Unit 13: Physiology of Fluid Balance

Unit code: F/600/8967

QCF Level 3: BTEC Nationals

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit aims to develop learners' knowledge of the microstructure of animal cells and understanding of the importance of maintaining fluid balance in the human body, the mechanisms by which this is regulated and some of the implications when these systems fail.

Unit introduction

Water is essential for maintaining life, and so the maintenance of fluid balance in the human body is of primary importance when caring for individuals. This unit will provide learners with an understanding of a number of fundamental scientific principles that will underpin further studies in health-related science, as well as an overview of physiology in relation to the homeostatic control of water.

The unit extends the basic knowledge of cells investigating the microstructure of cells and the contribution made by cell organelles to the overall functioning of cells. The movement of materials into and out of cells is then considered, followed by the distribution of fluids and the role of water and dissolved substances in the body.

Learners will then go on to examine the renal system and its role in homeostasis, particularly in relation to water balance. Finally, they will be able to apply the knowledge and understanding gained to dysfunctions in relation to water balance. The unit will be useful for those learners intending to work in the health or social care sectors, or to progress to further or higher studies. The scientific principles gained through studying this unit will support learners and link with several other science units within the programme.

Learning outcomes

On completion of this unit a learner should:

1 Know the microstructure and functions of a typical animal cell

2 Know the movement of materials into and out of cells

3 Know the distribution and constituents of fluids in the human body

4 Understand homeostatic processes in relation to water balance.

Unit content

1 Know the microstructure and functions of a typical animal cell

Cell structure: as visible under light and electron microscope; nuclear and cell membranes (as a phospholipid bilayer), nucleus, nucleolus, chromosomes, DNA; m-RNA, t-RNA, endoplasmic reticulum (rough, smooth), ribosomes, Golgi body, mitochondria, other microstructures, eg lysosomes, centrioles, cilia

Functions: nuclear and cell membranes, nucleus, chromosomes, endoplasmic reticulum (rough, smooth), ribosomes, Golgi body, mitochondria, others, eg cilia

2 Know the movement of materials into and out of cells

States of matter: solid, liquid, gas

Materials: particulate, ionic, in solution, relevant colloidal forms, eg protein sols, emulsions

Movement of materials: diffusion, facilitated diffusion, osmosis, active transport, endocytosis, exocytosis; factors affecting movement

Influences on movement of materials: size, distance, temperature, concentration gradient, osmotic potential, electrochemical gradient, permeability of cell membrane, channel proteins, carrier molecules

3 Know the distribution and constituents of fluids in the human body

Constituents of body fluids: water; solutes, eg glucose, urea; electrolytes – acids, bases, salts

Role of electrolytes: essential minerals, in control of osmosis/osmotic pressure, maintenance of acid-base balance

Acid-base balance: pH; importance of maintaining hydrogen ion concentration in body fluids; buffer systems, eg carbonic acid, phosphate, protein

Role of water: constituent of body fluids; in relation to properties, eg specific heat capacity, as a solvent

Distribution of water: intracellular, extracellular, eg plasma, lymph, intercellular; role of intercellular fluid in homeostasis

4 Understand homeostatic processes in relation to water balance

Water intake: ingested liquids and foods; from metabolic processes, eg respiration; effect of water gain on cells

Water output/loss: through skin, lungs, gastrointestinal tract, kidneys; effect of water loss on cells

Renal system: gross anatomy; associated blood supply; physiological overview: urine production, composition and storage, micturition

Kidneys: gross anatomy; structure and function of nephrons/kidney tubules; ultrafiltration, and selective reabsorption, counter-current mechanism, principles of osmoregulation and role of hypothalamus/ relevant hormones, eg anti-diuretic hormone

Dysfunctions in relation to water balance: oedema, kidney failure; renal dialysis, transplantation

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the microstructure of a typical animal cell and the functions of the main cell components [SM2; SM3; SM5]		
P2 describe the ways in which materials move in and out of cells [SM2; SM3; SM5]	**M1** explain factors that influence the movement of materials in and out of cells	**D1** analyse the role of the phospholipid bilayer in terms of the movement of materials in and out of cells
P3 describe the distribution and constituents of body fluids [IE4; IE6; SM2; SM3; SM5]	**M2** explain functions of the constituents of body fluids	
P4 explain the role of the kidney in the homeostatic control of water balance [SM2; SM3; SM5]		
P5 explain dysfunction in relation to water balance and its possible treatments. [IE4; SM2; SM3; SM5]	**M3** discuss dysfunction in relation to water balance and its possible treatments.	**D2** analyse the impact on the human body of the dysfunction in relation to water balance.

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills which are embedded in the assessment of this unit. By achieving the criteria, learners will have demonstrated effective application of the referenced elements of the skills.

Key	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

This unit needs to be delivered by tutors with a clear understanding of scientific knowledge and principles. Access to laboratory facilities would be useful but is not essential.

The unit could be introduced by reviewing the microstructure of a typical animal cell, based on knowledge and understanding initially gained in *Unit 5: Fundamentals of Anatomy and Physiology for Health and Social Care* and previous study of science at Key Stage 4.

This should then be extended, with learners needing to understand cell microstructure in more detail, and the functions of the organelles, including their contribution to the overall functioning of the cell. The significance of the phospholipid bilayer in the structure of cell membranes needs to be understood. Delivery could include the use of electron micrographs, and possibly consideration of the contribution of different types of microscopy to current knowledge and understanding of cells if time allows.

Consideration of the structure of cell membranes can lead on to discussion of the means by which materials enter and leave cells, and the factors affecting this movement. It would be beneficial to carry out some practical experiments here so learners can observe diffusion and osmosis and gain an understanding of the significance of solute concentration and osmotic potential.

This could be extended to discuss the importance of water in the human body, the functions of water in relation to the structure of the water molecule, and in particular its role as a solvent. This could lead on to considering the importance of aqueous solutions as media for metabolic reactions, and then to the composition of body fluids.

The role of substances in solution needs to be discussed, including the role of electrolytes. Learners need to understand the importance of electrolytes, including in the maintenance of the acid-base balance. A number of scientific concepts can be embedded, including pH and the role of buffers, as indicated in the unit contents.

Supporting practical activities could include, for example, investigating the solubility of materials such as glucose or salt, measurement of pH, and investigating the characteristics of acids and bases and the role of buffers.

The distribution of water within the body can be introduced at this stage, in terms of intracellular and extracellular fluids. Discussion of the composition of, and relationship between, blood, tissue fluid and lymph could be useful. Learners need to understand the role of intercellular fluid as the environment of cells, and its importance in homeostasis. Differences in the constituents of the different body fluids can be discussed, as can the various means by which the human body takes up and loses water.

The importance of water balance in the body, and the means by which this is achieved should be discussed. Charts and models could be used to illustrate the gross anatomy of the renal system, including the kidneys. Dissection of a kidney would also be a useful vehicle for learning. The structure and functioning of the kidney tubules, and their role in water maintenance, require tutor input.

Relevant practical activities could include chemical tests to investigate the composition of synthetic urine. Learners could discuss, for example, the effect of sweating on a hot day in relation to the volume of urine produced.

This would link different aspects of homeostasis and enable learners to examine the adjustments individuals make to their fluid intake according to factors such as environmental temperature and exercise.

Learners should be encouraged to relate their learning to health or social care settings. For example, observations in placements of how the fluid balance of patients/service users is managed could enhance learning. The use of intravenous drips for rehydration could also be explained.

Knowledge and understanding of the homeostatic control of water in the human body should then be applied to consideration of dysfunctions in relation to water balance.

Case studies would be useful, or small group-work where learners gather articles from the media/health and social care literature on relevant topics such as dehydration, renal failure, or transplantation. Context setting could also be related specifically to groups who are particularly vulnerable to dehydration, for example infants and young children, older people or those with food poisoning symptoms, especially in situations where water and sewage treatment is limited.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Unit introduction.
Learning outcome 1 This learning outcome is essentially a review of work covered in *Unit 5: Fundamentals of Anatomy and Physiology for Health and Social Care* and could be cross-referenced as long as the unit content is covered. Learners could each research a different organelle and present their findings to the rest of the group. They could produce a quiz including both micrographs and written questions to test each other's knowledge.
Assignment 1: Cell microstructure and function (P1)
Learning outcome 2 Tutor input: different methods of transport in and out of cells
Practical experiments: to demonstrate osmosis (various methods are available and one common method is to weigh Visking tubing sausages with solutions of glucose immersed in different solutions of varying concentration of glucose). A more advanced experiment involves the sausage containing a mixture of starch and glucose and testing the external fluid at intervals for presence of glucose or absence of starch to demonstrate the partial permeability of membranes.
Assignment 2: Movement in and out of cells (P2, M1, D1)
Learning outcome 3 Buzz group: all the different locations of body fluids using Post-it notes on a large outline of a human body. Group discussion: function of these locations followed by research into the constituents of the fluids. Comparisons of the similarities and differences of the fluids would extend more-able learners.
Assignment 3: Body fluids (P3, M2)
Learning outcome 4 Tutor input/demonstration: the gross morphology of the renal system could be covered using diagrams which learners label and annotate. Dissection of a pig or lamb kidney and/or the use of models is useful. Tutor input: explanation of the stages of urine formation and its regulation. Learner activity: carry out simple surveys on how much water their peers drink. They might be able to extend this to their placement although this would have to be carried out sensitively. Learner research: different dysfunctions related to water balance, then present their findings to the rest of the group. A dialysis nurse may be available to deliver a session to add relevance to the topic.
Assignment 4: Homeostasis and the renal system (P4, P5, M3, D2)
Unit review and assessment

Assessment

Four assignments could be used as the basis of evidence for this unit.

The first, based on cell microstructure and physiology, could be used as a vehicle for the evidence required for P1. A well-annotated diagram, supported by written work, should be sufficient for this purpose. Care should be taken to ensure the authenticity of learner work, in particular in relation to images and descriptive work downloaded from the internet or taken from textbooks

A second assignment could then be used to assess P2, M1 and D1, in relation to the movement of materials into and out of cells. For P2, learners are required to describe the ways in which materials move into and out of cells, extending this for M2 to include an explanation of factors that influence this. For D1, the role of the phospholipid bilayer needs to be analysed in terms of the movement of materials across cell membranes. For example, learners need to consider the overall membrane structure in terms of the phospholipid bilayer, the need for protein receptor sites and how, for example, hormone molecules may alter cell membrane permeability through interference with these active sites, thus altering the uptake of selected materials. Evidence could a report of practical work associated with cell movement.

A third assignment could be used as the basis for P3 and M2. For P3, learners could use annotated diagrams, supported by a piece of writing, to describe the distribution and constituents of fluids in the body. For M2, this needs to be extended to include an explanation of the functions of the constituents, water and solutes.

Finally, a fourth assignment could be based on the functioning of the renal system, covering P4, P5, M3 and D2. A combination of annotated diagrams and explanatory work could be produced as suitable evidence, with case studies providing appropriate opportunities for learners to demonstrate evidence of understanding associated dysfunctions.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1	Cell microstructure and function	You are a trainee science teacher preparing a lesson on cell structure and function. You need to produce annotated diagrams which describe the function of these structures.	Annotated diagrams
P2, M1, D1	Movement in and out of cells	You are a science technician within a university hospital assisting with an investigation. You need to carry out and write up an experiment to demonstrate one method by which materials can move in and out of cells.	Report and practical write up
P3, M2	Body fluids	A doctor in the hospital has asked you to describe to a patient how body fluids are distributed around the body and to explain their functions	Annotated diagrams and explanatory notes

Criteria covered	Assignment title	Scenario	Assessment method
P4, P5, M3, D2.	Homeostasis and the renal system	You are now supporting the doctor in treating the patient who, it seems, has been experiencing a problem with water balance.	Annotated diagrams, explanatory notes and report based on a discussion and analysis of a case study.

Links to National Occupational Standards (NOS), other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Health and Social Care sector suite (see *Appendix A*) and has links with units from other qualifications in that suite. See *Appendix E* for NOS links and *Appendix G* for a mapping of the NHS Knowledge and Skills Framework against particular units in this qualification.

Essential resources

The following resources are essential for delivery of this unit:

- an appropriately qualified tutor
- library resources with key texts and other reference materials
- equipment for the practical tasks.

In addition, the following resources are considered to be highly valuable:

- models of human torso, individual organs such as the kidneys and systems such as the renal system
- electron micrographs of cell structure
- videos/DVDs.

Employer engagement and vocational contexts

It would be beneficial to arrange guest speakers from, or work placements with, settings such as hospitals, care homes or nursing homes.

Indicative reading for learners

Textbooks

Adds J, Larkcom E and Miller R – *Molecules and Cells* (Nelson Thornes, 2003) ISBN 9780748774845

Ashurst S, Coe J and Lyne P – *HAL Physiology* (Churchill Livingstone, 1995) ISBN 9780443052743

Boys D, Langridge E and Michie V – *BTEC National Health and Social Care Book 2* (Nelson Thornes, 2007) ISBN 9780748781720

Clancy J and McVicar A – *Physiology and Anatomy: A Homeostatic Approach* (Hodder Arnold, 2002) ISBN 9780340762394

Clegg CJ and Mackean DG – *Advanced Biology Principles and Applications* (John Murray, 2000) ISBN 9780719576706

Green N P O, Stout G W and Taylor D J – *Biological Science 2 systems, Maintenance and Change* (Cambridge University Press, 1997) ISBN 9780521567206

Kent M – *Advanced Biology* (Advanced Science) (Oxford University Press, 2000) ISBN 9780199141951

Myers B – *The Natural Sciences* (Nelson Thornes, 2004) ISBN 9780748785834

Shaw L – *Anatomy and Physiology* (Nelson Thornes, 2004) ISBN 9780748785841

Stretch B and Whitehouse M – *BTEC National Health and Social Care Book 2* (Heinemann, 2007) ISBN 9780435499167

Stretch B and Whitehouse M – *BTEC Level 3 Nationals in Health and Social Care Student Book 1* (Pearson, 2010) ISBN 9781846907663

Stretch B and Whitehouse M – *BTEC Level 3 Nationals in Health and Social Care Student Book 2* (Pearson, 2010) ISBN 9781846907470

Toole A and S – *Understanding Biology for Advanced Level* (Nelson Thornes, 1999) ISBN 9780748739578

Ward J, Clarke R W and Linden R – *Physiology at a Glance* (Blackwell Publishing, 2005) ISBN 9781405113281

Journals and magazines

Biological Science

New Scientist

Nursing Times

Website

www.bbc.co.uk/science/humanbody	BBC resource on human mind and body

Delivery of personal, learning and thinking skills

The following table identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are ...
Independent enquirers	[IE4] analysing and evaluating information to enable them to annotate diagrams and researching renal dysfunction [IE6] supporting conclusions based on evidence
Self-managers	[SM2] carrying out their assignments showing perseverance and commitment [SM3] producing written work by organising time and prioritising [SM5] producing written work whilst dealing with competing pressures of work and personal issues.

Functional Skills – Level 2

Skill	When learners are ...
ICT – Use ICT systems	
Select, interact with and use ICT systems independently for a complex task to meet a variety of needs	using ICT systems to research and produce assignments
ICT – Find and select information	
Select and use a variety of sources of information independently for a complex task	researching for their assessments they will select information from a variety of sources
Access, search for, select and use ICT-based information and evaluate its fitness for purpose	researching for their assessments they will need to be able to use search engines and assess the relevance of the information they retrieve
ICT – Develop, present and communicate information	
Bring together information to suit content and purpose	producing annotated diagrams they will need to be able to bring together and organise components of images and text
Present information in ways that are fit for purpose and audience	producing written work proofreading to ensure accuracy producing a practical report using an accepted convention.
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching in this area will provide opportunities to gather information from a variety of sources
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	communicating ideas in a concise, clear and logical manner using an appropriate style of writing when producing their practical reports presenting work with accurate spelling, punctuation and grammar.