

## AS and A LEVEL

*Delivery Guide*

# **BIOLOGY A**

**H020/H420**

For first teaching in 2015

## **Cell Division, Cell Diversity and Cellular Organisation 2.1.6**

Version 2

# AS and A LEVEL BIOLOGY A

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 [resources.feedback@ocr.org.uk](mailto:resources.feedback@ocr.org.uk)

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### 2.1.6 Cell division, cell diversity and cellular organisation

- (a) the cell cycle  
To include the processes taking place during interphase ( $G_1$ , S and  $G_2$ ), mitosis and cytokinesis, leading to genetically identical cells.  
HSW8
- (b) how the cell cycle is regulated  
To include an outline of the use of checkpoints to control the cycle.
- (c) the main stages of mitosis  
To include the changes in the nuclear envelope, chromosomes, chromatids, centromere, centrioles, spindle fibres and cell membrane.  
HSW8
- (d) sections of plant tissue showing the cell cycle and stages of mitosis  
To include the examination of stained sections and squashes of plant tissue and the production of labelled diagrams to show the stages observed.  
**PAG1**
- (e) the significance of mitosis in life cycles  
To include growth, tissue repair and asexual reproduction in plants, animals and fungi.  
HSW2
- (f) the significance of meiosis in life cycles  
To include the production of haploid cells and genetic variation by independent assortment and crossing over.  
HSW2, HSW5
- (g) the main stages of meiosis  
To include interphase, prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, telophase 2 (no details of the names of the stages within prophase 1 are required) and the term *homologous chromosomes*.  
**PAG1**  
HSW8

- (h) how cells of multicellular organisms are specialised for particular functions  
To include erythrocytes, neutrophils, squamous and ciliated epithelial cells, sperm cells, palisade cells, root hair cells and guard cells.  
**PAG1**
- (i) the organisation of cells into tissues, organs and organ systems  
To include squamous and ciliated epithelia, cartilage, muscle, xylem and phloem as examples of tissues.
- (j) the features and differentiation of stem cells  
To include stem cells as a renewing source of undifferentiated cells.
- (k) the production of erythrocytes and neutrophils derived from stem cells in bone marrow
- (l) the production of xylem vessels and phloem sieve tubes from meristems
- (m) the potential uses of stem cells in research and medicine.  
To include the repair of damaged tissues, the treatment of neurological conditions such as Alzheimer's and Parkinson's, and research into developmental biology.  
HSW2, HSW5, HSW6, HSW7, HSW9, HSW10, HSW11, HSW12

**Activity 1****Cell Division Transition Guide** (OCR)

<https://www.ocr.org.uk/Images/170253-cell-division-ks4-ks5.pdf>

This guide focuses on making the transition from KS4 knowledge to KS5 and provides links to a wealth of useful resources, grouped as suitable for KS4 or initial AS teaching, and a separate section of resources for delivering the content at advanced KS5 level. It can be used alongside this delivery guide as a source of ideas.

**Activity 2****Cell Division Checkpoint Task Activities** (OCR)

<https://www.ocr.org.uk/Images/170196-cell-division-checkpoint-task.docx>

The 'checkpoint' here refers to checking students have acquired a deep enough KS4 knowledge to proceed to KS5. The first task relates to mitosis and the second to meiosis. These could form tests at the end of the cell division topic in GCSE, or could begin the teaching of section 2.1.6 at AS level. Teacher instructions are available via this link:

<https://www.ocr.org.uk/Images/170194-cell-division-checkpoint-task-instructions.pdf>

**Activity 3****Mitosis and Cell Division** (Nature Education)

<http://www.nature.com/scitable/topicpage/mitosis-and-cell-division-205>

This 2008 article for Nature Education provides an up to date overview of mitosis. It covers the history of our knowledge of mitosis (including Walther Flemming's original drawings of mitosis from 1882), the reversible condensation of chromatin to form chromosomes, cohesin protein, some recent research into SMC (structural maintenance of chromosomes) proteins, cell cycle checkpoints, spindle formation and an updated description of the main events of the stages of mitosis. It could be used to inform teaching or as a source for comprehension to challenge students.

**Activity 4****Mitosis Animation** (University of Arizona)

[http://www.biology.arizona.edu/cell\\_bio/tutorials/cell\\_cycle/cells3.html](http://www.biology.arizona.edu/cell_bio/tutorials/cell_cycle/cells3.html)

This webpage gives information on the process of mitosis with an animation included.

**Activity 5****Mitosis models and slides** (Bio 137 Virtual Labs)

<https://bluegrass.kctcs.edu/education-training/media/natural-sciences/biology/bio137/lab4/137labexercise4.pdf>

This resource discusses the cell cycle process with photographs of models set in the different stages. It also includes a procedure for viewing the stages in onion root tip cell slides.

Student activities which relate to this document can be found here: [https://bluegrass.kctcs.edu/education-training/programs/biology/bio\\_137\\_virtual\\_lab/lab\\_4/index.aspx](https://bluegrass.kctcs.edu/education-training/programs/biology/bio_137_virtual_lab/lab_4/index.aspx)

**Activity 6****Meiosis Animation** (Sumanas Inc)

<http://www.sumanasinc.com/webcontent/animations/content/meiosis.html>

This shows a narrated animation of the stages of meiosis.

**Activity 7****What are Stem Cells?** (Stem Cell Network)

<https://stemcellnetwork.ca/stem-cells/>

This site contains a wealth of text, videos and downloadable resources about stem cells.

### Approaches to teaching the content

Four conceptual sub-sections are apparent in 2.1.6:

- Learning outcomes (a) to (e) introduce mitosis
- Outcomes (f) and (g) outline meiosis
- Specialisation of cells and organisation into tissues and organs is covered in (h) and (i)
- Stem cells link learning outcomes (j) to (m).

The topics mitosis, meiosis, cell specialisation and stem cells could be taught in the order given, with the advantage that students tend to prefer predictability when keeping track of their learning against the syllabus. The two types of nuclear division with the focus on chromosome movement and sub-cellular activity are dealt with together, and then later the products of division are considered, i.e. what happens to the new cells formed by cell division. The various end-products (types of cells, and the way they are organised into tissues) are considered before looking at the intervening stages, the journey from undifferentiated stem cells produced by mitosis to the formation of the differentiated end-product.

An alternative approach is to link stem cells – mitosis – specialised cells in that order. This starts with the idea that stem cells are undifferentiated and self-renewing and explains first, how they renew (mitosis) and secondly, how they differentiate and into what (specialised cells). This concludes with the teaching of meiosis. As students often confuse mitosis and meiosis there is some merit in dealing with them separately, allowing understanding of mitosis to be reinforced first, and giving an opportunity for revision or testing of mitosis at the start of the meiosis topic.

### Common misconceptions or difficulties students may have

Many students have difficulty imagining events on the small-scale level of cells, even in this case where 'the dance of chromosomes' is visible under a light microscope and can be filmed and speeded up to provide a live window into cell activity (e.g. the pig cell mitosis footage referenced in the context section below). Modelling the nuclear division process with pipe cleaners or icing the stages onto cupcakes may help.

The terms chromosome, chromatid and chromatin may be confused and need to be carefully taught so students both recognise the specific import of these terms when used in questions, and that they select the correct term when writing or labelling a diagram. The distinction between nuclear division and cell division by cytokinesis is also worth highlighting.

Students often have difficulty relating the stylised diagrams in a textbook or examination question to the appearance of real slides of cell division, or photographs of the process imaged with various types of microscope. They also frequently have difficulty slotting their understanding of mitosis into the context of the growth and development of whole

organisms and of meiosis to the ideas of independent assortment and linkage of genes in Mendelian crosses.

The relationship of packaged chromosomes to students' knowledge of the linear DNA molecules of interphase also needs to be carefully explained. A common mistake to watch out for is students thinking mitosis occurs in prokaryotic cells.

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

To enhance synoptic understanding, links between section 2.1.6 and other topics can be highlighted at the appropriate time:

- 2.1.1(a) microscopy as a pre-requisite for the discovery of mitosis
- 2.1.1(g) eukaryotic cell structure – the nucleus, centrioles, microtubules
- 2.1.3(d) – (g) structure and function of DNA
- 2.1.4(a) enzymes controlling the cell cycle, e.g. CDK enzymes
- 3.1.1(c) and (h) exchange epithelia as specialised tissues
- 3.1.2 the transport system (blood) links to haemopoietic stem cells 2.1.6(k)
- 3.1.3(b) xylem and phloem as specialised transport tissues
- 4.1.1(e) neutrophils as specialised immune system cells
- 4.2.2(f) meiosis relates to genetic variation in evolution
- 5.1.4(f) stem cell treatment of Type 1 diabetes (see links in context section)
- 5.1.5(h) the brain – link to stem cell research into degenerative brain diseases
- 5.2.2(a) movement of chromosomes in cell division is an example of why energy from respiration is needed
- 6.1.1(c) embryonic stem cell research into development relates to Hox genes
- 6.1.1(d) mitosis and apoptosis controlling body development
- 6.1.2(a) meiosis and genetic variation in sexually reproducing species
- 6.1.2(b) Mendelian genetics including dihybrid inheritance and linkage of genes
- 6.2.1(a)-(d) mitosis and cloning.

**Learner Activity 1****Cell Division Activity** (OCR)

<https://www.ocr.org.uk/Images/170198-cell-division-activity.docx>

This includes a mixture of written and practical activity tasks concerning mitosis and meiosis for use in teaching or testing. The accompanying teacher sheet can be found at <https://www.ocr.org.uk/Images/170197-cell-division-activity-teacher-instructions.pdf>

**Learner Activity 2****Modelling Nuclear Division** (practical activity)

This can be done with pipe-cleaners or with modelling clay. Students will need to refer to illustrations outlining the stages of either mitosis or meiosis (on a sheet, the whiteboard or in a textbook). They can either produce tableaux of each stage and display these in sequence, or run-through the process moving and manipulating one starting set of chromosomes. It is usual to consider only 2 or 3 pairs of chromosomes. It is important after the working out stage that students have the opportunity to orally describe the process, i.e. to talk through their range of models or to demonstrate the process. This can be in pairs, one pair to another, to the teacher walking round the room, or to the whole class. Students usually make errors with terminology in their descriptions, or miss out key information, so it is best if the teacher listens to each description. It could be turned into a group learning game like 'I'm Sorry I Haven't a Clue' if the first student is stopped by students, or the teacher sounding the alarm at a mistake or omission, and then the task passed to the next student.

In the case of meiosis, maternal and paternal homologues need to be different colours, and the different homologous pairs should be distinguishable by being different lengths. So, for example, two blue (paternal) and two red (maternal) pipe-cleaners can be cut into a two-thirds length to represent chromosome 1 and the smaller third length can be chromosome 2. The two long blues are crossed and twisted over each other at one point to represent a centromere, and the same for the short blue, long red and short red. At this stage, prophase 1 in a cell where  $n=2$  can be modelled. Scissors and sticky tape are needed to show crossing over with pipe-cleaners. While modelling clay can be pulled apart and stuck together more easily, students are more prone to going off-task when using it.

**Learner Activity 3****Cake Icing Nuclear Division** (practical activity)

The idea here is the same as with pipe-cleaners or modelling clay, to re-create the stages of division and then talk through them. A tray of twelve cupcakes is enough to model meiosis (with the second meiotic division of course providing revision of the events of mitosis). If the cakes are pre-iced in white, this saves time. Each student, pair, or group, needs at least two colours of writing icing tubes to draw in the maternal and paternal chromosomes in different colours. A third colour, e.g. black, is useful for drawing nuclear envelopes and spindle fibres. If the baton for describing the process is passed around at a mistake, as suggested in the above activity, this could be linked to a prize structure for winning the cakes.

**Learner Activity 4****Mitosis and Meiosis Comparison** (Diffen.com)

[http://www.diffen.com/difference/Meiosis\\_vs\\_Mitosis](http://www.diffen.com/difference/Meiosis_vs_Mitosis)

This webpage has a useful table and video comprising the processes of mitosis and meiosis as well as commentary on the different stages.

## Activities

Theoretical understanding of mitosis should be related to practical investigation, learning outcome 2.1.6(d). The resources below outline the standard protocol for staining chromosomes in the apical meristem of an onion or garlic root tip, and give practice in the skill of drawing (linking to module 1 and **PAG 1**), plus some work of a mathematical nature in calculating the duration of each stage of mitosis from the percentage of cells viewed in each stage (linking to mathematical skills such as *M0.3* and *M0.4*). These figures obtained by practical work could be compared to figures obtained from the time lapse film of mitosis viewed in 3D, as described in more detail below.

Practical work should also include viewing stages of meiosis 2.1.6(g), for example in prepared slides of lily anthers or locust testes. If time allows, students might find it more interesting and challenging to make their own slides, using freshly-killed locusts, or the anthers of chive flowers. The virtual lab for investigating meiosis in lily anthers offers a shortcut for individual study compared to viewing slides directly.

The stem cells topic provides a broad context for students to explore stimulating questions. Resources are listed covering stem cell ethics, stem cells and neurological disorders, regeneration of limbs and organs, treatment for type 1 diabetes and how Superman links to stem cells.

**Learner Activity 1****Mitosis in Onion Root Tip Cells** (Marietta College, Ohio)

<http://w3.marietta.edu/~biol/introlab/Onion%20root%20mitosis.pdf>

This is a detailed student resource and worksheet giving background information, lab instructions and space for student results and observations when carrying out an onion (or garlic) root tip squash procedure to show mitosis. This could relate to **PAG1** and calculation of mitotic index and the percentage of cells in each stage, would cover mathematical skills such as *M0.3*.

**Learner Activity 2****Observing mitosis and meiosis in cells** (Nuffield Foundation)

<https://pbiol.rsb.org.uk/cells-to-systems/cell-division>

This resource gives two practical procedures. One involves a class practical in preparing an anther squash to observe meiosis and the other is an alternative method for observing mitosis in an allium root tip squash. The latter also includes sample results for counts of cells at different stages of mitosis. This method does not include a student worksheet so could be used in conjunction with the Marietta College resource above.

**Learner Activity 3****Chromosome movements in the cell of a pig CIL:36292** (The Cell™ An Image Library)

<http://www.cellimagelibrary.org/images/36292>

The technique used shows 3D fluorescent chromosomes moving in a time-lapse film of mitosis in a living cell. As a class resource after the first showing it could be repeated with students raising their hands or calling out at the points when one recognisable stage is succeeded by the next. The time clock in minutes could then be used for students to note down how long each stage takes and to work out the percentage of time of mitosis spent in each stage. Depending on when the filming started and ended, the accuracy of this approach could be discussed, and how these figures from live imaging could be validly compared with estimates of how long each stage takes from students' own work counting cells at each stage in their own root squash or a prepared root tip slide (linking to mathematical skills *M0.3*, *M1.5*). The remarkable nature of this footage could also stimulate discussion and revision of microscopy techniques (2.1.1a-f).

**Learner Activity 4****Meiosis Virtual Lab** (School of Arts and Sciences, Rutgers, the State University of New Jersey)

[https://bio.rutgers.edu/~gb101/lab10\\_meiosis/meiosis\\_web/10notebook3.html](https://bio.rutgers.edu/~gb101/lab10_meiosis/meiosis_web/10notebook3.html)

Lily anther slides provide the basis for this interactive virtual practical, which gives practice in identifying the stages of meiosis, with feedback for incorrect answers.

**Learner Activity 5****Using Chives to Study Meiosis** (ABLE)

<https://www.ableweb.org/biologylabs/wp-content/uploads/volumes/vol-7/2-robinson.pdf>

This gives practical instructions for two methods of obtaining and staining cells from chive anthers for viewing stages of meiosis (this could relate to **PAG1**).

**Learner Activity 6****The Use of Grasshopper Chromosomes to Study Meiosis** (Victoria University of Wellington)

<http://nzetc.victoria.ac.nz/tm/scholarly/tei-Bio18Tuat01-t1-body-d1.html>

This link has been included, although it relates to grasshoppers in New Zealand, because it gives details of how to dissect a freshly-killed grasshopper in order to locate the testes, and how to stain it to show chromosomes. This can be applied to a locust. There is a protocol suited to A level for doing this using a locust and acetic-orcein stain in the Students' manual of 'Biology, A Functional Approach' by M.B.V.Roberts. (This could relate to **PAG1** and **PAG2**).

**Learner Activity 7****Euro Stem cell Home Page** (Euro Stem cell)

<http://www.eurostemcell.org/>

This site is a comprehensive resource offering information, videos and fact sheets on all aspects of stem cell research, including the ethical debate (HSW9, HSW10) and research regarding neurological disorders.

Article on the ethics of embryonic stem cell research:

<https://www.eurostemcell.org/embryonic-stem-cell-research-ethical-dilemma>

Article on stem cell therapy for neurological disorders: <https://www.eurostemcell.org/embryonic-stem-cell-research-ethical-dilemma>

**Learner Activity 8****From stem cells to billions of insulin producing cells** (Harvard College)

<http://hsci.harvard.edu/news/stem-cells-billions-human-insulin-producing-cells>

This reports Harvard's breakthrough in treating Type 1 diabetes by stem cell transplantation. Dr. Douglas Melton is the lead researcher. The research was published in Cell on 9th October 2014 and an author's proof copy of the article is downloadable at this link. Newspaper coverage of the work includes:

<http://www.theguardian.com/society/2014/oct/10/diabetes-stem-cell-type-1-breakthrough-harvard>

from The Guardian newspaper

<https://www.telegraph.co.uk/news/health/news/5153823/Stem-cell-transplants-free-diabetics-from-daily-jabs.html> from The Telegraph newspaper. There is a useful video 'What are Stem cells?' on this page.

Simultaneous publication of the peer-reviewed research, the announcement on the institution's website and the issuing of press releases to give widespread media coverage provides a context for students to examine HSW7, HSW8 and HSW11.

**Learner Activity 9****5 Animals that Re-grow Body Parts** (National Geographic)

<https://www.nationalgeographic.com/news/2013/8/axolotl-regrow-regeneration-body/>

This review of five examples of regeneration in animals can be used to stimulate discussion of tissue repair in humans and what is possible naturally and in the laboratory. The links that follow provide more resources to explore this theme. This line of enquiry links learning outcome 2.1.6 (e) with (m).

<https://www.nationalgeographic.com/magazine/2018/08/embark-breakthroughs-salamanders-mars-fungi-tick/>

<https://www.nationalgeographic.com/science/phenomena/2012/02/28/will-we-ever-grow-organs/>

<https://www.nationalgeographic.com/science/phenomena/2011/02/02/research-into-reprogrammed-stem-cells-an-interactive-timeline/>

The last link gives a timeline of breakthroughs in obtaining induced pluripotent stem cells.

**Learner Activity 10****Stem Cell Research Center** (Christopher and Dana Reeve Foundation)

[http://www.christopherreeve.org/site/c.ddJFKRNoFiG/b.4435071/k.7013/Stem\\_Cell\\_Research\\_Center.htm](http://www.christopherreeve.org/site/c.ddJFKRNoFiG/b.4435071/k.7013/Stem_Cell_Research_Center.htm)

This page of the Christopher and Dana Reeve Foundation website focuses on stem cell research. The actor Christopher Reeve who played the title role in the Superman films in the 1980s was paralysed by a fall from a horse in 1995. He set up a foundation to fund research into repairing spinal cord injuries. The context of a famous actor who epitomised strength and physical power being incapacitated but refusing to give up in his quest to recover appeals to challenge and inspire students. Students could be set an open brief to find out who Christopher Reeve was, the two reasons why he was famous and how his life links to section 2.1.6.

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