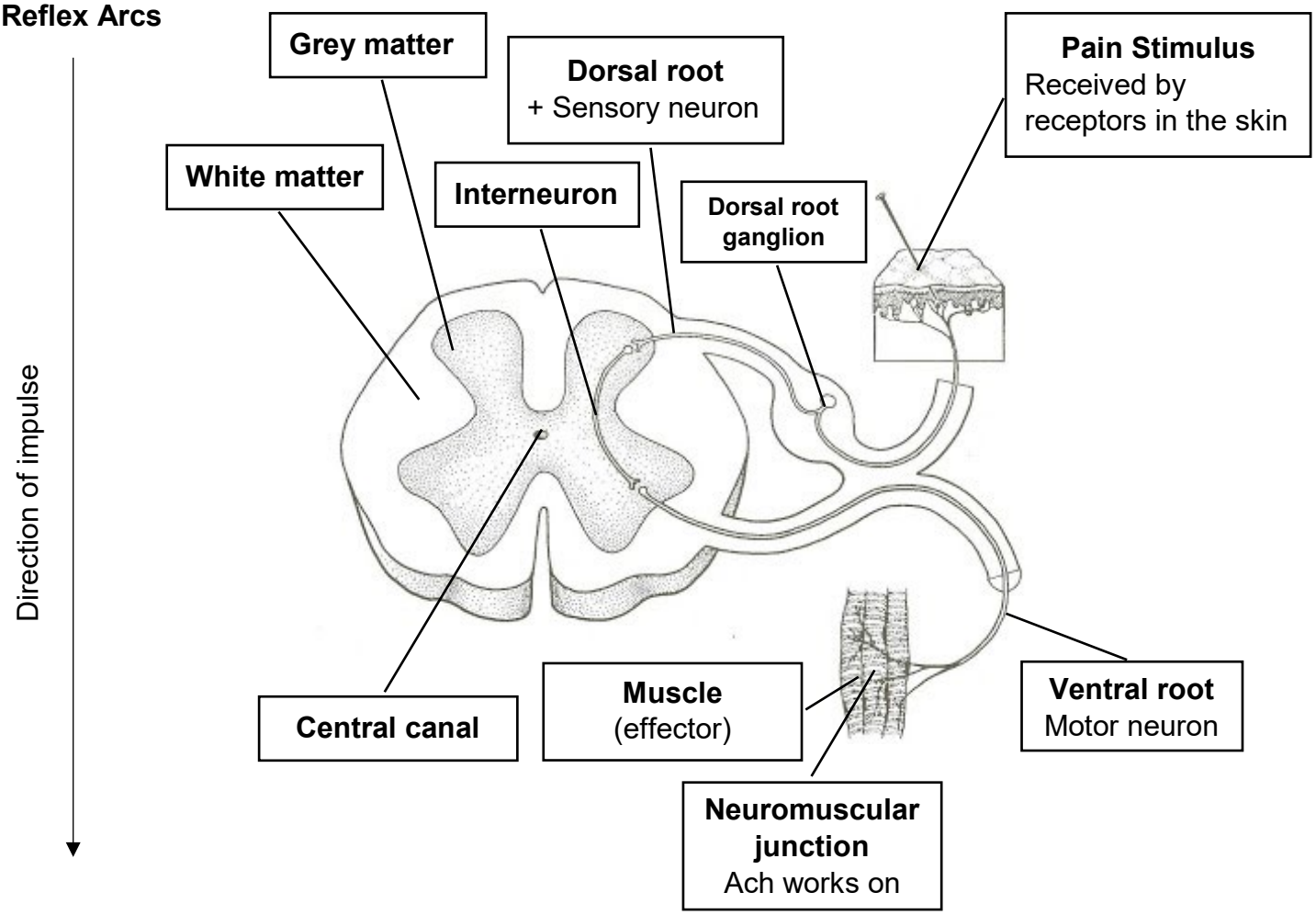
Spinal Cord



Functional properties of reflex arcs

- Involuntary – no thought needed for the reflex to occur
- Stereotypical – the arc happens the same way every time
- Rapid – the stimulus is changed as soon as possible

Reflex Arcs



Autonomic division

Structure	Sympathetic Fight of flight	Parasympathetic Rest and digest
Heart	Increase cardiac output CO = Stroke volume x heart rate	Decrease cardiac output
Eyes	Dilates pupils	Constricts pupils
Lungs	Dilates bronchioles Increase breathing rate	Constricts bronchioles Decrease breathing rate
Bladder and anus	Contracts sphincters	Relaxes sphincters
Saliva production	Decreases saliva	Increases saliva
Liver and gall bladder	Increase breakdown of glycogen → glucose (glycogenolysis) Inhibits gall bladder	Increase conversion of glucose → glycogen (glycogenesis) Stimulates gall bladder
Stomach and intestines	Inhibited movement	Stimulates movement
Adrenal Medulla	Stimulates hormone secretion Adrenaline and Noradrenaline	No obvious effect
Sweat glands	Increase sweat production	No obvious effect
Skin	Vasoconstriction	Little effect
Skeletal muscles	Vasodilation of blood vessels	No effect
Internal organs	Vasoconstriction of all except heart and lungs	Little effect

Nervous vs. Endocrine

the nervous and endocrine systems work together to co-ordinate functions of all body systems, but differ in terms of:

- *speed of action*
- *duration of action*
- *nature and transmission of the message*
- *specificity of message*

Structure	Nervous System	Endocrine System
Speed of Action	Rapid – within milliseconds	Slower – can take seconds to days for action
Duration of Action	Brief – usually short lived	Longer lasting – usually continues after stimulus has stopped
Nature	Electrochemical – Electrical impulse (sodium-potassium pump) and neurotransmitters	Chemical messengers - hormones
Transmission	Along the membrane of neurons	Blood stream
Specificity	Localised specificity – very specific	Wide spread specificity – can affect many cells, general

Homeostasis

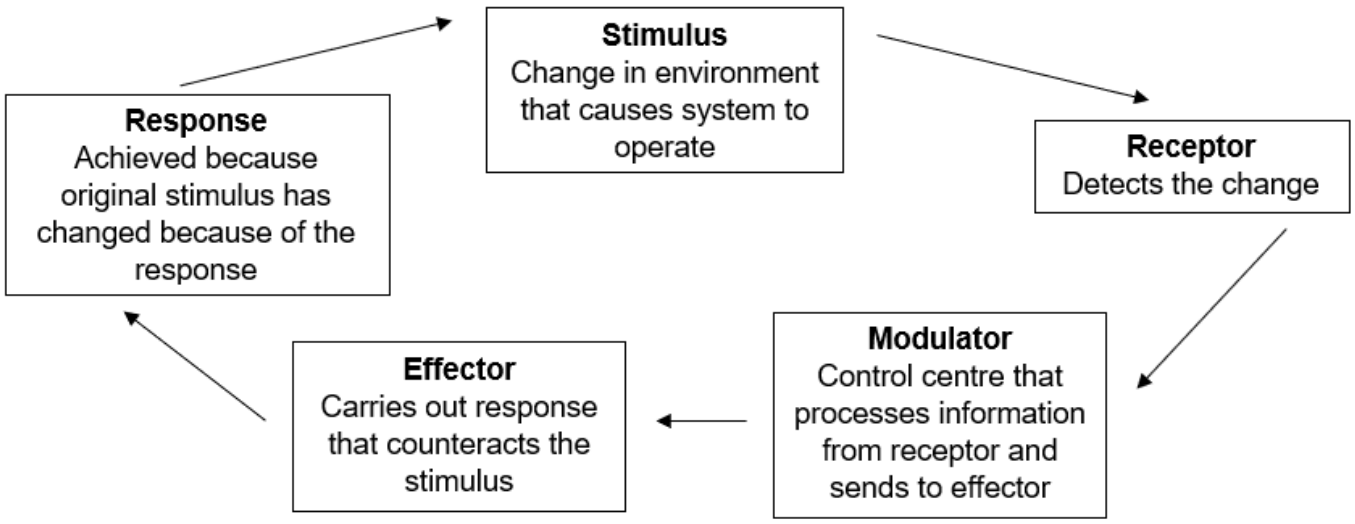
homeostatic processes involve nerves and hormones in maintaining the body's internal environment within tolerance limits through the control of metabolism and physiological and behavioural activities

Homeostasis: the maintenance of a constant internal environment where cells can carry out their specific functions as efficiently as possible.

Feedback Systems

- Body responds to stimulus → response alters original body stimulus
- Two types of feedback loops
    - Positive: The response reinforces the stimulus
      e.g. Oxytocin
- Negative: The response counteracts the stimulus

e.g. Anti-diuretic hormone



Thermoregulation

Thermoregulation occurs by the control of heat exchange and metabolic activity through physiological and behavioural mechanisms

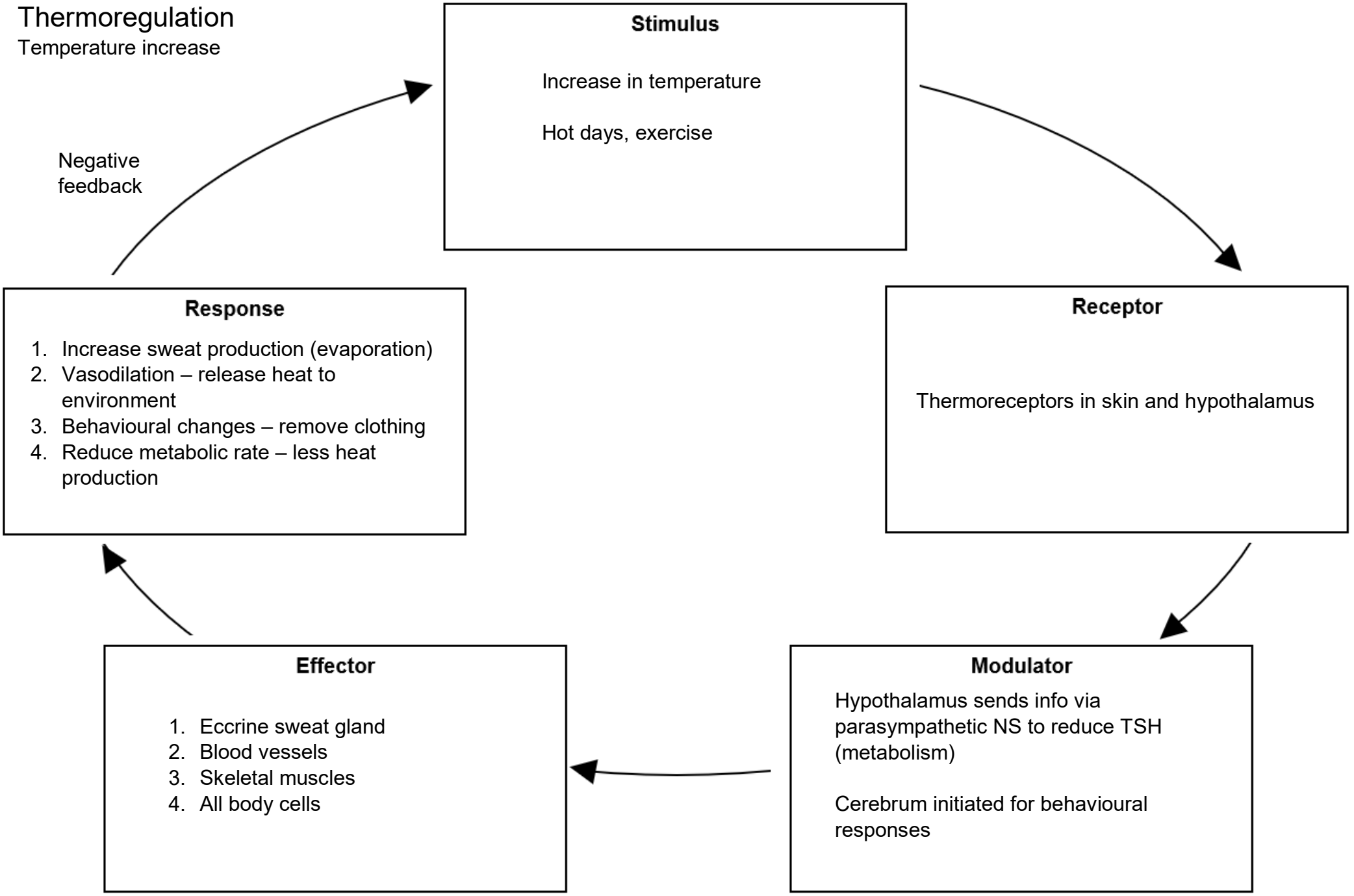
Rise in body temperature		Fall in body temperature	
Increase heat loss	Decrease heat production	Decrease heat loss	Increase heat production
Vasodilation Body increases blood flow to the skin, allows heat loss via radiation, prompts cooling of the blood that is flowing through the skin Sweating Sweat secreted from sweat glands to skin, contains salt, urea, lactic acid, K^+ ions and water. Cools by evaporation, environmental temperature has to be greater than body temperature to be effective. Behavioural response Decreasing activity, air conditioning, removing clothing Surface area Increase surface area by spreading out	Activity Decrease in voluntary activity, meaning there is a decrease in cellular respiration (heat is a product) Metabolic rate A reduction in the secretion of thyroxine decreases the metabolic rate, meaning there is a decrease in cellular respiration (heat is a product)	Vasoconstriction Body decreases blood flow to the skin, which decreases the transfer of heat from internal body organs to the skin, allowing less heat to be lost from the body surface Sweating Reduction in sweating Behavioural response Putting on more clothes, using a heating device Surface area Reduction of surface area by curling into a ball or huddling Pyloerection Goosebumps – hairs stand on end to keep heat in	Shivering Hypothalamus stimulates part of the brain that increases skeletal muscle tone. This increases body heat production Activity Increase in voluntary activity, meaning there is an increase in cellular respiration (heat is a product) Metabolic rate An increase in the secretion of thyroxine increases the metabolic rate, meaning there is an increase in cellular respiration (heat is a product)

Heat Transfer

Conduction Contact between the skin and another surface	**Convection** Heat through the air, e.g. wind
Evaporation We all know what evap is but can't define it	**Radiation** Like from a fire

Thermoregulation

Temperature increase



Thermoregulation

Temperature decrease

Stimulus

Decrease in external temperature

Receptor

Thermoreceptors in skin and hypothalamus

Modulator

Hypothalamus sends info via sympathetic NS to increase TSH

Cerebrum initiated for behavioural responses

Effector

1. Skeletal muscle
2. Blood vessels
3. Cerebral cortex
4. All body cells
5. Arrector pili muscle

Response

1. Shivering to generate heat in muscles
2. Vasoconstriction reduces heat transfer
3. Behavioural changes – put on a jumper
4. Increase metabolic rate to increase heat production
5. Pyloerection – hair stands on end

Negative feedback

Blood Sugar Levels

blood sugar levels are maintained by controlling of sugar uptake, its storage and release by cells and use in metabolism; these processes involve the hormones of the pancreas and adrenal glands

- Glucose energy source of cell – correct amounts must be maintained to supply these cells
- BGL is maintained by storing unused glucose as glycogen
- BGL (blood glucose level) is coordinated by the liver, pancreas and adrenal glands
- Liver is able to store 100g of glycogen
- Skeletal muscle is able to store 500g of glycogen
- Blood travels to the liver from the intestines
    - Glucose used by the liver
    - Stored as glycogen
    - Continues to circulate
    - Converted to fat for long term storage

Glycogenesis: Synthesis of glycogen from glucose

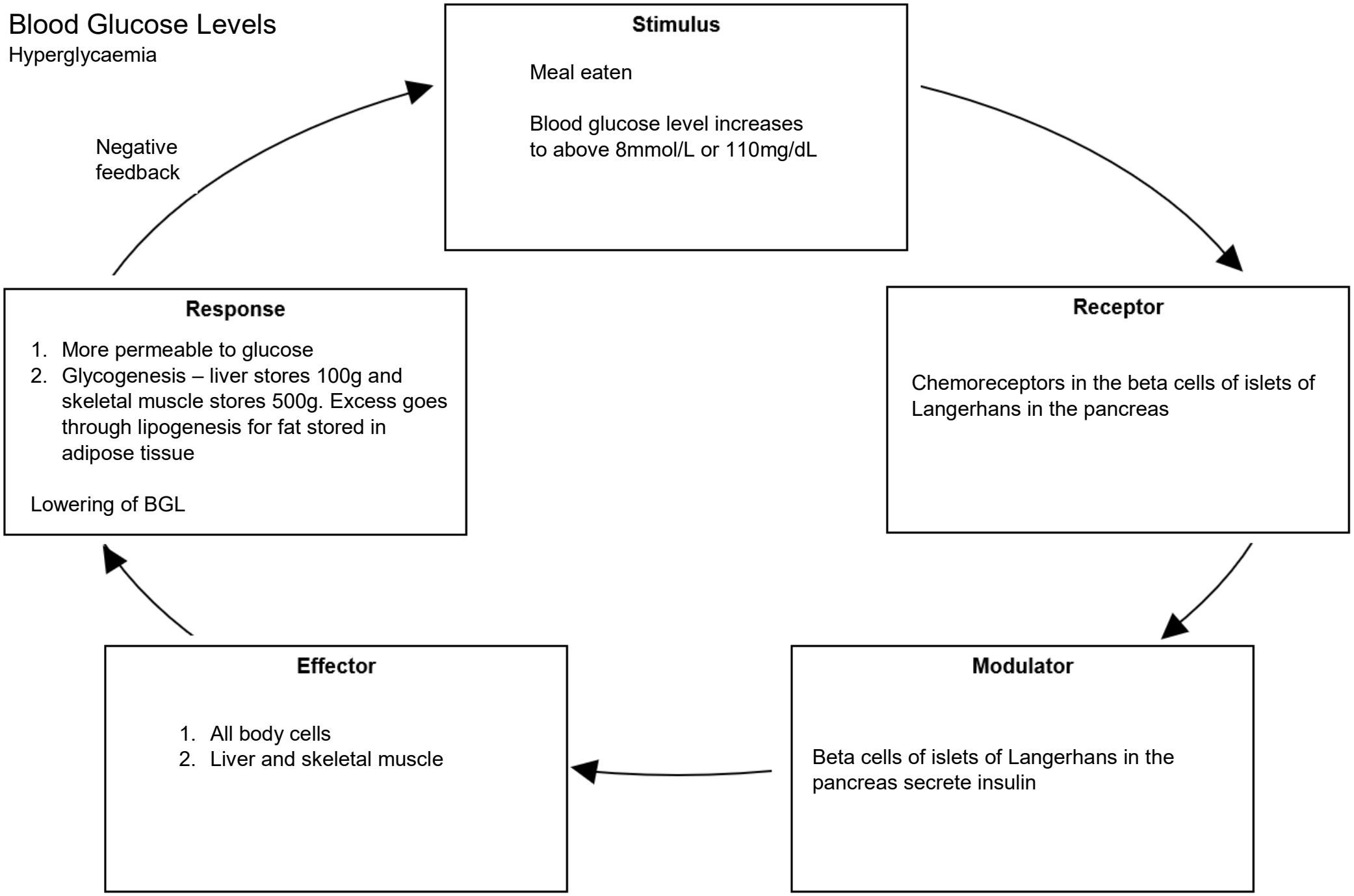
Gluconeogenesis: Producing glucose from fats and amino acids

Lipogenesis: Conversion of glucose to fatty acids for long term storage

Glycogenolysis: Process of converting glycogen back to glucose

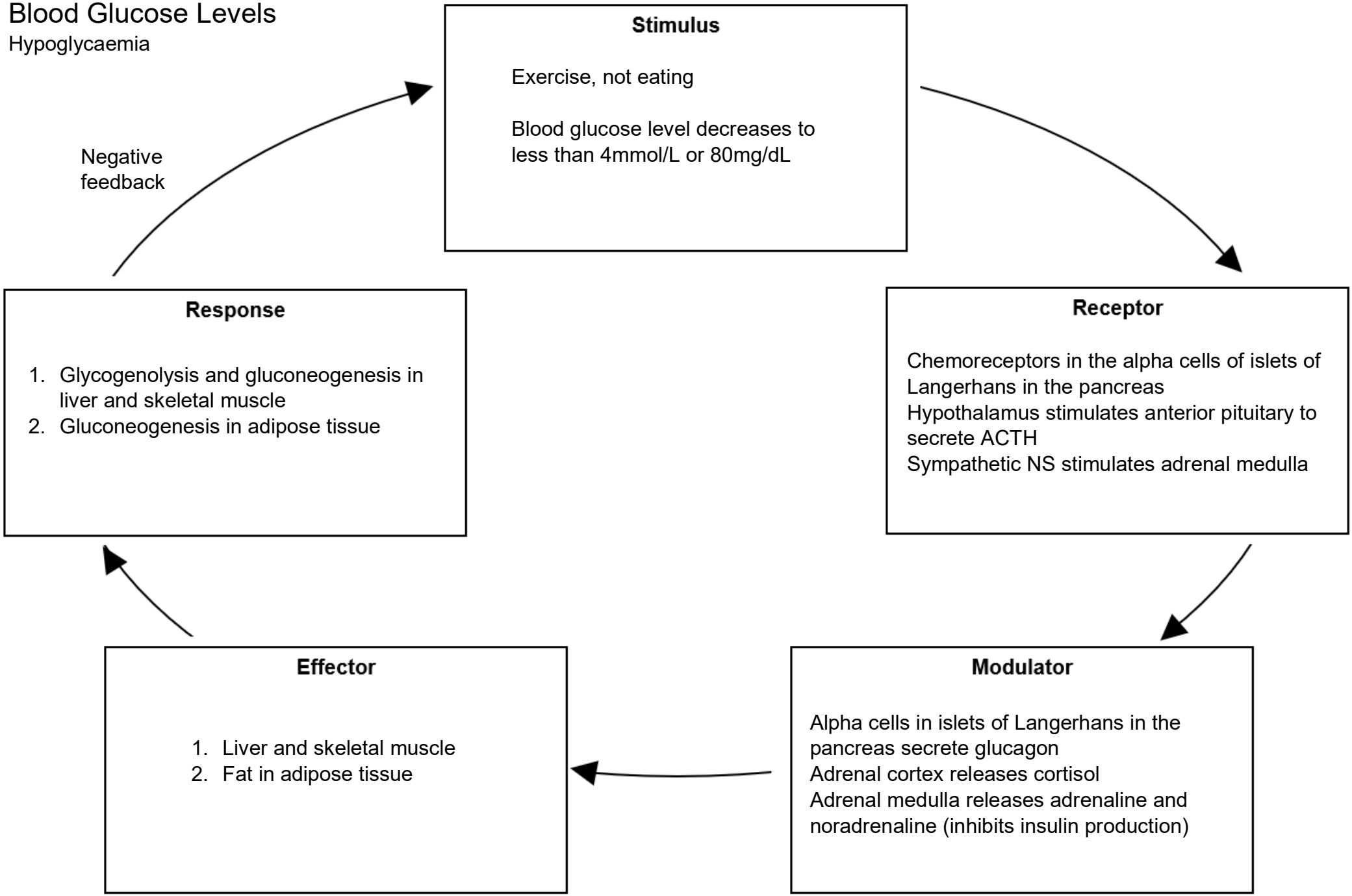
Blood Glucose Levels

Hyperglycaemia



Blood Glucose Levels

Hypoglycaemia



Osmoregulation

body fluid concentrations are maintained by balancing water and salts via the skin, digestive system and the kidneys, which involve the actions of antidiuretic hormone (ADH) and aldosterone on the nephron, and the thirst reflex

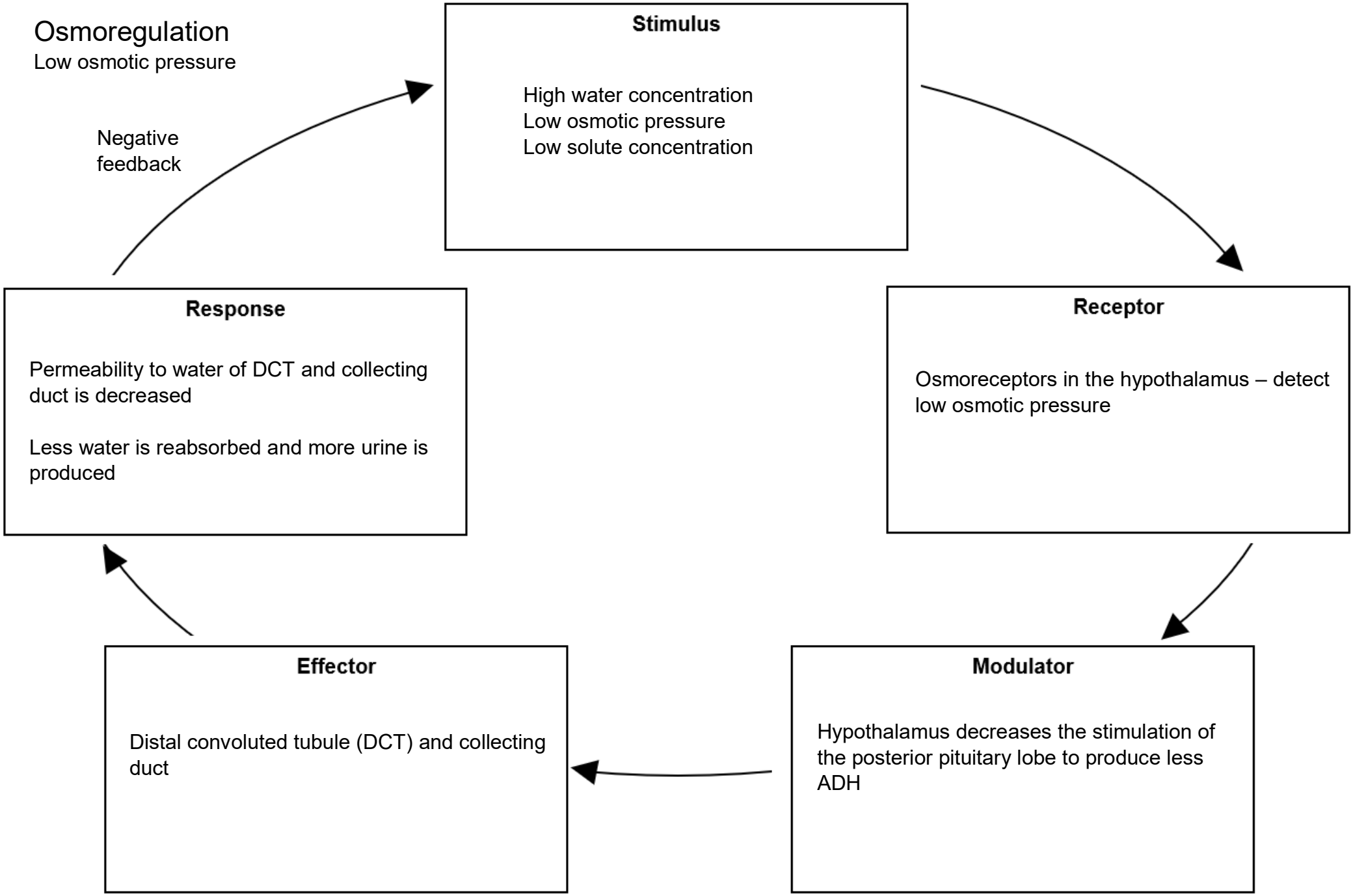
- Body approx. 60% water
- Types of fluid:
    - Intracellular: fluid inside cells
    - Blood plasma
    - Intercellular/extracellular/interstitial: fluid outside cells
- Water must be kept fairly constant and is obtained by drinking, eating and respiring
- 2.5L of water lost daily
    - lost through skin, lungs, kidneys and intestines

Kidneys
- 60% of water is excreted by the kidneys as it is the only water loss that can be regulated by the body
- Each kidney has approx. 1.2 million nephrons

Control of water loss
- Level of reabsorption of water is controlled by Anti-Diuretic Hormone (ADH)
    - Causes distal convoluted tubule (DCT) and collecting duct to reabsorb more water
    - Secreted by posterior pituitary
- When we are short of water, osmotic pressure rises
    - Water from interstitial fluid diffuses into plasma
    - Water from intracellular fluid diffuses across membranes into intracellular fluid
    - Cell shrinks

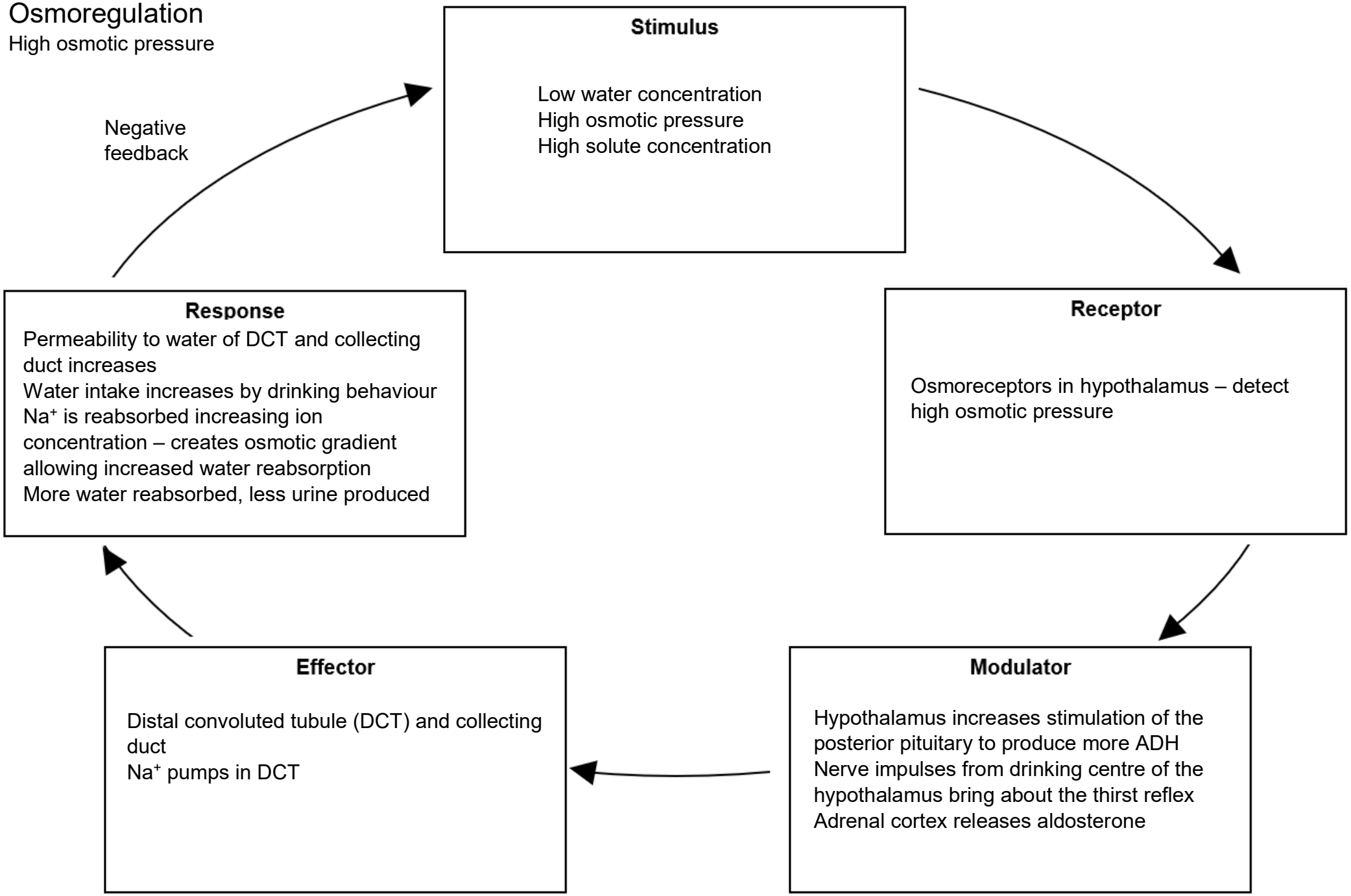
Dehydration
- Too little water
- Can be caused by sweating, vomiting, diarrhea
- Leads to headaches, dizziness, thirst, deliriousness and death

Intoxication
- Too much water
- Can be cause by drinking too much water
- Leads to headaches, vomiting, light-headedness, collapse, and rare: death


Osmoregulation
Low osmotic pressure
Negative feedback
Stimulus
High water concentration
Low osmotic pressure
Low solute concentration
Receptor
Osmoreceptors in the hypothalamus – detect low osmotic pressure
Modulator
Hypothalamus decreases the stimulation of the posterior pituitary lobe to produce less ADH
Effector
Distal convoluted tubule (DCT) and collecting duct
Response
Permeability to water of DCT and collecting duct is decreased
Less water is reabsorbed and more urine is produced

Osmoregulation

High osmotic pressure



Gas Concentrations

gas concentrations are controlled by balancing the intake of oxygen and the removal of carbon dioxide via the lungs, through the actions of the medulla oblongata and the autonomic nervous system

- All cells need a constant supply of oxygen
- Carbon dioxide must be removed from the blood stream
- Diaphragm and intercostal muscles carry out breathing
    - Stimulated by phrenic and intercostal nerves – controlled by medulla oblongata

Oxygen concentration
- O_2 does not affect rate of breathing unless it as at dangerously low levels
- Chemoreceptors in aortic and carotid bodies detect O_2 concentration in the blood
- Chemoreceptors also in medulla oblongata

Carbon dioxide concentration
- CO_2 the major stimulatory factor for breathing
- Chemoreceptors respond to increase in H^+ ions and CO_2 concentrations

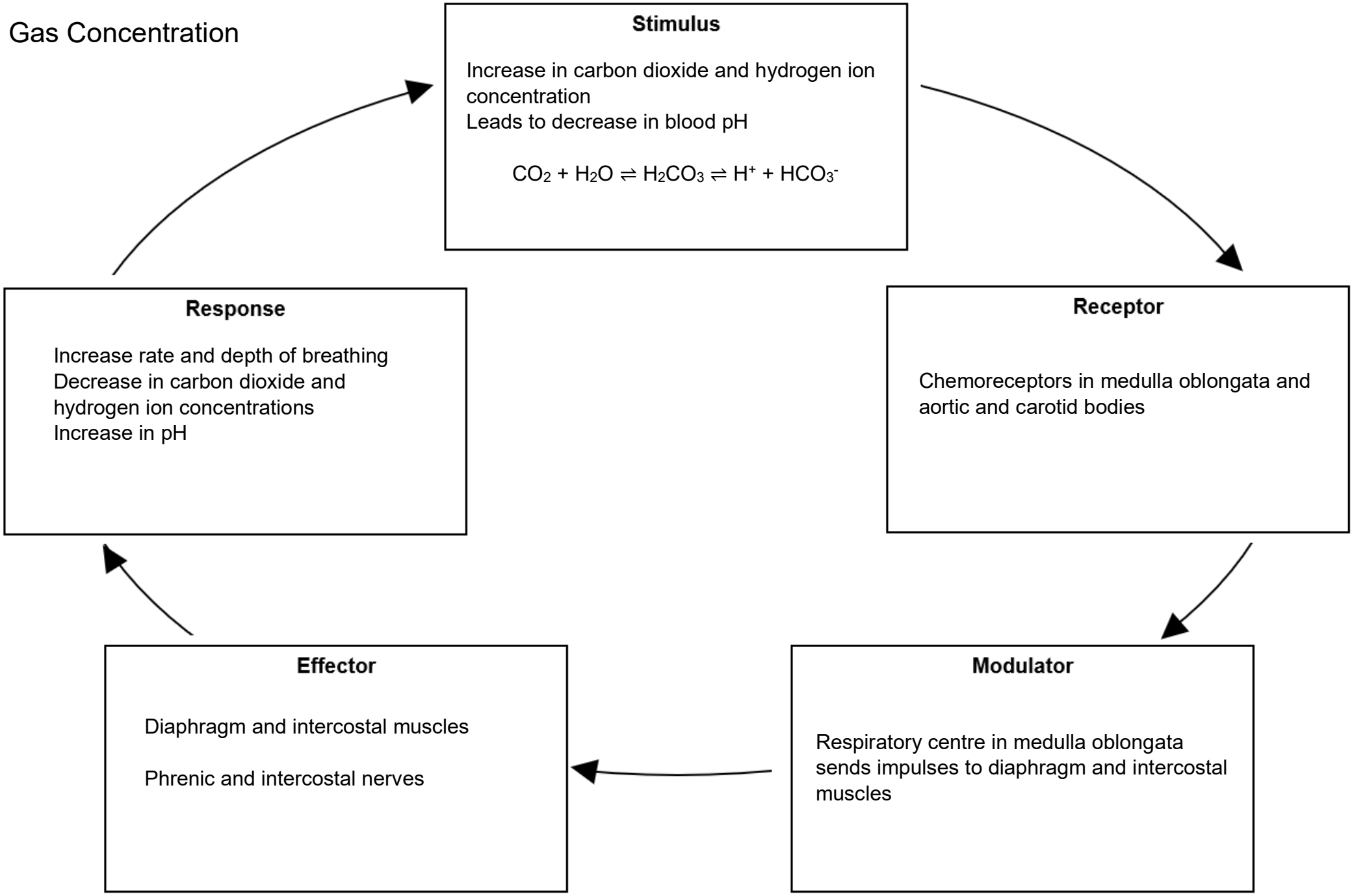
$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

- More H^+ ions – lower blood pH

Voluntary control of breathing
- Needed for speech, music, swimming, etc.
- Build up of CO_2 forces us to take a breath

Hyperventilation
- Rapid deep breathing that provides more oxygen and less carbon dioxide than what is necessary for the body
- Hyperventilation before swimming means that the swimmer may lose consciousness due to the lack of oxygen before needing to take a breath due to carbon dioxide build up
    - Can lead to drowning

Gas Concentration



Response to Infection

Infectious diseases caused by invasion of pathogens in the form of viruses and bacteria can be transmitted from one host to another

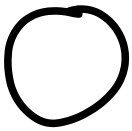
Pathogen: A disease-causing organism; often referred to as a pathogenic organism

Types of Pathogens

Bacteria

- Mostly non-pathogenic
- Lots on our skin and in our body
- Uni-cellular shape

Rod-shaped
Bacillus



Spherical
Cocci

Spiral
Spirillum

Curved rod
Vibrio

Transmission

- Contact
- Body fluids
- Droplets
- Ingestion
- Airborne

Examples

- Chlamydia
- Cholera
- Diphtheria

Viruses

- When a virus infects a living cell its DNA or RNA induces the cell to manufacture more virus particles
- Some viruses multiply in bacterial cells – these are called bacteriophages
- Virus infected cells secrete cytokines called interferons, which introduce resistance to viral infection in the surrounding cells

Transmission

- Contact
- Body fluids

Examples

- HIV/AIDS
- Influenza
- Measles

Transmission of Pathogens

Transmission of pathogens occurs by various mechanisms, including through:

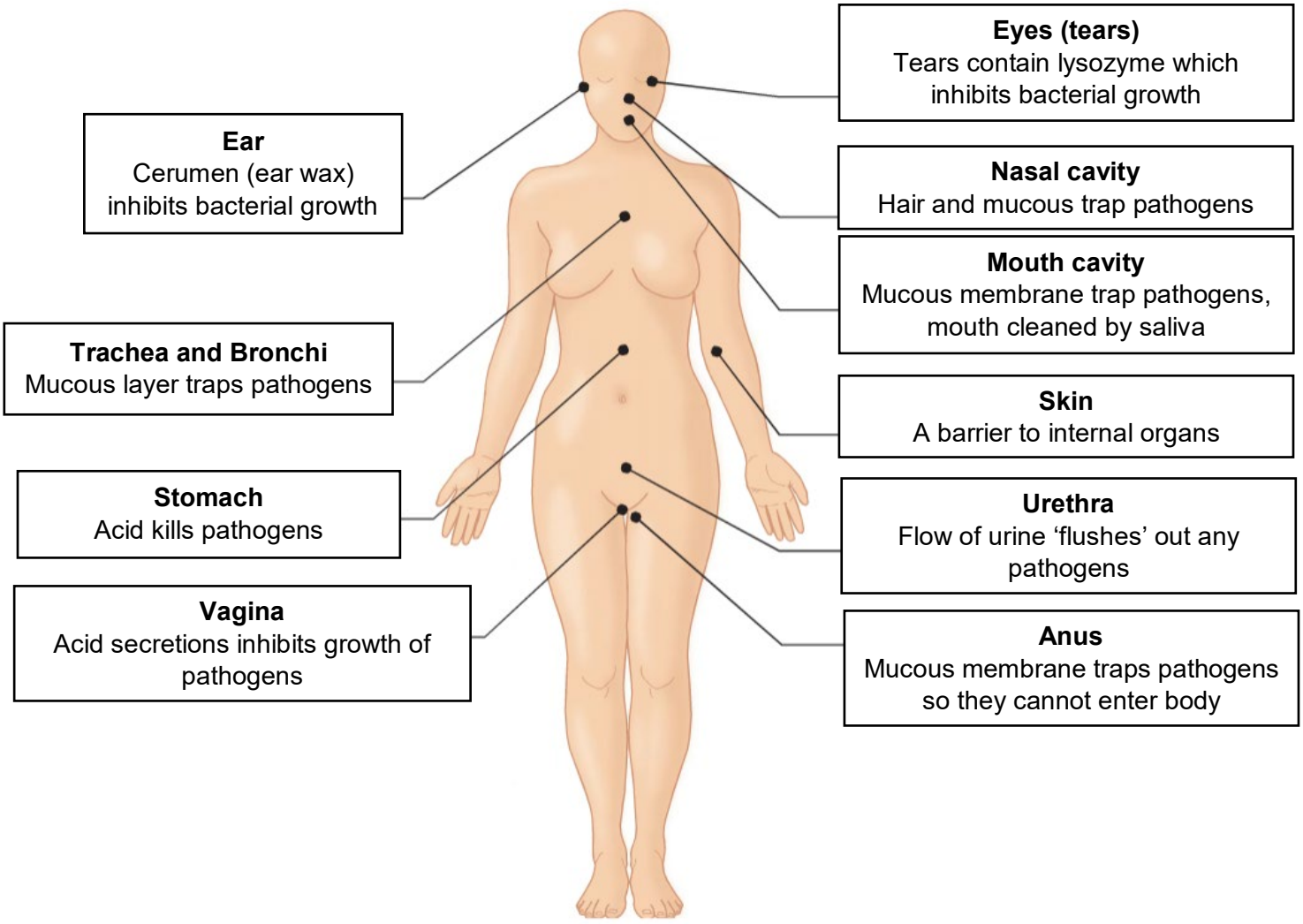
- *Direct and indirect contact*
- *Transfer of body fluids*
- *Disease-specific vectors*
- *Contaminated food and water*

Contact	• Spread of pathogen by physical contact • May be direct: actually touching an infected person • May be indirect: touching an object that has been touched by an infected individual • Skin infections and STIs
Body fluids	• Transfer of body fluids from one person to another • Blood or other body fluids from an infected person comes into contact with the mucous membranes of an uninfected person, then pathogens may enter the body of that person • HIV, Hep B and C
Vectors	• Transfer of pathogens by other animals (insects, ticks, mites) • Some vectors transfer the pathogen directly • Many vector-borne diseases are spread by a specific vector • Malaria, dengue fever, lyme disease, bubonic plague
Contaminated food and water	• Contamination of food and water during food preparation, or through vectors that spread the pathogen to food or water • Cholera, Hep A, Typhoid

First Line of Defence

The body's external defence mechanisms against pathogens include features of the:

- Skin
- Digestive tract
- Urogenital tract
- Respiratory system
- The ear
- The eye



- External
- Non-specific

Protective reflexes

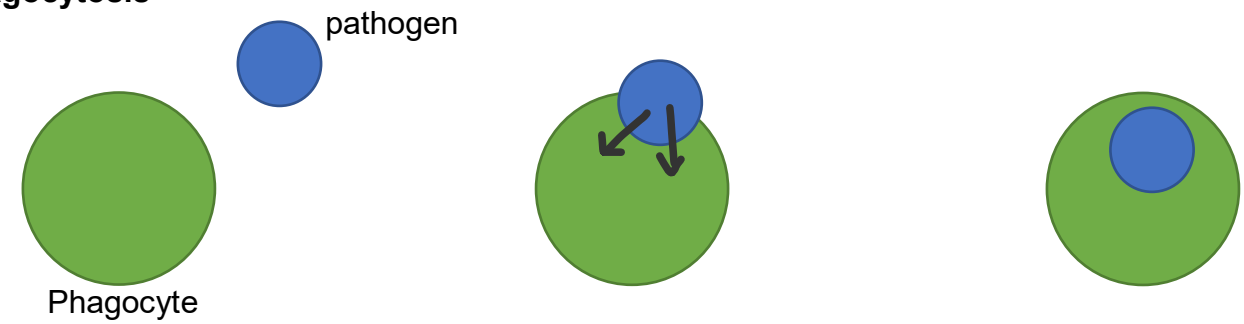
Sneezing	Stimulus: irritation of the nasal cavity Response: Forceful expulsion of air from lungs results in mucous and foreign particles to be expelled through nose and mouth
Coughing	Stimulus: Irritation of lower respiratory tract Response: Air is forced from the lungs to try and release or remove the irritant. Can release mucous and foreign particles out of the trachea and into the throat and mouth
Vomiting	Stimulus: As a result of bacterial toxins or due to overstretching (eat too much) Response: Involuntary forceful expulsion of stomach contents
Diarrhoea	Stimulus: Irritation of the walls of the small and large intestine Response: Faeces is more watery leading to faster expulsion of foreign bacteria/viruses from the anus

Second Line of Defence

pathogens that enter the body are targeted by non-specific immune responses of inflammation and fever

- Internal
- Non-specific

Phagocytosis



1. Phagocyte attracted to the foreign particle. Ingestion by the phagocyte/macrophage occurs
2. Vacuole forms inside the phagocytic cell. A lysosome binds to the vacuole and releases digestive enzymes
3. Enzymes break down the foreign particle leaving soluble debris
4. Vacuole leaves via exocytosis

Inflammation

1. Tissue is damaged. The skin becomes red, swollen, hot and painful
2. Mast cells stimulate production of histamine, heparin and phagocytes

Histamine: increase blood flow, causing capillaries to become more permeable. Increase metabolic heat (causing redness) with more fluid being filtered, the site swells
Heparin: prevents blood clotting. Allows phagocytes to be attracted to chemicals released by the mas cells. Blood clots form around injury, slowing down blood flow and pathogen movement
Phagocytes: are attracted to chemicals released by the mast cells

3. Pain receptors are stimulated
4. The phagocytic cells fill with debris, forming pus

Fever

- Increase in body temperature to above 37.5^{o}C – usually 39^{o}C
- As macrophages attack a pathogen, they secrete interleukins/pyrogens into the blood
- Pyrogens work directly on the hypothalamus, triggers an increase in body temperature
- Body feels cold and responds by shivering and vasoconstriction in skin
- Body temperature falls to normal

Benefits of fever:

- A higher temperature is thought to prevent the growth of some bacteria and viruses
- Increases the effects of interferon (introduce resistance to viral infection in surrounding cells and prevent replication of virus particles in host cells)

Third Line of Defence

immunity is gained through the exposure to specific antigens by the production of antibodies by B lymphocytes and the provision of cell-mediated immunity by T lymphocytes; in both cases memory cells are produced

- Internal
- Specific

Antibody-mediated / Humoral response

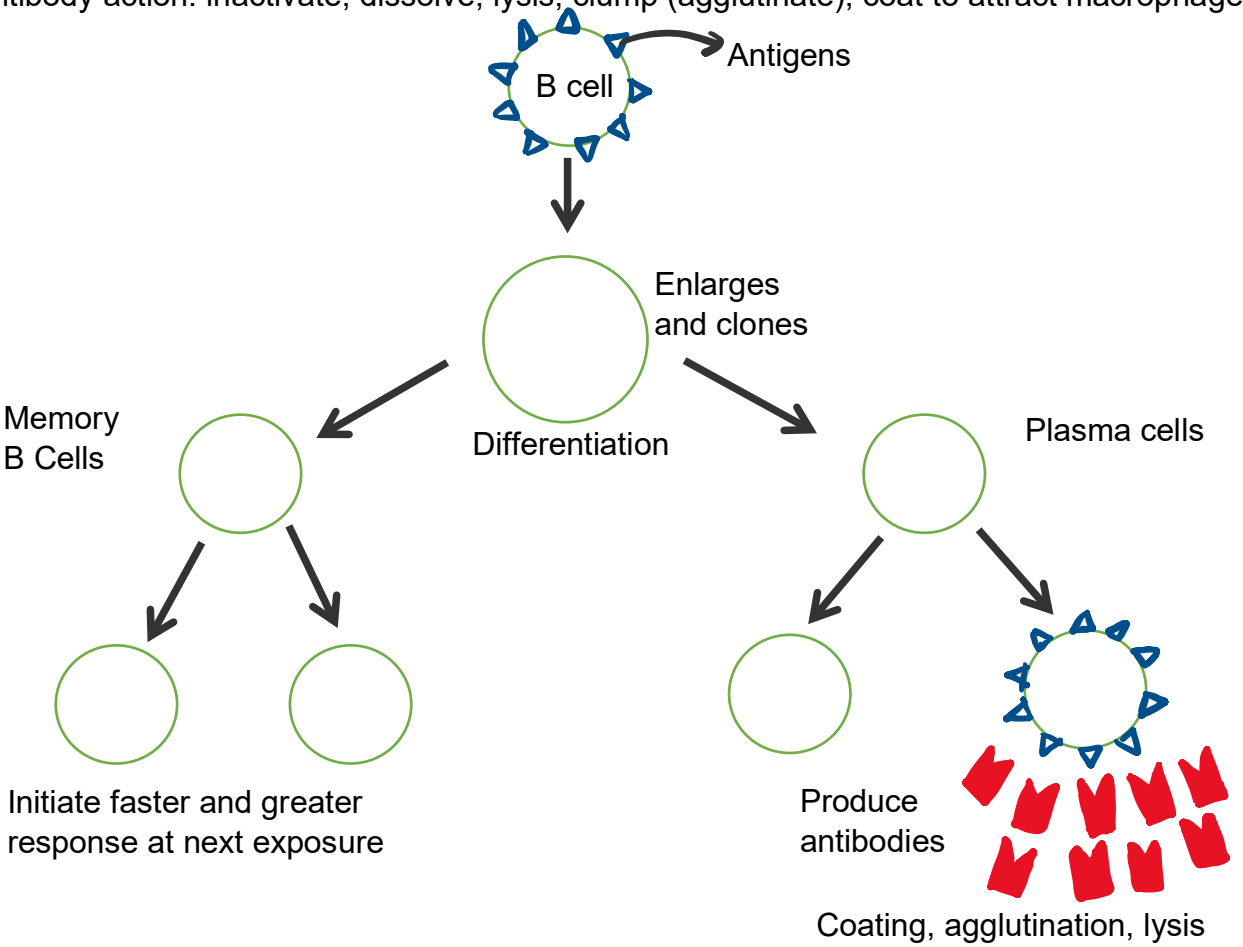
Antigen: any substance capable of causing formation of antibodies when introduced into the tissues

Self-antigen: any large molecule produced in a person's own body; does not cause an immune response in that person

Non-self-antigen: any compound foreign to the body that triggers an immune response

Antibody: a substance produced in response to a specific antigen; combines with antigen to neutralise or destroy it

- B-lymphocytes/B-cells
- Gives resistance to intercellular/extracellular antigens
- Specific antigen engulfed by macrophages
- Antigens presented to specific B cells in lymphoid tissues
- Each B cell has a specific receptor protein that match a specific antigen (antigen-antibody complex)
- B cell is sensitised, enlarges, clones, divides and differentiates into:
    - Memory cells for faster and larger response at next exposure to the pathogen
    - Plasma cells that make antibodies specific to the antigen and release into lymph to attack antigens
- Antibody action: inactivate, dissolve, lysis, clump (agglutinate), coat to attract macrophages



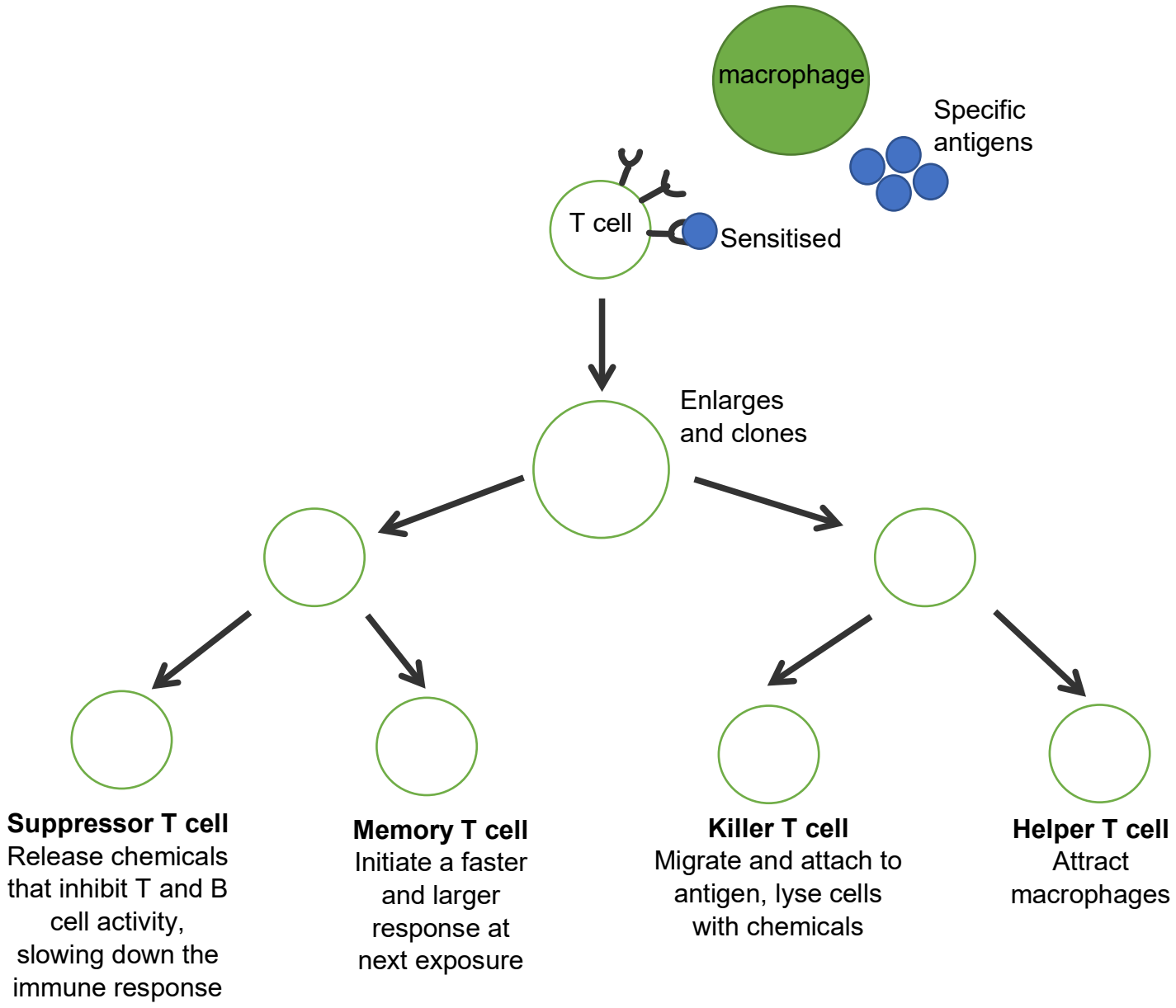
Antibody action

Antibodies combine with the antigen to form an antigen-antibody complex

- Coating - pathogen to attract phagocytes and digest easier
- Agglutination – pathogens clump together to stop them spreading
- Lysing – punch holes in bacterial cells so they burst/lyse
- Binding – bind to pathogen surface, stops them entering or damaging cells
- Dissolving – dissolve the pathogens

Cell-mediated response

- Attack pathogens that get inside cells (intracellular) where antibodies are unable to get to the pathogen, e.g. viruses
- T cell receptors are activated by antigen-presenting macrophages or B-cells
- Mobile, move around the body, mature in the Thymus
- Stimulate B cells and macrophages that lyse/kill cells e.g. cancer and transplant cells



Types of Immunity

passive immunity can be acquired as antibodies gained through the placenta, or antibody serum injections; active immunity can be acquired through natural exposure to the pathogen, or the use of vaccines

	Natural No human intervention	**Artificial** Injection, etc. of antibodies
Active Long lasting immunity	Antigens enter the body naturally, microbes cause the person to catch the disease. Stimulates the immune response but suffers symptoms. Body produces own lymphocytes and antibodies	Immunisation/vaccinations. Antigens (weakened or dead microbes or subunits) are injected as vaccines. Immunity without symptoms – body produces antibodies and specialised lymphocytes
Passive Short lasting immunity	Antibodies pass from mother to foetus via placenta during pregnancy or via breast milk during breast feeding. A baby does not produce antibodies of its own	Anti-venom. Pre-formed animal antibodies are injected into the body (treat snake bites, tetanus). The body does not produce antibodies

Treatment of Infection

antiviral and antibiotic drugs are used for treating infections and differ in their specificity to pathogens

the decision to participate in immunisation programs can be influenced by the social, economic and cultural context in which it is considered

Antibiotics

- Used for fighting the infection of bacteria
- Two types:
    - Bactericidal antibiotics: kill bacteria by changing the structure of the cell wall or cell membrane or disrupting the action of essential enzymes
    - Bacteriostatic antibiotics: stop bacteria from reproducing, usually by disrupting protein synthesis
- Broad spectrum: affect a wide range of bacterial infections
- Narrow spectrum: effective against only a couple of types of bacterial infections
- Multiple drug resistance: some strains of bacteria are resistant to most antibiotics, hastened by the overuse of antibiotics
- Total drug resistance: the resistance of some strains of bacteria to all antibiotics

Antivirals

- Antibiotics do not affect viruses
- Antivirals specific to viruses
- Inhibit the development of the virus

Vaccines

- 4 types of vaccines

Type	Explanation	Examples
Living attenuated micro-organisms	Micro-organisms of reduced virulence (disease-producing power)	Measles, mumps, rubella, TB
Dead micro-organisms	Micro-organisms that have been cultured and killed	Cholera, typhoid, whooping cough, influenza, Hep A
Toxoids	Filtrates of bacterial cultures containing inactivated toxins	Diphtheria, tetanus
Sub-unit	A fragment of the organism is used to make the vaccine	HPV, Hep B

Risks of Vaccines

- Allergic to the culture medium, e.g. Influenza vaccine cultured in egg protein
- Inability to completely isolate a virus from another, risk of introducing cross species virus – recombinant DNA prevents this
- Vaccines use preservatives such as Formaldehydes and acetone which some claim affect use of nervous system
- Ethical concerns over vaccines centre around its manufacture, testing and risks
- Other vaccines require human tissue to manufacture, this eliminates risk of cross species viruses being introduced
- Rubella vaccine is manufactured using cells of aborted foetuses which is an ethical concern for those who oppose abortion, they must weigh up health vs. stance on abortion
- Trial groups for vaccines may not be aware of the risks involved
- Vaccines usually tested on animals before human trials begin
- Some country's governments do not subsidise vaccines – economical concerns for families