5.1 Homeostasis

2023年9月18日 18:42

5.1 Homeostasis

- Homeostasis definition
  - The regulation of the internal conditions of a cell or organism to maintain optimum conditions for function in response to internal and external changes
  - e.g. enzyme action and all cell functions
- Process
  - (In this order)
  - Stimuli
    - Changes in the environment
  - Receptor
    - Cells that detect changes in the environment
  - Coordination centre
    - e.g. Brain, spinal cord, pancreas
    - Areas that receive and process information from receptors
  - Effectors
    - Muscles or glands that bring about responses which restore optimum levels
  - Response
    - Restore the optimum level
- What homeostasis control

Internal condition	Stimulus	Receptor	Coordination centre	Effector
Body temperature	Change in temperature	Skin	Hypothalamus in brain	Skin / muscles
Water level	Change in water content	Brain	Pituitary gland	Kidney
Blood glucose concentration	Change in blood glucose level	Pancreas	Pancreas	Liver

  - These automatic control systems may involve nervous responses or chemical responses

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5.2 The human nervous system

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5.2.1 Structure and function

- Nervous system
  - Enables humans to react to their surroundings and to coordinate their behaviour
- Automatic control system pathway
  - Stimulus → Receptor → Coordinator → Effector → Response
- Transmitting information to brain
  - A stimuli is detected by the receptor
  - The receptor send electrical impulses down the sensory neurone to the CNS
    - CNS = brain and the spinal cord, act as coordination centre
    - Travels up the spinal cord to the conscious area of the brain
  - Electrical impulses now pass from CNS to the effectors through motor neurone which brings a response
- Types of effectors
  - Muscles
    - Contraction to allow movement
  - Glands
    - Secrete hormones into the bloodstream which transport them into the effector (target organ)
- Reflex action definition
  - Response that does not involve conscious part of the brain (automatic)
- Reflex arc characteristics
  - No decision making from the conscious part of the brain
    - This makes reflex actions automatic and rapid to protect us from danger
- Reflex arc process
  - The stimulus is detected by the receptors
  - Electrical impulses pass down the sensory neurone and travel towards the CNS
  - The electrical impulses reach the synapse at the end of the sensory neurone
  - A chemical signal is released at the synapse and diffuses to the relay neurone in the CNS
  - An electrical impulse is triggered in the relay neurone and travel down the relay neurone
  - At the next synapse a chemical signal is released and diffuses to the motor neurone
  - Electrical impulses are triggered in the motor neurone
  - The impulses travel away from the CNS and reach the effector
  - The effector brings the response
  - * Signal travels to the conscious area of the brain up the spinal cord as well but slower
- Neurone structure
  - All have:
    - A long fibre (axon) which is insulated by a fatty (myelin) sheath
      - They are long so they can carry messages up and down the body
    - Tiny branches (dendrons) which branch further as dendrites at each end
      - These receive incoming impulses from other neurones
- Synapse
  - Neurones are not joined up directly to each other but instead have junctions between them called synapse
  - The electrical impulses cannot cross the synapse so chemical signals are diffused across the synapse
  - Slower than the electrical impulse in the neurones

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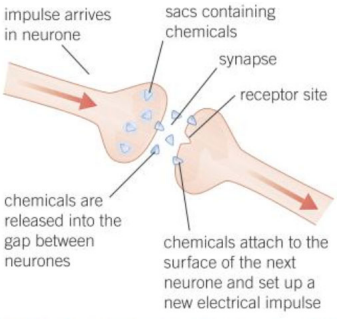
- 

5.2.1 Required practical 7

- Method
  - The person being tested have their arm resting on the bench
  - The other person hold a ruler vertically between thumb and index finger of the person
  - Drop the ruler without telling
  - The person being tested catch the ruler as soon as possible
  - Measure the distance dropped
  - Note down results, repeat
  - Find reaction time using a conversion table
- Control variables
  - Same distance between thumb and index finger (and ruler)
  - Drop the ruler from the same height each time
  - Same measurement method e.g. from top of the thumb
  - Use the same hand / all use dominant hand to catch the ruler each time
  - Carry out the experiment with the lower arm resting in the same way on the table so cannot compensate
- Other factors that may affect reaction time
  - Practising
  - Dominant / Non-dominant hand
  - Time of day / tiredness
  - Caffeine / alcohol
- Advantages of using a computer
  - More precise measurement of reaction time in milliseconds
  - You might be able to tell when the person is about to drop the ruler
  - Easier to keep the control variables the same (make it a fair test)
    - e.g. may be difficult to keep the distance between thumb and index finger

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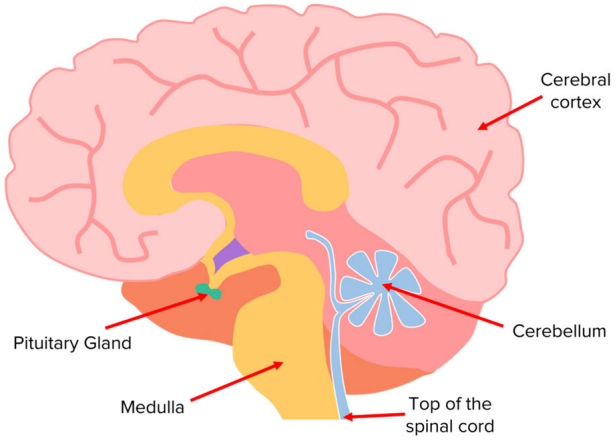
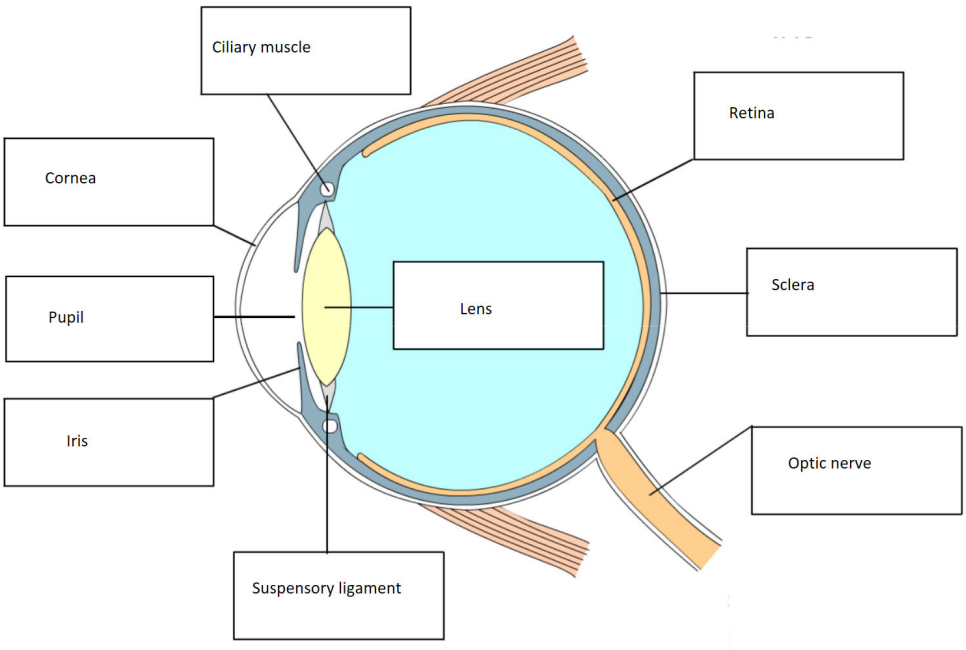
5.2.2 The brain

- How the brain control complex behaviour
  - It has billions of interconnected neurones and has different regions that carry out different functions
- Structure of the brain
  - Cerebral cortex
    - Control complex behaviours
    - Control consciousness, intelligence, memory, and language
  - Cerebellum
    - Coordinate muscular activity and balance
  - Medulla
    - Control unconscious activities e.g. breathing, heartbeat, movement of the gut

- 

- Difficulties of investigating brain function and treating brain damage and disease
  - Surrounded by the skull so it is hard to access
  - Delicate and easy to damage
  - Complex structure so it is difficult to work out exactly which parts have which function
- Ways to study the brain
  - Look at patients with brain damage
    - Compare with normal people
    - Work out the function of the damaged part
  - Electrically stimulate different parts of the brain
    - Apply a weak electrical impulse to different parts of the brain
    - Ask what the person tested feels / look at the effects on person's behaviour
    - Narrow down specific regions to their functions
  - MRI (magnetic resonance imaging) scanning
    - Look at which parts of the brain are most active during different activities

5.2.3 The eye

- Diagram
- 

- Different parts of the eye

Structure	Function
Sclera	• The white tough outer structure that protects the eye
Cornea	• Transparent front of the eye • This starts the focussing of light
Iris	• Coloured part of the eye • Adaptation • Adjusts the size of the pupil in response to light intensity by

	contracting specific muscles
Pupil	• The hole in the centre of the iris • Light passes through this before passing through the lens
Lens	• Focusses light onto the retina • Changes shape when viewing distant or near objects
Retina	• Light is focussed on the retina • The retina contains the receptors (rod and cone) for light intensity and colour intensity
Optic nerve	• Carries electrical impulses from the retina to the brain
Suspensory ligaments	• Work with the ciliary muscles to change the shape of the lens for focussing on near or far objects
Ciliary muscles	• The ciliary muscles change the shape of the lens for focussing on near or far objects

- Rods and cones
  - Rod
    - More sensitive to light, used in dark environment
    - Cannot detect colour
  - Cone
    - Less sensitive to light
    - Can detect colour
- Changing pupil size
  - The change in light intensity is sensed by light receptors in the retina
  - The receptors send electrical impulses to the brain
  - The brain then sends electrical impulses to specific muscles in the iris
  - These muscles contract
  - The pupil to become dilated (dark) / contracted (bright)
  - This now allows more / less light to enter the eye (protection)
  - (Reflex action)
- Focusing light
  - Accommodation
    - The process of changing the shape of the lens to focus on near or distant objects
  - Light that enters the eyes has to be focused on light-sensitive cells of the retina to see clearly
  - If the light is focused in front or behind the retina the image will get blurred
  - A lot of focusing is carried out by cornea but it is a fixed focus
  - The rest of the focus is carried out by the lens
  - Focus on distant objects
    - Light from distant objects only need to be refracted for a relatively small amount
    - Ciliary muscle is relaxed
    - Suspensory ligaments are pulled tight
    - Lens becomes thinner
    - Light rays are refracted less strongly
    - Light focused onto the retina
  - Focus on near objects
    - Light from near objects only need to be refracted for a large amount
    - Ciliary muscle is contracted
    - Suspensory ligaments are loose
    - Lens becomes thicker
    - Light rays are refracted more strongly
    - Light focused onto the retina
- Defects in eye
  - Hyperopia / long sight
    - The eye ball is too short for the strength of the lens
    - In some cases lens become less elastic
      - Lens cannot become thick enough to focus on near objects

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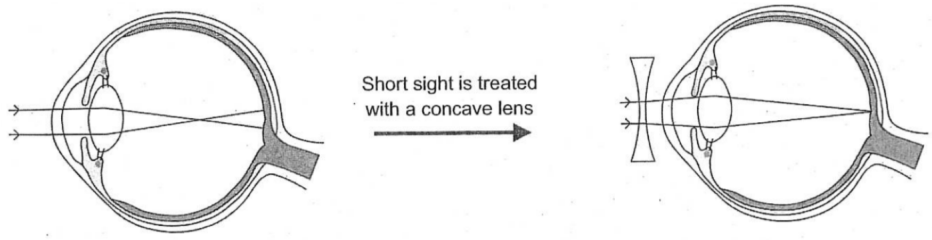
        - Light focus at a point behind the retina
        - 

    - Myopia / short sight
        - The eye ball is too long for the strength of the lens
        - In some cases lens become less elastic
            - Lens cannot become thin enough to focus on far objects
        - Light focus at a point in front of the retina
        - 

- Treating defects in eye
    - Hyperopia / long sight
        - Convex lenses
        - Partially focuses light before it passes into the eye / refracts light more
        - Lens can complete the focusing of light <u>onto retina</u>
    - Myopia / short sight
        - Concave lenses
        - Partially unfocuses light before it passes into the eye / refracts light less
        - Lens can complete the unfocusing of light <u>onto retina</u>
- Alternative ways of treating long and short sights
    - Contact lenses
        - Sit on the eyeball
        - Refract the light in the same way as glasses
    - Laser surgery
        - Only available to adults whose eyes have stopped growing and their vision have become stable
        - Change the shape of the cornea
        - Treats myopia by reducing the thickness of the cornea so it refracts light less strongly
        - Treat hyperopia by changing the curve of the cornea to refract light from close objects more effectively
    - Artificial lens
        - Faulty lens can be replaced using artificial lens or a permanent contact lenses can be put
        - Correct the visual defect permanently
        - Has the risk of damaging retina, cataracts developing if natural lens remain in place, and infections.

<u>5.2.4 Control of body temperature</u>

- Thermoregulation
    - Thermoregulatory centre in the brain monitors and controls body temperature
        - It has receptors sensitive to the temperature of the blood
    - The skin also contains sensory neurone and sends electrical impulses to the thermoregulatory centre
    - In the hypothalamus
- Negative feedback process
    - Detecting temperature change
        - Temperature receptors in the thermoregulatory centre
            - Detect that the temperature of the blood is too high or too low

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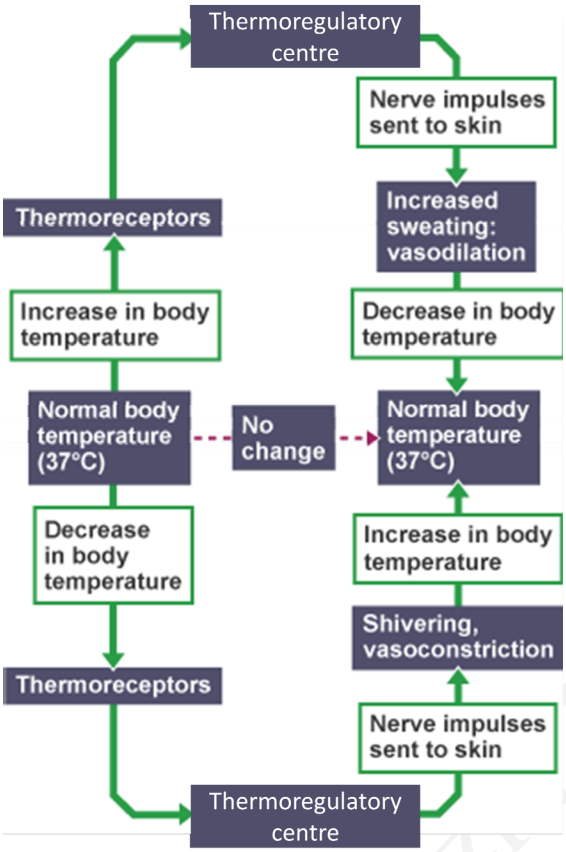
        - Temperature receptors on the skin
            - Also detect the change in body temperature
            - Send electrical nerve impulses to the thermoregulatory centre
    - The thermoregulatory centre will then coordinate a response and send impulses to specific effectors
    - Effectors will produce responses that will increase or decrease body temperature accordingly, returning it back to normal
    - 

- Responses to increase in body temperature
    - Vasodilation
        - The skin contains capillaries supplied by arterioles deeper in the skin
        - When the body gets too hot the arterioles dilate and more blood flows through the surface capillaries in the skin
        - More heat energy is transferred from the skin to the environment
        - Cooled blood cools the body
    - Sweating
        - Sweat glands release sweat onto the skin surface
        - When sweat evaporates heat energy is transferred from the skin to the external environment
- Responses to decrease in body temperature
    - Vasoconstriction
        - The skin contains capillaries supplied by arterioles deeper in the skin
        - Muscles in the arteriole constrict and arterioles become narrower
        - Less blood flows through the skin capillaries
        - Less heat energy transferred from the skin to the environment which helps increase the temperature of the body
    - Shivering
        - During shivering skeletal muscles contract
        - To provide energy for contraction muscle cells increase the rate of respiration
        - Some of the energy is released as heat in respiration which helps increase the temperature of the body
    - No sweating
        - Less heat transferred from the skin into the surroundings due to evaporation of sweat

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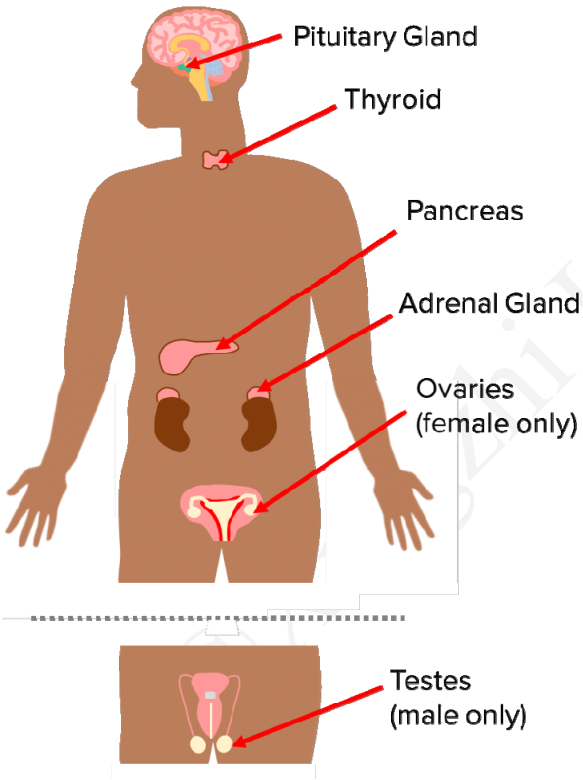
5.3 Hormonal coordination in humans

2023年10月12日 13:33

5.3.1 Human endocrine system

- Hormones
  - Chemical messengers
  - Produced by the endocrine system
  - Affect specific tissues / organs
  - Released into the bloodstream
- Human endocrine system
  - Composed of glands which secrete hormones directly into the bloodstream
  - The blood carries the hormones to a target organ where it produces an effect
  - Slower but longer effects compared to the nervous system
- Glands
- 

- Pituitary gland
  - The master gland which secretes several hormones into the blood in response to body conditions
  - These hormones in turn act on other glands to stimulate other hormones to be released to bring about effects
- Thyroid
  - Controls growth and the body's basal metabolic rate
- Pancreas
  - Controls the concentration of glucose in the bloodstream
- Adrenal gland
  - Release adrenaline in response to fear and stress
- Ovary
  - Control puberty and reproduction in females
- Testes
  - Control puberty and reproduction in males
- Comparison of endocrine and nervous system

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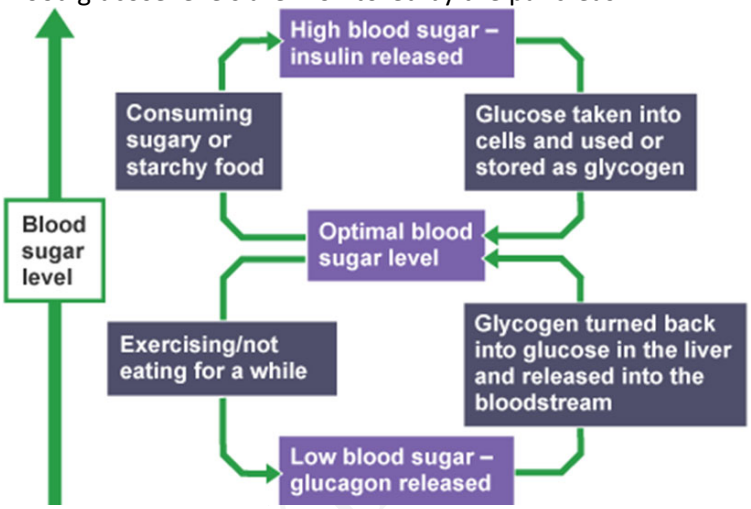
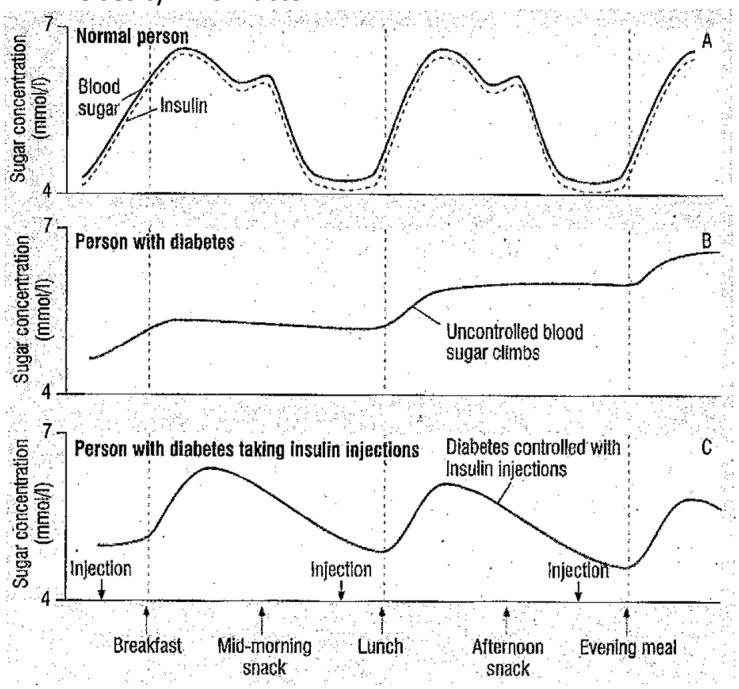
	Hormonal	Nervous
Type of signal	Chemical	Electrical impulse
Transmission of signal	By the bloodstream	By nerve cells
Effectors	Target cells in particular tissues	Muscles or glands
Types of response	Chemical change	Muscle contraction or secretion
Speed of response	Slower	Very rapid
Duration of response	Long	Short

5.3.2 Control of blood glucose concentration

- Importance of controlling blood glucose
  - Glucose is needed for respiration
  - Glucose concentration affects osmosis because glucose is soluble
    - Lower blood glucose concentration = higher concentration of water
      - Water diffuse into cells through osmosis → cells burst
    - Higher blood glucose concentration = lower concentration of water
      - Water diffuse out of cells through osmosis → cells shrink
- Negative feedback cycle of blood glucose concentration
  - Blood glucose levels are monitored by the pancreas
  - 

- When blood glucose concentration increases
  - e.g. after a meal high in carbohydrates
  - The rise in blood glucose is sensed by the pancreas
  - The pancreas secretes insulin into the bloodstream
  - Insulin triggers cells to absorb glucose from the blood
  - Muscle and liver cells convert excess glucose to glycogen for storage
  - Blood glucose concentration returns back to normal levels
- When blood glucose concentration decreases
  - e.g. in between meals / exercising
  - The fall in blood glucose is sensed by the pancreas
  - The pancreas secretes glucagon into the bloodstream
  - Glucagon triggers liver cells to convert glycogen to glucose
  - Glucose is released into the bloodstream by cells
  - Blood glucose concentration returns back to normal level
- Diabetes
  - A serious condition in which the body is unable to regulate blood glucose levels
  - Type 1 diabetes
    - Pancreas cannot secrete enough hormone insulin
    - Characterised by uncontrolled high blood glucose levels
    - Normally treated with insulin injections
  - Type 2 diabetes
    - Pancreas makes insulin but the body cells no longer respond to the insulin produced

- Common treatments = carbohydrate controlled diet and exercise regime
- Obesity = risk factor



5.3.3 Maintaining water and nitrogen balance in the body

- Ways of losing water
  - Water leaves the body via the lungs during exhalation
    - More exhalation in sports so more water lost
  - Water (also ions and urea) are lost from the skin in sweat
  - There is no control over water, ions, and urea lost by lungs and skin
  - Excess water (also ions and urea) are removed via the kidneys in urine
  - The body can control how much water is lost in urine
- Function of the kidney and nephron
  - Filtration
    - Blood with waste products enters the renal artery at high pressure
    - Small molecules including glucose, water, ions, and urea are filtered out
    - Large molecules such as proteins, WBC and RBC remain in the blood
  - Selective reabsorption
    - Kidneys selectively reabsorb the molecules that are needed
      - All of the glucose and some of water and ions depending on the body's neeed to maintain a constant balance in the blood plasma
      - Urea is not reabsorbed
  - Formation of urine
    - Molecules that are not selective absorbed including urea and excess ions and water pass along the tubule of the nephron as urine
    - Urine flow in the ureter to the bladder

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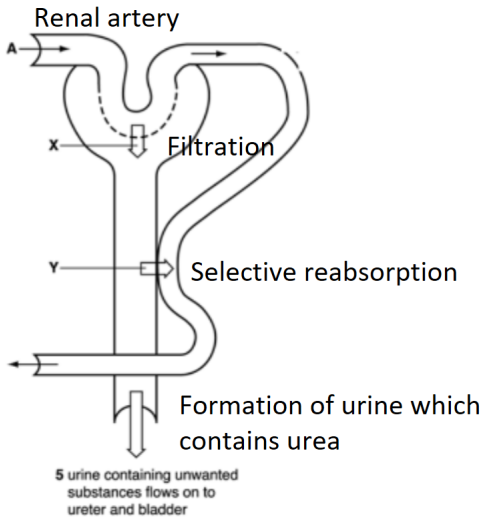
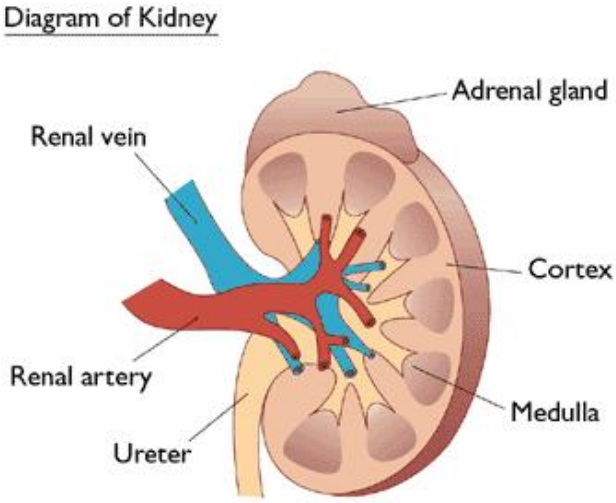
- 

- Kidney parts
  - 

- Concentration change
  - Glucose
    - Not changed
    - All glucose is reabsorbed back into the blood
  - Ions / water
    - Decreases
    - Filtered out of the blood and a certain amount is reabsorbed depending on the need of the body
  - Urea
    - Falls to zero
    - Filtered out and not reabsorbed
- Deamination
  - Digestion of protein from the diet results in excess amino acids which need to be excreted
  - Amino acids are deaminated in the liver to form ammonia
  - Ammonia is toxic and must be converted to urea by the liver immediately for safe excretion
- Controlling water level
  - The pituitary gland senses the rise / fall in the concentration of water in the blood
  - Concentration falling
    - The pituitary gland releases the hormone ADH into the bloodstream
    - ADH travels in the blood to the kidney, the target organ
    - ADH increases the permeability of the kidney tubules to water
    - The kidney tubules reabsorb more water back into blood → less water lost in urine
  - Concentration rising
    - The pituitary gland releases less ADH into the bloodstream
    - ADH travels in the bloodstream to the kidney

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        - The permeability of kidney tubule to water falls
        - The kidney tubules reabsorb less water back into blood → more water lost in urine
    - The concentration of water in the blood returns back to normal
    - The pituitary gland senses that the concentration of water in the blood is returning to normal
    - The pituitary gland stops producing ADH
- Kidney failure
    - The blood containing a higher concentration of water, ions, and urea than it should
- Kidney dialysis
    - The patient's blood passes over a semi-permeable membrane
    - Urea, ions, water pass through the membrane, large particles (e.g. proteins) or blood cells cannot
    - Dialysis fluid on the other side of the membrane
    - Dialysis fluid contains the normal concentrations of glucose, water and ions but no urea
        - There is a concentration gradient for urea so urea diffuse into the dialysis fluid
        - Normal concentrations of water and ions → excess ions and excess water is removed from the blood by diffusing into the dialysis fluid
        - Glucose remains in the blood for use in the body
        - Refreshed constantly to maintain concentration gradient for urea
    - Concentration return to normal
- Comparison between kidney dialysis and kidney transplant

	Kidney dialysis
Advantages	• No shortage of dialysis machines • No anti-rejection / immunosuppressant drugs • No major surgery needed
Disadvantages	• Expensive in the long term • Requires frequent treatments and a controlled diet - inconvenient • Risk of infection and blood clots from frequent needle punctures / blood contacting machine • May need anti-clotting drugs • Only work for a number of times before transplant is needed

	Kidney transplant
Advantages	• Allows patient to lead normal life, no need for regular hospital visits • No risk of infection from frequent needle punctures or blood contacting the machine • Less need to control diet • Maintains correct concentration of substances in the body → less damage to body cells • Only expensive initially / cheaper in the long run
Disadvantages	• Shortage of kidney donors • Patients have to take anti-rejection drugs for rest of life • Immunosuppressant drugs = prone to infection • Risk from major surgery • Only lasts for 8-9 years → another surgery needed

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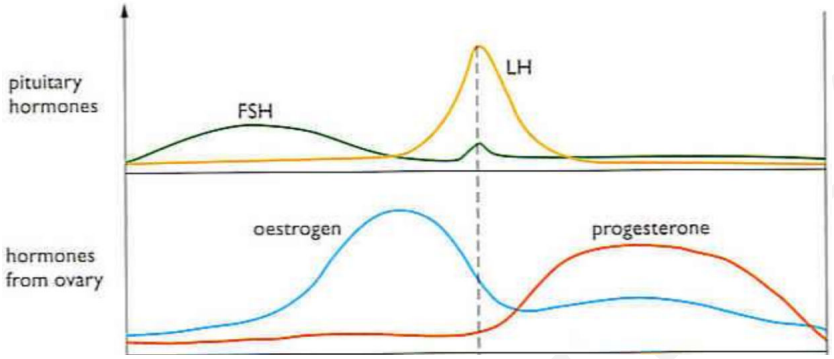
5.3.4 Hormones in human reproduction

- Main reproductive hormones
    - Main female reproductive hormone = oestrogen
        - Produced in the ovary
    - Main male reproductive hormone = testosterone
        - Produced by the testes
        - Stimulates sperm production
    - Cause secondary sex characteristics to develop during puberty
- Hormones involved in the menstrual cycle
    - Follicle stimulating hormone (FSH)
        - Produced by the pituitary gland

- Transported by the bloodstream to ovary
- Cause egg to mature in the ovary + ovary to produce oestrogen

- Oestrogen
  - Produced by the ovary
  - Causes the uterus lining to grow
  - Inhibits FSH release
  - Stimulates LH release (cause an egg to be released)
- Luteinising hormone (LH)
  - Produced by the pituitary gland
  - Stimulates ovulation (the release of an egg) at day 14
- Progesterone
  - Produced in the ovaries by the remains of follicle after ovulation
  - Maintains the uterus lining during the second half of the cycle
  - Inhibits FSH and LH release
  - If egg not fertilised the level of progesterone falls and the uterus lining breaks down
- ★ Oestrogen and progesterone maintains uterus lining



5.3.5 Contraception

Method	How it works	Advantages	Disadvantages
Oral contraceptives	• Contains oestrogen + progesterone to inhibit FSH production so no eggs mature	• Very effective	• Must be taken daily to prevent pregnancy • Increased risk of cancer • Does not protect against STD
Injection, implant, skin patch	• Release of progesterone slowly to inhibit the maturation and release of eggs for a number of months	• Very effective. • Long lasting	• Does not protect against STD
Barrier methods e.g. condoms, diaphragms	• Prevents the sperm from reaching the egg	• No side effects as no hormones used • Reduces risk of STD	• Can break
Intrauterine devices	• Prevents implantation of an embryo or release a hormone to reduce chance of fertilisation	• Long lasting up to ten years	• Does not protect against STD
Spermicidal agents	• Kill or inactivate sperm	• Reduced chance of fertilisation if used with a condom or diaphragm	• Applied before every intercourse

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Abstaining from intercourse	• Abstaining when egg in the oviduct	• Natural contraception	• Difficult to know if woman has ovulated • Does not protect against STD
Surgical	• Male sterilisation prevents sperm from leaving the testes • Female sterilisation prevents egg from reaching the uterus	• Effective	• Involves surgery • Difficult to reverse • Does not protect against STD

5.3.6 Hormones to treat fertility

- Fertility drugs
  - Contains FSH and LH
  - Causes the woman to ovulate more than usual → higher chance to become pregnant through sexual intercourse
- In vitro fertilisation (IVF)
  - Egg and sperm collected from the parents
    - The woman is treated with FSH and LH
    - Several eggs mature in the ovary
    - The eggs are collected
    - Sperm is collected from the father
  - The eggs are fertilised by the sperm in a lab
  - The eggs are allowed to develop into embryos
  - The embryos are inserted into the uterus of the woman
  - The embryos develop into babies
- Disadvantages of IVF
  - Risks of multiple births
  - Low success rate so several rounds of IVF may be required
  - IVF is physically and emotionally stressful
  - During IVF many embryos are produced and not all embryos are used, unused embryos are destroyed (ethical issues)
  - IVF is very expensive

5.3.7 Negative feedback

- Negative feedback definition
  - A mechanism where changes to conditions cause an action to reverse the change, to keep conditions stable
- Hormones in different systems

System	Hormones involved
Basal metabolic rate	Thyroxine
Menstrual cycle	FSH, LH oestrogen and progesterone
Blood glucose regulation	Insulin and glucagon
Osmoregulation	ADH

- Thyroxine
  - Produced from the thyroid gland
  - It stimulates the basal metabolic rate to increase
    - A high basal metabolic rate involves increasing the rate of respiration
  - Also plays an important role in growth and development
- Thyroxine level negative feedback

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    - Low thyroxine levels in the bloodstream stimulate pituitary gland to release thyroid stimulating hormone (TSH) into the blood
    - TSH triggers the thyroid gland to produce more thyroxine
    - Increasing thyroxine levels are detected by the brain
    - Pituitary gland stops releasing TSH
    - Thyroid gland produces less thyroxine
- Adrenaline
    - Adrenaline is produced by the adrenal glands in times of fear or stress
    - It increases heart rate so a greater volume of blood is pumped by the heart per minute
    - Therefore more oxygen and glucose is delivered in the blood to muscle cells and diverted from the digestive system
    - Extra oxygen and glucose is used in aerobic respiration by muscle cells
    - This prepares the body for a quick 'fight and flight' response
    - The effects of adrenaline will stop when the hormone is broken down by the liver

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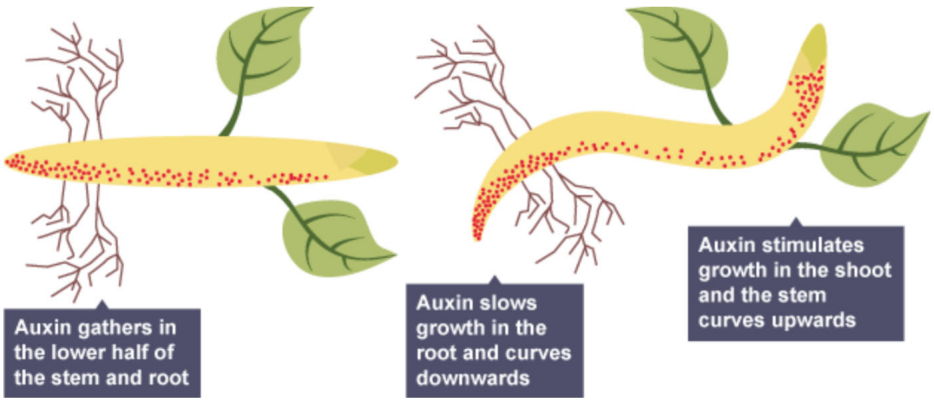
5.4 Plant hormones

2023年10月23日 22:45

5.4.1 Control and coordination

- Types of plant tropism
Tropism	Phototropism	Gravitropism / Geotropism	Hydrotropism
Stimulus	Light	Gravity	Water
Shoot response	Positive phototropism	Negative	Negative
Root response	Negative phototropism	Positive	Positive
- Phototropism
  - Even light
    - Even light is detected by the tip of the shoot
    - Auxin is released from the tip of a shoot
    - Auxin diffuses down the shoot evenly giving equal concentrations of auxin on all sides
    - Equal concentrations of auxin cause equal growth by cell elongation on all sides
    - Shoot grows upwards towards the light
  - Unilateral light (from one side)
    - Unilateral light is detected by the tip of the shoot
    - Auxin is released from the tip of the shoot and diffuses to the dark side below the shoot tip
    - Cells on the darker side grow more than cells on the light side
    - The shoot grows and bends towards the light
- Gravitropism / geotropism
  - Shoots
    - Auxin collects on lower side
    - Auxin stimulates growth in shoots on the lower side
    - Shoots grow and bend upwards away from gravity
  - Roots
    - Auxin collects on the lower side
    - Auxin inhibits growth of roots on the lower side
    - Roots grow downwards towards gravity
  - 

- Clinostat
  - Used for tropism experiments
  - It is a rotating drum that allows light and gravity to be distributed evenly
  - Equalises the effect of light and gravity
  - Therefore gravity acts equally on all sides of the root and light acts equally on all sides of the shoot
- Other hormones in plants
  - Gibberellins are important in initiating seed germination
  - Ethene controls cell division and ripening of fruits

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5.4.2 Use of plant hormones

- Hormone uses
  - Auxins
    - Weedkillers
    - Rooting powders
    - Promoting growth in tissue culture
  - Gibberellins
    - End seed dormancy / promote seed germination
    - Promote flowering
    - Increase fruit size
  - Ethene
    - Used in the food industry to control ripening of fruit during storage and transport

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6.1 Reproduction

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6.1.1 Sexual and asexual reproduction

- Sexual reproduction
  - Genetic information from a mother and father is mixed together to form genetically different offspring
  - Involves the fusion of male and female gametes formed during meiosis
  - The fusion of gametes is known as fertilisation
  - There is variation in the offspring because every gamete is genetically different so there is mixing of genetic information
  - Examples
    - Sperm and egg cells in animals
    - Pollen and egg cells in flowering plants
- Asexual reproduction
  - Involves one parent and no fusion of gametes
  - Asexual reproduction happens by mitosis only
  - There is no mixing of genetic information → formation of genetically identical offspring which are called clones
- Comparison

	Sexual reproduction	Asexual reproduction
Parents	Two parents needed	Only one parent needed
Cell division	Involves meiosis	Only involves mitosis
Gametes	Involves gametes	No gametes used
Fertilisation	Involves fertilisation and mixing of genetic information	Does not involve fertilisation and no mixing of genetic information
Offspring	Offspring not genetically identical	Offspring genetically identical called CLONES

6.1.2 Meiosis

- Process of meiosis
  - All of the chromosomes are copied
  - Cell divides into two genetically identical cells
  - Both cells divide one more time forming gametes with single set of unpaired chromosomes
  - Number of chromosome halved in each cell
  - One original cell produced four gametes that are all genetically different from each other (different alleles)

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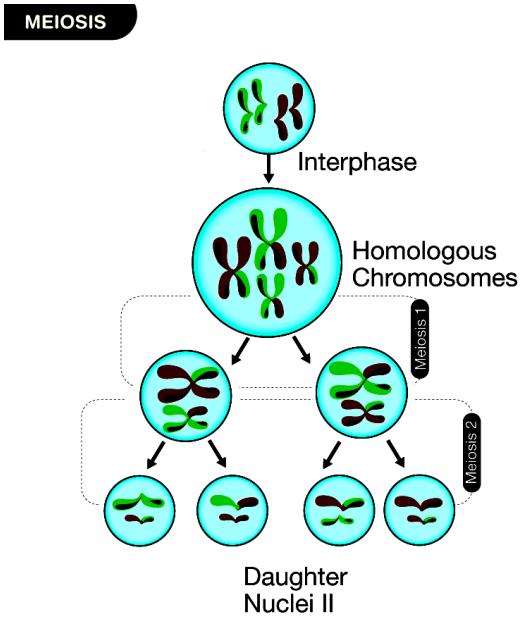
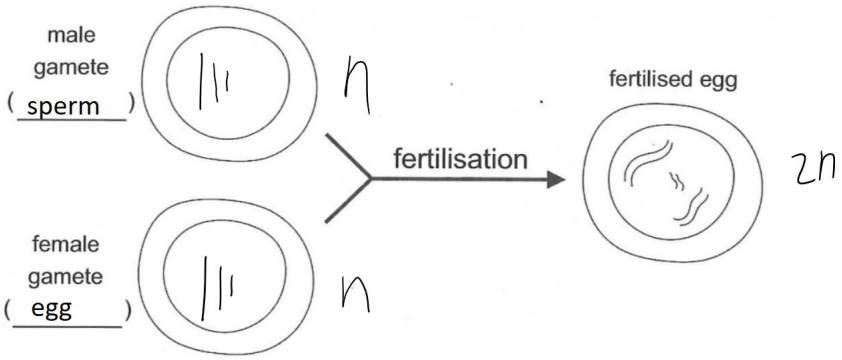
- 

- Comparison to mitosis

	Meiosis	**Mitosis**
Chromosome change	2n → n (diploid cells → haploid cells)	2n → 2n (diploid cells → diploid cells)
Number of cell divisions	2 cell divisions	1 cell division
Number of cells finishing with	End up with 4 cells / gametes	End up with 2 cells gametes
Gene of cells formed	Genetically different	Genetically identical
DNA replication	Once	Once

- Fertilisation + embryo process
  - Gametes (sperm + egg cell in human) join together
  - Normal number of chromosomes restored
  - New cell divides by mitosis to produce an embryo
  - Cells start to differentiate as embryo develops forming different cell types (e.g. muscle and nerve cells)
- 

6.1.3 Advantages and disadvantages of sexual and asexual reproduction

- Advantages and disadvantages of sexual reproduction

Advantages	**Disadvantages**
Offspring show genetic variation	Two parents are required therefore less time and energy efficient as need to find a mate. Also a chance of not finding a mate
Variation allows a species to adapt to environmental changes. In a rapidly changing environment this can	Slower reproductive cycle than asexual reproduction

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increase the chance of survival due to natural selection	
Allows humans to use selective breeding to increase food production in crops.	Sexually transmitted diseases can be transmitted
Variation also means diseases are less likely to affect the whole population	

- Advantages and disadvantages of asexual reproduction

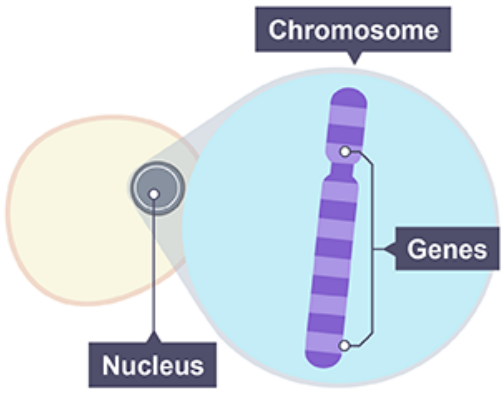
Advantages	**Disadvantages**
Only one parent needed so an organism can reproduce by itself, population can increase rapidly	The individuals are all genetically identical clones, limited genetic variation
More energy efficient as do not need to find a mate	Genetic identity means the individuals are vulnerable if the environment changes or diseases are introduced
Many identical offspring can be produced quickly when conditions are favourable	
Successful traits passed on to offsprings	

- Organisms reproducing by sexual and asexual reproduction depending on circumstances

Organism	**Sexual reproduction**	**Asexual reproduction**
Malarial parasite	Mosquito (vector)	Human (host)
Fungi	Spores produced by fusion of gametes	Asexual spores
Plants	Seeds produced by fertilisation of eggs with pollen	Runners e.g. strawberry plants Bulb division e.g. daffodils

6.1.4 DNA and the genome

- DNA definition
  - Deoxyribonucleic acid
  - The material inside the nucleus of cells, carrying the genetic information of a living being
  - A polymer made up of two strands forming a double helix
- Chromosome definition
  - The structure found in the nucleus of a cell, made of DNA, and organised into genes
- Gene definition
  - A small section of DNA on a chromosome
  - Each gene codes for a specific sequence of amino acids to make a specific protein
- Genome definition
  - Entire genetic material of an organism
- Cell structure



- Importance of studying the human genome
  - Identifying genes for different types of diseases e.g. cancer, Alzheimer's disease

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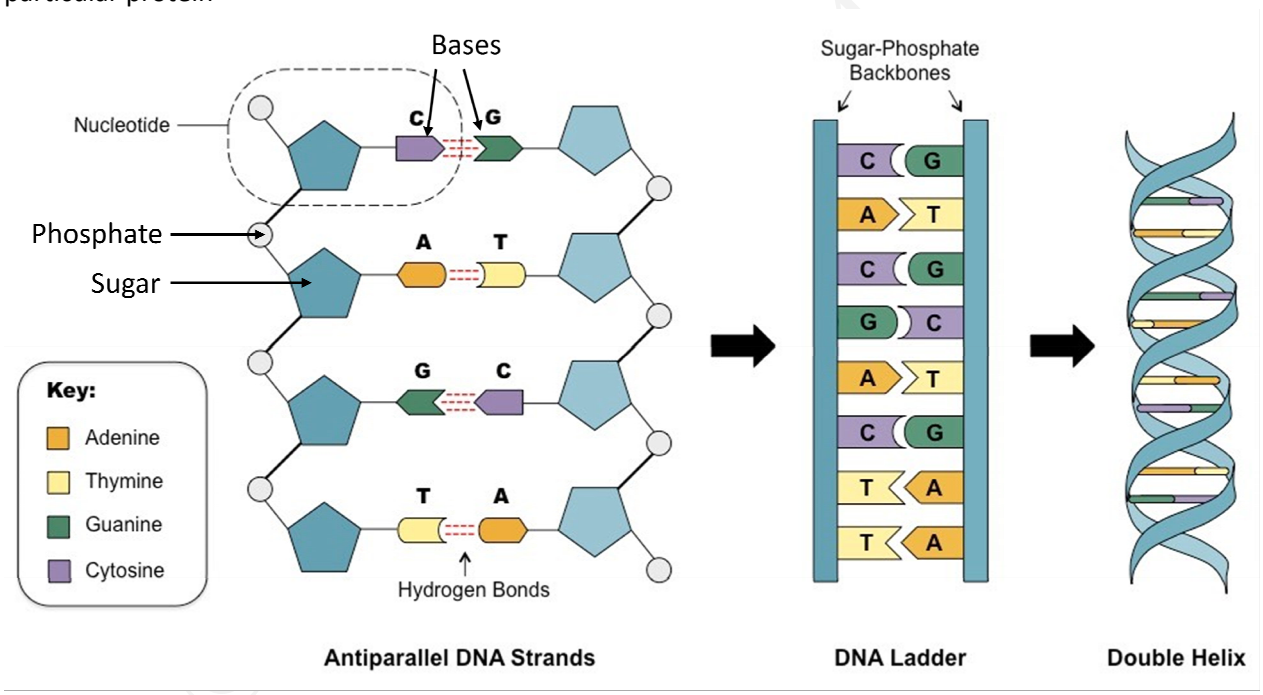
- Understanding and treatment of inherited diseases e.g. cystic fibrosis
- Tracing human migration patterns from the past is useful for determining our ancestry
- (Tracing human evolution)
- * The whole human genome have now been studied

6.1.5 DNA structure

- Structure of DNA
  - A polymer made of four different nucleotides
  - Has repeating nucleotide units
  - Have two strands of nucleotides forming a double helix
  - In each nucleotide
    - Alternating sugar and phosphate sections, phosphate attached to common sugar
    - 1 of the 4 bases attached to sugar
    - Bases = A, T, C, G
    - Complementary base pairs: A + T = 2 bonds, C + G = 3 bonds
    - (A = adenine, T = thymine, C = cytosine, G = guanine)
  - A triplet of bases code for a particular amino acid
  - The order of bases controls the order in which amino acids are assembled to produce a particular protein
  -



- Protein synthesis process
  - Coding proteins
    - Proteins are coded by bases
    - A triplet of bases code for a specific amino acid
    - Amino acids make up a protein
    - Protein is a particular sequence of amino acids
  - Stage 1: transcription
    - Takes place in the nucleus.
    - The base sequence of the gene is copied into a complementary template molecule (= messenger RNA / mRNA)
    - The single stranded mRNA moves from the nucleus to the cytoplasm through the nucleic membrane
  - Stage 2: translation
    - The mRNA attaches to a ribosome
    - Amino acids are brought on carrier molecules called tRNA
    - The ribosome uses the triplets of bases on the mRNA to join the correct amino acids in the correct order
      - Carrier molecules attach to the template in the order given by the DNA
    - When the amino acids have been assembled it folds into a unique shape which has a

specific function
    - Examples of the function of proteins:
    - Enzymes – act as biological catalysts e.g. amylase
    - Hormones – carry messages e.g. insulin
    - Structural proteins – physically strong e.g. collagen
- Mutations
    - A mutation = when a base changes
    - Mutation are random and occur continuously
    - Mutations change the sequence of DNA bases in a gene
    - Triplets of bases change which codes for the sequence amino acids that make up a protein
    - This can lead to changes in the amino acid → mutations in a gene can <u>sometimes</u> lead to changes in the protein
    - Most mutations have little or no effect on the protein but some change the shape of protein and affect the function e.g. a different active site of an enzyme so it cannot bind to the substrate anymore
    - A mutation in a non-coding region may switch on or off a gene
        - e.g. A gene could be switched on producing a protein causing a cell to divide by mitosis and cause cancer

<u>6.1.6 Genetic inheritance</u>

- Key words

Word	Definition
Allele	Different forms of the same gene.
Dominant gene	This allele determines the phenotype even if only one copy is present.
Recessive gene	The allele determines the phenotype only if two copies are present.
Genotype	The alleles the individual has for a gene.
Heterozygous	Individual with different alleles for a characteristic.
Homozygous	Individual with the same alleles for a characteristic.
Phenotype	The physical characteristics of an individual caused by the alleles

- Determining characteristics
    - Some characteristics are controlled by individual genes
        - Each gene has different forms called alleles
        - e.g. fur colour in mice, red-green colour blindness in humans
    - The different alleles present in an organism (genotype) dictate the proteins made and therefore the characteristics expressed as a phenotype
    - Alleles can be recessive or dominant
        - Dominant = always expressed even if only one copy is present
        - Recessive = only expressed if two copies are present
    - Individuals can be homozygous or heterozygous for a specific trait
        - Homozygous = two alleles present are the same, heterozygous = different
    - Most characteristics are as a result of the interactions between multiple genes

<u>6.1.7 Inherited disorders</u>

- Cystic fibrosis
    - An inherited disorder of cell membranes that affects the lungs, digestive, and reproductive system
    - Is inherited through a recessive allele, affected by a single gene
- Polydactyly
    - Results in babies born with extra fingers and/or toes
    - Inherited by a dominant allele
        - The individual only has to inherit only one copy of the dominant allele to have polydactyly
- Embryo screening
    - Used when there is a risk of passing on an inherited disorder

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    - The embryos are tested for the presence of the defective allele
    - Embryos without the defective allele are implanted into the woman and develop into healthy offspring
    - Ethical issue
        - Large number of embryos created but only a small amount is implanted
        - Some healthy embryos are destroyed and some people feel its unethical
    - Social issue
        - Some people worry that they could allow us to select offspring for desirable features
    - Expensive to carry out
- Gene therapy
    - Could allow doctors to change alleles to prevent inherited disorders
    - Social issue
        - Some people worry that they could allow us to select offspring for desirable features

6.1.8 Sex determination

- Chromosome pairs
    - Ordinary human body cells contain 23 pairs of chromosomes / 46 chromosomes
    - 22 pairs control characteristics only, but one of the pairs carries the genes that determine sex
    - In females the sex chromosomes are the same (XX)
    - In males the chromosomes are different (XY)

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6.2 Variation and evolution

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6.2.1 Variation

- Definition
  - All the differences in the characteristics of individuals in a population
- Main causes of variation
  - Genetic variation from different alleles that individuals inherit from their parents e.g. hair / eye colour
  - Environmental variation due to the conditions in which they have developed e.g. language
  - Combination of genetic and environmental variation e.g. height
- Variation in population
  - A massive amount of genetic variation in any population
  - All of these variations are due to mutations
  - Mutation = random change of DNA, take place all the time
  - Most mutations have no effect at all on the phenotype, some can influence the phenotype, very few determine the phenotype
  - Very rarely a mutation will lead to a new phenotype
  - A new phenotype can be beneficial if the environment changes → can lead to rapid change in the species

6.2.2 Evolution

- Evolution
  - Evolution is the change in the inherited characteristics of a population over time through a process of natural selection which may result in the formation of a new species
  - If two populations have become so different in phenotype that they can no longer interbreed to produce fertile offspring, they have formed two new species
- Theory of evolution by natural selection
  - Life first developed on Earth more than 3 billion years ago
  - These first life forms were very simple e.g. simple cells
  - All species of living things have evolved from these simple life forms
- Evolution by natural selection process
  - Individuals within a particular species show a wide range of phenotypes and genotypes due to mutation
  - Individual with characteristics most suited to the environment are more likely to survive to breed successfully
  - The alleles that have enabled these individuals to survive are passed to the next generation
  - The proximity of the individuals with those variations increase over time

6.2.3 Selective breeding

- Selective breeding
  - The process by which humans breed plants and animals for particular genetic characteristics
  - Humans have been doing this for thousands of years since they first bred food crops from wild plants and domesticated animals
- Method
  - Choose parents with the desired characteristics from a mixed population and breed these individuals together
  - Select from the offspring those individuals with the best desired characteristics and breed these offspring together
  - Repeat over several generations until all the offspring show the desired characteristic
- Characteristics chosen
  - Disease resistance in food crops
  - Animals with more meat or milk
  - Domestic dogs with a gentle nature

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    - Large or unusual flowers
- Disadvantage of selective breeding
    - Inbreeding between closely related animals
    - Lead to genetic disorders caused by recessive genes or being prone to diseases

6.2.4 Genetic engineering

- Definition
    - A process which involves modifying the genome of an organism by introducing a gene from another organism to give a desired characteristic
- Current uses
    - GM crops
        - Greater yield than normal crops
        - Resistant to disease or insect attack
        - Produce bigger or better fruits
        - Can be resistant to herbicides so farmers can spray their fields to kill weeds without harming the GM crop
        - e.g. golden rice
    - Bacterial cells have been genetically modified to produce useful substances such as human insulin to treat diabetes
- Process
    - Enzymes are used to isolate the required gene from humans or other animals
    - The gene is inserted into a vector, usually a bacterial plasmid or virus
    - The vector is used to insert the gene into the required cells
    - Genes are transferred to the cells of animals, plants or microorganisms at an early stage of their development (e.g. early embryo stage for animals) so that they develop with desired characteristics
- Genetic engineering for insulin
    - Human cell with insulin + insulin gene cut from DNA using a restriction enzyme
    - Bacteria plasmid cut with the same restriction enzyme
    - Insulin gene inserted into plasmid using the enzyme ligase
    - The plasmid is the vector that puts insulin gene into the bacterium
    - Plasmid multiplies in bacterium and bacteria divide rapidly
    - Insulin separated and purified
- Concerns of GM seeds
    - GM seeds can be very expensive so it is not affordable by smaller farms
    - Higher use of herbicide that can kill weeds which can damage the environment
    - Genes e.g. herbicide resistant could be transferred to wild plants by pollinators so herbicides may no longer be effective
    - Modifying the plants to be resistant to herbicides can reduce the biodiversity of the area and have repercussions for animals further up the food chain
    - Effect of GM crops on humans eating them have not been fully explored, some people believe there could be harmful long-term effects
- Gene therapy
    - Currently being explored as a way to treat inherited disorder in humans
    - Long term effects unknown
    - If we modify a gene we do not know the potential effects on other genes
- Benefits of genetic engineering
    - Genetic modification is a faster and more efficient way of getting the same results as selective breeding
    - Improve crop yields or crop quality, which is important in developing countries → may help reduce hunger around the world.
    - Introduce herbicide resistance → less herbicides being used as weeds are quickly and selectively killed
    - Insect and pest resistance can be developed and inserted into the plants
        - The plant produces toxins which would discourage insects from eating the crop
    - Sterile insects could be created such as a mosquito
        - They would breed and lead to infertile offspring

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    - This may help with spread of diseases e.g. malaria, dengue fever and the Zika virus
- Risks of genetic engineering
    - Transfer of the selected gene into other species, what benefits one plant may harm another
    - Some people believe it is not ethical to interfere with nature in this way
    - GM crop seeds are often more expensive and so people in developing countries cannot afford them
    - GM crops could be harmful, for example toxins from the crops have been detected in some people's blood
    - GM crops could cause allergic reactions in people
    - Pollen produced by the plants could be toxic and harm insects that transfer it between plants

6.2.5 Cloning

- Advantage of cloning plants
    - All the plants are genetically identical so we know exactly what characteristics each clone would have
    - It allows a variety of a plant with desirable characteristics to be produced cheaply, quickly and on a large scale
- Cuttings
    - A branch from the parent plant is cut off, its lower leaves are removed, and the stem is planted in rooting powder
    - Rooting powder contains plant hormones and this encourages the plant to develop roots
    - The cutting is usually covered in a clear plastic bag to keep it moist and warm
    - After a few weeks, new roots develop and a new plant grows that is genetically identical to the old plant
      Good if we just wants a few clones from a plant
- Tissue culture (micropropagation)
    - Take a plant that we want to clone and divide the plant into hundreds of tiny pieces
    - Each of these pieces contain a small number of cells
    - These small groups of cells are then incubated with plant hormones
    - The plant hormones stimulate the plants to grow and develop into fully-grown clones
    - The condition for tissue culture must be sterile so no microorganism is introduced
    - Useful in commercial plant nurseries
    - Allows growers to produce thousands of genetically identical plants quickly and cheaply
    - All the plants are clones so gardeners will get the characteristics they want in all plants
    - Can also preserve rare species of plants
- Embryo transplants
    - Sperm + egg cell with desired characteristics
    - Fertilisation produces a fertilised egg
    - We then allow the fertilised egg to develop into an early stage embryo
        - Cells in the embryo must nor have started to specialise
    - Split the embryo into several smaller cells and the cells develop into an embryo again
    - Transplant the embryos into host mothers
    - The embryo then grow and develop into identical offsprings
    - Problem: started with sperm + egg so cannot be certain that the offspring will have the desired characteristics
- Adult-cell cloning
    - The nucleus is removed from an unfertilised egg cell.
    - The nucleus from an adult body cell, such as a skin cell, is inserted into the egg cell.
    - An electric shock stimulates the egg cell to divide to form an embryo.
    - These embryo cells contain the same genetic information as the adult skin cell.
    - When the embryo has developed into a ball of cells, it is inserted into the womb of an adult female to continue its development.
    - We are choosing from an adult so we can be certain of the characteristics that the clone will have

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6.3 The development of understanding of genetic and evolution

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6.3.1 Theory of evolution

- Charles Darwin
  - Took an expedition around the world in the 1800s
  - Collected a vast number of different animals and plants
  - Observed geology and fossils and found out that many species of animals and plants alive today are similar to extinct species
  - Developed the theory of evolution by natural selection after years of experimentation and discussion
    - Individual organisms within a particular species show a wide range of variation for a characteristic
    - Individuals with characteristic most suited to the environment are more likely to survive to breed successfully
    - The characteristics that have enabled these individuals to survive are then passed on to the next generation
  - Published his ideas in *On the Origin of Species* in 1859
  - Extremely controversial and only gradually accepted
    - The theory challenged the idea that God made all the animals and plants that live on Earth
    - There was insufficient evidence at the time the theory was published to convince many scientists
    - The mechanism of inheritance and variation was not known until 50 years after the theory was published
- Jean-Baptiste Lamarck
  - When a characteristic is regularly used, it becomes more developed and inherited by the offspring
  - We now know that in the vast majority of cases this type of inheritance cannot occur

6.3.2 Speciation

- Alfred Russell Wallace
  - Worked worldwide gathering evidence for evolutionary theory
  - Best known for his work on warning coloration in animals and the theory of speciation
  - Independently proposed the theory of evolution by natural selection
  - Darwin and Wallace realised that they have the same theory so they jointly published their findings in 1858
  - This prompted Darwin to publish *On the Origin of Species* in 1859
  - Found out that closely related species were often separated by geographical barriers
  - Did much pioneering work on speciation but more evidence over time has led to our current understanding of speciation
- Speciation definition
  - The formation of new species and can happen as a result of isolation and natural selection
- Speciation process
  - Populations of species are separated due to a physical barrier such as a river or mountain range
  - Environmental conditions differ between the two areas
  - Genetic variation in each population due to mutation
  - Certain individuals in each population will be more adapted to the new environment
  - Natural selection will cause individuals with the advantageous traits to survive, reproduce and pass on the advantageous genes
  - This causes the advantageous traits to become more common in certain populations

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- Over time, the isolated populations will become so different that they will not be able to interbreed to produce fertile offspring and so will be two separate species

6.3.3 The understanding of genetics

- Gregor Mendel
  - Carried out thousands of breeding experiments on pea plants in the middle 1800s
  - Scientists did not understand how inheritance worked at the time
  - Many believed that characteristics were blended when they were inherited
  - Looked a lot of different characteristics in pea plants
  - Realised that characteristics are not blended during inheritance
  - Said that characteristics are determined by inherited units that do not change when passed on to descendants, now called genes
  - Also showed that some characteristics could be masked and reappear in later generation - recessive alleles
  - Published his work in a scientific papers but was not understood
  - Scientists looked at how chromosomes behaved during cell division and rediscovered his work in late 1800s
  - Realised that his units behaved in a similar way to chromosomes in early 1900s
  - In mid 1900s scientists determined the structure of DNA and how genes function
  - This scientific work by many scientists led to the gene theory being developed

6.3.4 Evidence for evolution

- Evidence for Darwin's theory
  - Characteristics are passed on to offspring as genes
  - Further evidence in the fossil record + antibiotic resistance evolves in bacteria

6.3.5 Fossils

- Fossil definition
  - The remains of organisms from millions of years ago which are found in rocks
- Formation of fossils
  - Parts of organisms are not decayed
    - Condition needed for decay not present
    - Too cold for enzyme activity
    - Not enough oxygen
    - Not enough water
    - Too acidic
  - Parts of organism replaced by mineral during decay process
    - Organism body covered in sediments
    - Soft parts decay, bones / shell / hard parts do not decay
    - Bones replaced by minerals
  - Preserved traces of organisms
    - e.g. footprints, burrows, rootlet traces
- Why are fossil records not clear for older organisms
  - Many early forms of life were soft-bodied organisms so most of the tissues decayed
  - Fossils smaller so harder to find
  - Many fossils formed destroyed by geological activities
  - A lot of fossil not discovered as they are buried too deep
  - Scientists cannot be certain about how life began on Earth
- Uses
  - Learn how much or how little different organisms have changed as life developed on Earth

6.3.6 Extinction

- Definition
  - Occur when there are no remaining individuals of a species still alive
- Causes
  - Drought
  - Ice age / global warming

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- Natural disasters **(name specific examples)**
- Asteroid / meteor collision
- New predators
- New disease
- Competition with new species for food, water, etc.
- Lack of habitat / habitat change

6.3.7 Resistant bacteria

- Development of resistance
  - Bacteria can evolve quickly because they reproduce at a fast rate
  - Random mutations occur in the genes of individual bacterial cells
  - Some mutations protect the bacterial cell from the effects of the antibiotic
  - Bacteria without the mutation die or cannot reproduce when the antibiotic is present
  - Resistant bacteria can reproduce with less competition from normal bacterial strains
  - The population of the resistant strain rises
  - Resistant strain Spread because people are not immune to it and there is no effective treatment
- MRSA
  - Common strain of antibiotic resistance
- Methods to reduce development of resistant strains
  - Doctors should not prescribe antibiotics inappropriately e.g. non-serious / viral infections
  - Patients should complete their course for antibiotics so all of the bacteria are killed and none survive and mutate to form resistant strains
  - Restrict the use of antibiotics in agriculture
- Researching new antibiotics
  - Takes a long time and extremely expensive
  - Unlikely to keep up with the speed of new antibiotic resistant strains emerging

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6.4 Classification

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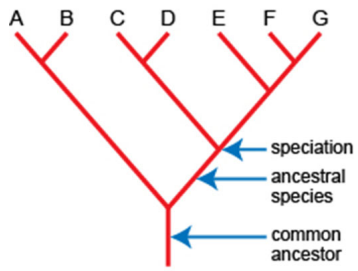
- Carl Linnaeus
  - Developed the traditional system for classification
  - Living things classified based on their structure and characteristics
- Linnaeus classified living things into:
  - Kingdom
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - Species
- Binomial system for naming
  - Every species has its own scientific name
  - It consists of two words: genus and species
  - Genus capitalised, species in lower case
  - Uses Latin so it is only in one language and stops confusion
  - It helps with conservation as species can be clearly identified
  - (The name is usually written in italics or underlined)
- Impact of scientific developments
  - Advances in microscopy, biochemical analysis and DNA sequencing
  - More knowledge about the internal structures of living things
  - More understanding of biochemical processes
  - New models of classification were proposed
- Three domain system
  - Developed by Carl Woese due to evidence available from chemical analysis
  - Archaea: primitive bacteria usually living in extreme environments
  - Bacteria: true bacteria
  - Eukaryota: protists, fungi, plants and animals
- Evolutionary trees
  - A method used by scientists to show how they believe organisms are related
  - Use current classification data for living organisms and fossil data for extinct organisms
  - 

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7.1 Adaptations, interdependence and competition

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7.1.1 Communities

- Definitions

Habitat	The environment in which an organism lives
Population	The number of organisms of the same species living in the same geographical area
Community	The population of all the different species living in the same habitat
Ecosystem	The living and non-living parts of an environment and how they interact
Biotic	The living organisms in an ecosystem
Abiotic	The non-living parts of an ecosystem
Interdependence	The complex way in which organisms in an ecosystem depend upon each other

7.1.2 Abiotic factors

- Light intensity
  - Low light intensity = low rate of photosynthesis
  - Plants grow more slowly
  - May not have enough food for herbivores
- Temperature
  - If temperature change distribution of species can change
  - Animals migrate / plants disappear
- Water (avoid saying temperature / humidity)
  - Water is needed for both plant and animal to survive
- Soil pH and mineral content
  - Plants cannot grow on soil that is too acidic or alkaline
  - Minerals needed e.g. nitrate ions to make amino acid for protein synthesis
- Wind intensity and direction
  - Strong wind from inland to sea can cause plant to lose water
  - Higher transpiration rate in strong wind
- Carbon dioxide levels for plants
  - CO_2 level fall = rate of photosynthesis decrease
- Oxygen levels
  - Level of dissolved oxygen can fall in water on hot days
  - Harmful to aquatic organisms e.g. fish

7.1.3 Biotic factors

- Availability of food
  - Less food = population fall
- New predators arriving
  - Number of prey species fall
  - Competition with existing predators
- Competition
  - For food / mates / territories / etc.
  - Out competed = number fall
  - May lead to extinction if there is no sufficient number to breed
- New pathogens / disease
  - Fall in number of population if new infectious disease emerges and spread

7.1.4 Adaptations

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- Adaptation types
  - Structural
    - Adaptations of body shape / structure
  - Behavioural
    - How an animal behave
    - e.g. cold blooded reptiles bask in the sun to absorb heat
  - Functional
    - Biological processes within the organism
    - e.g. snake produce venom to kill prey
- Adaptations to the cold regions
  - Structural adaptations
    - Small surface area to volume ratio to minimise heat loss to their surroundings
      - e.g. small ears of the Arctic fox
    - A thick layer of fat (seal blubber) or fur (polar bears) insulates against the cold
- Adaptations to desert regions
  - Structural
    - High surface area to volume ratio to aid heat loss
      - e.g. large ears of African elephants
  - Behavioural
    - Only active in the early mornings, late evenings or at night when it is cooler
  - Functional
    - Specially adapted kidneys which produce very concentrated urine, helping the animal to retain water
- Extremophiles
  - Some organisms live in environments that are very extreme, such as high temperature, pressure, or salt concentration
  - e.g. Bacteria living in deep sea vents
- Types of extremophiles
  -

Halophile	High salt concentration
Thermophile	High temperatures
Cryophile	Very low temperature
Acidophile	Low pH
Alkaliphile	High pH
Barophile	High pressure

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7.2 Organisation of an ecosystem

2023年5月2日 20:05

7.2.1 Levels of organisation

- Sun
  - Source of energy on Earth
  - Photosynthetic organisms are the producers of biomass for life on Earth
- Food chain
  - Represent feeding relationships within a community
- Food chain pattern
  - Begin with a producer which synthesises molecules
    - Usually a green plant or algae which makes glucose by photosynthesis
  - Producers are eaten by primary consumers
  - Primary consumers may be eaten by secondary consumers, then tertiary
  - Arrows point toward the consumer of the energy from the previous trophic level
- Predators and preys
  - Predators: consumers that kill and eat other animals
  - Those that are eaten are prey
  - In a stable community the numbers of predators and prey rise and fall in cycles
- Quadrats
  - Used to investigate the size of a population of plants / very slow animals
  - Each sample area selected randomly
    - More accurate / precise mean; avoid bias; representative data
    - Random coordinates
      - e.g. Place two tape measures at right angles to form a grid, use a random number generator to locate the position
  - Data taken from each quadrat
    - Use the same standard each time (especially for plants partly in)
    - Use a key
  - Use the same size of quadrat every time
  - Sample at least 10 areas
  - Other control variables mentioned
  - Calculation: population size = $\frac{\text{total area}}{\text{area sampled}}$ × number of plant species
- Transects
  - Measuring the distribution of organisms with a abiotic factor
  - Normally line transect
  - Stretch a tape measure between two points (running through areas of different e.g. light intensity)
  - Place a quadrat next to the tape measure
  - Sample the organisms along the line at regular intervals e.g. flip over after measuring
  - Can also measure abiotic factors e.g. light intensity by light metre
  - Large number of quadrats needed
  - (Compare data from different light intensity etc.)

7.2.2 How materials are cycled

- Carbon cycle
  - Photosynthesis
    - Plants and algae remove CO_2 from atmosphere for photosynthesis
    - Carbon is used to make glucose
  - Respiration
    - Plants and algae are eaten by animals so carbon in glucose is passed on to animals
    - Glucose is used for aerobic respiration in <u>both animals and plants</u> and CO_2 is released to atmosphere as a waste product
    - Animals can be eaten by its predator to pass on carbon

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- Decomposition
    - Animal waste products e.g. urine, faeces and dead remains of plants / algae / animals are broken down by decomposing organisms e.g. fungi and bacteria
    - Bacteria/fungi secreting enzymes out of their cells into the soil or dead organism
    - The enzymes digest the organic material
    - Large molecules are broken down into small molecules
    - The products of digestion are absorbed by the bacteria/fungi
    - They release CO_2 back into atmosphere when respiring
    - They also release mineral ions e.g. nitrate ions back into soil
- Combustion
    - Carbon in dead remains are slowly converted to fossil fuels
    - Fossil fuels contain lots of carbon
    - When fossil fuels or woods are burnt CO_2 is released back into the atmosphere

- Water cycle
    - Most water on Earth is salt water in the oceans
    - Sun makes water evaporate from ocean surface
    - Water vapour rises into air and then cools down and condenses to form clouds
    - Water then falls to the ground by precipitation e.g. rain and snow as fresh water
    - Once water reaches the ground
        - Some evaporates back to water vapour
        - Some drains through rocks into aquifers → travel back into sea
        - A lot forms streams and river and eventually travel back into the sea
    - Plant
        - Absorb water in soil by roots by osmosis
        - Water travel up the plant to the leaves through xylem
        - Used for photosynthesis + support in xylem
        - Evaporate from cell surfaces and leaves through stomata by diffusion
        - = Transpiration + evaporation if intercepted by leaves
    - Animals
        - Take in water through drinking and food
        - Release water in urine / faeces / exhale gas

7.2.3 Decomposition

- Factors affecting rate of decomposition
    - Temperature
        - Enzymes are needed by organisms to break down organic matters
        - Work best at optimum temperature
        - Faster in warm temperatures
        - Denatured if too hot
        - Slow or even stop when too cold
    - Water
        - Microorganisms grow fast under moist conditions
        - Easier to digest food and prevent them from drying out
        - Therefore decay takes place faster as there are more microorganisms
    - Availability of oxygen
        - Most decomposers respire aerobically
        - They need oxygen for energy to break down food and transfer energy, grow, and reproduce
- Biogas generators
    - Large vessels
    - Animal waste or specially grown crops such as maize are allowed to be anaerobically digested inside
    - Anaerobic decay produces methane
    - Methane and carbon dioxide produced = biogas

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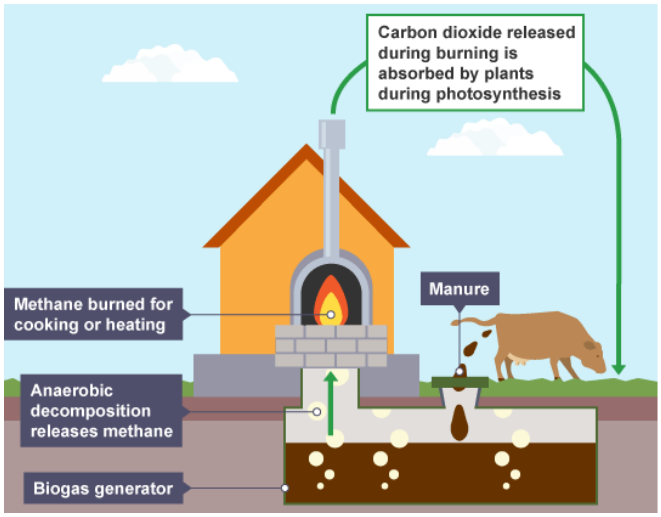
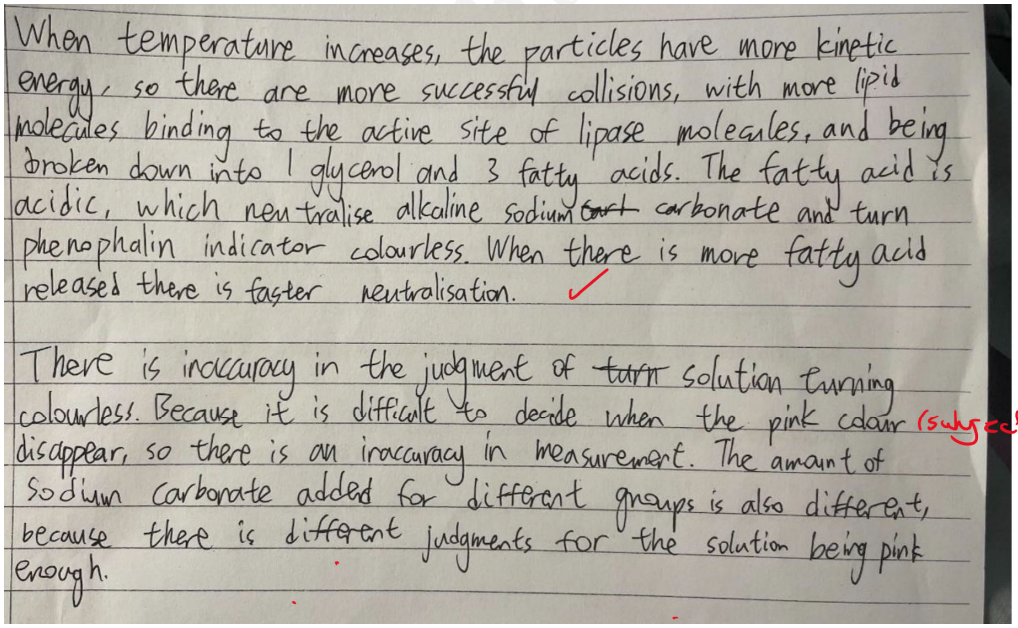
- 

- Compost
  - Used as a natural fertiliser for growing garden plants or crops
  - Compost is made from dead plants
  - Once spread on the soil, compost is broken down into minerals e.g. nitrogen by decomposing bacteria and fungi / other organisms, such as worms
  - Minerals can be absorbed by new plants
  - Production
    - Farmers try to provide optimum conditions
    - Open container for oxygen to get in and lower temperature
    - Turned with a gardening fork to prevent the content from becoming compact and introduce oxygen
    - Water added at regular intervals

7.2.3 Required practical 10

- Explanation
- 
When temperature increases, the particles have more kinetic energy, so there are more successful collisions, with more lipid molecules binding to the active site of lipase molecules, and being broken down into 1 glycerol and 3 fatty acids. The fatty acid is acidic, which neutralise alkaline sodium ~~carb~~ carbonate and turn phenophalin indicator colourless. When there is more fatty acid released there is faster neutralisation. ✓

There is inaccuracy in the judgment of ~~turn~~ solution turning colourless. Because it is difficult to decide when the pink colour disappear, so there is an inaccuracy in measurement. The amount of Sodium carbonate added for different groups is also different, because there is different judgments for the solution being pink enough. (subjective experiment)

- Equilibration solution to the temperature of water
  - Put the enzyme and solution at different test tubes in a water bath until they get to the temperature in the water bath
- Controls
  - Volume of milk
  - Volume of Na_2CO_3
  - Volume of lipase
- Control experiment
  - Add denatured lipase to solution

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7.3 Biodiversity and the effect of human interaction on ecosystems

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7.3.1 Biodiversity

- Biodiversity definition
  - The variety of all the different species of organisms on earth, or within an ecosystem
- Importance for ecosystems
  - Greater biodiversity = better stability of ecosystems
  - Reduce the dependence of one species on another for food, shelter and the maintenance of the physical environment
  - Fewer species = greater impact on other species if one species is removed
  - More species = others can replace the removed species
- Importance for human
  - Human also depend on other species
  - A good level of biodiversity need to be maintained
  - Many human activities are reducing biodiversity and only recently have measures been taken to try to stop this reduction

7.3.2 Waste management

- Population growth trend
  - Increasing quickly for the last 200 years
  - Reasons for growth
    - Improved technology = abundance of food = higher birth rate
    - More diseases can be cured with better medicine and hygiene = lower death rate
    - No natural predators
  - Population growth + increase in SoL = more resources are used and more waste is produced = more pollution
  - Unless waste and chemical materials are properly handled, pollution will continue to be created
- Water pollution

Pollutant	Source	Damage

Toxic chemicals	• From pesticides and herbicides sprayed
	• Runoff from agricultural land to watercourses if applied with too high concentration
		• Cannot be broken down with organisms
		• Bioaccumulation
		  • Absorbed by aquatic plants or invertebrates and build up in their tissues over time
		  • Concentration of the chemical increases in the organism over time
		• Biomagnification
		  • At each stage of the food chain increasing levels of chemicals build up in organisms
		  • Eventually build up to dangerous toxic levels in top predators → die / fail to breed

Fertilisers	• Runoff to watercourse when raining / concentration too high	• **Eutrophication** • Contains high concentration of nitrate → high nitrate level in water • Stimulate the growth of algae • Block sunlight → plants beneath cannot

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		photosynthesise → plants lower in water die → less oxygen released from photosynthesis • Dead plants broken down by microorganisms • A lot of oxygen is used for respiration • Lower level of dissolved oxygen in water • Cannot support some animals and they die • They are decomposed so even more oxygen is used • Eventually all aerobic aquatic animals die
Untreated sewage	• Lack of sewage treatment plants in inhabited areas	• Also have nitrate • Provides a good source of food for bacteria • Bacteria increase rapidly and deplete the oxygen dissolved in water (aerobic respiration) • Aquatic organisms die due to the lack of oxygen

- Land pollution

Pollutant	**Source**	**Damage**
Toxic chemicals	• From pesticides and herbicides sprayed • Get into the soil when sprayed	• Cannot be broken down with organisms • Bioaccumulation + Biomagnification (same as in water) • Absorbed by plants and other organisms in the soil
Discarded rubbish	• Household waste that cannot be recycled is buried in landfill sites	• Landfill sites take up a lot of room • Their creation often results in destroying natural habitats • Toxic chemicals can spread from the waste into the soil • A lot of rubbish e.g. plastic is non-biodegradable • Remains in the environment for hundreds of years

- Air pollution

Pollutant	**Source**	**Damage**
Sulphur dioxide and nitrogen oxides (Acid gases)	• Combustion of fossil fuels that contain sulphur impurities produce SO_2, NO is also produced	• React with oxygen and dissolve in rainwater to produce dilute sulphuric acid and nitric acid → acid rain • Acid rain damage leaves = less photosynthesis, buds, flowers and fruit • When it soaks into the soil it can also destroy the roots • Can make rivers and lakes too acidic → death of aquatic organisms • Can also cause the leaching of minerals that are toxic to fish, such as Al, into lakes • Damage alveoli = breathing

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		difficulties e.g. bronchitis
Smoke (Carbon monoxide)	• Burning fossil fuels and releasing chemicals e.g. sulphur • Any type of burning	• An increase of the number of particulates in the air • Reflect sunlight so less sunlight hit the surface of the Earth → dimming effect and can lead to cooling of Earth surface • Damage to human health when the particles are breathed in • Damage the lungs and the cardiovascular system

- (Try to explain as much as possible)
- Ways to reduce air pollution
  - Use low sulphur diesel / petrol
  - Reduce the use of fossil fuel / use more renewable nergy
  - Use catalyst converters to remove pollution gases from the exhaust fumes in vehicles
  - Systems in power station chimneys to clean the gases before they are released into the atmosphere
- Pollution's effect on biodiversity
  - Pollution kill plants and animals and may reduce biodiversity

7.3.3 Land use

- Types of land uses
  - Building
  - Quarrying
  - Farming
  - Dumping waste
- Effects of increasing land use
  - Less land available for other animals and plants
  - Destruction of habitats e.g. rainforests and woodlands
  - Reduces biodiversity of these areas and interrupts food chains and webs
    - More species may be extinct because their prey is gone
- Peat bog
  - Made of peat
    - Plant material that cannot decay completely because the condition is very acidic and lack oxygen
  - Forms over thousands of years by peat accumulating
  - Over the time peat bogs may dry out to form peatlands
  - Massive carbon store
    - Carbon released in decomposition as CO_2 is stored in the peat instead
    - When mixed with air microorganism introduced respire using O_2 + substances in peat
  - Unique ecosystems, important habitat to a wide range of organisms
- Reasons for peat bog destruction
  - Burnt as a fuel
  - Used to produce compost for gardens and farms
  - Peat bogs are drained so the area can be used for farming
- Negative impacts of peat bog destruction
  - CO_2 released into atmosphere when burned → global warming + carbon store lost
  - Non-renewable energy source because they take very long time to form
  - Less habitat for other organisms → reduce biodiversity
  - Destroyed faster than it regenerates → unsustainable

7.3.4 Deforestation

- Main reasons for deforestation
  - Provide more land for farming
    - To grow staple foods such as rice, or ingredients for making cheap food in the developed

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world, e.g. palm oil from oil palms
        - Rear more cattle, particularly for the beef market
        - Grow crops that can be used to make biofuels based on ethanol
            - Incl. Sugarcane and maize
    - To provide land for quarrying
    - To provide land for building
    - To provide wood for building materials
    - To provide fuel
    - To provide paper
- Negative effects
    - More CO_2 released into the atmosphere
        - Burning of the trees releases CO_2 by combustion
        - Microorganisms release CO_2 when decomposing dead vegetation (respiration)
    - Less CO_2 removed
        - Less plant for photosynthesis to remove CO_2
    - Reduced biodiversity
        - Forests have a high biodiversity
        - Species may become extinct due to deforestation
        - The forests are often replaced by a single species of trees
    - Loss of soil
        - Root of the trees hold the soil in its place
        - Tree roots absorb nutrients and minerals in the soil
        - Without trees the nutrients are washed away into rivers and lakes by rain (leaching)
        - Soil nutrient permanently lost, difficult for trees to regrow
    - Flooding
        - Less water in soil is absorbed by the roots of the trees
        - Topsoil is loose and unstable without the roots and can be easily washed away
        - The soil can hold less water
        - Higher risk of landslides

7.3.5 Global warming

- Greenhouse gas
    - Gas that absorbs infrared radiation from the Sun so it remains trapped in the Earth's atmosphere
    - Important to ensure that the Earth is warm enough for life
    - If levels of these gases in the atmosphere increase it leads to an increase in the greenhouse effect
    - Earth's average temperature rises
- Types of greenhouse gases
    - Water vapour
    - Carbon dioxide
    - Methane
    - Nitrous oxides
    - CFCs (Chlorofluorocarbon)
- Source of greenhouse gases
    - Carbon dioxide is produced during the combustion of fossil fuel
    - Methane is produced by cattle as they digest grass and released by rice paddy fields
- Greenhouse effect
    - Energy from the Sun reaches Earth
    - Much of the energy is reflected from the Earth's surface and radiated back into space
    - Greenhouse gases in the atmosphere absorb some of the energy transferred as the Earth cools down
    - Energy absorbed is trapped in the Earth's atmosphere (normal)
    - The Earth and its surrounding atmosphere are kept warm for life
    - As the levels of greenhouse gases in the atmosphere rise due to human activities the Earth's average temperature rises beyond normal (an enhanced greenhouse effect), causing global

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warming
    - More heat energy reabsorbed than needed by GHG
    - More greenhouse effects
- Consequences of global warming
    - Loss of habitat
        - Polar ice caps melt → low-lying areas are flooded by rising sea levels, arctic animals e.g. polar bear lose habitat
        - Biodiversity of the areas fall
        - Homes and factories destroyed, cannot grow food
    - Changes in distribution
        - Temperature and rainfall patterns change
        - Climate change make conditions more favourable for some species and less for other
        - Some may extend their range
        - Other may have their range shrinking / disappearing completely from an area
    - Changes in migration patterns
        - Climate and season change cause migration pattern of birds, insects and mammals to change
        - Increasing migration may result in increasing pests and diseases
    - Reduced biodiversity
        - Many organisms become extinct as climate change
            - Unable to survive
            - Food chains are disrupted

7.3.6 Maintaining biodiversity

Method	**Explanation**
Breeding programmes for endangered species	• Restore population to sustainable level • Allow breeding when habitat lost • Allow breeding when natural breeding is not fast or easy • No inbreeding
Protection and regeneration of rare habitats	• Allows maintenance of rare or unique habitats • These habitats often have high biodiversity • Animals & plants are not adapted to live anywhere other than these habitats • Protect biodiversity or even increase
Reintroduction of field margins and hedgerows	• Hedgerows have a high biodiversity + habitat for animals • Increases biodiversity • Can reduce soil erosion • Can increase soil fertility
Reduction of deforestation and CO_2 emissions	• Maintains biodiversity as forest has a high biodiversity • Reduces CO_2 emission, reduce global warming • Increases tourism / economic benefit to the country
Increased recycling of resources	• Reduces land lost to landfill sites thereby increasing biodiversity • Reduces CO_2 emissions from production of new materials • Reduces fossil fuel consumption

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7.4 Trophic levels in an ecosystem

2023年5月5日 19:05

7.4.1 Trophic levels

- Representation
  - Represented by numbers
  - Starting at Level 1 with plants and algae
  - Further trophic levels are numbered subsequently according to how far the organism is along the food chain
- Levels
  - Level 1
    - Producers
    - Plants and algae make their own food
    - Photosynthesise using light absorbed by chlorophyll / chloroplasts
  - Level 2
    - Primary consumers
    - Herbivores eat plants / algae
  - Level 3
    - Secondary consumers
    - Carnivores that eat herbivores
  - Level 4
    - Tertiary consumer / apex predators
    - Carnivores that eat other carnivores
    - Apex predators are carnivores with no predators
- Decomposers
  - Break down dead plant and animal matter by secreting enzymes into the environment
  - Break down larger molecules into smaller molecules
  - Small soluble food molecules then diffuse into the microorganism

7.4.2 Pyramids of biomass

- Biomass
  - The dry mass of an organism is called its biomass
  - It is measured in mass per unit area e.g. kg/m^2
  - The total biomass at a particular step in a food chain is always less than the total biomass at the step before it
  - Energy is stored in biomass
- Pyramids of biomass
  - Constructed to represent the relative amount of biomass in each level of a food chain
  - Trophic level 1 is at the bottom of the pyramid

7.4.3 Transfer of biomass

- Loss of biomass
  - Only approximately 10% of the biomass from each tropic level is transferred to the level above it
  - Reasons for loss
    - Not all of the ingested material is absorbed as there are indigestible parts
      - Some biomass is egested as faeces
    - Inedible parts of animals not eaten
    - Some biomass is converted to waste products of metabolism and excreted
      - e.g. carbon dioxide and water (during respiration) and water and urea in urine
    - Large amount of biomass is used in respiration to release energy
      - Some biomass used to produce carbon dioxide and water (waste products) and excreted
      - Energy released is used for movement and maintaining a constant body temperature (transferred as heat into the environment)

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7.5 Food production

2023年6月6日 23:02

7.5.1 Factors affecting food security

- Food security definition
  - Having enough food to feed a population
- Biological factors affecting food security
  - Increasing birth rate / population
  - Changing diets in developed countries
    - Scarce food resources are transported around the world
  - New pests and pathogens that affect farming
  - Environmental changes that affect food production
    - e.g. widespread famine occurring in some countries if rains fail
  - The cost of agricultural inputs
  - Conflicts / wars that have arisen in some parts of the world which affect the availability of water or food

7.5.2 Farming techniques

- Intensive farming methods
  - Feed the animals high protein food to increase growth
  - Reduce energy use
    - Restricting movement so less energy used in respiration
    - Regulating surrounding temperature so less energy needed to maintain body temperature / less heat transferred to the environment
    - More energy available for growth
  - Feed antibiotics to prevent disease spreading
- Advantages of intensive farming
  - Higher yield
  - More efficient use of land
  - Quality control (easier to monitor)
- Disadvantages of intensive farming
  - Diseases spread rapidly
  - Antibiotic resistance
  - Cruel to animals, ethical issues
  - Damaging to the environment
    - Reduced biodiversity
    - Greenhouse gases from fossil fuels released lead to climate change
    - Damage soil quality

7.5.3 Sustainable fisheries

- It is important to maintain fish stocks at a level where breeding continues or certain species may disappear altogether in some areas
- Methods to conserve fish population
  - Control size of fish net
    - Smaller immature fish can get through the nets so they won't be caught
    - They can live long enough to develop into adults and breed
  - Quota
    - Strictly enforced limit on the number of fish that can be caught for each species
    - By reducing the number caught the remaining fish can breed and bring the population back to normal levels
    - Can lead to dead fish thrown back into the sea

7.5.4 Role of biotechnology

- Fusarium

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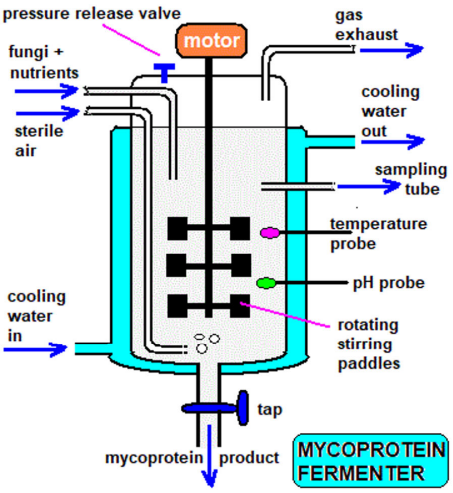
- A fungus
- Grown on glucose syrup in a fermenter
- In aerobic conditions Fusarium convert the glucose syrup into mycoprotein
- The mycoprotein is harvested and purified before being made into products
- pH and temperature are maintained at the optimum
- Sterile oxygen added for aerobic condition
- Mycoproteins
    - Suitable for vegetarians
    - Can grow very large amount of mycoprotein in a relatively small amount of space
    - Very efficient protein source
- 

1. The pH and temperature are maintained at the **optimum**
2. The temperature is controlled by a water jacket that surrounds the whole fermenter
3. Sterile oxygen is added to make sure that aerobic **respiration** occurs
4. A food source like glucose syrup is added
5. The mixture inside is stirred to make sure all the oxygen and nutrients are equally distributed

- Insulin
    - Genetically modified bacteria produces human insulin
        - Cut plasmid with enzyme, cut the gene out
        - Use ligase to glue human insulin gene with plasmid
    - Insulin can then be harvested and purified to treat people with diabetes
- GM crops
    - Has a higher yield so providing more food or providing food with an improved nutritional value
    - Can also have stronger pest resistance
    - e.g. golden rice
        - Natural rice have no molecules that the body needs to make vitamin A
        - Vitamin A is needed for effective vision
        - Around 0.5m people go blind every year due to lack of vitamin A
        - Golden rice is genetically modified to provide these molecules (beta carotene) to prevent night blindness / blindness
- Transgenic organism
    - Genetically modified organism using DNA from another organism
- Methods used for improving crop and livestock yields

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	Natural selection	Selective breeding	Genetic engineering
Number of generations needed for change	Very many	Many	One
Human intervention	Not needed	Needed	Needed
Desired outcome known?	No	Yes	Yes
New species formed?	Yes	No	No
Notes	This is the mechanism of change in Darwin's theory of evolution	This is how new varieties or breeds are usually produced	Genetic information can come from the same species or from a different one

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