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AS and A LEVEL

Delivery Guide

H020/H420

BIOLOGY A

Theme: Enzymes 2.1.4

April 2015

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Introduction

Delivery guides are designed to represent a body of knowledge about teaching a particular topic and contain:

- Content: A clear outline of the content covered by the delivery guide;
- Thinking Conceptually: Expert guidance on the key concepts involved, common difficulties students may have, approaches to teaching that can help students understand these concepts and how this topic links conceptually to other areas of the subject;
- Thinking Contextually: A range of suggested teaching activities using a variety of themes so that different activities can be selected which best suit particular classes, learning styles or teaching approaches.

If you have any feedback on this Delivery Guide or suggestions for other resources you would like OCR to develop, please email resourcesfeedback@ocr.org.uk.

KEY

	Click to view associated resources within this document.
Click here	Click to view external resources
AS Level only	AS Level content only

Curriculum Content

Content (from AS and A Level)
The content from the specification that is covered by this delivery guide is:

2.1.4 Enzymes

(a) the role of enzymes in catalysing reactions that affect metabolism at a cellular and whole organism level	To include the idea that enzymes affect both structure and function.
(b) the role of enzymes in catalysing both intracellular and extracellular reactions	To include catalase as an example of an enzyme that catalyses intracellular reactions and amylase and trypsin as examples of enzymes that catalyse extracellular reactions.
(c) the mechanism of enzyme action	To include the tertiary structure, specificity, active site, lock and key hypothesis, induced-fit hypothesis, enzyme-substrate complex, enzyme-product complex, product formation and lowering of activation energy. HSW1, HSW8
(d) (i) the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity **(ii)** practical investigations into the effects of pH, temperature, enzyme concentration and substrate concentration on enzyme activity	To include reference to the temperature coefficient (Q_{10}). An opportunity for serial dilutions. *M0.1, M0.2, M0.3, M1.1, M1.3, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6* **PAG4** HSW1, HSW2, HSW4, HSW5, HSW6, HSW8

(e) the need for coenzymes, cofactors and prosthetic groups in some enzyme-controlled reactions	To include Cl– as a cofactor for amylase, Zn2+ as a prosthetic group for carbonic anhydrase and vitamins as a source of coenzymes. **PAG4**
(f) the effects of inhibitors on the rate of enzyme-controlled reactions.	To include competitive and non-competitive and reversible and non-reversible inhibitors with reference to the action of metabolic poisons and some medicinal drugs, and the role of product inhibition **AND** inactive precursors in metabolic pathways (covered at A level only). *M0.1, M0.2, M0.3, M1.1, M1.3, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6* **PAG4** HSW1, HSW2, HSW4, HSW5, HSW6, HSW8

Enzymes are studied at GCSE. Most students beginning A Level will have an understanding of the nature of enzymes, the mechanism of enzyme action, and factors that affect the rate of enzyme-controlled reactions. Students' prior knowledge and understanding can be used as a base from which to introduce the greater depth and breadth required at A Level. The enzymes topic also provides an opportunity for students to develop some of the practical skills required by Module 1 of the specification. The topic also provides opportunities, as a part of practical or theoretical activities, to develop many of the mathematical skills listed in section 5e of the specification.

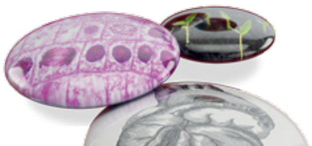
Curriculum Content

Activities	Resources
Biological processes 2.1.4 (a) and (b) To begin with students could generate a list of biological processes. This could be done from memory, of GCSE Biology or A level topics already covered, or by researching using the internet or any GCSE textbook. With guidance from the teacher, some discussion of the list could draw out the idea that the vast majority of these processes involve enzymes. Having generated a list of processes, such as respiration, photosynthesis or digestion, students could discuss the likely location of each process, perhaps using their knowledge and understanding of specification point 2.1.1(g) cell ultrastructure. This discussion would then clarify and exemplify these specification points.	
Enzyme action 2.1.4(c) Students should have studied 2.1.2(m) levels of protein structure at this point and it would be good to ensure that students have a thorough understanding of protein tertiary structure before beginning the enzymes topic. There are many animations of enzyme action available on the internet, such as **How Enzymes Work** (McGraw-Hill Higher Education) http://highered.mheducation.com/sites/0072495855/student_view0/chapter2/animation__how_enzymes_work.html Short animation describing basics of enzyme action using A level terminology. **Lock and key model vs. induced fit model** (University of Surrey) https://learni.st/boards/15314/learnings/110380-lock-and-key-model-vs-induced-fit-model This site also discusses the lock and key and induced fit models. Students could also make and present models using, for example, modelling clay, emphasising differences between the lock and key and induced fit models. More able students could consider the limitations of representing the enzyme as the 'lock' and the substrate as the 'key'.	Click here Click here

Curriculum Content

Activities	Resources
Investigating enzyme activity 2.1.4(d) The number of practical activities students could carry out is limited only by the time and resources available. Any quick internet search will generate a list such as this one: **Factors Affecting Enzyme Activity** (Nuffield Foundation) http://www.nuffieldfoundation.org/practical-biology/factors-affecting-enzyme-activity List of 5 simple experiments that could be used or adapted, for example by changing the variable being tested. One of the investigations in the link above uses trypsin. This could be used as a starting point for an extension activity exploring the idea of inactive precursors of protease enzymes. **Enzyme catalysis: the serine proteases** (Nature Education) http://www.nature.com/scitable/topicpage/enzyme-catalysis-the-serine-proteases-14398894 Provides text-based information on serine proteases for more able students. Investigating the effect of substrate concentration on the rate of hydrogen peroxide breakdown by catalase offers the opportunity for students to carry out serial dilutions. The carrying out of any these practical activities would relate to part of the OCR Biology Practical Endorsement (**PAG4**) and could cover the following learning outcomes: • From Module 1: 1.1.1(a-c), 1.1.2(a-c), 1.1.3(a-d), 1.1.4(a-e), 1.2.1(b-f), 1.2.2(a-c) and (f). • From How Science Works: HSW1, HSW2, HSW4, HSW5, HSW6, HSW8. • From the list of mathematical skills: *M0.1, M0.2, M0.3, M1.1, M1.3, M1.11, M3.1, M3.2, M3.3, M3.5, M3.6.*	Click here Click here
Chloride ions, a cofactor for amylase 2.1.4(e) Students could investigate the effect of chloride ion concentration on the rate of starch breakdown by amylase. This would provide further opportunity to cover some of the Module 1, HSW and mathematical skill areas listed above. Class discussion could explain the results in terms of protein structure, providing a link to Biological Molecules, 2.1.2(m), (p-r).	

Activities	Resources
Enzyme inhibition 2.1.4(f) Another practical activity students could carry out can be found below: **Enzyme inhibition: the effect of phosphate on phosphatase** (Science and Plants for Schools) http://www.saps.org.uk/attachments/article/106/SAPS%20-%20Enzyme%20inhibition%20-%20the%20effect%20of%20phosphate%20on%20phosphatase%20-%20Student%20Guide.doc This includes full practical instructions including a student and teacher guide. Enzyme inhibition is an ideal topic for exploring contextual examples (see below) and could again be discussed in terms of learning outcome 2.1.2(m) levels of protein structure.	Click here



Thinking Conceptually

Approaches to teaching the content

Students' prior knowledge and understanding can be used as an introduction to the enzymes topic as many of the concepts will have been met at GCSE. However, assessment at A Level is much higher in its expectations of language precision, use of key terms, and links to other parts of the specification. Balancing the time available between theoretical and practical approaches to delivering the topic is important. Whether taught theoretically or practically, the topic generates a number of graphs. These provide an opportunity for students to learn the meanings of the exam command words 'describe' and 'explain' by first getting students to describe a given graph, then asking them to explain why it looks like it does.

Common misconceptions or difficulties students may have

Most students are comfortable with a basic understanding of the concepts of enzyme action and the effects of inhibitors, cofactors and other variables that will affect the rate of a reaction. However, they often struggle to fully appreciate the importance of using certain key terms precisely and using them in a way that is clear and unambiguous. For example, many students will be well aware, by the end of a period of teaching, of the answer to the question "why does this reaction speed up?" A typical answer might be "because there are more collisions with the enzyme"; such a response is unlikely to gain much credit in an exam. It can take some time to get students to write "because there are more *frequent* collisions between *substrate* and the *active site*". Likewise, when discussing practical procedures many students use the term 'amount' as a go-to word of choice. This is not usually acceptable at A Level as there is always a more precise term available, such as 'concentration' or 'volume'. A useful approach to teaching these skills involves producing a set of deliberately weak answers and asking students to correct them.

Conceptual links to other areas of the specification – useful ways to approach this topic to set students up for topics later in the course

Teaching of this topic should be firmly embedded in an understanding of protein structure, 2.1.2(l-n), the practical activities are supported by 2.1.2(q-r), qualitative and quantitative tests, and the role of cofactors might have already been mentioned when covering 2.1.2(p), inorganic ions. Some appreciation of 2.1.1(g), cell ultrastructure, might also help when looking at 2.1.4(b), the intracellular and extracellular role of enzymes. If the topic is introduced by examining a range of biological processes that involve enzymes then students are likely to find it easier to make links with contextual examples met later in the course.

Thinking Conceptually

The concepts learnt in 2.1.4 Enzymes are relevant to the following areas of the specification:

Enzymes involved in DNA replication and transcription	2.1.3(e) and (g)
Involvement of carbonic anhydrase in the carriage of carbon dioxide in the blood	3.1.2(j)
Many organisms have enzymes that allow them to function in extreme conditions	4.2.2(g)
Natural selection of organisms with enzymes that confer, e.g. resistance to antibiotics	4.2.2(h-i)
The need for organisms to maintain a relatively constant internal temperature in order for enzymes to function effectively	5.1.1(d)
The importance of enzymes in liver function	5.1.2(b)
The role of acetylcholinesterase at a cholinergic synapse	5.1.3(d)
The role of adenylyl cyclase in 2nd messenger systems	5.1.4(a)
Enzymes are involved in leaf loss and seed germination	5.1.5(b)
The role of enzymes and coenzymes in photosynthesis, including the effect of temperature on RuBisCO.	5.2.1(d-g)
The role of enzymes and coenzymes in respiration	5.2.2(c-i)
Control of β-galactosidase expression by the *lac* operon	6.1.1(b)
Enzymes are involved in apoptosis	6.1.1(d)
Polymerase in PCR	6.1.3(d)
The importance of restriction enzymes and ligase in genetic engineering	6.1.3(f)
Understanding why the rate of microbial growth is influenced by temperature and pH	6.2.1(e-h)
The uses of immobilised enzymes in biotechnology	6.2.1(i)

CONTEXTS

Enzymes are ubiquitous and fundamental so the range of potential contextual examples is enormous. The most useful ones are likely to fall into a few broad categories:

- enzymes that are either intracellular or extracellular,
- digestive enzymes that allow laboratory practical activity to be carried out,
- enzymes from organisms that live at extremes of temperature or pH and their possible use in industrial applications,
- enzymes that work more quickly in the presence of a cofactor,
- examples of enzymes that are inhibited by medicinal drugs or metabolic poisons.

There are many such examples and a few are listed below.

Students are likely to already be familiar with catalase. They are perhaps more familiar with extracellular digestive enzymes, such as amylase, proteases like pepsin, and lipase. These are particularly useful in practical procedures as their activity can be monitored using the common tests for biological compounds that are part of the same module (2.1.2q) (see Biology A, Module 2 Delivery Guide: Biological Molecules 2.1.2).

The list below is a selection of other interesting examples. They could be presented to students and discussed, or students themselves could research them and use their knowledge and understanding to produce a display, poster or PowerPoint presentation.

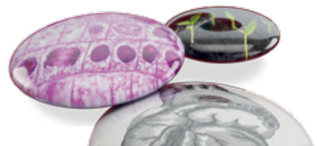
The digestive enzymes can also be considered in the context of biological washing powders, the efficacy of which is affected by temperature.

Amylase activity is increased in the presence of chloride ions and this could be considered in the context of biological washing powders.

Also, students will encounter many cofactors in the A Level topics respiration and photosynthesis but an introduction at this stage might be useful.

Thinking Contextually

Activities	Resources
Hot Spots for Cold Fish (Nature) http://www.nature.com/news/1998/980917/full/news980917-7.html Many organisms possess enzymes that work in extremes of temperature or pH. This Nature article is written in accessible language and discusses lactate dehydrogenase in Antarctic fish with several references to 2.1.4 learning outcomes.	Click here
Medicines that work as enzyme inhibitors Many drugs are enzyme inhibitors, for example angiotensin-converting enzyme (ACE) inhibitors are used to treat hypertension. Students could research this example in depth or generate a list of other medicines that work as enzyme inhibitors, such as the antibacterial effects of penicillin or sulphonamide.	
Metabolic poisons Many metabolic poisons are enzyme inhibitors. Students could link ahead to other topics in this context by studying α-amantin as an RNA polymerase inhibitor or the use of acetylcholinesterase inhibitors as insecticides or nerve gas.	
Read all about it The illegal addition of antifreeze to some wines in the 1980s could be used as a starting point to look at inhibition of alcohol dehydrogenase by diethylene glycol and the potential reversal of this inhibition by high concentrations of ethanol. Students could start by searching for news articles from the time, for example, http://www.nytimes.com/1985/08/02/world/scandal-over-poisoned-wine-embitters-village-in-austria.html http://articles.sun-sentinel.com/1985-07-31/news/8501310848_1_austrian-wine-diethylene-glycol-wine-export-market	Click here Click here



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