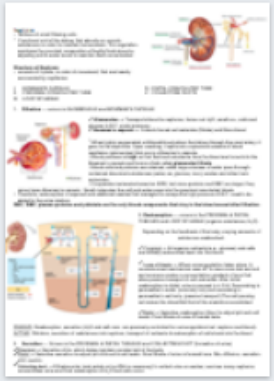
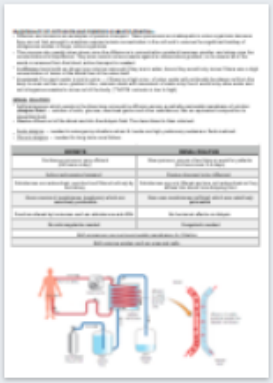
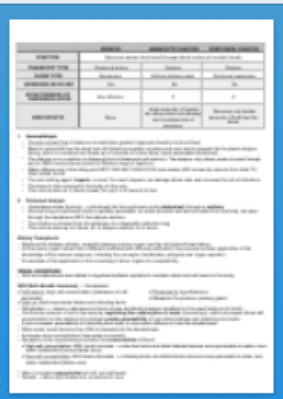



| | KIDNEYS | HAEMOLYTIC DIALYSIS | PERITONEAL DIALYSIS |
|---|---|---|---|
| **FUNCTION** | Removes wastes from blood & keeps blood solutes at constant levels | | |
| **TRANSPORT TYPE** | Passive & Active | Passive | Passive |
| **FILTER TYPE** | Glomerulus | Artificial (dialysis tube) | Peritoneal membrane |
| **HORMONES INVOLVED** | Yes | No | No |
| **EFFECTIVENESS OF OSMOREGULATION** | Very effective | X | X |
| **SIDE EFFECTS** | None | Large amounts of heparin can cause blood cell damage and increased risk of infections. | Removes only limited amounts of fluid from the blood |

1. **Haemodialysis**
   - Counter-current flow to balance concentration gradient (opposite direction to blood flow)
   - Blood is extracted from the body from AV fistula (connection of artery and vein) and is passed into the plastic dialysis tubing, which is a medical unit made up of a bundle of hollow fibres (semi-permeable membrane)
   - The dialyser is in a solution of dialysing fluid (of balanced salt solution). The dialyser only allows waste to pass through and no RBCs and proteins (similar to filtration stage of nephron).
   - Water diffuses out of the tubing and INTO THE SALT SOLUTION, and excess H2O moves by osmosis from tube TO DIALYSING FLUID
   - The anti-clotting agent, **heparin**, is used. Too much heparin can damage blood cells and increase the risk of infections.
   - The blood is then returned to the body via the vein.
   - This can be done for 3 times a week, for up to 4-5 hours at a time.

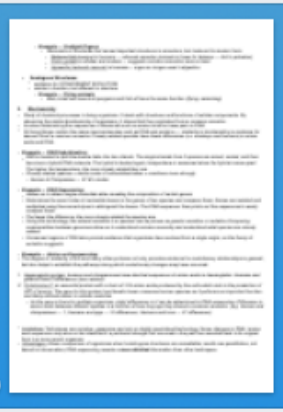
2. **Peritoneal dialysis**
   - Undertaken inside the body → introduced into the peritoneal cavity (**abdominal**) through a **catheter**.
   - Internal lining of peritoneal cavity is partially permeable, so waste products and excess water from the body can pass through the membrane INTO the dialysis solution.
   - The solution is drained from the abdomen to a disposable collection bag.
   - This can be done up to 4 times (2L of dialysis solution) for 4 hours.

**Kidney Transplants**
- Replaces the kidneys entirely, surgically placing a donor organ over the old dysfunctional kidney.
- As the donor organ comes from a different individual with different antibodies, this process involves application of the knowledge of the immune response, including the concepts of antibodies, antigens and 'organ rejection'.
- An example of this application is the screening of donor organs for compatibility.

***RENAL HORMONES:***
- ADH and aldosterone are related in negative feedback systems to maintain water and salt levels in the body.

**ADH (Anti-diuretic hormone)** — Vasopressin
- ✓*Activates in:* high salt concentration (imbalance of salt and water)
- ✓*Produced by:* hypothalamus
- ✓*Stored in:* the posterior pituitary gland
- ✓*Acts on:* distal convoluted tubule and collecting ducts
- Dehydration → causes a decrease in blood volume and blood pressure (enables $H_2O$ to pass freely out of ducts)
- Controls the amount of salt in the body by **regulating the reabsorption of water** (increasing it, which decreases blood salt concentration) in the nephrons by changing **water permeability** of convoluted tubules and collecting duct walls.
- It also increases permeability of collecting duct walls to urea which diffuses in from the bloodstream.
- When water levels become low, ADH is released into the bloodstream.
- Increases urine concentration (less water is present).
- Receptors in the hypothalamus monitor the **concentration** of blood:
  - ✓High salt concentration: ADH levels increase → collective ducts and distal tubules become more permeable to water, more water reabsorbed (concentrated urine)
  - ✓Low salt concentration: ADH levels decrease → collecting ducts and distal tubules become less permeable to water, less water reabsorbed (dilute urine)

* Note: it controls **concentration** of salt, not salt levels.
* Diuretic → More $H_2O$ flushed out, as well as $K^+$ ions



- ***Example — Vestigial Organs***
  - *Remnants of structures that served important structures in ancestors, but irrelevant to modern form.*
    - *Reduced tail (coccyx) in humans — arboreal ancestor (animals in trees for balance — link to primates)*
    - *Pelvic griddle in whales and snakes — suggests common ancestors was on land*
    - *Appendix (reduced caecum) in humans— organ no longer used in digestion*

- **Analogous Structures:**
  - evidence for CONVERGENT EVOLUTION
  - similar in function, but different in structure
    - ***Example — Flying animals***
      - *Bats, birds and insects & penguins and fish all have the same function (flying, swimming)*

**5. Biochemistry**

- Study of chemical processes in living organisms. It deals with structures and functions of cellular components. By observing the similar biochemistry of organisms, it shows that they originated from a common ancestor.
- Involves determining the sequences of chemicals such as amino acids or base pairs in DNA
- All living things contain the same macromolecules such as DNA and proteins — similarity in biochemistry is evidence for descent from a common ancestor. Closely related specials have fewer differences (i.e. monkeys and humans) in amino acids and DNA.

- ***Example — DNA Hybridisation:***
  - *DNA is heated to split the double helix into two strands. The single strands from 2 species are mixed, cooled, and then becomes a hybrid DNA molecule. The hybrid is heated again, temperature is measured when the hybrid comes apart. The higher the temperature, the more closely related they are.*
  - *Closely related species = similar order of nucleotides bases = combines more strongly*
    - *Human & Chimpanzee — 97.6% similar*

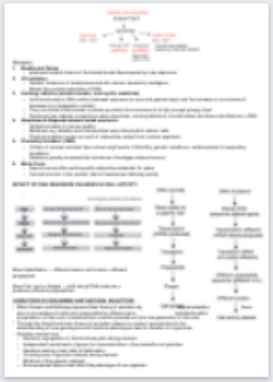
- ***Example — DNA Sequencing:***
  - *Allows us to obtain single nucleotide data revealing the composition of certain genes.*
  - *Determines the exact order of nucleotide bases in the genes of two species and compare them. Genes are isolated and multiplied using fluorescent dyes to distinguish the bases. The DNA sequencer then prints out the sequences to easily compare them.*
  - *The fewer the difference, the more closely related the species are.*
  - *Using this technology, the natural variation in a species can be proven as genetic variation or mutation.Comparing commonalities between genomes allow us to understand common ancestry and understand what species are closely related.*
  - *Conserved regions of DNA also provide evidence that organisms have evolved from a single origin, as the theory of evolution suggests.*

- ***Example — Amino acid sequencing:***
- The degree of similarity of this and many other proteins not only provides evidence for evolutionary relationships in general, but also helps to establish the pathways along which evolutionary changes may have occurred.

1. *Haemoglobin protein: humans and chimpanzees have identical sequences of amino acids in haemoglobin. Humans and gibbons have 3 differences (less related).*
2. *Cytochrome-C: an essential protein with a chain of 104 amino acids produced by the cells which aids in the production of ATP of energy. The gene for this protein has therefor been conserved across species as it performs an important function and likely evolved earlier in cellular evolution.*
   - *As the gene is found in multiple organisms, slight differences in it can be determined in DNA sequencing. Difference in amino acids between different species is a function of how long ago they shared a common ancestor. (e.g. Human and chimpanzees — 1; Humans and pigs — 10 differences; Humans and tuna — 21 differences)*

- *Limitations:* Techniques are complex, expensive and rely on highly specialised technology. Some changes in DNA / amino acid sequences may also not be identified if a particular change that occurred in the past has reverted back to its original form in a more recent organism.
- *Advantages:* Allows comparison of organisms when homologous structures are unavailable; results are quantitative, not based on observation; DNA sequencing reveals a **more detailed** information than other techniques.

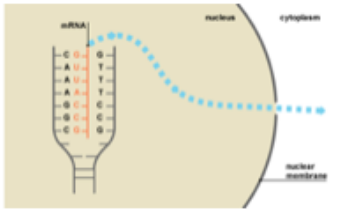


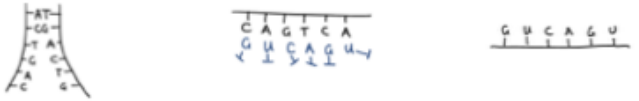



**mRNA** — contains genetic information. It is a copy of a portion of the DNA. It carries genetic information from the gene (DNA) out of the nucleus, into the cytoplasm where it is translated to produce protein.
**tRNA** — functions to transport amino acids to the ribosomes during protein synthesis. They have an anticodon on one end and a docking site for a specific amino acid on the other. They are essential for translation of mRNA as they carry amino acids to ribosome site and allow for correct a.a. to be added to the polypeptide sequence.

**TRANSCRIPTION** (Happens in the nucleus. DNA → mRNA)

1. A section of DNA (gene) begins to unzip itself by the **helicase**, breaking the H-bonds between the double helix strands of the DNA. One side is the template.
2. Single strand of DNA is exposed (template).
3. **RNA polymerase** matches free RNA nucleotides floating in the nucleus to the corresponding bases of the template (G-C, A-U).
4. Weak hydrogen bonds form between base pairs.
5. Sugar phosphate bonds form between RNA nucleotides.
6. mRNA strand is synthesised.
7. mRNA is modified so that it contains only protein-coding exons.
8. mRNA peels off from the DNA and moves out of the nucleus and into the cytoplasm. DNA rezips.

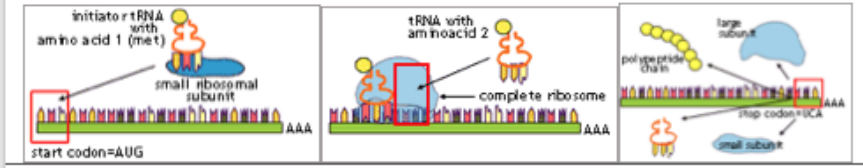


- The newly formed mRNA is modified before it can be used as genes contain regions that are not translated into proteins.
- **Introns** are removed from the mRNA and the remaining portion of DNA called **exons** are spliced together, then translated into proteins.

**TRANSLATION** (Happens in cytoplasm at the ribosomes in the rough ER. mRNA + tRNA → polypeptide → protein)

1. mRNA attaches to a ribosome & threads through. Ribosome moves along the mRNA strand to 'read' more of its bases.
2. tRNA has an anti-codon end, and its other end is able to bind with an amino acid corresponding to the specific anti-codon. Corresponding tRNA molecules transport specific amino acids to the ribosome.
3. Each mRNA codon codes for a specific amino acid. Anti-codons and codons match up and form complementary base pairs.
4. Ribosome reads next codon and amino acids continue to be deposited until peptide bonds form between adjacent amino acids to form polypeptide.
5. Process stops when ribosomes read a stop codon. Polypeptide is released into the cytoplasm.

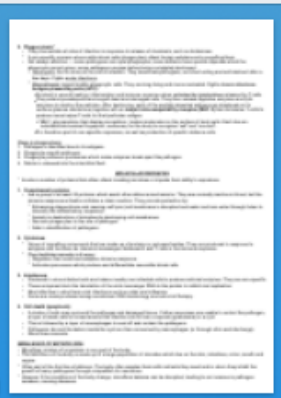




** tRNA is reused and collects another specific amino acid. Once the protein has been synthesised, mRNA may move to another ribosome to make a further protein or it can be broken down into free nucleotides to be reused.

***BEADLE AND TATUM***

- At the beginning of the 20th century, biologists were still not sure of the chemical nature of hereditary material and it was debated to be either protein or DNA.
- In 1941, Beadle and Tatum experimented on irradiated bread mould *(Neurospora crassa)* onto x-rays to induce mutations






2. **Phagocytosis***
   - They concentrate at sites of infection in response to release of chemicals, such as histamines.
   - A non-specific process where white blood cells (phagocytes) attack foreign substances by engulfing them.
   - Not always effective — some pathogens can repel phagocytes; some bacteria have special capsules which the phagocyte cannot grasp; some pathogens escape before being completely destroyed.
     - *Neutrophils*: first to arrive at the site of infection. They deactivate pathogens, are short-acting and self-destruct after a few days. Fights acute infections.
     - *Macrophages*: largest mobile phagocytic cells. They are long-living and mono-nucleated. Fights chronic infections. **Antigen-presenting cells (APC).**
       - ✓Involved in wound healing, inflammation and immune response when activated by lymphokines released by T-cells.
       - ✓They extend pseudopodia and engulf dead and damaged cells. They then release digestive enzymes and lytic enzymes to destroy the particles. After destroying, parts of the partially digested antigens are displayed on its surface (plasma membrane) together with an **major histocompatibility complex (MHC II)** that stimulates T-cells to produce more helper T-cells for that particular antigen.
         - ✓MHC: glycoproteins that display recognition / marker molecules on the surface of body cells. Each has an individual biochemical fingerprint, necessary for the body to recognise 'self' and 'non-self'.
       - ✓It is therefore part of non-specific responses, as well as production of specific defence cells.

Steps in phagocytosis:
1. Pathogen is identified due to its antigens.
2. Phagocyte engulfs pathogen.
3. Phagocyte produces lysosomes which make enzymes break apart the pathogen.
4. Debris is released into the interstitial fluid.

**MOLECULAR DEFENCES**

- Involve a number of proteins that either attack invading microbes or impede their ability to reproduce.

1. **Complement proteins**
   - Are a group of at least 20 proteins which assist other defence mechanisms. They are normally inactive in blood, but the immune response activation initiates a chain reaction. They provide protection by:
     - Enhancing phagocytosis and causing cell lysis (cell membrane is disrupted and water and ions enter through holes to intensify the inflammatory response).
     - Assists in destruction of microbes by destroying cell membranes.
     - Recruits phagocytes to the site of pathogen.
     - Aids in identification of pathogens.

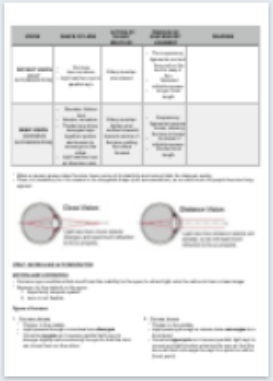
2. **Cytokines**
   - Group of signalling compounds that are made up of proteins or polysaccharides. They are produced in response to antigens and functions as chemical messengers between B and T cells in the immune response.
   - They facilitate immunity in 2 ways:
     - Regulates the innate and adaptive immune response.
     - Activates processes which produce and differentiate new white blood cells.

3. **Interferons**
   - Produced in virus-infected cells and induce nearby non-infected cells to produce antiviral enzymes. They are non-specific
   - These enzymes block the translation of the viral messenger RNA to the protein to inhibit viral replication.
   - Most effective in short-term viral infections such as colds and influenza.
   - Some are mass produced using recombinant DNA technology and anti-viral therapy.

4. **Cell death (apoptosis)**
   - A cluster of cells may surround the pathogen and damaged tissue. If other responses are unable to control the pathogen, a layer of dead cells is formed around the infection site to form a capsule (granuloma) or a cyst.
   - This is followed by a layer of macrophages to seal off and contain the pathogens.
   - Pathogens die and the debris inside the cyst are then consumed by macrophages (or through nitric acid discharge).
   - Worst case scenario

***IMBALANCE OF MICROFLORA***

- Microflora: mixture of organisms in any part of the body.
- The microflora of the body is made up of a large population of microbes which live on the skin, intestines, colon, mouth and vagina.
- Often part of the first line of defence. The body often supples them with nutrients they need and in return they inhibit the growth of many pathogens through competition for resources.
- However if the conditions of the body change, microflora balance can be disrupted, leading to an increase in pathogen numbers, causing diseases.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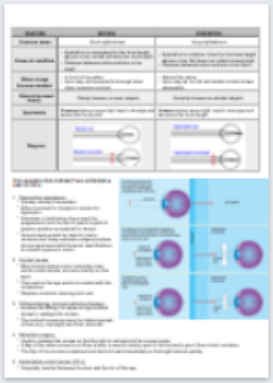
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***DEPTH PERCEPTION***

- Ability to judge distance between two objects and required 3D vision.
- Human eyes are separated by 5cm each so each eye sees a different image and there is an overlap between the fields of view of each eye.
- 3D vision involves two sources of vision (binocular and stereoscopic). It is dependent on stereoscopic or binocular vision where the fields of vision overlap.
  - ✓ *Binocular vision* → occurs when both eyes are focused on the same visual field. Each eye captures its own image of the view and sends the messages to the brain. The brain compares the two images, which are slightly different, and the final interpretation gives a stereoscopic vision.
  - ✓ *Stereoscopic vision* → is 3D vision where distance, depth, height and width of vision is perceived. It is a single perception of a slightly different image form each eye, resulting in depth perception. Information from two eyes is used to form a single image.
- When the images from each eye overlap, they are superimposed by the brain. It matches similarities, notes differences and the combined picture is a three-dimensional, stereo picture of the view — giving depth perception (ability to accurately judge the distance of an object).

- The brain processes the 2 images to determine the distance to an object and produces stereoscopic (3D) vision. This gives humans depth perception.
- If two images are dissimilar then the object is close. If two objects are almost the same then the object is perceived to be distant.

- Animals such as monkeys with eyes on the front of their heads have **binocular vision** and therefore good depth perception (easier to catch prey).
- Animals with eyes on the side of their heads such as horses have a greater peripheral field of view and less depth perception. They have a more **monocular field of view**. They have a greater ability in recognising approaching objects.

***CATARACTS***

- Clouding and increasing opacity of the lens, a structure that is normally transparent. The become opaque and the transmission of light trough the eye is obstructed. Visions involving both near and far objects becomes blurred.
- Lens of the human eye contain fibres made up of proteins and water clef. When clumps of protein are left on the eye, cataract occurs.

| FEATURE | DESCRIPTION |
|---|---|
| **Cause of cataracts** | - Injury or trauma to the eye<br>- Severe inflammatory disease of the eye<br>- Drug reaction (excessive use of corticosteroids) or radiation (excessive infrared or ionising radiation)<br>- Sun exposure<br>- Diseases such as glaucoma, diabetes mellitus (Type II) or thyroid disorders<br>- Smoking<br>- Congenital cataract<br>- Ageing (senile cataract) |
| **Appearance of lens** | - Cloudy<br>- Older people's lens become yellowish and loses it transparency. |
| **Effect on individual** | - Visual clarity fades<br>- Images appear as though you are looking through a waterfall<br>- Eyes may become more sensitive to the glare of the bright sunlight<br>- Individual needs brighter reading lights |
| **When blindness occurs** | If the lens become completely opaque, the individual will become blind as the light does not reach the retina anymore, even though the photoreceptors are still functional. |
| **Cure** | - In the past, cataract surgery involved the removal of the entire lens, leaving the patient functionally blind unless they wore extremely thick glasses to compensate.<br>- Today, the IOL implantation replaces the cloudy damaged lens with a plastic or silicone intraocular lens (lens within the eye) which is similar in shape to a natural human lens and is usually placed within the existing lens capsule.<br>  - *'Small incision no stitch'* → a small vibrating probe (*phacoemulsification*) is inserted into the lens of the eye which break them up into small particles that can be suctioned out with an aspirator, The artificial kens is the inserted into the space left and the incision into the eye may be so small that no stitches are needed. |