SNAB Topic 7 Run for your life

This teaching scheme is divided into three parts.

- Introduction.
- Road map: a suggested route through Topic 7.
- Guidance notes for teachers and lecturers. These include a commentary that runs parallel with the student book with hints and tips on teaching and references to the associated activities.

Note: There are more detailed notes about individual activities in the teacher/lecturer sheets that accompany most of the activities

Introduction

The Road map starting on page 2 is a suggested route through Topic 7.

The learning outcomes are numbered as in the specification.

Splitting the final topic (Topic 8) is difficult therefore if two teachers/lecturers are sharing a class it might be better for one teacher to cover Topic 7 and the other to cover Topic 8. If the two topics cannot be taught in parallel then Topic 7 can be split, the first teacher starts at the beginning and completing sessions 1 to 4, followed by 18 to 23. The second teacher starts at session 5 and works through to session 17.

It is assumed that each session is approximately an hour in length. There are more activities than can be done in the time available in most centres, so select a balanced collection according to your and your students' interests, and the time and resources available. Some activities are labelled 'Core'. Core activities contain experimental techniques included in the specification, and may appear in questions on the unit exam for this topic. These learning outcomes are in **bold** in the specification, and in the Road map grid below. They are underlined in the Guidance notes below. In the Road map grid, activities are in *italics* if there is an additional activity covering the same material more directly. Choose which activities students complete, and substitute your own activities as appropriate.

There are various activities – particularly the interactive tutorials associated with some of the activities – which could be completed by students outside of class time. These activities are shown in the lower half of each 'Possible activities' box.

There is an A2 summary chart at the end of the guidance notes. This shows where concepts are introduced and revisited in later topics.

SNAB Road map: a route through Topic 7 'Run for your life'

Session	Learning outcomes to be covered	Possible activities
1	Introduction to topic	
		Interactive introduction
2	Joints and movement 4 Recall the way in which muscles, tendons, the skeleton and ligaments interact to enable movement, including antagonistic muscle pairs, extensors and flexors.	Card test to confirm KS4 terminology Activity 7.1 Antagonistic muscles and movement (A7.01L) (Interactive tutorial and practical – dissection)
3	Muscle structure and function 3 Explain the contraction of skeletal muscle in terms of the sliding filament theory, including the role of actin, myosin, troponin, tropomyosin, calcium ions (Ca^{2+}), ATP and ATPase.	
		Activity 7.2 Muscle structure and function (A7.02L) (Interactive tutorial)
4	Muscle structure and function 3 Explain the contraction of skeletal muscle in terms of the sliding filament theory, including the role of actin, myosin, troponin, tropomyosin, calcium ions (Ca^{2+}), ATP and ATPase.	Activity 7.3 Muscle model (Optional) (A7.03L) (Practical)
		Checkpoint question 7.1
5/6	ATP and glycolysis 5 Describe the overall reaction of aerobic respiration as splitting of the respiratory substrate (eg glucose) to release carbon dioxide as a waste product and reuniting of hydrogen with atmospheric oxygen with the release of a large amount of energy. 7 Recall how phosphorylation of ADP requires energy and how hydrolysis of ATP provides an accessible supply of energy for biological processes. 8 Describe the roles of glycolysis in aerobic and anaerobic respiration, including the phosphorylation of hexoses, the production of ATP, reduced coenzyme and pyruvate acid (details of intermediate stages and compounds are not required).	Activity 7.4 Aerobic respiration (A7.04L) (Interactive video clip)

Session	Learning outcomes to be covered	Possible activities
	9 Describe the role of the Krebs cycle in the complete oxidation of glucose and formation of carbon dioxide (CO_2), ATP, reduced NAD and reduced FAD (names of other compounds are not required) and that respiration is a many-stepped process with each step controlled and catalysed by a specific intracellular enzyme.	
7/8	Electron transport chain and chemiosmosis 10 Describe the synthesis of ATP by oxidative phosphorylation associated with the electron transport chain in mitochondria, including the role of chemiosmosis and ATPase.	Activity 7.5 Mitochondrial diseases (A7.05L) (Interactive tutorial)
		Activity 7.6 Respiration and other metabolic pathways (A7.06L)
9	Measuring respiration **6 Describe how to investigate rate of respiration practically.**	**Activity 7.7 Measuring the rate of oxygen uptake (Core) (A7.07L) (Practical)**
10	Anaerobic respiration 11 Explain the fate of lactate after a period of anaerobic respiration in animals.	Activity 7.8 Anaerobic respiration (A7.08L)
		Checkpoint question 7.2
11	Aerobic capacity 13 Explain how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre.	Activity 7.9 Aerobic capacity (A7.09L) (Practical)
12	Cardiac output 13 Explain how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre.	Activity 7.10 Effect of exercise on cardiac output (A7.10L)

Session	Learning outcomes to be covered	Possible activities
13	Control of a single heart beat 12 Understand that cardiac muscle is myogenic and describe the normal electrical activity of the heart, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN) and the bundle of His, and how the use of electrocardiograms (ECGs) can aid the diagnosis of cardiovascular disease (CVD) and other heart conditions.	Activity 7.11 Conductive pathway of the heart (A7.11L) Activity 7.12 What does an ECG show? (A7.12L)
14	Control of heart rate 12 Understand that cardiac muscle is myogenic and describe the normal electrical activity of the heart, including the roles of the sinoatrial node (SAN), the atrioventricular node (AVN) and the bundle of His, and how the use of electrocardiograms (ECGs) can aid the diagnosis of cardiovascular disease (CVD) and other heart conditions.	
15	Measuring lung volumes and breathing rate **14 Describe how to investigate the effects of exercise on tidal volume and breathing rate using data from spirometer traces.**	**Activity 7.13 Investigating breathing (Core) (A7.13L) (Interactive tutorial, Practical)**
16	Control of breathing rate 13 Explain how variations in ventilation and cardiac output enable rapid delivery of oxygen to tissues and the removal of carbon dioxide from them, including how the heart rate and ventilation rate are controlled and the roles of the cardiovascular control centre and the ventilation centre.	Activity 7.14 Locust practical (A7.14L) (Practical) Checkpoint question 7.3
17	Adaptation 2 Describe the structure of a muscle fibre and explain the structural and physiological differences between fast and slow twitch muscle fibres.	Activity 7.15 Fish muscles (A7.15L) (Practical) Checkpoint question 7.4

Session	Learning outcomes to be covered	Possible activities
18	Temperature regulation 15 Explain the principle of negative feedback in maintaining systems within narrow limits. 16 Discuss the concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium during exercise, including the role of the hypothalamus and the mechanisms of thermoregulation.	Activity 7.16 Body temperature (A7.16L) (Practical)
19	Homeostasis 16 Discuss the concept of homeostasis and its importance in maintaining the body in a state of dynamic equilibrium during exercise, including the role of the hypothalamus and the mechanisms of thermoregulation.	Activity 7.17 Homeostasis (A7.17L)
20	Disadvantages of exercising too much 18 Analyse and interpret data on possible disadvantages of exercising too much (wear and tear on joints, suppression of the immune system) and exercising too little (increased risk of obesity, coronary heart disease (CHD) and diabetes), recognising correlation and causal relationships.	Activity 7.13 Immune system review (A7.13L)
21	Disadvantages of exercising too much or too little 18 Analyse and interpret data on possible disadvantages of exercising too much (wear and tear on joints, suppression of the immune system) and exercising too little (increased risk of obesity, coronary heart disease (CHD) and diabetes), recognising correlation and causal relationships. 19 Explain how medical technology, including the use of keyhole surgery and prostheses, is enabling those with injuries and disabilities to participate in sports, eg cruciate ligaments repair using keyhole surgery and knee joint replacement using prosthetics.	Activity 7.20 Bone damage and repair (A7.20L) (Interactive video clips) Activity 7.19 Too much or too little (A7.19L) Checkpoint question 7.5

Session	Learning outcomes to be covered	Possible activities
22	Performance-enhancing substances 17 Explain how genes can be switched on and off by DNA transcription factors including hormones.	Activity 7.21 Transcription factors (A7.21L)
		Activity 7.22 Testosterone (A7.22L) Checkpoint question 7.6
23	Performance-enhancing substances 20 Outline two ethical positions relating to whether the use of performance-enhancing substances by athletes is acceptable.	Activity 7.23 What's wrong with doping? (A7.23L)
24	End of topic test	

Guidance notes for teachers and lecturers

There are no GCSE style reviews and tests at the start of the A2 topics.

Introduction

The introduction to Topic 7 makes a comparison between the fast-moving cheetah and the slower but long-distance travels of the wildebeest, with each dependent on movement for their survival. This is complemented by a comparison between human sprinters and long-distance athletes. The context of this topic is running; speed of movement. It looks at how bodies achieve movement and explores the link between structure, physiology and performance. The topic also examines how animals cope with the consequences of energy release during activity and considers some of the effects for humans of too much exercise and the use of performance-enhancing substances. All these ideas are touched on in the interactive introduction.

7.1 Getting moving

This first section of the textbook is largely recall of material that should have been covered at KS4. A starter activity to check students' recall of the GCSE terminology could be used to help determine how much further work on this area is required. Students could each be given a set of eight cards showing the words: Flex, Extend, Antagonist, Antagonistic, Ligament, Tendon, Synovial and Cartilage. These cards can then be displayed by individual students in response to the questions below, thus determining whether they have a good grasp of the ways in which muscles, tendons, the skeleton and ligaments interact to enable movement to occur. There may be more than one correct answer for some questions and some answers are used more than once. Students may not be familiar with the term 'synovial'.

1. When you contract your biceps muscle what happens to your arm? [Flex]
2. It holds bones together. [Ligament]
3. When you contract your triceps what happens to your elbow joint? [Extend]
4. It attaches muscle to bone. [Tendon]
5. A moveable joint. [Synovial]

6. Prevents wear and tear in the joint. [Cartilage or synovial fluid]
7. When you straighten your leg what happens to your knee joint? [Extend]
8. Must be passively stretched to allow movement. [Antagonist]
9. Can be damaged with overuse of a joint. [Cartilage, tendon or ligament]
10. Complete this sentence: 'When you bend your arm your biceps muscle is contracting and your triceps is relaxing. The muscles are …' [Antagonistic]

The first activity and the textbook could be used in preparation for this card exercise. The textbook is written so that it reminds students of the terminology and uses questions to make them engage with the text and diagrams.

Activity 7.1 Antagonistic muscles and movement (A7.01L)
This activity uses an interactive movie to explore the action of the knee joint. Students complete a written description and label a diagram of a synovial joint. The second part of the activity provides a detailed procedure for dissecting a pig's trotter; bones, tendons, ligaments and cartilage can be identified, and exposing the tendons allows the knuckle joint to be extended.

The textbook then goes on to consider how muscles work in more detail, covering the structure and function of a muscle fibre. The arrangement of protein filaments within the sarcomere and the sliding filament theory are described. Note that the specification identifies the terms required. Students can become confused when using muscle-specific terms for cell structures, e.g. sarcolemma and sarcoplasm, rather than those learned previously. To avoid such confusion when introducing a raft of new terms a quick quiz-style activity may help. Using a large drawing of a muscle cell with numbered labels, give the muscle cell terms. Then get the students, without looking at the textbook, to match terms and labels. Mitochondria should be included so students do not come away with the impression that muscle cells do not have all the standard organelles.

Activity 7.2 Muscle structure and function (A7.02L)
The student sheet that accompanies this activity can be completed using the interactive tutorial or the description in the textbook. The interactive tutorial could be completed out of class time.

After completing Activity 7.2, Activity 7.3 could be used to confirm that students can explain the sliding filament theory. Checkpoint question 7.1 is also related to muscle contraction and the sliding filament theory.

Activity 7.3 Muscle model (A7.03L) Optional
Students use a range of materials such as straws and Plasticine® to make a model of a sarcomere; this is then used by students to describe the contraction of the sarcomere to their peer group. There is a student sheet but clear oral instructions should be sufficient for this activity.

There are some video sequences available online that show contraction of muscle, for example within the University of Edinburgh Computer-aided learning in Veterinary Education Muscle contraction tutorial. The website is available in the weblinks that accompany Activity 7.2.

Extension 7.1 describes how muscle contraction is prevented by toxins including the botulinum toxin A, used in the wrinkle-control treatment known as Botox.

In many textbooks the differences between fast and slow twitch muscle fibres would be discussed at this point. In SNAB these appear later, after the section on respiration, so that the student has a better understanding of anaerobic and aerobic respiration when they are relating the fibre types to function.

7.2 Energy for action

The second section of the textbook looks in detail at the supply of energy for the contraction of muscles. The section opens by linking back to the ideas about basal metabolic rate that appeared in Topic 1. The role of ATP as the immediate supply of energy for biological processes was introduced in Topic 5 and is revisited here. The section starts with an overview; this is followed by a more detailed consideration of the reactions. The underlying principle of hydrogen stored in glucose being brought together with oxygen to form water which was introduced in Topic 5 is revisited.

In the textbook the fate of pyruvate in the presence and then the absence of oxygen is covered after glycolysis. The few intermediates whose names students need to learn are listed in the specification. The emphasis is on the processes that occur.

Activity 7.4 Aerobic respiration (A7.04L)

This activity provides a set of summary questions through which students annotate some simple diagrams for glycolysis and the Krebs cycle. This style of diagram could be used in a round-the-room test when the study of respiration has been completed. Students in small groups could each be given the diagram; this would be passed around the group and each person has to add one label to the diagram. Alternatively, the exercise could start with a plain piece of paper and the whole summary diagram could be built up by the group. A video clip of the reaction between hydrogen and oxygen is provided with this activity.

Extension 7.2 explores in detail the discovery of the Krebs cycle.

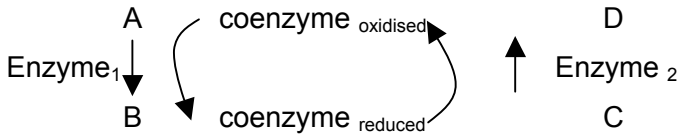
Students have already met many of the chemical ideas that appear here in respiration when they covered photosynthesis, so rather than addressing respiration as a series of pathways to be learnt the link can be made back to the ideas of photosynthesis. If a summary diagram, see below, is given out, then the similarities between the two processes could be identified by students. This might be done as an introduction or as a summary, having gone over the whole process in more detail.

The following chemical ideas are covered in respiration:

1. Energy is given out in a chemical reaction when the energy released as products are formed is more than the energy needed to break the bonds in the reactants. Other chemical reactions require energy because the energy needed to break the bonds in the reactants is greater than the energy given out when the products form.
2. Sometimes there needs to be an input of energy to start a reaction, even if the overall reaction gives out energy.
3. Biochemical pathways consist of a series of small, stepped reactions, often controlled by an enzyme at each stage.
4. Redox reactions involve the transfer of electrons.
5. Electrons can be passed along electron carrier molecules embedded in a membrane, forming an electron transport chain. The electrons reduce the carriers; then the same carriers are oxidised as the electrons pass to the next carrier in the chain. Electrons lose energy as they pass along an electron transport chain. ATP can be synthesised using energy released from electrons as they pass along the chain.

6. ATP is made when a phosphate group is added to ADP. Adding phosphate requires energy; removal of phosphate from ATP releases energy that can be transferred to energy-requiring processes in the cell.

7. In enzyme-controlled reactions any associated coenzymes alternate between two forms. In enzyme-controlled redox reactions involving coenzymes, the coenzymes are oxidised or reduced; they transfer hydrogen and electrons between two enzyme-controlled reactions.



8. In respiration and photosynthesis, the reactants do not come into contact with each other. Electron transfer takes place via coenzymes and the electron transport chain.
9. The supply of coenzyme available to take part in redox reactions would run out if the reactions adding or removing electrons stopped, because the coenzymes are recycled.
10. The electron transport chain allows energy from the electrons to be released in small steps. This allows great control of energy transfer.

These numbered chemical ideas can be put on to Figure 1 as shown in Figure 2 (the diagrams are on the following two pages).

The textbook discusses the electron transport chain and the synthesis of ATP by chemiosmosis. The interactive tutorial that accompanies Activity 7.5 guides students through both these processes.

The number of ATP produced in respiration is often stated to be 38, the text book highlights that this is an over simplification of the situation.

Activity 7.5 Mitochondrial diseases (A7.05L)
The student sheet with this activity uses mitochondrial diseases as a context to explore electron transfer and chemiosmosis. The animation in the interactive tutorial shows ATP synthesis on the inner membranes of mitochondria.

Activity 7.6 Respiration and other metabolic pathways (A7.06L)
This aim of this activity is to reinforce the understanding of the reactions of respiration. Students locate the respiration reactions on the interactive metabolic pathways chart downloaded from the Internet, this highlights how these reactions are only a part of the metabolic pathways in the cell. This could be used as a revision exercise.

Activity 7.7 Measuring the rate of oxygen uptake (A7.07L) Core practical
The investigation of rate of respiration is specified in the learning outcomes, the activity sheet provides a detailed procedure for the use of respirometers with invertebrates or seeds; germinating peas work well.

Biological Sciences Review for February 2003 contains a very good article on respiration – 'Fats burn in the flame of carbohydrates' Mike Grant, Volume 15, number 3, pages 37–41.

The textbook finishes this section with anaerobic respiration. It links back to the sporting aspect of the context with oxygen debt and the use of the different energy systems in supplying energy during exercise. Oxygen debt is not a learning outcome itself but provides a link to the need for transport of oxygen to the muscles to enable prolonged periods of strenuous but sub-maximal activity. This can be linked back to the wildebeest migration. The use of creatine phosphate for regeneration of ATP during bursts of explosive activity is

described. This can be linked back to when considering the different types of muscle fibres. Creatine use as a performance-enhancing substance is covered later in the topic.

Activity 7.8 Anaerobic respiration (A7.08L)
This activity provides a worksheet that gives a summary of the basic reactions in glycolysis and asks some questions that focus on the processes occurring.

In Checkpoint question 7.2 students compare aerobic and anaerobic respiration.

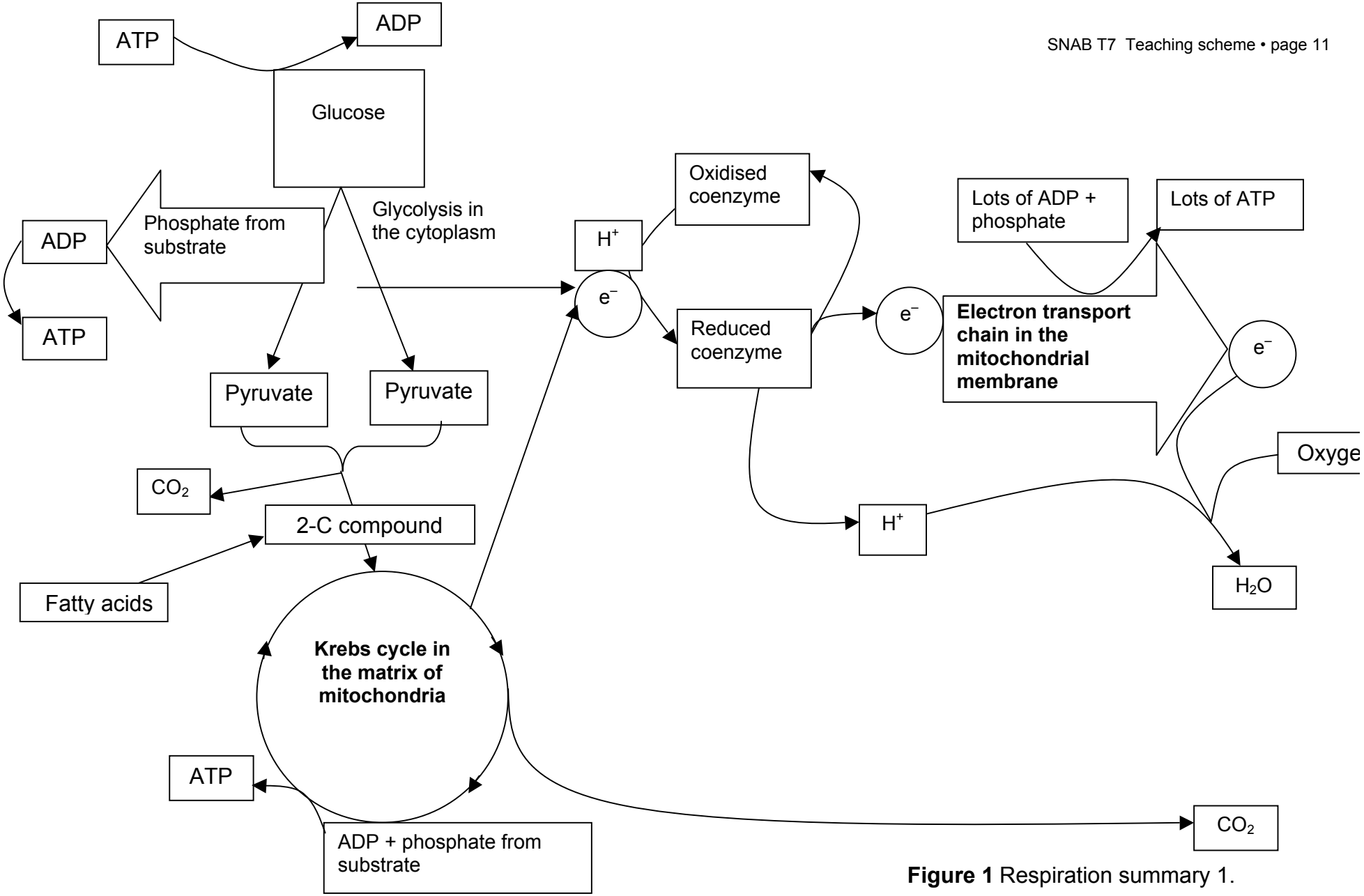


Figure 1 Respiration summary 1.

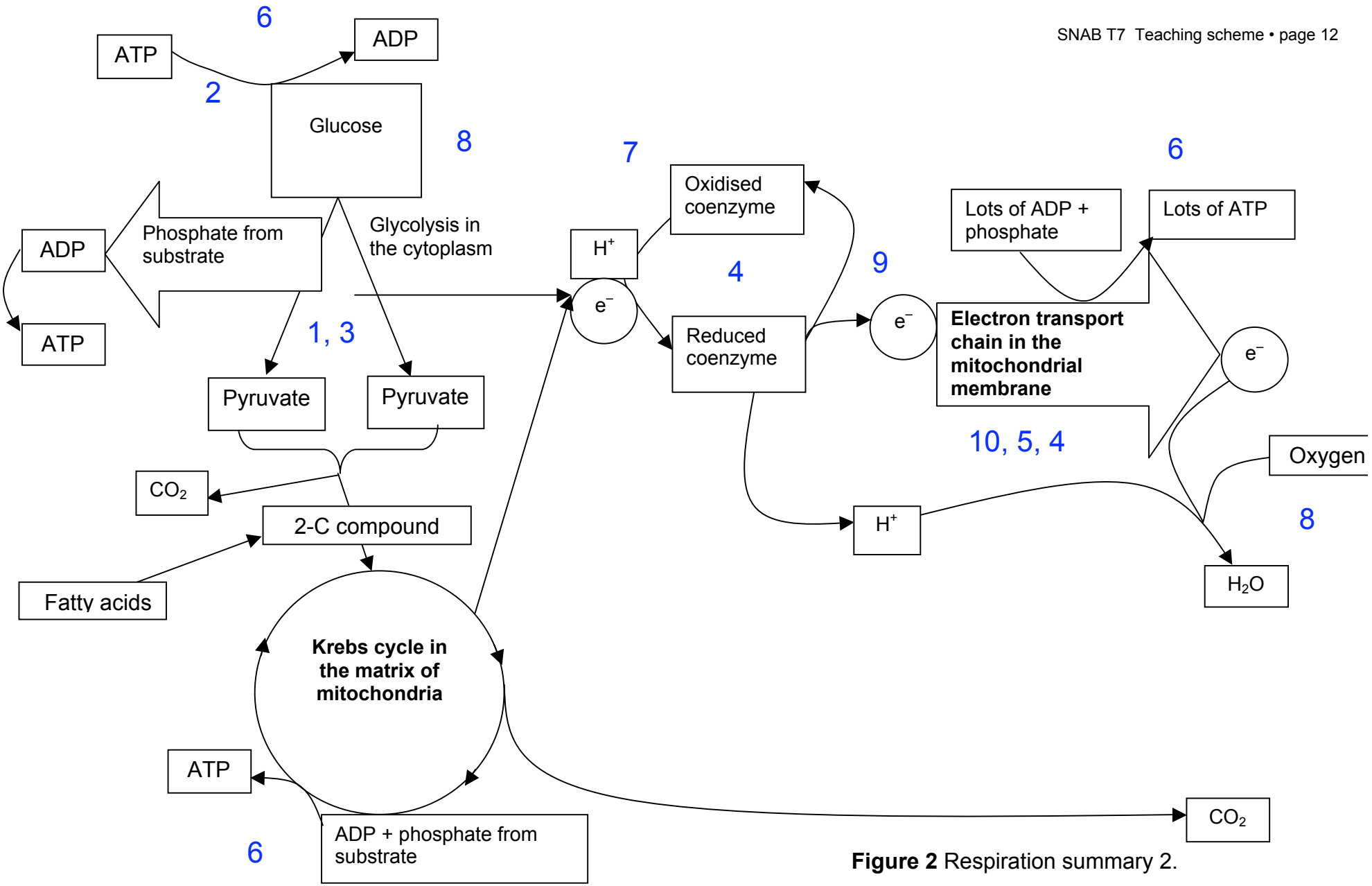


Figure 2 Respiration summary 2.

7.3 Peak performance

Long periods of strenuous but submaximal exercise are only possible if an individual has a high aerobic capacity – the ability to take in, transport and use enough oxygen – thus maintaining ATP regeneration by aerobic respiration. Endurance athletes have a high VO_2 (max) (oxygen consumption per minute during maximum exercise); this is dependent on the efficient uptake and delivery of oxygen by the lungs and cardiovascular system. This section of the book deals with how this is achieved through changes in cardiac output, control of heart rate, lung volumes and control of breathing. There is no specification point relating to VO_2(max) but it provides a context to allow the introduction of the need for efficient uptake and delivery of oxygen to tissues and removal of carbon dioxide from them.

Activity 7.9 Aerobic capacity (A7.09L)

This activity allows students to determine their own VO_2 (max). This activity could be omitted, instead using VO_2 (max) values to introduce the idea of needing efficient delivery of oxygen to tissues and removal of carbon dioxide from them.

The section that follows builds on ideas from Topics 1 and 2; students may need to refresh their memory of the structures and functions of the heart and lungs. The textbook talks about cardiac output and includes a question that requires students to calculate values for cardiac output.

Activity 7.10 Effect of exercise on cardiac output (A7.10L)

The student sheet reviews heart structure and provides practice at calculating cardiac outputs and stroke volumes.

The textbook goes on to consider electrical activity of the heart to control a single heart beat, how this can be observed using an elctrocardiogram and how heart rate is controlled.

Activity 7.11 Conductive pathway of the heart (A7.11L)

Students need to be able to describe the normal electrical activity of the heart before looking at control of heart rate. This activity uses an animation to illustrate the conductive pathway. The animation shows the role of the sinoatrial node (SAN) in generating an electrical impulse that spreads across the atria to the atrioventricular node, and the passage of the impulse down the Bundle of His and then upwards via the Purkyne fibres. The activity sheet can also be completed using just the textbook.

Activity 7.12 What does an ECG show? (A7.12L)

A normal ECG trace and several abnormal ECG traces are included in the textbook and as part of this activity. Students have to apply their knowledge of the electrical activity of the heart and the cardiac cycle to understand the problems facing each patient.

There is no activity associated with the control of heart rate, students could be asked to produce a summary diagram of their own and complete the questions in the textbook.

The textbook describes the control of breathing and there is a series of questions in the text which require students to apply the ideas. Checkpoint question 7.3 also relates to control of ventilation and cardiac output. Note that the chemoreceptors are on the edge of the medulla and they detect the changes in the cerebrospinal fluid and not in the blood directly.

Biological Sciences Review has an article ‘Lungs and the control of breathing’ Volume 14, number 4, pages 2–5, April 2002. There is an accompanying worksheet in the teacher/lecturer notes.

Activity 7.13 Investigating breathing (A7.13L) Core practical
This activity is a core practical and students should be familiar with the techniques for measuring the effects of exercise on lung volumes and breathing rate. If a spirometer is not available, there is an animation that accompanies this activity and simulates the practical. In addition, there are results provided on the worksheet for students to analyse.

Activity 7.14 Locust practical (A7.14L)
This practical investigates the effect of carbon dioxide on the rate of ventilation in the locust.

All muscle fibres are not the same
The textbook now returns to different muscle fibre types. Most students will probably be familiar with the different fibre types in chicken, visible as the dark and light meat. The different fibre types can also often be seen in fish such as mackerel even when cooked. If you look closely, such fish have a thin strip of very dark muscle that runs along the outside of the fish, near its lateral line. This muscle performs the normal continuous swimming movement of a pelagic fish. However, the rest of the fish muscle is paler. The paler-coloured muscle is for rapid sprints either away from predators or towards prey. The same pattern can be seen in tuna steaks, and those of marlin and swordfish. Some fish, such as monkfish, have almost no slow twitch muscle at all. They are bottom-sitting fish that ambush their prey, relying on a rapid lunge and the suction from a huge mouth opening to pull their food in.

Activity 7.15 Fish muscles (A7.15L)
This activity provides a detailed procedure for the dissection of mackerel to observe the fast and slow twitch muscles.

Questions in the text book examine the difference in some detail.

7.4 Breaking out in a sweat
The consequence of excess heat production during exercise is used to present the underlying principle of homeostasis as illustrated by temperature control. The Key biological principle box covers these ideas, allowing students to complete the summary diagram and questions in Activity 7.17. We have tried to avoid the use of the terms ‘heat gain’ and ‘heat loss’ except for the names of the centres in the hypothalamus, instead referring to gain or loss of energy.

Activity 7.16 Body temperature (A7.16L)
Using thermometers or ibuttons, students investigate temperature change with exercise.

Activity 6.10 Homeostasis (A6.10L)
In this activity students complete a concept map for the sequence of events that occurs when body temperature rises and it is brought back to the norm. No other example of homeostasis is specified for students to learn in the specification but they should be able to identify the key features of a system (receptors, coordinating mechanism, effectors and response) when it is presented in a question using an alternative example.

7.5 Overdoing it
This section is effectively split into two parts. The first deals with the effects of doing too much exercise, focusing on the effects of excessive exercise on immune suppression and joint damage. The second part looks at the effects of doing too little exercise which links back to ideas covered in AS Topic 1.

The effect on the immune system of excess exercise gives students the opportunity to refresh their memory of the immune system and extend their knowledge with the introduction of an additional type of cell: natural killer cells.

Activity 7.18 Immune system review (A7.18L)
This activity requires students to revise the information on the immune system they have already met in Topic 6 and then answer questions in an exercise context.

Activity 7.19 Too much or too little (A7.19L)
This activity gives students the opportunity to analyse and interpret data on the possible disadvantages of doing too much exercise or not taking enough exercise. This links back to AS Topic 1.

Activity 7.20 Bone damage and repair (A7.20L)
This activity highlights the use of keyhole surgery and prostheses in overcoming the problems that arise from wear and tear to joints through exercise. A video accompanying this activity links back to the knee joint used at the start of the topic.

Checkpoint question 7.5 is related to the disadvantages of exercising too much and too little.

7.6 Improving on nature

The use of performance-enhancing substances is examined in this final section of the topic. In the specification details of particular substances are not required. In the textbook the effects of three substances, creatine, testosterone and erythropoietin, are describe as a background to the required discussion on whether the use by athletes of performance-enhancing substances is ethically acceptable. The context of performance enhancing substances is used to present theory about hormones and also revisit protein synthesis by considering the role of transcription factors in the switching on hormone production. There is not a separate activity on hormones. The activity on transcription factors does highlight steroid and peptide hormones.

Checkpoint 7.6 requires students to write a summary about the role of transcription factors in switching on and off genes.

Activity 7.21 Transcription factors (A7.21L)
An animation and board game illustrate the role of transcription factors.

Activity 7.22 Testosterone (A7.22L)
A worksheet provides data interpretation questions on the use of testosterone and synoptic links to drug trials terminology.

Activity 7.23 What's wrong with doping? (A7.23L)
This gives students the opportunity to think about the ethical issues surrounding the use of performance-enhancing substances. The ethical frameworks presented earlier in the course are used to structure the students' thinking.

There is a good *Biological Sciences Review* article on 'Hormonal manipulation by athletes'; it includes the use of testosterone and erythropoietin and is found in volume 15, number 2, pages 2–5, November 2002. The article in the January 2000 issue, 'Creatine – performance enhancer', Volume 12, number 2, pages 23–24, is also useful here.

Checkpoint question 7.7 relates to the use and misuse of the performance-enhancing substances mentioned in the specification.

Activity 7.24 Check your notes
Students can use the checklist of learning outcomes in this activity in their revision.

End-of-topic tests

There is an online interactive end-of-topic test. This test is not accessible to students initially unless set by their teacher/lecturer. There is also a paper-based test and mark scheme for Topic 7 with examination-style questions. The questions are similar in layout and style to those that are found on exam papers. However, the restriction of questions to only one topic in each test has meant that it has not been possible to include some types of questions that draw on material from different topics. The test is only accessible if set for students or made open access.