Module 8: Non-infectious Disease and Disorders

Outcomes

A student:

- analyses and evaluates primary and secondary data and information BIO11/12-5
- solves scientific problems using primary and secondary data, critical thinking skills and scientific processes BIO11/12-6
- communicates scientific understanding using suitable language and terminology for a specific audience or purpose BIO11/12-7
- explains non-infectious disease and disorders and a range of technologies and methods used to assist, control, prevent and treat non-infectious disease BIO12-15

Content Focus

Students engage with the study of non-infectious disease and disorders, including their causes and effects on human health. They explore technologies and their uses in treating disease and disorders as well as the epidemiology of non-infectious disease in populations.

This module examines the practical applications of STEM. It looks at the importance of understanding the multidisciplinary nature of science applications. It also examines physiology and engineered solutions to problems related to the management of human disorders.

Working Scientifically

In this module, students focus on collecting and processing data to analyse trends and patterns and solve problems. They also focus on communicating ideas about non-infectious disease and disorders. Students should be provided with opportunities to engage with all Working Scientifically skills throughout the course.

Content

Homeostasis

Inquiry question: How is an organism's internal environment maintained in response to a changing external environment?

Students:

- construct and interpret negative feedback loops that show homeostasis by using a range of sources, including but not limited to: (ACSBL101, ACSBL110, ACSBL111)
  - temperature (ACSBL098)
  - glucose
- investigate the various mechanisms used by organisms to maintain their internal environment within tolerance limits, including:
  - trends and patterns in behavioural, structural and physiological adaptations in endotherms that assist in maintaining homeostasis (ACSBL099, ACSBL114)
  - internal coordination systems that allow homeostasis to be maintained, including hormones and neural pathways (ACSBL112, ACSBL113, ACSBL114)
  - mechanisms in plants that allow water balance to be maintained (ACSBL115)

Causes and Effects

Inquiry question: Do non-infectious diseases cause more deaths than infectious diseases?

Students:

- investigate the causes and effects of non-infectious diseases in humans, including but not limited to:
  - genetic diseases
  - diseases caused by environmental exposure
  - nutritional diseases
  - cancer
- collect and represent data to show the incidence, prevalence and mortality rates of non-infectious diseases, for example:
  - nutritional diseases
  - diseases caused by environmental exposure

Epidemiology

Inquiry question: Why are epidemiological studies used?

Students:

- analyse patterns of non-infectious diseases in populations, including their incidence and prevalence, including but not limited to:
  - nutritional diseases
  - diseases caused by environmental exposure
- investigate the treatment/management, and possible future directions for further research, of a non-infectious disease using an example from one of the non-infectious diseases categories listed above
- evaluate the method used in an example of an epidemiological study
- evaluate, using examples, the benefits of engaging in an epidemiological study

Prevention

Inquiry question: How can non-infectious diseases be prevented?

Students:

- use secondary sources to evaluate the effectiveness of current disease-prevention methods and develop strategies for the prevention of a non-infectious disease, including but not limited to:
  - educational programs and campaigns
  - genetic engineering

Technologies and Disorders

Inquiry question: How can technologies be used to assist people who experience disorders?

Students:

- explain a range of causes of disorders by investigating the structures and functions of the relevant organs, for example:
  - hearing loss
  - visual disorders
  - loss of kidney function
- investigate technologies that are used to assist with the effects of a disorder, including but not limited to: (ACSBL100)
  - hearing loss: cochlear implants, bone conduction implants, hearing aids
  - visual disorders: spectacles, laser surgery
  - loss of kidney function: dialysis
- evaluate the effectiveness of a technology that is used to manage and assist with the effects of a disorder (ACSBL100)

MODULE 8: NON-INFECTIOUS DISEASE + DISORDERS

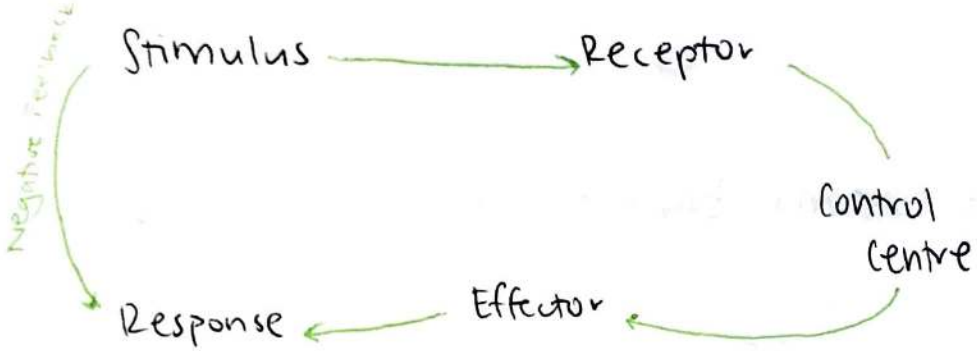
HOMEOSTASIS

- state of balance

Negative Feedback Loops

- maintains Homeostasis by
  - Detecting changes from the stable state
  - Counteracting changes in Negative Feedback Loop
    - oppose stimulus through change made.

eg.



For: temp, pH, [metabolite], osmotic pressure + toxin prescence

Senses / Receptors:

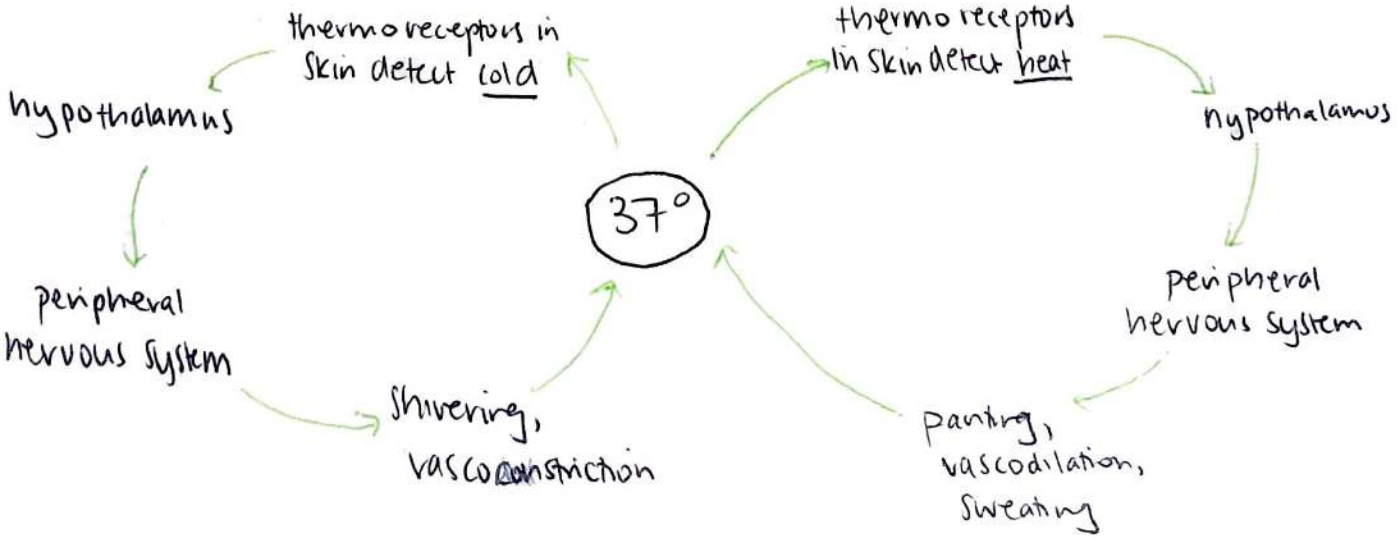
Skin → Thermo + Mechanoreceptors → Heat, pressure, movement

Ears → Mechanoreceptors → Sound

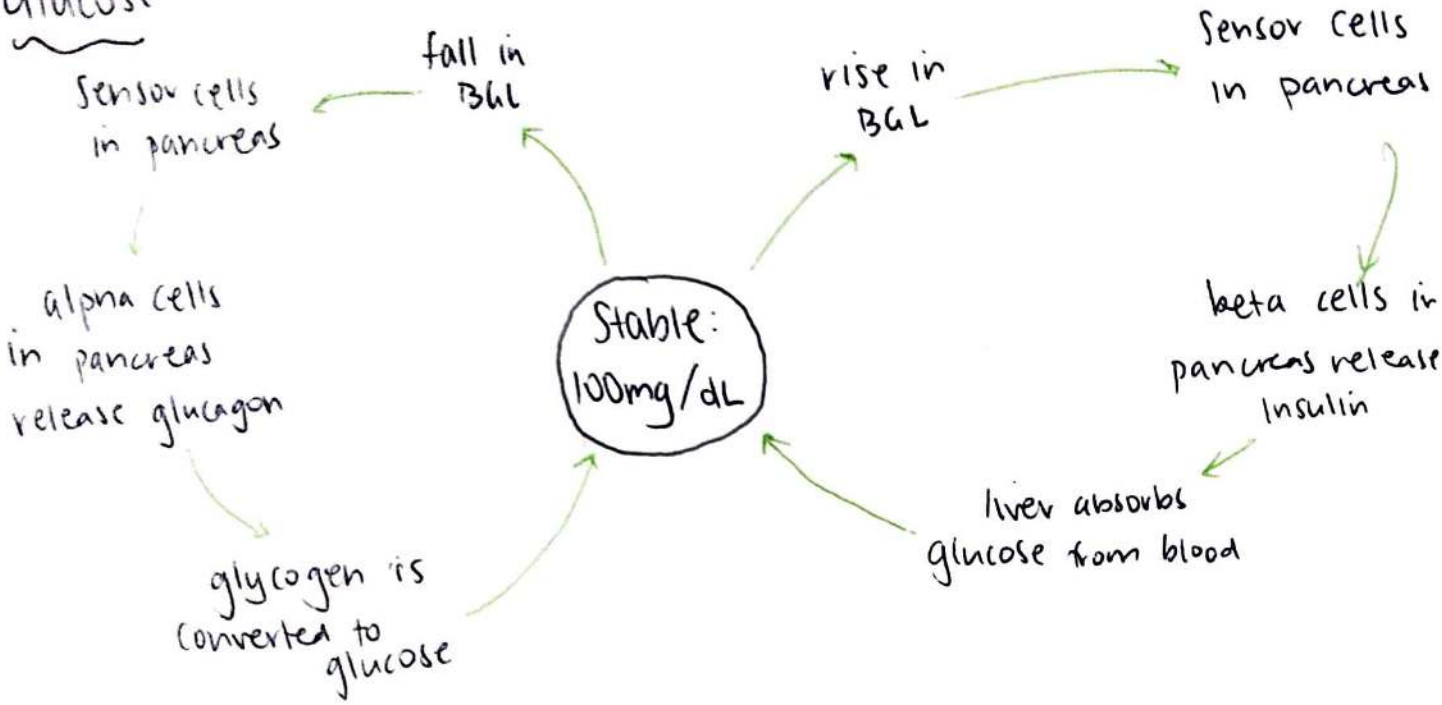
Eyes → Photoreceptors → Light

Nose / Tongue → Chemoreceptors → Chemicals

Temperature - optimal 37° — For endotherms — no environmental impact



Glucose



Maintaining Internal Environment (within Limit)

Adaptations in Endotherms

- behavioural → relate to organisms behaviour
- Structural → relate to size / shape + body parts
- Physiological → how organism's body works

	Behavioural	Structural	Physiological
Temp control Cool down	◦ seek shade ◦ cool in water ◦ licking for cooling ◦ stretch out	◦ Large ears ↑ SA:V evaporate water/heat loss ◦ thin forearm skin	◦ sweating + blood vessel dilation ◦ increased blood flow to extremities
retain heat	◦ hibernation ◦ migration ◦ huddling	◦ insulation (fat, fur) ◦ smaller SA:V minimise loss	◦ decreased blood flow to extremities ◦ Shivering ◦ increased metabolism

Internal Co-ordination Systems

- Receptors + effectors linked via control centre by nervous and hormonal pathways

Nervous System

- regulate internal environment + respond to external environment
  → transmit electrochemical signals
- rapid and specific response to stimuli
- Central Nervous System (CNS)
  - Control centre — receives, interprets + initiates response.
- Peripheral Nervous System (PNS)
  - branches of nerves connect effectors + receptors
  - messages to and from CNS.

Endocrine System

- Glands that secrete hormones
  ⇒ chemical signals
- slower + less specific response to stimuli
- includes hypothalamus, pituitary glands, adrenals, pancreas etc.
  Eg. Glucagon maintain BGL with insulin from pancreas.

Plant Mechanisms for Water Balance

* For optimum osmotic levels for metabolism and water regulation (transpiration)

Structural Adaptations:

- thin leaves, waxy cuticle, sunken stomata on only one side, deep/extensive root systems → Aus. sclerophyll plants minimise water loss.
- decrease photosynthesis + close stomata reduce transpiration
- hairs on leaves and roots
- fleshy leaves that store water → succulents.

CAUSE + EFFECTS

OF Non Infectious Disease

Genetic Disease: Huntington's Disease

Cause: Mutation in the Huntingtin Gene resulting in 35+ CAG repeats

effect: neurodegeneration — decline in movement, cognitive and psychiatric ability / function

Always Fatal - 2.27 per million / year

Prevalence: 5.7 per 100,000 people have HD

Incidence: 5.49 per 100,000 diagnosed each year.

Environmental Exposure Disease: Malignant Melanoma (Skin Cancer)

Cause: excessive / unprotected exposure to uv radiation → mole / spot becomes cancerous

Effect: most lethal skin cancer causing new / unusual growths on skin once spread has no cure.

Prevalence: 53.5 per 100,000 have Melanoma

Incidence: 21.5 per 100,000 new cases / year

Nutritional Disease: Iron Deficiency Anaemia

Cause: Deficient Iron levels in bloodstream - diet, pregnancy, blood loss

Effects: Blood unable to carry enough oxygen to tissues / produce new RBCs result in extreme fatigue, dizziness etc.

Prevalence: 30% of women in reproductive age.

Incidence: 24.2 per 1000 people new cases / year

Cancer: Breast Cancer

Cause: uncontrollable cell division - metastatic growth → BRCA 2+1 genes, older age, radiation exposure.

Effect: pain, changed breasts, weakness, reduced survival rate with development

Prevalence: 1 in 8 women Incidence: 57 new cases / day

Mental Illness: Depression.

Cause: biological, psychological + social sources of stress

Effect: Physical effect on energy / behaviours, emotional function

Prevalence: 1in6 Australians

Incidence: 11% of population new cases / year.

Data of Non-Infectious Diseases

Prevalence: Total number of cases at a specific time

Incidence: number of new cases/infection during a particular time period.

Nutritional Diseases: Iron Deficiency Anaemia

Incidence: 672 cases per 100,000 population

Prevalence: 30% of women of reproductive age → 1.8 Billion WW.

Mortality Rate: 0.08 deaths per 100,000 people

Environmental Exposure Disease: Melanoma Cancer

Incidence: 21.5 per 100,000 new cases / year

Prevalence: 53.5 per 100,000 have melanoma
1 in 13 males + 1 in 23 females diagnosed by 85.

Mortality Rate: 4.0 deaths per 100,000 people.

EPIDEMIOLOGY

Patterns in populations

Study Design:
- appropriate control group.
- adequate time span
- statistical ability to detect an effect.

→ NO Bias

Nutritional Diseases - Iron Deficiency Anaemia
- Approx 13.5% higher incidence rate in females than males.
- Highest in females 14-50 → 38-40% incidence

Environmental Exposure - Melanoma (Cancer)
- higher incidence in males than females.
- Incidence has increased for both genders, then peaked 2005, now slight decrease.

Treatment / Management + Future Direction

Disease: Melanoma

Treatment:
- depends on stage + location.
- initial treatment → surgery to remove tumour and lymph nodes if needed.
- Additional treatment – Chemotherapy → prolong survival
  - Radiotherapy → treat recurring / remaining
  - Targeted therapy → damaged BRAF gene to slow growth.
  - Immunotherapy

Management:
- Additional Treatment – prolong survival / manage symptoms to improve quality life when incurable.

Future Direction:
- Focused radiotherapy limit healthy tissue damage.
- Cancer vaccines tailored to cancer mutations. - combined with immunotherapy.
- BRAF gene inhibitor
- Early Detection measures.

Methods of Epidemiological Studies

Can be
- Descriptive – study patterns across populations
- Analytical – study testing hypothesis
  - → cohort – Disease vs Healthy
  - → case control – without exposure vs with
- Experimental – study measure effectiveness of interventions.

Example: Melanoma study from 2016

Group 1: cohort study → recorded UV exposure + annual checks of 18-50s in high schools. * takes long time.

Group 2: Case control → surveyed hospital patients then compared Melanoma to without, then compared UV exposure.

* Systematic error present.

Benefits of Epidemiology

- potentially save lives
- Determine cause + populations affected - how know melanoma caused by high UV exposure + develops later in life, Men at more risk
- Control Disease + improve public health - public health campaigns eg. Slip Slop Slap + No Hat No Play educating sun safety to reduce risk
- know mortality rates have plateued - effective treatments available.

PREVENTION

Effectiveness of current disease-prevention methods

Educational Programs + Campaigns

- Educate + Motivate, Awareness.

Eg: Slip Slop Slap For Melanoma

- 1980s implemented TV ads, catch phrase, flyers
- led to more Gov-Funded research
- led to decline in Melanoma Incidence in under 55s.

Genetic Engineering

Gene therapy - introduce functional gene into cell
- used to treat severe immunodeficiency, Haemophilia, Parkinson's Disease.

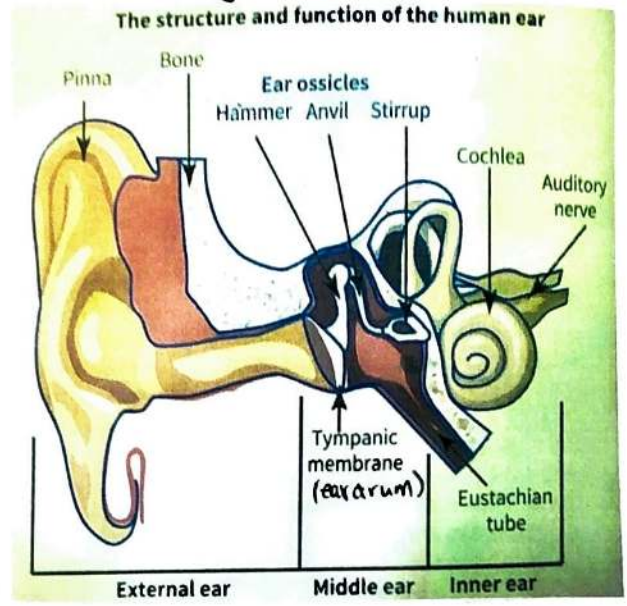
CRISPR/CAS9 - make point mutations accurately in genome
- lasting somatic effect.

Embryo screening - embryo implanted without genetic disorder + editing technologies

TECHNOLOGIES + DISORDERS

Cause of Disorders by structure/function of organs.

Hearing Loss



Sound enters the ear as waves + vibrates the eardrum

Structures:

- Pinna - funnels sound waves into outer ear
- eardrum - vibrated by sound waves which are conveyed to oval window at cochlear by ear ossicles.
- ear ossicles - three bones transmit waves to inner ear
- cochlear - receptors for sound, fluid vibrates - related to balance.
- auditory nerve - transmit sound vibration to brain.

Conductive Hearing Loss - caused by damage to outer/middle ear

- ineffective sound transfer to cochlear

→ May result from ear infections, or perforated eardrum.

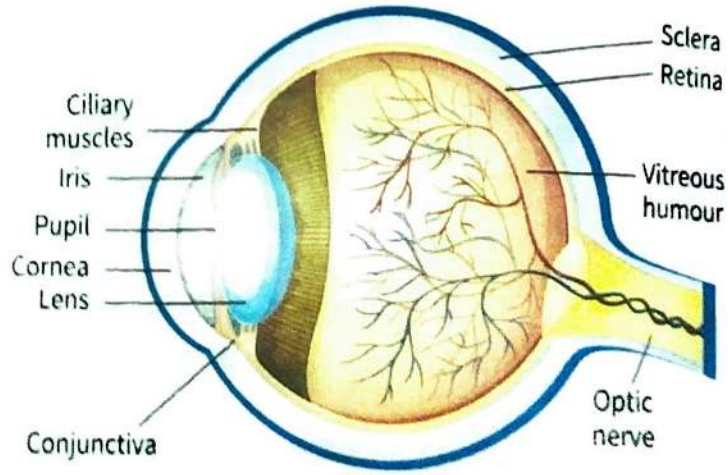
Sensorineural hearing Loss - caused by damage to inner ear.

- sound arrives at cochlear but auditory nerve cannot pass to brain

→ May result from age, noise exposure, trauma or meningitis

Mixed Hearing Loss - both conductive + sensorineural hearing loss.

Visual Disorders



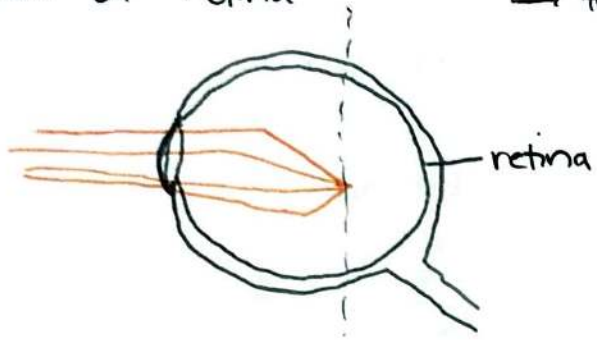
- conjunctiva - protects eye
- cornea - refract light rays
- Lens - refract light to focus by changing shape by ciliary muscles to find right focal point/length.
- retina - allows us to see images
- iris + pupil dilate to light rays.

Vitreous humour - fluid allows light to be transmitted

optic nerve - sends images to brain

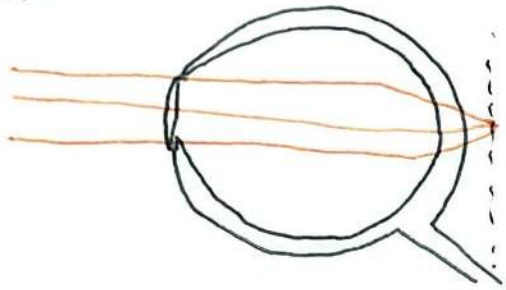
Myopia - short-sighted

- occurs when cornea is too curved - light refracted to focus in front of retina → far away = blurry



Hyperopia - far-sighted

- occurs when cornea is too flat - light refracted to focus behind retina → close-up = blurry.



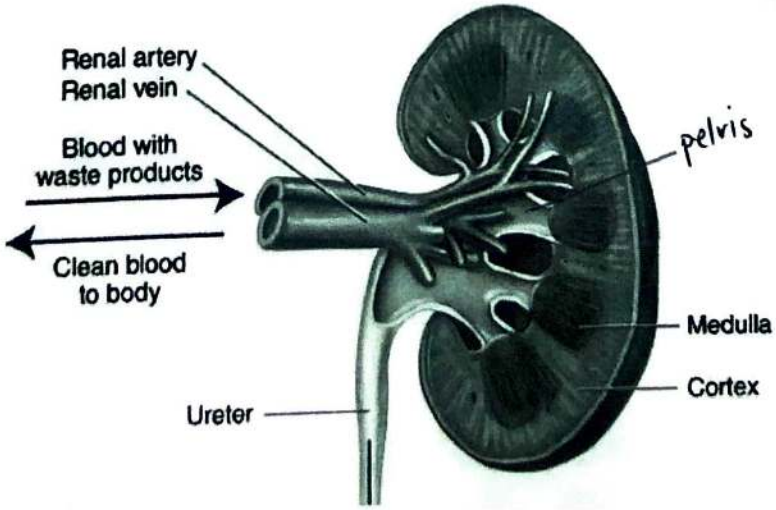
Astigmatism - disorder when vision is blurred at all distances

- caused by misshapen cornea where curvature is not uniform in all directions

Glaucoma - blindness due to pressure in eye causing optic nerve damage

Cataracts - Clouded areas in the lens causing blurry/tinted vision

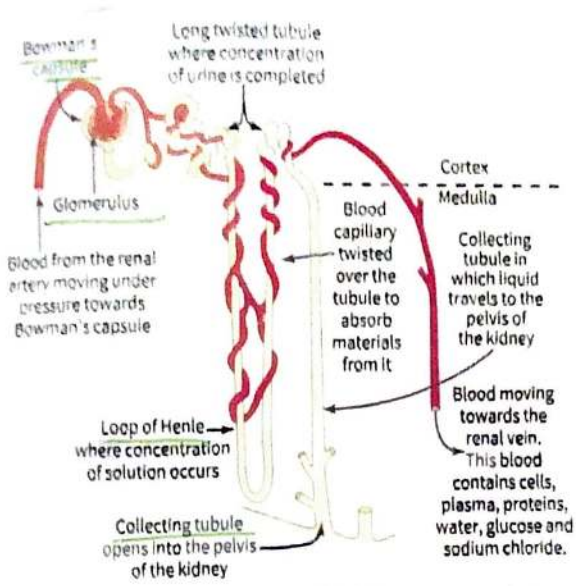
Loss of Kidney Function



- Filter the blood
- renal vein - clean blood to body
- renal artery - blood to kidney
- ureter takes urea to bladder
- renal pelvis - drainage area at centre of kidney - collect urine
- renal medulla + renal cortex - form urine remove waste from blood.
- Nephrons are in outer cortex + central medulla.

Nephron made up of

Nephron →



- filtering unit, areas of passive + active reabsorption and collecting area for urine.
- bowman's capsule- encloses glomerus, first step to filtering blood.
- glomerus - ball of capillaries within Bowman's capsule ⇒ act as ultra-filter.
- Loop of Henle - role in reabsorption
- collecting tubule - opens to pelvis where urea goes to bladder via ureter.

Kidney Failure - when kidneys cannot remove waste from blood + control fluid level

- If untreated cause blood toxicity → fatal.

- May be caused by
  - polycystic kidney Disease
  - diabetes
  - high blood pressure
- Can be Acute = occurs suddenly or Chronic = gradually

Nephrosis - kidney disorder where body excretes too much protein in urine
- caused by disfunctional glomeruli

Kidney Stones - clumps of dissolved minerals that collect in lining of kidneys caused by lack of water.

Technologies to Assist with disorder

Hearing Loss - depend on type of hearing loss.

Cochlear implants

- used for severe deafness due to missing/damaged cochlea hair cells.
- have a sound processor worn behind ear which converts sound waves to a digital code. Electrical impulses sent to cochlea which directly stimulate cochlea + auditory nerve
- Must have functioning cochlea (just not hairs) and sensorineural hearing loss - be implemented before 5 years + surgically implanted.

Bone conduction implants

- For damaged outer/middle ear (conductive/unilateral HL)
- create vibrations that move across skull to inner ears to be sensed by cochlear
- can be trialled before surgery implants - very effective

Hearing Aids

- Fits on outside ear. Contains microphone, amplifier and speaker to amplify sound into outer ear
- For Mild - severe Hearing Loss of either type.

Visual Disorders - depends on cause.

Spectacles - glasses and contact lenses

- artificial lens to correct refractive errors of visual disorder

eg. Hyperopia

flat lense

Concave lens allows sharp close-up images

Myopia

convex lens allows sharp distant images.

- Glasses + Contacts also used for Astigmatism → bifocal lens.

Laser Surgery

- more permanent - involves reshaping cornea to correct refractive error using cool temp. laser.
  - LASIK most common type
- Thin flap created in cornea, then laser removes exact amount of tissue to reshape cornea. Cornea flap then replaced.

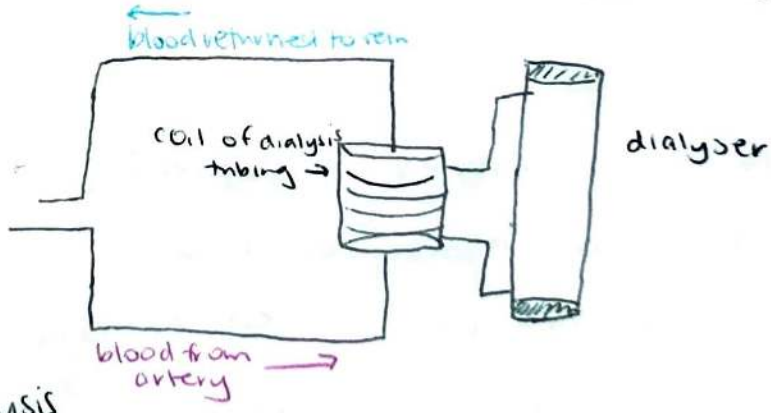
Cataract Surgery

- involves removal of opaque lens
- replaces with clear artificial lens called intraocular lens.

Loss of Kidney Function

Dialysis : Haemodialysis

- most common
- done 4-5 hours x 3 times/week (or overnight)



Peritoneal Dialysis

- Done at home via the abdominal lining using catheter for cleansing fluid — waste fluid then drawn + discarded.
  → Able to travel

Kidney Transplant

- preferred treatment where donor kidney surgically placed into some-one with end stage kidney disease / kidney failure.

Effectiveness of Technology

For Kidney Disease:

Haemodialysis

Benefits:
- keeps patient alive
- Maintains homeostasis of bodily fluids
- Not painful.

Limitations:
- Time consuming
- Invasive
- Expensive
- Restricts lifestyle / mobility
- Risk of infection
- Not completely effective, does not cure.

For other Disorders:

Laser Eye Surgery

- Permanent + effective treatment
  - 92 - 98% satisfaction rate.
- 10% have conjuctival bleeding, 95% dry eyes.

Cochlear Implants

- very effective especially in children.
- expensive, must learn sounds they hear, invasive