PHYSIOLOGY

AHS 278

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2020

UNIVERSITEIT iYUNIVESITHI STELLENBOSCH UNIVERSITY

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PHYSIOLOGY (AHS) 278
2020

1. GENERAL

The Physiology (AHS) 278 module is a service course for second year BSc Physiotherapy and BSc Dietetics students, and is presented by the Division of Medical Physiology. The module covers all physiological systems in sufficient detail to provide the student with:

a) an understanding of how the different parts of the body work.
b) the ability to read and understand the physiological literature (textbooks etc).
c) the ability to acquire additional applied physiological information, to understand it, and place it in proper context.

2. PRESCRIBED TEXTBOOK

Silverthorn, DU (2019). Human Physiology: An integrated approach, 8th Edition. Pearson. ISBN-13 978-1292259543. Earlier editions may also be used. The IP-10 cd is especially useful, as it contains worksheets, animations and quizzes relevant to most of the physiological systems.

3. CONVENOR

Dr. Shantal Windvogel, Medical Physiology Division, F511, 5th Floor, Fisan building, Faculty of Medicine and Health Sciences.
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4. CONTENT

The following topics are covered:

Topic	Number of lectures
Cells and membranes	4
Muscle physiology	9
Neurophysiology	24
Respiratory system	10
Cardiovascular system	10
Immunology	6
Renal physiology	9
Endocrinology	15
Reproductive system	5
Haematology	10
Digestive system	10
Total	**112**

5. LECTURE HALL

Lectures are presented in Lecture Hall 4 (Education building).

6. NOTICES AND OTHER INFORMATION

Information regarding the module will be placed on SUNLearn.

7. CONTACT DETAILS OF LECTURERS

Lecturer	Office	E-mail
Prof. Stefan du Plessis	F515	ssdp@sun.ac.za
Dr Gerald Maarman	F510	gmaarman@sun.ac.za
Dr. Erna Marais	F508	et4@sun.ac.za
Dr Lihle Qulu	F517	qlul@sun.ac.za
Ms. Bongekile Skosana	F564	bts@sun.ac.za
Prof. Hans Strijdom	F509	jgstr@sun.ac.za
Dr. Shantal Windvogel	F511	shantalw@sun.ac.za

8. TIMETABLE

The timetable will be published on SUNLearn. **Please take note of any updates.**

a) **Lectures** are presented between 12h00-12h45, on Mondays, Tuesdays, Thursdays and Fridays in Lecture Hall 4 from:

13 January – 20 March
30 March - 15 May
20 July - 4 September
14 September - 23 October
Attendance is compulsory and students are required to sign the class register.

b) **Practical Classes** are scheduled on the following days from 14h00-16h00:
Friday 3 April
Friday 17 April
Friday 15 May
Attendance is compulsory and a rotation roster will be issued closer to the start of these classes.

c) **Project submissions** are on 11 August and **presentations** are scheduled on 15 October from 11h00-14h00. Please take note of any other important dates regarding the project, as indicated on the AHS278 Physiology timetable and/or SUNLearn.

9. ASSESSMENT OPPORTUNITIES FOR CALCULATION OF THE CLASS MARK

Class Mark (out of 100) = Sum of the assessments obtained, relative to the weighting, as outlined in table 1.

a) Class tests
There will be 5 class tests. Information regarding the work which will be tested, venues and other relevant information will be placed on SUNLearn.

b) Practicals
Your practical attendance, as well as practical reports will contribute 10% in total to the class mark.

c) Project
Your project assignment will be to create a literature review on a topic under the general theme “Physiology in everyday life”. Group literature reviews must be submitted by 11 August, whereafter it will undergo evaluation by project supervisors and peer groups. Groups will present their projects on 15 October. Topics for the project, group allocations and other relevant information will be made available on SUNLearn.

d) Assessment dates and weightings

Table 1: Assessment opportunities for calculation of the class mark.

Semester 1			
Assessment opportunity	**Date**	**Time**	**Weighting (out of 100)**
Class test 1	Friday, 13 March	14h00-15h15	**12.5**
Practical1	Friday, 3 April	14h00-16h00	**3.33**
Practical 2	Friday, 17 April	14h00-16h00	**3.33**
Class test 2	Friday, 8 May	14h00-15h15	**12.5**
Practical 3	Friday, 15 May	14h00-16h00	**3.33**
Semester 2			
*Class test 3	Friday, 31 July	14h00-16h30	**25**
Class test 4	Friday, 21 August	14h00-15h15	**12.5**
**Project	Tuesday, 11 August (**submission date)	16h30	**15**
	Thursday, 15 October (group presentations)	11h00-14h00	
Class test 5	Friday, 9 October	14h00-15h15	**12.5**

***Please note that class test 3 makes a substantial contribution to your class mark.**
**** Please take note of other important dates and information regarding the project, as published on SUNLearn.**

10. TUTORIALS

Tutorials are **compulsory** for students who obtain an average of <50% in their class tests.
Contact person: Dr Shantal Windvogel shantalw@sun.ac.za

11. ADMISSION TO EXAMS AND EXAM DATES

a) A student will not be allowed to gain access to the exam unless he or she has obtained in the module, a subminimum of **40** as a class mark.

b) To qualify for the re-evaluation, candidates must after having written the first examination opportunity achieved a Final Mark of **40 - 49%**.

c) A list of students who qualify for the re-evaluation will be posted on SUNLearn.

The **provisional** dates for the examinations are:
Final exam: **Monday, 26 October**
Re-evaluation: **Monday, 16 November**

12. FINAL MARK

a) Final Mark = (Class Mark + Exam Mark)/2

b) In order to pass the re-evaluation, a student must obtain a mark of not less than 50 in the re-evaluation. The only possible results of the re-evaluation are: 40%, 45%, or 50%. This mark becomes the candidate's Final Mark but shall not be lower than the Final mark allocated in the first examination (subject to par. 8.3.3.3 and par. 8.3.3.4 of the examination rules in the 2019 Stellenbosch University (SU) Calendar).

c) The candidate **passes** the course if i) the **Exam Mark** is **50% or more,** or ii) the **Final Mark** is **50%** or more, **subject to the Exam Mark not being less than 40%**.

Dr. Shantal Windvogel, 3 December 2019

AHS278 PHYSIOLOGY MODULE OUTCOMES

A. The module outcomes may be used to identify the competencies of the student after completion of the following subject areas.
B. It should be used along with your lecture and practical notes, as well as other resources such as your textbook.
C. The module outcomes are only a guide and additional outcomes may be provided to you by your lecturer.

SEMESTER 1

1. CELLS AND MEMBRANES

After the completion of this section, you should be able to:

1. Have a basic comprehension of what “Physiology” entails.
2. Know and be able to recognize the different levels of organization.
3. Have knowledge regarding the functions of cellular membranes.
4. Be knowledgeable and demonstrate insight concerning the different components of cellular membranes, as well as their importance and functions in the determination of the characteristics of cellular membranes.
5. Demonstrate knowledge and insight in the different ways in which molecules can transverse membranes; including diffusion, osmosis, the different forms of facilitated diffusion and active transport, as well as vesicular transport.
6. Understand the concept of tonicity.
7. Be knowledgeable and demonstrate insight into what is meant with the “Membrane potential” and which factors determine it.
8. Apply this knowledge in order to know and understand how an action potential occurs.
9. Know the different types of cell junctions and the importance of each.

2. MUSCLE PHYSIOLOGY

After the completion of this section, you should be able to:

A. SKELETAL MUSCLE PHYSIOLOGY

1. Be knowledgeable concerning the contractile apparatus of skeletal muscle, with special reference to the molecular structure, as well as the mechanisms of contraction (i.e. the cross-bridge cycle and the sliding filament theory).
2. Know and understand excitation-contraction coupling.
3. This knowledge must be related to the duration of a muscle twitch, as well as the mechanism of summation.
4. Distinguish between different types of contraction: isometric and isotonic (concentric and eccentric).
5. Demonstrate insight in the relationship between load and contraction rate.
6. Describe and understand the contractile characteristics of whole muscle in terms of the following:
   a) motor units;
   b) the different types of muscle fibres;
   c) the control of tension generation and shortening velocity;
   d) antagonist muscle pairs.

B. SMOOTH MUSCLE PHYSIOLOGY

1. Distinguish between the different types of smooth muscle.
2. Understand how unitary muscles function as a unit.
3. Know and understand the mechanism of contraction and relaxation.
4. Be knowledgeable of the different stimuli which can influence smooth muscle contraction.

C. CARDIAC MUSCLE PHYSIOLOGY

1. Know and be able to distinguish between the different types of cells in the heart.
2. Know what an intercalated disc is and how it is adapted for its function.
3. Know and understand how an action potential is generated in heart muscle and how it influences the contractile activity of the heart.
4. Know and understand how excitation-contraction coupling happens in heart muscle.
5. Be knowledgeable and demonstrate insight into the mechanism by which pacemaker cells automatically and rhythmically generate electrical signals.
6. Know how the rapid and effective conductance of electrical signals occurs in the heart.

3. NEUROPHYSIOLOGY

After the completion of this section, you should be able to:

A. CELLULAR AND NETWORK PROPERTIES OF NEURONS

1. Define the concepts of physiological communication and control systems and understand why the nervous system is both a communication and control system of the body.
2. Explain the basic structure and components of a typical neuron.
3. Describe the source of myelin in the nervous system and the role of the myelin sheath that surrounds certain neurons.
4. Supply an overview of the two main categories of messengers found in the nervous system.
5. Define the term: Graded Potential and explain briefly, in table format, the similarities and differences between graded potentials and action potentials.
6. Explain how an action potential originates in a neuron.
7. Draw a graphical representation with explanatory annotations to describe the formation of an action potential in a neuron and to demonstrate the movement of ions that are responsible for these changes.
8. Make an annotated line drawing of an axo-dendritic synapse and explain how the message is transferred from one neuron to the next.

B. FUNCTIONAL ORGANISATION OF THE CENTRAL NERVOUS SYSTEM

1. Briefly describe the physical structures that contribute to the protection and support of the brain and spinal cord.
2. Name the tissue involved in the formation of cerebrospinal fluid (CSF).
3. Describe how the CSF is formed.
4. Describe the function of cerebrospinal fluid.
5. Explain the basic components of the nervous system: central nervous system (CNS) and peripheral nervous system (PNS) and understand how the CNS and PNS fit together anatomically and functionally to form a unit.
6. Describe the main structures of which the CNS is composed.
7. Name the four functional regions of the brain, understand the anatomical location of each and supply a brief, concise summary (in table format) of the function of each (cerebrum, diencephalon, cerebellum and brainstem).
8. Supply a brief description of the anatomy of the cerebrum (w.r.t. the cerebral lobes) and note the resemblance between the names of the most important cerebral lobes and the regions of the skull.

9. Be aware of the structures that can be observed if a coronal section is made through the cerebrum: cerebral cortex, gray matter, white matter, basal ganglia, corpus callosum, and ventricles.
10. Give a brief, concise definition of the limbic system and be aware of the brain structures that form the limbic system. Understand how the limbic system can serve as a hypothetical link between emotions and physiological function.
11. Name the 4 brain structures that form the diencephalon and give a brief, concise description of each of these structures.
12. Explain the role of the brainstem in the control of vital functions, namely heart and blood pressure control and control of breathing.
13. Briefly explain the statement: “The cerebral cortex integrates sensory inputs and motor outputs.”
14. Understand clearly the following functional cortical regions: sensory cortex (primary somatosensory cortex; visual cortex; auditory cortex; olfactory cortex; gustatory cortex) and motor cortex (primary somatomotor cortex).
15. Understand the role of cortical association areas w.r.t. the integration of sensory inputs and motor outputs.
16. Explain the primary somatosensory cortex in terms of anatomical location and from which body regions sensory inputs are received here.
17. Give an explanation for the “sensory homunculus”.
18. To develop a sound understanding of the anatomical location and basic role of the following central nervous system components involved with the control and integration of movement: cerebral cortex; basal ganglia; brain stem; cerebellum and spinal cord.
19. Give a brief explanation of the cerebral cortex with regard to the motor cortex (primary somatomotor cortex).
20. Describe briefly the pathway that a sensory message would follow from a sensory receptor in the skin to the primary somatosensory cortex and eventually the primary somatomotor cortex.
21. Supply a definition of the so-called Motor Homunculus.
22. Explain the following statement: “An asymmetry exists between the cerebral hemispheres w.r.t. the execution of the following functions: writing, language, speech and maths.”

C. AFFERENT DIVISION OR SENSORY NERVOUS SYSTEM

1. Name the sensory modalities detected by the somatosensory system.
2. Describe the properties of somatosensory receptors and thus the function that receptors fulfil in the nervous system.
3. Make a line drawing to describe the parts of the brain involved in processing sensory information.
4. Explain what a reception field is.
5. Explain the concept “two-point discrimination”.
6. Explain how the nature of a stimulus is identified by the nervous system.
7. Explain how a stimulus is localised in the nervous system.
8. Explain how the intensity of a stimulus is coded through the nervous system.
9. Explain what adaptation is and what the implications of this are for receptor functioning.
10. Explain the meaning of the term “lateral inhibition” in the context of the sensory system and what the advantages thereof are.
11. Make a line drawing to describe the pathways and parts of the cortex involved in the conscious recognition of touch, pressure, pain and temperature.
12. Explain how the properties of receptors responsible for detection of mechanical energy distinguish between light touch, pressure and vibration.
13. Name different stimuli that can be perceived as pain.
14. Compare the stimuli that initiate pain at the skin pain receptors with those that initiate pain at visceral pain receptors.
15. Explain how the properties of the nerves that carry afferent pain information influence the pain experience.

16. Make a line drawing to describe the nerve pathways and parts of the cortex involved in the conscious perception of pain.
17. Explain how the pain experience can be suppressed and exaggerated.
18. Explain the term “referred sensation” and explain possibilities on how referred sensations can occur.
19. Compare the signal transduction in odorant receptors with type II and III taste cells.
20. Make a line drawing of the external, middle and inner ear, and use captions to describe the function(s) of each.
21. Explain how a sound wave gives rise to the initiation of action potentials in neurons of the cochlear nerve.
22. Explain how different pitches of sound are detected.
23. Make a line drawing to describe the pathways and sections of the brain involved in the perception of sounds.
24. Describe which sensors occur in the vestibular apparatus, and how they work.
25. Explain the difference between otokinetic and optokinetic nystagmus.
26. Make a line drawing to describe the structure of the eye.
27. Make a line drawing to describe the structure of the retina.
28. Explain how different coloured lights are perceived.
29. Explain phototransduction in rods. Start with bleaching and end with release of neurotransmitter.
30. Explain the on-centre/off-surround concept of the ganglion visual receptive field of the retina.
31. Make a line drawing to describe the pathways and parts of the brain involved in the perception of visual images.

D. EFFERENT DIVISION OF THE NERVOUS SYSTEM

1. Define the “Efferent Division of the nervous system” in terms of the position it occupies in the nervous system (control system flow diagram).
2. Compare the EFFERENT division of the nervous system and the AFFERENT division w.r.t. the type of information being conducted, the direction of signal transduction, the final destination of the message being conducted, as well as possible differences / similarities w.r.t. the number of neurons and synapses found in a single neuronal pathway.
3. Explain how the autonomic nervous system maintains homeostasis and compare antagonistic control with tonic control.
4. Compare chemical signalling in the two autonomic branches—including ganglionic and postganglionic synapses, all neurotransmitters, receptors, target tissues and their responses.
5. Give a brief definition for the term: Somatomotor Nervous System.
6. Compare the autonomic and somatomotor nervous systems as follows: (i) diagrammatic, and (ii) in table format.
7. Supply a clear description of the following types of synapses: (i) neuro-effector; and (ii) neuromuscular.

E. REFLEXES AND THE CONTROL OF BODY MOVEMENT

1. Explain the difference between somatic motor and autonomic reflexes.
2. Briefly describe how skeletal muscles contracts.
3. Explain what the term “alpha-gamma coactivation” means.
4. Explain how the physiology of the reflex changes during an upper motor neuron lesion, i.e. why are the muscles spastic and the reflexes exaggerated?
5. Make a diagram of how muscle spindle and Golgi tendon reflexes help prevent damage to the muscle.
6. Draw a map of how stretch reflexes and reciprocal inhibition control movement around a joint.
7. Draw a reflex map to explain how you could pull your foot away from a pinprick and still maintain your balance.

4. THE RESPIRATORY SYSTEM

After the completion of this section, you should be able to:

1. Name and describe the key functions of the respiratory system.
2. Explain the role of each structure in the respiratory system in external respiration.
3. Understand the different gas formulae as well as their application in respiratory physiology.
4. Use these formulae to explain the response of gases and air flow within the respiratory system.
5. Define and describe the lung volumes and lung capacities and how they are related.
6. Explain alveolar and intrapleural pressure as well as the changes in these pressures during inspiration and expiration.
7. Explain a pneumothorax and the effect thereof on intrapleural pressure.
8. Discuss compliance and elastance in the context of the respiratory system and give examples of disease states that accompany changes in compliance and/or elastance.
9. Explain the role of surfactant in the lung.
10. Name the factors affecting airway resistance.
11. Explain what is meant by “anatomic dead space” and explain how it affects ventilation.
12. Explain what is meant by “alveolar and physiological dead space.”
13. Discuss total pulmonary ventilation and alveolar ventilation.
14. Describe the pulmonary circulatory system and its key functions.
15. Explain ventilation-perfusion matching.
16. List the factors that influence the diffusion of gases across the alveoli.
17. Explain the difference between the concentration of a gas in solution and the partial pressure of that gas in solution and identify the factors that influence the movement of gas into solution.
18. Discuss the solubility of oxygen and carbon dioxide in the blood.
19. Know what normal physiological pressures of oxygen and carbon dioxide are in the alveolus, arterial blood, venous blood and resting cells.
20. Use pressure gradients to explain the direction of oxygen and carbon dioxide movement at the sites of gas exchange.
21. Describe the structure of haemoglobin.
22. Draw the oxyhaemoglobin dissociation curve (for normal conditions) and explain the physiological significance of the shape of this curve.
23. Use a diagram to explain the shifts in the oxygen-haemoglobin dissociation curve that result from changes in pH, temperature, and levels 2, 3-DPG.
24. Explain the differences between foetal and adult haemoglobin.
25. Diagram the factors affecting total oxygen content of arterial blood. Start with the equation: total arterial oxygen content = amount dissolved in plasma + amount bound to haemoglobin. Work from there to map the factors that contribute to the amount of oxygen dissolved in plasma and the amount bound to haemoglobin.
26. Write down and understand the reversible chemical reaction for the conversion of carbon dioxide to bicarbonate ions.
27. Explain the role of the bicarbonate buffer system.
28. Use a flow diagram to explain in detail, the three ways in which carbon dioxide is transported in the blood.
29. Use a flow diagram to explain how CO_2 is removed from the body.
30. Use a flow diagram to explain the neural control of breathing.
31. Use a flow diagram to explain the mechanisms by which central and peripheral chemoreceptors monitor carbon dioxide, oxygen, and pH levels for the purpose of regulating ventilation.

5. THE CARDIOVASCULAR SYSTEM

The main topics covered in this section include:

A. Brief overview of the Cardiovascular System
B. Understanding the concepts of pressure, volume, flow and resistance in the cardiovascular system
C. Cardiac muscle and the heart
D. Pumping action of the heart
E. Blood flow and Blood Pressure

After the completion of this section, you should be able to:

A. BRIEF OVERVIEW OF THE CARDIOVASCULAR SYSTEM

1. Describe main function functions of the cardiovascular system.
2. Know the basic anatomy of the cardiovascular system and describe the flow of blood in the cardiovascular system.

B. UNDERSTANDING THE CONCEPTS OF PRESSURE, VOLUME, FLOW AND RESISTANCE IN THE CARDIOVASCULAR SYSTEM

1. Understand the terms: pressure, flow (rate), velocity, radius, area, cross-sectional area and resistance and know the mathematical relationships between them and apply these principles in the cardiovascular system.

C. CARDIAC MUSCLE AND THE HEART

1. Know the differences between the two muscle types in the heart, namely contractile and autorhythmic cells.
2. Know and be able to explain how action potentials differ between the two types of cardiac cells.
3. Explain the process of excitation-contraction coupling in cardiac muscle and compare it the process in other muscle types.
4. Describe the structural and functional relationships of the heart chambers.
5. Know the locations of the heart valves, their functions and effects of valvular dysfunction.
6. Describe the electrical conducting system within the heart.
7. Describe the physiological basis of the electrocardiogram (ECG).
8. Explain how action potentials in cardiac contractile and cardiac autorhythmic cells differ.
9. Explain how neurotransmitters and other agents such as beta blockers or calcium channel blockers affect the heart.

D. PUMPING ACTION OF THE HEART

1. Give a detailed explanation of the events taking place during the cardiac cycle.
2. Interpret the Wiggers diagram
3. Know and be able to diagram the factors that affect cardiac output.
4. Explain length-tension relationships in the heart.
5. Know the Frank-Starling law of the heart and its application in the heart.

E. BLOOD FLOW AND BLOOD PRESSURE

1. Compare and contrast the following structures: arteries, arterioles, capillaries, venules, and veins.
2. Explain and know the formulae for: pulse pressure; mean arterial pressure (as a function of pulse pressure as well as its relationship to cardiac output).
3. Know the relationships between pressure, flow and resistance in the cardiovascular system.
4. Explain how the factors above affect blood pressure and blood distribution.
5. Explain the control mechanisms (intrinsic and extrinsic) that influence arteriolar resistance.
6. Know and explain the effect of chemicals that act as vasoconstrictors or vasodilators.
7. Explain how vascular smooth muscle regulates peripheral resistance.

8. Explain how myogenic autoregulation, paracrines and the sympathetic branch affect vascular smooth muscle.
9. Know the distribution of blood within the body.
10. Name the forces that regulate blood flow in capillaries (Starling's forces).
11. Explain the relationship between the lymphatic system and the cardiovascular system.
12. Explain and be able to represent using a flow diagram, the baroreceptor reflex under condition of both increased and decreased blood pressure.
13. Know and be able to diagram the fast and slow responses to control blood pressure.
14. Explain and be able to diagram all the factors influencing peripheral blood flow.
15. Describe atherosclerosis and hypertension and their role in cardiovascular disease.

6. THE IMMUNE SYSTEM

After the completion of this section, you should be able to:

1. Identify the different:
   a) defense lines of the immune system.
   b) cells, chemicals and processes of the innate internal defence line and describe the function of each.
   c) type of cells and processes of the adaptive defence line and describe the function of each.
   d) type of lymphoid tissue, where they are found in the body, as well as the function of each.
2. Write down the similarities and differences between B and T lymphocytes w.r.t. how and where they are form, how they are activated and how they protect the body.
   Where do you find MHC I and II proteins and what are their functions?

SEMESTER 2

7. RENAL PHYSIOLOGY

The main topics covered in this section include:

A. Kidney function
B. Filtration
C. Reabsorption, secretion and excretion
D. Micturition
E. Fluid and electrolyte balance
F. Acid base balance

After the completion of this section, you should be able to:

A. KIDNEY FUNCTION

1. Describe the main functions of the kidneys.
2. Name the components of the urinary system.
3. Describe the nephron and its components.
4. Describe the processes of filtration, reabsorption and secretion in the kidney
5. Explain how fluid volume and osmolarity is modified along the length of the nephron.
6. Explain how final urine volume and concentration are related to the body's needs.

B. FILTRATION

1. Describe and be able to diagram the glomerular filtration membrane and know how each contributes toward the filtrate composition.
2. Describe the factors involved in determining the net filtration pressure, know the typical values of each and know the direction of fluid movement.
3. Define glomerular filtration rate (GFR) and know its average value.
4. Describe the factors and forces that can influence the GFR.

C. REABSORPTION, SECRETION AND EXCRETION

1. Explain the processes of reabsorption and secretion along the length of the nephron.
2. Review the processes of osmosis, active transport, passive transport, vesicular transport, transcellular transport, paracellular transport.
3. Explain how the filtrate is changed along the length of the proximal tubule.
4. Explain the specific mechanisms involved in the transport of substances in the proximal tubule.
5. Explain how the transport of substances differs in the descending and ascending loop of Henle.
6. Explain how the filtrate is changed along the loop of Henle.
7. Explain the specific transport mechanisms involved in the transport of substances in the loop of Henle.
8. Explain the processes of reabsorption and secretion in the distal tubule and collecting ducts.
9. Explain how glucose in the plasma and urine can be used to determine the reabsorption properties of the nephron.
10. Define the following terms, transport maximum, renal threshold, saturation, osmotic diuresis, glucosuria and be able to apply these principles using a diagram of glucose handling by the nephron.
11. Explain the concept of renal clearance and give the formula for it.
12. Explain what the functional significance of measuring GFR is.
13. Explain the significance for using inulin and creatinine to measure GFR.
14. Determine GFR, when given plasma inulin/creatinine concentration and rate of inulin/creatinine excretion.
15. Analyze renal handling of a substance when GFR, plasma concentration, and the excretion rate of the substance are known and by comparing clearance of the substance to clearance of inulin or creatinine.

D. MICTURITION

1. Describe and explain the micturition reflex.

E. FLUID AND ELECTROLYTE BALANCE

1. Explain how water is gained and lost in the body.
2. Name the three most important hormones that regulate water balance in the body.
3. Explain the role of ADH in the regulation of water balance.
4. Explain the stimuli for secretion, transport in the blood, target cells and location, and action of ADH on its target cells.
5. Explain the principle of countercurrent exchange in the nephron and the physiological importance thereof.
6. Explain the body's responses to changes in blood volume and blood pressure changes.
7. Know the normal levels of sodium and potassium in the extracellular fluid.
8. Explain the effects of disturbances in sodium and potassium balance in the body.
9. Explain the body's responses to the ingestion of salt.
10. Name the factors that cause the secretion of aldosterone and explain the impact thereof on the transport of sodium and potassium in the distal nephron.
11. Name the factors that stimulate renin secretion.
12. Name the components of the Renin Angiotensin Aldosterone System (RAAS) and its effects on blood pressure, blood volume and osmolarity.
13. Give a detailed explanation of the effect of natriuretic peptides on salt and water excretion.
14. Describe behavioural mechanisms involved in salt and water balance.
15. Explain the body's response to correct disturbances in salt and water balance.
16. Explain the homeostatic response of the body to severe dehydration.

F. ACID BASE BALANCE

1. Define: pH, acids, bases, buffers, acidemia, alkalemia, acidosis, and alkalosis.
2. Explain how the body handles changes in pH.
3. Know the location of the various buffer systems and understand their mechanisms of action.
4. Use the equation $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$ to describe how buffers regulate fluctuations in pH.
5. Explain how the lungs and kidneys help to maintain acid-base balance by describing their compensatory roles during pH changes.
6. Explain the transport mechanisms and transporters in the kidney that help to maintain acid-base balance.
7. Identify the causes and compensations of respiratory acidosis, metabolic acidosis, respiratory alkalosis, metabolic alkalosis and indicate how the levels of CO_2, H_2O, H_2CO_3, H^+, and HCO_3^- are affected.

8. THE ENDOCRINE SYSTEM

Endocrinology can be divided into 4 sections:

1. Contextualizing “Endocrinology” within the broader theme of homeostasis.
2. Examining the GENERAL CHARACTERISTICS of the different categories of hormones.
3. Applying these general characteristics to the different WATER soluble hormones.
4. Applying these general characteristics to the different FAT soluble hormones.

Endocrinology requires two “levels” of knowledge:

a) You must know the FACTS associated with the different hormones and hormonal systems. This will be tested by simple questions e.g.: *Name one variable in blood plasma which influences insulin levels*.
b) You must UNDERSTAND the implications and applications of these different FACTS. This will require INSIGHT which will be tested with questions focusing on application: e.g.: *A rat breaks into your cookie cupboard and stuffs itself with Romany Creams. What do you expect will happen to its insulin levels immediately after eating all your cookies?*

After the completion of this section, you should be able to:

A. BASIC INTRODUCTION AND PRINCIPLES

1. Have knowledge and insight regarding the concept of homeostasis, as well as the importance and contribution of communication within the body to the maintenance of homeostasis.
2. Have knowledge concerning control mechanisms and understand what is meant by negative and positive feedback.
3. Understand that the endocrinology system is a communication system which can send different types of messages.
4. Have insight into the factors which determine the characteristics of a message which is being relayed by a hormone.
5. Have knowledge regarding the chemical classification of hormones as water soluble, fat soluble or amines.
6. Show insight regarding how the chemical characteristics of a hormone determine the physical characteristics and effects of hormones in the body.
7. Have knowledge concerning the cyclical nature of hormone secretion.

B. APPLICATION: WATER SOLUBLE HORMONES

1. For each of the hormones which we will look at it is important to apply the knowledge gained from the “Basic introduction and principles” section.
2. Have knowledge regarding the different groups of water soluble hormones, as well as the type of message conveyed by each.
3. For each hormone you must have knowledge regarding their general functions in the body and how they contribute to homeostasis.
4. Have insight into the concept of “reign control” / counter-regulatory control.
5. Understand what is meant by the “ballistic control” hormones.
6. Have insight regarding the negative feedback mechanisms involved in the secretion and end-effects of the trophic hormones.

C. APPLICATION: FAT SOLUBLE HORMONES

1. For each of the hormones which we will look at it is important to apply the knowledge gained from the “Basic introduction and principles” section.
2. Have insight regarding the type of message and effects which are elicited by the fat soluble hormones.
3. Understand the control mechanisms which are involved in the regulation of the fat soluble hormones.
4. For each hormone you must have knowledge regarding their general functions in the body and how they contribute to homeostasis.

9. THE REPRODUCTIVE SYSTEM

After the completion of this section, you should be able to:

1. Diagram the internal and external anatomy of both males and females.
2. Diagram the processes of sexual differentiation that occur during male and female embryonic development.
3. Contrast mitosis with meiosis, haploid with diploid, and autosomes with sex chromosomes.
4. Describe how the reproductive systems of males and females change with puberty and then how they change again with menopause and andropause.
5. Diagram the common hormonal control pathway that governs reproductive function in both males and females. Include the feedback pathways on this diagram.
6. Explain the pulsatile secretion of GnRH and its significance to reproductive physiology.
7. Diagram the process of spermatogenesis and explain the timeline on which this occurs.
8. Diagram the erection reflex.
9. Identify anatomical structures and the roles of hormones involved.
10. Diagram oogenesis and explain the timeline on which this occurs.
11. Diagram the menstrual cycle and its complex hormonal control patterns.
12. Diagram the process of fertilization and the process of embryo implantation in the endometrium.
13. Describe the role of the hormones secreted by the placenta during pregnancy.
14. Discuss the maternal changes during pregnancy.
15. Describe what we currently understand about the processes of labour and parturition.
16. Diagram a mammary gland and describe milk and colostrum production.
17. Diagram the let-down (milk ejection) reflex.
18. Describe methods of contraception currently available.

10. HAEMATOLOGY

After the completion of this section, you should be able to:

1. Discuss the main functions of blood.
2. Discuss the key components of plasma.
3. Explain the difference between plasma and serum.
4. Discuss the functions of plasma proteins.
5. Use a diagram to discuss haematopoiesis.
6. Explain the role of cytokines in haematopoiesis.
7. Describe the structural-functional relevance of the red blood cell, as well as the characteristics and role of the other cellular elements in blood.
8. Describe the structure of haemoglobin.
9. Explain the metabolism and role of iron in haemoglobin.
10. Discuss the life cycle of a red blood cell.
11. Explain what is meant by the term haematocrit.
12. Define anaemia.
13. Differentiate between the types of anaemias.
14. Use a flow diagram to explain the processes of haemostasis, the coagulation cascade, and fibrinolysis.
15. Explain what is meant by “transfusion of incompatible blood” and how this could be avoided.

11. THE DIGESTIVE SYSTEM

After the completion of this section, you should be able to:

1. Identify the different:
   a) basic functions of the digestive system.
   b) components of the gastro-intestinal tract.
   c) accessory organs and glands of the digestive system.
   d) types of secretions involved in food digestion, where they are released from and in response to which stimuli, what the secretions are composed of and the functions thereof.
   e) forms of motility in the digestive tract, where it occurs and the function of each, as well as the stimuli that regulate it.
   f) digestive hormones and their functions, where they are secreted from and what are the stimuli responsible for secretion.
   g) enzymes responsible for digestion of proteins, carbohydrates and fats.
   h) respective locations in the digestive system where the breakdown products of proteins, carbohydrates and fats are absorbed, and how they are absorbed.
2. Explain the importance of water and salts in the process of food digestion and absorption of its breakdown products.
3. Explain the difference between Type I and II Diabetes.

PRACTICALS

Important:

1. Practical attendance as well as practical reports will contribute 10% in total to the class mark.
2. Information regarding the practical venues and groups will be displayed on the Physiology notice board, outside the Main Lecture Hall in the Fisan building, as well as on SUNLEARN.
3. You have only one opportunity to attend a given practical.
4. Bring a pocket calculator, a ruler and note paper to each practical.
5. Questions about these practical classes may be included in the tests or exams.

PRACTICAL 1: RESPIRATORY AIR FLOW AND VOLUME

INTRODUCTION

In this laboratory, you will be introduced to spirometry as a technique for recording respiratory variables and you will analyse a recording to derive respiratory parameters. You will examine lung volumes and capacities, as well as the basic tests of pulmonary function and simulate an airway restriction.

BACKGROUND

Gas exchange between air and blood occurs in the alveolar air sacs. The efficiency of gas exchange is dependent on ventilation; cyclical breathing movements alternately inflate and deflate the alveolar air sacs (see Figure 1). Inspiration provides the alveoli with some fresh atmospheric air and expiration removes some of the stale air, which has reduced oxygen and increased carbon dioxide concentrations.

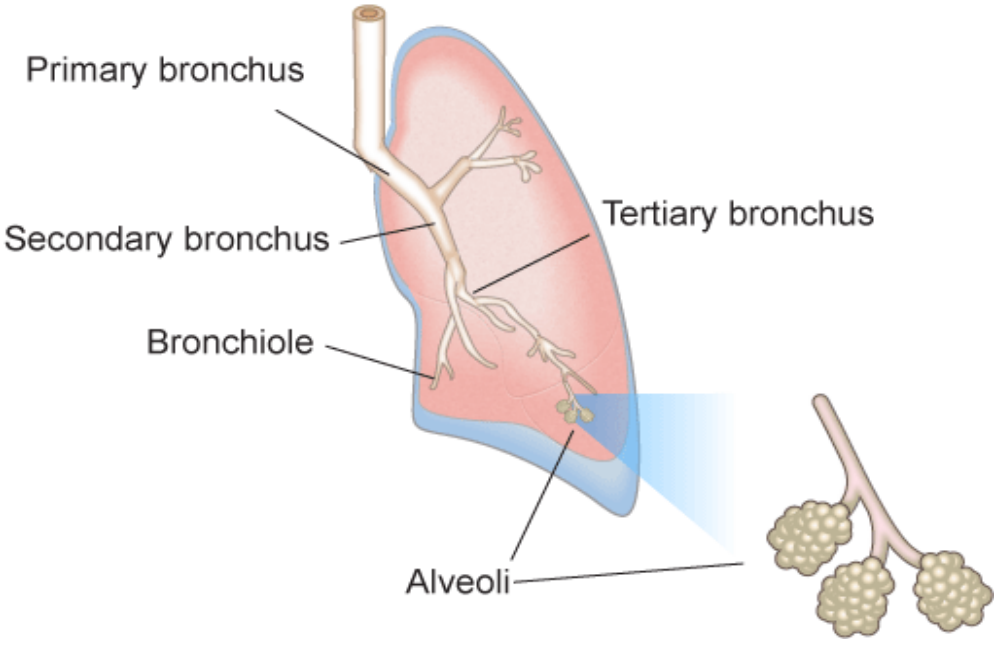


Figure 1. A schematic diagram of the human respiratory system.

Spirometry is becoming more and more important, as respiratory diseases are increasing world wide. Spirometry is the method of choice for a fast and reliable screening of patients suspected of having Chronic Obstructive Pulmonary Disease (COPD). COPD is the 12th leading cause of death worldwide and the 5th leading cause in Western countries. Studies suggest COPD could climb to be the 3rd leading killer by 2020. Most COPD cases are completely avoidable; 85-90% of cases are caused by tobacco smoking.

Many important aspects of lung function can be determined by measuring airflow and the corresponding changes in lung volume. In the past, this was commonly done by breathing into a bell spirometer, in which the level of a floating bell tank gave a measure of changes in lung volume. Flow, F, was then calculated from the slope (rate of change) of the volume, V:

$$F = \frac{dV}{dt} \qquad \textit{Equation 1}$$

More conveniently, airflow can be measured directly with a pneumotachometer (from Greek roots meaning “breath speed measuring device”). The PowerLab pneumotachometer arrangement is shown in Figure 2.

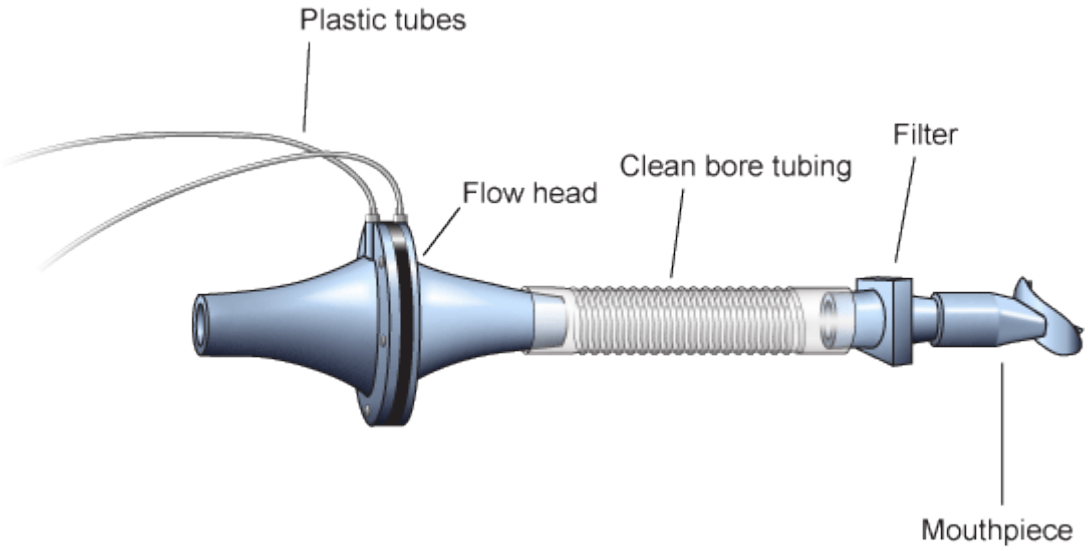


Figure 2. The PowerLab pneumotachometer.

Several types of flow measuring devices are available and each type has advantages and disadvantages. The flow head you will use today is a “Lilly” type that measures the difference in pressure either side of a mesh membrane with known resistance. This resistance gives rise to a small pressure difference proportional to flow rate. Two small plastic tubes transmit this pressure difference to the Spirometer Pod, where a transducer converts the pressure signal into a changing voltage that is recorded by the PowerLab and displayed in LabTutor. The volume, V, is then calculated as the integral of flow:

$$V = \int F \, dt \qquad \textit{Equation 2}$$

This integration represents a summation over time; the volume traces that you will see in LabTutor during the experiment are obtained by adding successive sampled values of the flow signal and scaling the sum appropriately. The integral is initialized to zero every time a recording is started.

A complication in the volume measurement is caused by the difference in air temperature between the Spirometer Pod (at ambient temperature) and the air exhaled from the lungs (at body temperature). The volume of gas expands with warming, therefore the air volume expired from the lungs will be slightly greater than that inspired. Thus a volume trace, as calculated by integration of flow, drifts in the expiratory direction. To reduce the drift, the flow has to be integrated separately during inspiration and expiration, with the inspiratory volume being corrected by a factor related to the BTPS factor (body temperature, atmospheric pressure, saturated with water vapour). The LabTutor software makes this correction.

Spirometry allows many components of pulmonary function (see Figure 3 below) to be visualized, measured and calculated. Respiration consists of repeated cycles of inspiration followed by expiration. During the respiratory cycle, a specific volume of air is drawn into and then expired from the lungs; this volume is the Tidal Volume (V_T). In normal ventilation, the breathing frequency (f) is approximately 15 respiratory cycles per minute. This value varies with the level of activity. The product of f and V_T is the Expired Minute Volume ($\dot{V}_E$), the amount of air exhaled in one minute of breathing. This parameter also changes according to the level of activity. Note that the volume of air remaining in the lungs after a full expiration, residual volume (RV), cannot be measured by spirometry as a volunteer is unable to exhale any further.

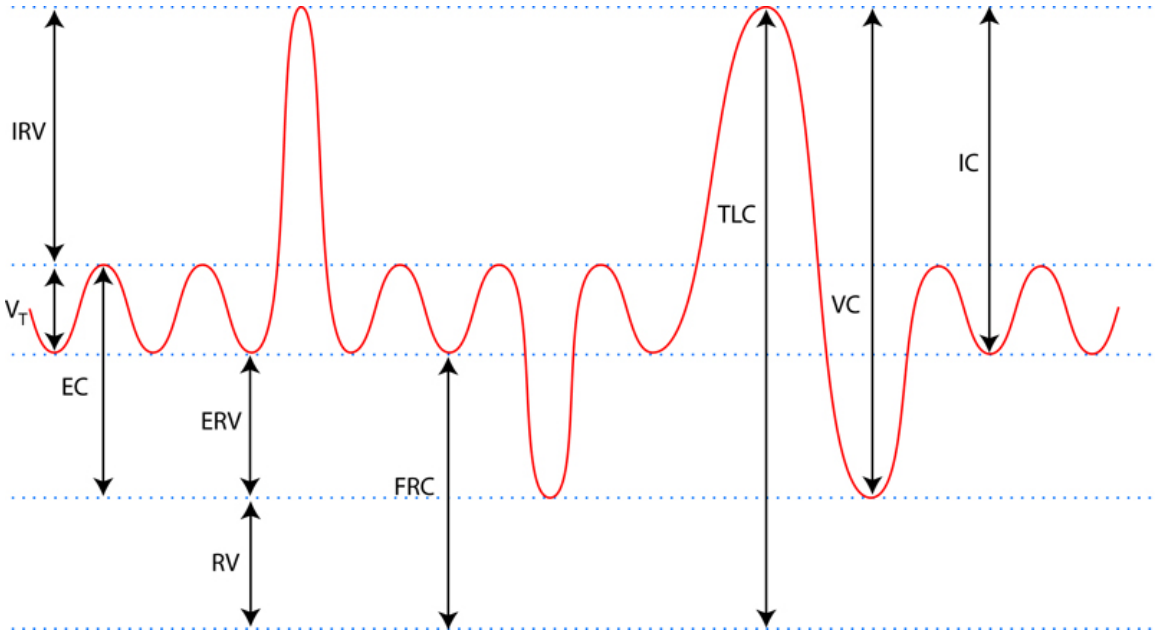


Figure 3. Lung volumes and capacities.

Terms that you should be familiar with *before* coming to class.

Term	Abbreviation / Symbol	Units
Respiratory Rate	RR	breaths / min (BPM)
Expired Minute Volume	$\dot{V}_E = RR \times V_T$	L/min
Lung Volumes		
Tidal Volume	V_T	L
Inspiratory Reserve Volume	IRV	L
Expiratory Reserve Volume	ERV	L
Residual Volume	RV (predicted)	L
Lung Capacities		
Inspiratory Capacity	IC = VT + IRV	L
Expiratory Capacity	EC = VT + ERV	L
Vital Capacity	VC = IRV + ERV + V_T	L
Functional Residual Capacity	FRC = ERV + RV	L
Total Lung Capacity	TLC = VC + RV	L
Pulmonary function tests		
Peak Inspiratory Flow	PIF	L/min
Peak Expiratory Flow	PEF	L/min
Forced Vital Capacity	FVC	L
Forced Expired Volume in one second	FEV_1	L
% FVC expired in one second	FEV_1/FVC x 100	

WHAT YOU WILL DO IN THE LABORATORY

There are five exercises that you will complete during this Lab.

1. **Becoming familiar with the equipment**. In this exercise, you will learn the principles of spirometry, and how integration of the flow signal gives a volume.

2. **Lung volumes and capacities**. Here you will examine the respiratory cycle and measure changes in flow and volume.

3. **Pulmonary function tests**. Here you will measure parameters of forced expiration that are used in evaluating pulmonary function.

4. **Simulating an airway restriction**. In this exercise, you will simulate an airway restriction.

5. **Variability amongst group members**. In this exercise, you will compare the parameters of forced expiration measured in different students.

PRACTICAL 2: THE MEASUREMENT OF BLOOD PRESSURE

WHAT TO DO BEFORE THE PRACTICAL

1. Read and note the outcomes.
2. Revise the appropriate cardiovascular physiology in your textbooks or notes.

WHAT TO BRING TO THE PRACTICAL

1. Pocket calculator

OUTCOMES

At the end of the practical you should be able to:

1. describe, and be able to use the sphygmomanometer and stethoscope;
2. use the sphygmomanometer to determine the arterial blood pressure by means of the palpatory, the "anaesthetist's", and auscultatory methods;
3. define the systolic and diastolic arterial blood pressures;
4. know what causes the Korotkov sounds, and how they relate to the systolic and diastolic blood pressures;
5. calculate the pulse pressure, and estimate the mean arterial pressure;
6. describe the effect of exercise and posture on the blood pressure;
7. know how normal values (for blood pressure in this case) are obtained.

THE INDIRECT MEASUREMENT OF THE BLOOD PRESSURE

In the direct method of measuring the arterial blood pressure, a canula is placed in an artery. This is a laborious, painful and potentially hazardous procedure. It is therefore seldom used.

The indirect method is non-invasive, safe, relative quick, and generally painless. It is therefore the method of choice for everyday use. It does however give falsely high readings if the upper arm is large (with muscle or fat), and it is sometimes difficult to get a reading for reasons that are not always obvious.

The apparatus used for the indirect method is the sphygmomanometer, which consists of three parts: a calibrated mercury manometer, a flat rubber balloon (cuff), and a hand operated air pump. The various parts are connected with rubber tubes, allowing the pump to be used to inflate the cuff, and the pressure in the cuff to be read off on the mercury manometer.

The cuff is in a material sleeve attached to a long bandage, which is used to secure the cuff to the upper arm of the patient. This must be done in such a way that the rubber cuff is over the brachial artery on the medial side of the humerus.

There are three methods of measuring the blood pressure:

a. The palpatory method

The subject sits or lies down comfortably. The sphygmomanometer cuff is secured to the upper arm, and the tubing is connected to manometer.

Feel for the radial pulse. When it has been located, pump the cuff up reasonably slowly. Note the pressure in the cuff when the radial pulse disappears. The pressure in the cuff is now obviously higher than the maximum pressure in the brachial artery (i.e. the systolic pressure), closing it off. This is likely to occur at about 120-140 mm Hg pressure in a young person at rest. Increase the pressure in the cuff by another 10-20 mm Hg. Now open the valve in the pump and very **slowly** release the pressure in the cuff, while feeling carefully for the reappearance of the radial pulse. Note the pressure at which it re-appears. This is the person's systolic arterial blood pressure. Record it to the nearest 5 mm Hg (more "precise" reportings are meaningless - the pressure in the artery varies by more than that amount during the ventilatory cycle, and the method does not allow for a more precise reading).

Do this a few times, and take the average reading (again to the nearest 5 mm Hg).

Note that only the systolic blood pressure can be measured this way.

b. **The "anaesthetist" method**

Proceed as before, noting when the radial pulse disappears on pumping the cuff up. Increase the pressure in the cuff by a further 10-20 mm Hg, and then very slowly release the pressure in the cuff.

This time, however, do not feel the pulse as the pressure falls. Watch the top of the mercury column as the pressure slowly falls. When the pressure reaches the systolic pressure in the brachial artery, the mercury column starts to bob up and down. Note the point at which this occurs. Continue to lower the pressure in the cuff, very slowly, and note where the bobbing of the mercury column stops, or suddenly becomes noticeably less. This is approximately the diastolic pressure in the artery.

It is a convenient, though not very accurate method of recording the blood pressure; but pressures recorded this way during an anaesthetic are comparable with one another. An anaesthetist is therefore conveniently able to monitor changes in a patient's blood pressure during an operation. This is also the method used to check the blood pressures of people who are about to donate blood.

c. **The auscultatory method**

Proceed as before, pumping the cuff up until the radial pulse disappears. Increase the pressure by a further 10-20 mm Hg.

This time, however, a stethoscope is needed. The tutor will advise you on the use of the stethoscope (e.g. which way round the ear pieces fit into the ears).

Place the diaphragm of the stethoscope over the elbow crease or just below it, on the medial side (over the brachial artery as it crosses the elbow joint). Now lower the pressure in the cuff, and listen for the tapping sounds (the Korotkov sounds) that occur when the systolic blood pressure is sufficient to open the artery momentarily during each beat, but slams shut again during diastole. Note the pressure in the cuff (to the nearest 5 mm Hg) when the Korotkov sounds are first heard. This is the systolic arterial pressure.

Continue to lower the pressure in the cuff. The Korotkov sounds become louder at first, and then (usually fairly suddenly) disappear when the diastolic pressure is sufficient to keep the artery open during the entire cardiac cycle (i.e. the artery is no longer being slammed shut by the pressure in the cuff at the end of each beat). Note the pressure in the cuff (to the nearest 5 mm Hg) when the Korotkov sounds disappear. This is the "diastolic" pressure (i.e. the lowest pressure in the artery, just before the next beat raises it to the "systolic", or maximum, pressure again).

Reporting the results

The blood pressure is traditionally reported in the form of a fraction (which it is not), with the systolic blood pressure as the "numerator" and the diastolic pressure as the "denominator". Thus, the blood pressure of a person whose systolic blood pressure was found to be 120 mm Hg, and whose diastolic pressure was 80 mm Hg is reported to have a blood pressure of:

$$\frac{120}{80} mmHg$$

Note that this is not a real fraction, and must not be simplified. It is merely a short hand way of reporting the blood pressure. This notation is internationally recognised.

All blood pressure values are rounded off to the nearest 5 mm Hg.

The **pulse pressure** is the difference between the systolic and diastolic pressures.

The **mean arterial pressure** (i.e. the average pressure in the artery during the cardiac cycle) can really only be measured with a canula, and some specialised equipment that damps out the pulsations that characterise the pressure in an artery. However, in a resting person, this pressure can be estimated from the systolic and diastolic pressures. It is not merely the arithmetic average between the two, because the pressure spends longer in the "diastolic" range than in the "systolic" range during each cycle. It is therefore **approximately**:

(diastolic pressure) + [(pulse pressure)/3]

TASKS

1. Record your blood pressure in your notebook using a table, similar to the one below. Collect all the values for the group (or the class, if available) at the end of the practical. These readings represent the "normal" values (average and range) for young women and/or men. (This is how "normal" values are obtained!)

2. Measure your blood pressure several times
   a. in the supine position;
   b. in the upright (standing) position;
   c. after exercise (running up and down 5 flights of stairs).

Repeat the measurement 3 times in every position and calculate the average of the diastolic and systolic values. Make use of the auscaltatory method to complete the systolic and diastolic measurement.

	Supine		**Upright**		**After exercise**	
	Systolic	*Diastolic*	*Systolic*	*Diastolic*	*Systolic*	*Diastolic*
Reading 1						
Reading 2						
Reading 3						
Average						
Pulse pressure						

3. Explain the differences in the blood pressure in the different postures.
4. Explain the change in the pulse pressure after exercise.

PRACTICAL 3: NEUROLOGICAL EXAMINATION

WHAT TO DO BEFORE COMING TO THE PRACTICAL

1. Read and note the outcomes.
2. Revise the following sections of the neurophysiology lectures:
   a. muscle stretch reflex
   b. upper and lower motor neurone lesions
   c. nystagmus

3. Find out what strength (in dioptres) spectacles/contact lenses you wear.

WHAT TO BRING TO THE PRACTICAL

1. A calculator
2. Come in colourful attire!

OUTCOMES

At the end of this practical you ought to be able to do the following:

1. describe and explain the clinical significance of the muscle stretch reflex, the foot sole reflex, and pupillary reflex;
2. determine visual acuity;
3. use the Ishihara and Snellen's charts, and understand how they works;
4. determine the visual and auditory reaction time, and be able to explain the difference between them;
5. bring about an optokinetic and otokinetic nystagmus;
6. distinguish between a conduction and a nerve deafness;
7. use the ophthalmoscope and otoscope.

REFLEXES

All variable activities in and of the body are ultimately the response to one or many stimuli. (There therefore has to be a sensor somewhere which can pick up the stimulus). Whenever a response is highly predictable and stereotyped we call such a response a "reflex". Reflexes are at one end of the spectrum of responses which can go from highly stereotyped responses (i.e. the "reflexes") to the most individualised and varied responses which are dependent on a multitude of factors such as time of day, mood, attention, social circumstances, etc etc.

Since a reflex response is, by definition, highly predictable, its presence or otherwise provides information about the nervous connections that are involved in the response. A more complex, conditional response cannot be used this way, as its presence or absence is dependent on too many variables - its absence can therefore not be ascribed simply to a break in the reflex arc, which it can in a "reflex".

a. The quadriceps muscle stretch reflex (so-called "patella reflex")

The person sits comfortably on a chair, with one leg crossed over the other. Tap the patella tendon of that leg with the "reflex hammer".

TASKS:

1. What happens when you tap the patella tendon in this way?

2. How do you explain this reaction, and why is it so stereotyped?

3. What and where are the sensors for this reflex?

4. What is the efferent pathway through which the quadriceps reacts?

b. **The pupillary reflex**

In a moderately dark room, with the eye shielded from direct light, shine a torch into one eye. Observe the reaction of both pupils.

Shine the light into the eye for only one second, and compare it to what happens when you shine it into the eye for 15 seconds.

TASKS:

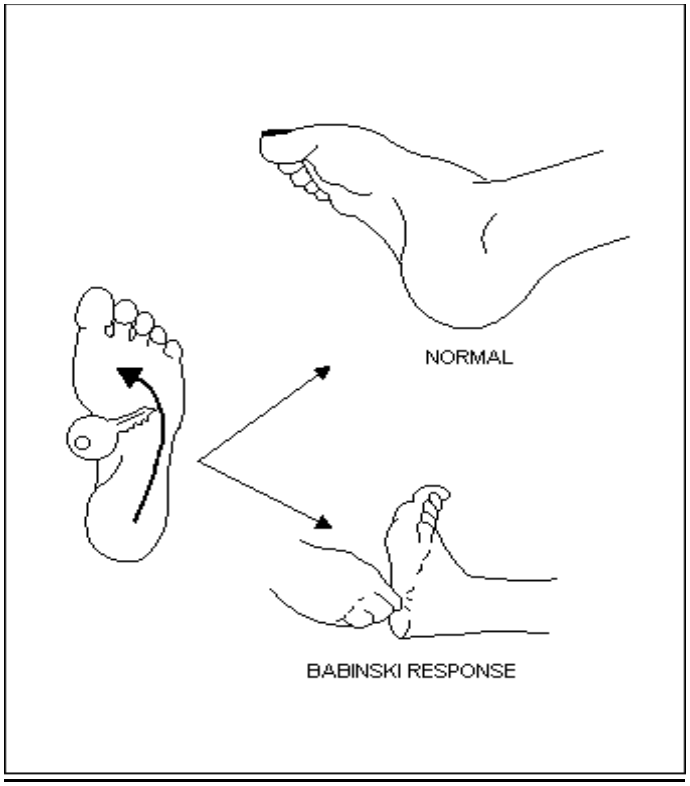
1. What happens to the eye into which the light is shone, and what happens in the other eye?

2. What and where are the sensors for this reflex?

3. What is the efferent pathway through which the pupil reacts?

c. **Foot sole reflex**

Stroke the foot sole as indicated in the sketch.



TASKS:

1. What do the toes do when you stimulate the foot sole in the manner indicated?

2. What and where are the sensors for this reflex?

3. What is the efferent pathway which causes the toes to react the way they do?

4. What is a Babinski response, and what does it signify?

d. **Optokinetic and otokinetic nystagmus**

The repeated back-and-forth movement of the eyes, moderately slowly in the one direction followed by a flick back in the opposite direction is called nystagmus. It can be caused by movement of a large part of the visual field across the retina (optokinetic nystagmus), as when watching the scenery along the railway line from a moving train; or by rotation of the head (with or without the body), as when performing a pirouette, or spinning on a rotating stool (otokinetic nystagmus). Otokinetic nystagmus is the result of stimulation of the vestibular apparatus (the sensors in the semicircular canals).

The purpose of nystagmus is to fixate the gaze on an object for as long as it remains in front of the eyes, and then flicking the eyes forwards to fix on a new part of the scenery as it moves by. In this way vision consists of a series of relatively stationary scenes, instead of a smear across the retina.
Sit the subject on a stool that can be spun. Turn the stool while the subject holds their head still in relation to the body. About 4 turns should be enough to see the effect.

Notice**:**

1. The movements of the eyes while the subject has their eyes open.
2. Look carefully at the movement of the eyes under the eyelids, when the procedure is repeated with the eyes closed.
3. Stop the stool suddenly and notice the direction of the nystagmus (with the eyes open) that this causes.

NB: Rotation causes, amongst others, nystagmus, which is accompanied by the subjective feeling of vertigo.

TASKS:

1. Where is the sensor for optokinetic nystagmus? (i.e. when the eyes are open)

2. Where is the sensor for otokinetic nystagmus? (i.e. when the eyes are closed)

3. What is the efferent pathway that causes they eye movements?

4. What causes the nystagmus when the spinning motion is suddenly stopped? Is this an optokinetic, or an otokinetic nystagmus?

HEARING TESTS

The following tests are aimed at distinguishing between conduction and nerve deafness.
Conduction deafness refers to anything that prevents a sound that reaches the external ear from reaching the sensors in the cochlea. The causes include foreign bodies or growths in the external auditory meatus (cotton wool, wax, or bony growths into the canal), scarring or fibrosis of the ear drum, arthritis of the ear ossicles, and fluid in the middle ear.
Nerve deafness refers to defects involving the sensors in the cochlea, and diseases of the VIII cranial nerve which conducts the hearing information to the brain.

<u>Rinne's test</u>

Place the handle of a vibrating tuning fork on the mastoid bone behind the ear. Wait until the person can no longer hear the sound, and then hold the vibrating arms of the tuning fork opposite the person's external auditory meatus. Ask whether the person can hear the vibrating fork again

Normally a sound is louder if it reaches the cochlea via air conduction, through the external auditory meatus, than when the sound reaches it via the vibrating skull bones. If, however, there is a conduction deafness, bone conducted sound will sound louder than air conducted sound. In nerve deafness, air conducted sound will be heard better than bone conducted sound, as in a normal person, except that the sounds have to be much louder than normal.

Weber's test

Place the foot piece of a vibrating tuning fork on the skull in the midline (e.g. in the middle of the forehead, or on top of the head). Ask on which side the sound is loudest. If it is equally loud in both ears, ask the person to put a finger in one ear (creating conduction deafness). Ask on which side the sound is now the loudest.

What will happen if there is one-sided nerve deafness?

OPHTHALMOSCOPY

If you do not wear spectacles turn the rotor on the ophthalmoscope till there is no lens in the peep hole (0 dioptres). If you wear spectacles, then take them off. While looking through the peephole, turn the rotor till you can see the room clearly again. You will then have placed a lens equivalent to your spectacles in the peep hole. If you happen to know the strength of your spectacle lenses you can turn the rotor to the right setting by looking at the values displayed above the peep hole. (If you wear contact lenses then carry on as for having normal vision.)

The test is best done in a dimly lit room, in order to get maximum dilation of the subject's pupils.

Ask the subject to stand or sit about 2 m away with their eyes at the level of your eyes. Ask them to stare into the distance over your **right shoulder**. Turn the light in the ophthalmoscope on, and look at the subject's face through the peep hole, using **your right eye**. Adjust the direction of the light so that it falls on the subject's face **with their right eye in the centre of the spot light**. You will see that if you do this the person's pupil glows red (like a cat's eye!).

Now approach **the subject's right eye**, making sure that the pupil continues to glow red. The subject keeps staring over your shoulder, and not at the light.

From a distance of about 2 cm from the subject's right eye you will see blood vessels against the reddish background of the retina. If they are not in focus turn the rotor with your index finger, while continuing to peer through the peephole, till the blood vessels have sharp edges.

Follow the blood vessels (the thin bright red arterioles, and the thicker, bluish venules) to their origin in the optic disc. If the subject is looking over your right shoulder the optic disc should be easy to find. If the subject is gazing at the light, you will be looking at the fovea of the retina, which is devoid of large, visible blood vessels.

TASK:

Try to get a good look at the "fundus of the eye" (the view of the retina obtained with an ophthalmoscope), and draw what you see.

USING THE OTOSCOPE

Ask the subject to sit or stand with their left or right ear at the level of your eye. Turn the otoscope light on, and insert the funnel of the otoscope into the auditory meatus while gently pulling the pinna upwards and backwards. Move the direction of the otoscope till you see the ear drum (tympanic membrane), which appears as an ivory coloured, semitransparent, tightly stretched membrane at the end of the meatus. Notice the attachment of the malleus to the membrane. From the end of the malleus, in the middle of the membrane, you will see a cone of reflected light going forwards and downwards across the lower, anterior quadrant of the membrane.

SNELLEN'S CHART

Snellen's chart consists of 9 rows of black letters printed on a white background. The largest letter is at the top, and the smallest letters at the bottom. The rows are labelled with numbers (60, 36, 24, 18, 12, 6, and 4). These indicate the distance in metres at which a person with average vision can just read the stated line. This means that the gap, for instance, in the letter "C", which distinguishes it from the letter "O", subtends an angle of 1 minute at the eye, which, in turn, means that the gap in the image of the letter C on the retina is greater than the width of one cone at the fovea. (You need one completely unstimulated cone in the "circle" of the C to know that there is a gap.) Snellen's test therefore determines the "two point discrimination capabilities" of the eye.

Procedure

i. Hang the chart on a well lit wall.
ii. The subject stands 6 metres from the chart.
iii. Close one eye (using a hand).
iv. Ask the subject to read the chart, starting from the large letter at the top, and note the row in which the subject makes two or more mistakes.
v. Note the label of the row above it (i.e. the last to be read correctly).
vi. Test the other eye in the same way, with and without glasses.

Reporting the results:

The visual acuity is indicated using two numbers, written in the form of a fraction (without it being a fraction!). The numerator is always the distance in metres at which the test was conducted (in your case "6"). The denominator is the label of the row just above the one in which the subject made two or more mistakes. Thus a person with average vision is reported as having 6/6 vision. If the person could only read the top row, their visual acuity is 6/60. These "fractions" are not simplified as they are merely shorthand for saying that the subject has to be as close as 6 metres to be able to read what normal people can read at 60 metres. (The Americans do the same test in "feet", so that 6/6 vision becomes 20/20 vision.) You have to have 6/12 vision, using both eyes and wearing your spectacles, to obtain a driver's licence.

RED-GREEN COLOUR BLINDNESS

Normal colour vision is trichromatic, meaning that there are 3 types of cones in the retina, each most sensitive to a different part of the spectrum: red, green and blue. In about 8% of men the red-sensitive cones are sensitive to a more orange or orangey red hue than normal in "protanomaly", or the green-sensitive cones are best stimulated by a more yellow or yellowy-green colour than normal in "deuteranomaly". Protanomaly and deuteranomaly give rise to so-called "red-green colour blindness". This is a misnomer as these people can see and distinguish red and green objects almost as easily as normal people can. Most red-green colour blind persons are, in fact, unaware that they have any abnormality at all. It is only certain tests which show them up. The primary "defect" is that they do not perceive red as being as prominent or as conspicuous a colour as normal people do. The Ishihara test exploits this "disability".

The Ishihara test

The test consists of a number of charts printed in multicoloured dots. Some of the dots (arranged in such a way that they form a number) contain a small amount of red dye, while the rest of the dots do not (or the other way round). Also hidden in the same chart are dots which together form another number but in, say, light colours, against a darkish background. Normal people immediately notice the pattern of reddish dots, whereas red-green colour blind persons notice the other number, even though they can usually correctly identify this spot as "pink", and that one as "orange" or "brown" etc.

Procedure

1. Unpack the Ishihara charts on to a well lit table, preferably in sunlight.
2. Ask the subject to read the charts from a normal reading distance.
3. Compare the subject's responses with your own, and with the information that comes with the charts.
4. Note the number of colour blind persons in the class, and their gender.
5. Using the red, green and blue filters (which allow you to see which dyes have been used where on the chart) examine the charts to reveal their secrets.
6. If you identify a red-green colour blind person in your class, test their ability to identify and distinguish different colours by presenting them with different coloured objects.

Note: The mothers and daughters of red-green colour blind men with have, interestingly, tetrachromatic colour vision: red, yellow (or yellow-green), green and blue cones in the case of deuteranomaly, and red, orange (or reddish orange), green and blue cones in the case of protanomaly. This means they can discriminate colours better than normal trichromats can!

TASKS:

1. What is the genetics of red-green colour blindness, and why are female carriers of the condition tetrachromats?

2. Can women be red-green colour blind?