Badger GCSE Science

Working Scientifically

Biology

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Badger LEARNING

Introduction

This is the first of a series of three books of Working Scientifically activities for GCSE science. They have been developed by teachers to give colleagues a range of resources to use in teaching science through the principles of Working Scientifically. These activities work well as an 'add on' to any of the KS4 schemes of work.

Working Scientifically is an essential part of the national curriculum for science. For many science teachers, this has meant getting to grips with a new approach to science teaching. The activities in this book have been designed to encourage structured discussion, improve knowledge and understanding of Working Scientifically, and to support learners to consider a range of viewpoints and make an informed decision.

The KS4 science national curriculum sets out the parameters for Working Scientifically, and the specifications for each of the GCSE examination boards have interpreted these in a variety of ways. These activities are suitable for use in all schools, whichever exam board they use.

We have found that learners do not necessarily have the required background knowledge about scientific issues such as genetically modified food. Without this information, it is hard for them to discuss the issue and form an opinion. The tasks we have created boost this background knowledge and help learners to consider evidence from a range of contexts and make a decision.

How to use these activities

The general approach is to introduce the learners to the task, then allow them to discuss it in pairs or groups of four. During this time, the teacher should circulate amongst the groups to encourage the discussions. Once the learners have had time to talk about their ideas and make decisions, the teacher can lead a class discussion to draw out the key points.

More specifically, the activities take a variety of forms that require slightly different management. Data analysis, graph drawing and predicting activities follow the general approach, but note that the discussion should focus on the process of analysing, data presentation and prediction rather than just what the answer is.

Card sorts also take different forms, but the general approach allows learners to sort statements physically into groups. Discussion should focus on the nature of evidence, or facts and opinions in the context of the content of the activity.

Timelines require more time and can be extended by allowing learners to add their own images and additional events. They are designed so that learners can identify how ideas change, and relate images to the text. Follow-up discussion should focus on how and why the ideas have changed and, perhaps, on imagining what may happen in the future.

A note about timing

We have identified the approximate time taken for the activities based on an average ability class. More able groups may need less time on the task but more time on the discussion, and lower ability learners may need support (particularly literacy) during the activities themselves. Most tasks have some differentiation suggestions.

Authors

Dr Andy Chandler-Grevatt trains teachers at the University of Sussex. Previously he was a science teacher and Advanced Skills Teacher, where he developed an interest in producing engaging resources. This publication is dedicated to his nephews, Toby and Olly.

Dr Deborah Shah-Smith is an experienced science teacher. She has a keen interest in developing resources using practice-based evidence. She would like to dedicate this publication to her husband, Paul, and daughter, Zaveri.

Acknowledgements

We would like to thank our colleagues who have helped us to develop these tasks. These include Ben Riley of Oriel High School, West Sussex and Ross Palmer of Cardinal Newman School, Brighton and Hove.

Contents and curriculum links

A. Cells to Systems

Title	NC WS	WS Programme of Study	Activity Type
1. Stem cell therapy: benefits, drawbacks and risks	1c, 1d, 1e	The development of scientific thinking	Card sort and discussion
2. History of the microscope	1a, 1c	The development of scientific thinking	Card sort
3. Which washing powder washes cleanest?	2b, 2c, 2d	Experimental skills and strategies	Planning written task and discussion
4. Effect of temperature on enzyme activity	2b, 2d	Experimental skills and strategies	Improving a plan, written task and discussion
5. Breathing volumes	3b, 3c	Analysis and evaluation	Graph interpretation
6. Osmosis graphs	3a, 3b, 3c, 3d, 3e	Analysis and evaluation	Graph drawing and interpretation
7. Definitions: cell transport	4a	Vocabulary, units, symbols and nomenclature	Card sort
8. Size matters: cells	4a, 4b, 4c, 4d	Vocabulary, units, symbols and nomenclature	Card sort
9. Using a light microscope	Experimental focus	Experimental skills and strategies	Card sort
10. Testing antibiotics	Maths skills	Analysis and evaluation	Calculating the area of a circle

B. Health, Disease and Medicine

Title	NC WS	WS Programme of Study	Activity Type
11. Cannabis and tobacco – the evidence	1a, 1c, 1d, 1e, 1f	The development of scientific thinking	Card sort and discussion
12. TB timeline	1a, 1b	The development of scientific thinking	Card sort and discussion
13. Drug trials	2b	Experimental skills and strategies	Card sort and discussion
14. Growing bacteria	2b, 2d, 2g	Experimental skills and strategies	Improving a plan, written task and discussion
15. Analysing measles data	3e, 3f	Analysis and evaluation	Graph interpretation and discussion
16. Deaths involving MRSA	3a, 3b, 3e, 3f	Analysis and evaluation	Graph drawing and interpretation
17. Weights and measures in medicine	4a, 4c, 4d	Vocabulary, units, symbols and nomenclature	Card sort and discussion
18. Definitions: microbes	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
19. Investigating antibiotics	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
20. Malaria and DDT	Maths skills	Analysis and evaluation	Graph interpretation and discussion

C. Coordination and Control

Title	NC WS	WS Programme of Study	Activity Type
21. Diabetes timeline	1a, 1b	The development of scientific thinking	Card sort and discussion
22. The contraceptive pill: the issues	1c, 1d, 1e	The development of scientific thinking	Card sort and discussion
23. Does caffeine affect reaction time?	2a, 2b, 2c, 2d	Experimental skills and strategies	Planning written task and discussion
24. Does sweating really cool you down?	2b, 2d	Experimental skills and strategies	Improving a plan, written task and discussion
25. Female hormone graph analysis	3d, 3e, 3f	Analysis and evaluation	Graph interpretation and discussion
26. Measuring reaction times	3g	Analysis and evaluation	Card sort, evaluating an investigation and discussion
27. Reflex actions	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
28. Conversion of time	4b, 4c, 4d	Vocabulary, units, symbols and nomenclature	Card sort and discussion
29. Investigating exercise	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
30. Blood sugar graphs	Maths skills	Analysis and evaluation	Graph interpretation and discussion

D. Photosynthesis and Ecosystems

Title	NC WS	WS Programme of Study	Activity Type
31. Pesticides: benefits, drawback and risks	1c, 1d, 1e	The development of scientific thinking	Card sort and discussion
32. Predicting fish populations	1a, 1c	The development of scientific thinking	Graph analysis and discussion
33. Ivy leaves	2b, 2c, 2d, 2e	Experimental skills and strategies	Planning written task and discussion
34. Sampling: quadrat, transect or satellite imaging?	2c, 2e, 2g	Experimental skills and strategies	Discussion and selection of sampling techniques
35. Fertiliser choices	3e, 3f	Analysis and evaluation	Analysing and drawing conclusions, and discussion
36. Lichens and air pollution	3e, 3f	Analysis and evaluation	Analysing and drawing conclusions, and discussion
37. Powers of 10: ecosystems	4b, 4c, 4d	Vocabulary, units, symbols and nomenclature	Card sort and discussion
38. Definitions: ecology	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
39. Effect of light intensity on photosynthesis	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
40. Quadrat data comparison	Maths skills	Analysis and evaluation	Graph interpretation and discussion

E. Genes, Genetics and Inheritance

Title	NC WS	WS Programme of Study	Activity Type
41. Genetics timeline	1a, 1b	The development of scientific thinking	Card sort and discussion
42. Genetic modification of crops: fact or opinion	1c, 1d, 1e, 1f	The development of scientific thinking	Card sort and discussion
43. How to clone	2b	Experimental skills and strategies	Card sort and discussion
44. Variation investigation	2b, 2c, 2d, 2e	Experimental skills and strategies	Discussion and selection of sampling techniques
45. Guinea pig genetics	3a, 3b, 3c	Analysis and evaluation	Analysis and drawing conclusions, and discussion
46. Analysing variation	3a, 3b, 3e, 3g	Analysis and evaluation	Graph drawing and discussion
47. Definitions: genetics and inheritance	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
48. Size matters: cell to gene	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
49. Variation in pelargoniums	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
50. Cloning success calculations	Maths skills	Analysis and evaluation	Calculations

F. Evolution

Title	NC WS	WS Programme of Study	Activity Type
51. Dinosaur extinction	1c, 1f	The development of scientific thinking	Card sort and discussion
52. Evolution timeline	1a, 1b	The development of scientific thinking	Card sort and discussion
53. Selectively breeding sweet peas	2b, 2c	Experimental skills and strategies	Card sort and discussion
54. Fossilisation	2a, 2c	Experimental skills and strategies	Card sort and discussion
55. Fossil evidence	3e	Analysis and evaluation	Analysis and drawing conclusions, and discussion
56. Evolution of the horse	3e, 3f	Analysis and evaluation	Graph drawing and discussion
57. Powers of 10: Earth history	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
58. Evolution card sort	4a	Vocabulary, units, symbols and nomenclature	Card sort and discussion
59. Investigating natural selection	Experimental focus	Experimental skills and strategies	Planning and discussing an investigation, written task
60. How we have grown!	Maths skills	Analysis and evaluation	Graph drawing

1

Cells to Systems

Stem cell therapy: benefits, drawbacks and risks

KS4 National Curriculum WS link

1. *The development of scientific thinking*
   c. appreciating the power and limitations of science and considering ethical issues which may arise
   d. explaining everyday and technological applications of science; evaluating associated personal, social, economic and environmental implications; and making decisions based on the evaluation of evidence and arguments
   e. evaluating risks both in practical science and the wider social context, including perception of risk

Resources:

Task sheet 1, cut into cards, with instructions: 1 between 2/4

Time:

Activity: 10 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** Starter, Main activity or Plenary
- **Key words/concepts:** benefit, drawback, risk, stem cells

Suggested answers

Below is the intention of each statement: Benefits: B, Drawbacks: D, Risks: R

1. Stem cells are capable of turning into any type of cell. **(B)**
2. Some of the most useful and versatile stem cells are extracted from embryos. **(D)**
3. A human egg has the same moral status as an adult human, so using embryonic cells is equivalent to murder. **(D)**
4. Stem cell therapy may increase the chance of developing cancer. **(R)**
5. Stem cells could be used to test the effects of new drugs. **(B)**
6. Stem cells are rare and hard to find in the adult body. **(D)**
7. Stem cells from adults can be used, which do not harm the donor. **(B)**
8. Transplants using stem cell therapy may pass on viruses and other diseases to the recipient. **(R)**
9. Stem cells have the potential to cure a wide range of diseases. **(B)**

Extension suggestion

List any questions you have about the statements.

Cells to Systems

Stem cell therapy: benefits, drawbacks and risks

1

Task

Cut out the statement cards. Discuss each one and decide whether it is a benefit, drawback or a risk of using stem cells to treat inherited conditions.

- A **benefit** is something that generally has a good effect on people.
- A **drawback** is something that is a hindrance or is the 'downside'.
- A **risk** is a possible danger or source of harm.

1. Stem cells are capable of turning into any type of cell.	**2.** Some of the most useful and versatile stem cells are extracted from embryos.	**3.** A human egg has the same moral status as an adult human, so using embryonic cells is equivalent to murder.
4. Stem cell therapy may increase the chance of developing cancer.	**5.** Stem cells could be used to test the effects of new drugs.	**6.** Stem cells are rare and hard to find in the adult body.
7. Stem cells from adults can be used, which do not harm the donor.	**8.** Transplants using stem cell therapy may pass on viruses and other diseases to the recipient.	**9.** Stem cells have the potential to cure a wide range of diseases.

2 Cells to Systems
History of the microscope

KS4 National Curriculum WS link

1. *The development of scientific thinking*
   a. the ways in which scientific methods and theories develop over time.
   c. appreciating the power and limitations of science and considering ethical issues which may arise

Resources:
Task sheet 2, cut into cards, with instructions: 1 set each

Time:
Activity: 30 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** Main or Homework activity
- **Key words/concepts:** light microscope, electron microscope, magnification, resolution

Suggested answers

C 14th century, the art of glass grinding led to the development of spectacles to improve eyesight.
H 1590, Hans and Zacharias Janssen created the first compound microscope.
J 1667 *Micrographia* published by Robert Hooke. First use of 'cell', to describe the structure of cork.
F 1675, Anton van Leeuwenhoek observes bacteria for the first time using a microscope.
E 18th century, microscope technology advanced by using two different types of glass to reduce chromatic effect.
G 1878, Ernst Abbe links the relationship between wavelength of light and resolution.
B 1903, ultramicroscope invented by Richard Zsigmondy. It used light scattering rather than light reflection which increased the resolution of the light microscope.
D 1932, Frits Zernike invented phase-contrast microscope which enabled transparent and colourless biological material to be studied.
A 1938, Ernst Ruska invented electron microscope which allowed the study of specimens smaller than the wavelength of light.
I 1981, Gerd Binnig and Heinrich Rohrer invented scanning electron microscope; specimens could be viewed in 3D down to the atomic level.

Extension suggestion

Learners research and add their own images and events.

Cells to Systems

History of the microscope

2

Task

Cut out the statements, read them carefully and arrange them in the correct chronological order on the timeline below.

Timeline	
0 AD	**A** Ernst Ruska invented the electron microscope in 1938. It allowed the study of specimens smaller than the wavelength of light. In 1986 Ruska shared the Nobel Prize for Physics for his work on electron microscopy.
	B The ultramicroscope was invented by Richard Zsigmondy in 1903; this used light scattering rather than light reflection which increased the resolution of the light microscope.
1600 AD	**C** The art of glass grinding began in Italy in the 14th century and this led to the development of spectacles made to improve eyesight.
	D In 1932 Frits Zernike invented the phase-contrast microscope which enabled transparent and colourless biological material to be studied.
1700 AD	**E** In the 18th century microscope technology was advancing through the discovery that using two different types of glass could reduce the halo seen around objects (chromatic effect).
	F Shortly afterwards, in 1675, Anton van Leeuwenhoek observes bacteria for the first time using a microscope. His microscope only had one lens, but he made his own excellent lenses.
1800 AD	**G** In 1878 Ernst Abbe links the relationship between wavelength of light and resolution (the ability to distinguish two objects as being separate entities).
	H In 1590 two Dutch spectacle makers, father and son, Hans and Zacharias Janssen, created the first compound microscope by encasing two glass lenses in a tube.
1900 AD	**I** In 1981 Gerd Binnig and Heinrich Rohrer invented the scanning electron microscope; specimens could be viewed in 3D down to the atomic level. They shared the Nobel Prize for Physics with Ruska.
	J *Micrographia*, Robert Hooke's book filled with illustrations of material viewed under a microscope, is published in 1667. Hooke is the first biologist to use the word 'cell' when he describes the structure of cork.
2000 AD	

3

Cells to Systems

Which washing powder washes cleanest?

KS4 National Curriculum WS link

2. *Experimental skills and strategies*
   b. planning experiments to make observations, test hypotheses or explore phenomena
   c. applying a knowledge to a range of techniques, apparatus, and materials to select those appropriate both for fieldwork and for experiments
   d. carry out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations

Resources:
Task sheet 3: 1 each or 1 between 2

Time:
Activity: 15 minutes
Discussion: 10 minutes

Notes

- **Suitable for:** extended Starter, Main activity or Plenary, or Homework activity
- **Key words/concepts:** planning an investigation; valid, reliable, accurate

Suggested answers

Prediction: Biological washing powders remove more stains than non-biological powders because they contain enzymes which break down stains.

Bullet point method should include:

- Same volume of water and temperature of water.
- Same amount of time being washed.
- Same mass of powder.
- Same treatment, e.g. agitation, stirring, etc.
- Same type of stain and length of time stain is left on material before washing.

Safety considerations: hot water; enzymes in powder could be harmful/irritant.

How to ensure that the experiment is:

- **valid** – comparing the two powders, controlling other variables.
- **reliable** – repeat readings.
- **accurate** – how stain removal is measured.

Extension suggestion

Draw a table for the results.

Cells to Systems

Which washing powder washes cleanest?

3

Traditional non-biological washing powders clean clothes very well; they make the clothes smell fresh and keep the colours looking bright. However, they usually need warm to hot water to work most effectively.

Biological washing powders use enzymes to break down stains and so they are said to clean clothes more effectively at low temperatures. This means that clothes can be washed in cold water which saves on energy. However, these washing powders can irritate sensitive skin.

Task

Your task is to plan an investigation to test how well a biological washing powder washes clothes compared with a traditional non-biological brand.

Include:

- Prediction with a scientific reason
- Bullet point method (how you will do the experiment)
- Safety considerations

State how you will ensure that the experiment is:

- valid
- reliable
- accurate

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Cells to Systems

Effect of temperature on enzyme activity

KS4 National Curriculum WS link

2. *Experimental skills and strategies*
   b. planning experiments to make observations, test hypotheses or explore phenomena
   d. carry out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations

Resources:
Task sheet 4: 1 between 2

Time:
Activity: 10 minutes
Discussion: 5 minutes

Notes

- **Suitable for:** Starter or Plenary, or Main or Homework activity
- **Key words/concepts:** enzyme, amylase, starch, iodine, temperature, control variable, risk assessment

Suggested answers

A Improvements to method:
- Concentrations of solutions
- Volumes of starch solution and amylase solution
- State range of temperatures.

B Risk assessment could include:
- Electronic water baths: risk of electrocution, always dry hands before switching baths on/off
- Glassware: sharp edges on shattered glass can cause cuts to skin; sweep up broken glass using a dustpan and brush
- Iodine: may irritate (and stain) skin, wash off skin immediately.

C Control variables could include:
- Volumes of starch solution and amylase: use a measuring cylinder; different volumes will affect results
- pH: use a buffer; changing pH may affect the activity of the enzyme.

Extension suggestion

Draw a table for the results.

Cells to Systems

Effect of temperature on enzyme activity

4

Task

Read the text below which outlines the method for investigating the effect of temperature on enzyme activity.

A. Suggest how the method could be improved.
B. Write a risk assessment for the investigation.
C. Identify any control variables, stating how and why they need to be kept the same.

Starch is made from long chains of glucose. The enzyme amylase, which is found in saliva, can be used to break down starch into glucose.

Iodine is an orange-brown transparent colour which changes to opaque blue/black when it comes into contact with starch. Glucose does not change the colour of iodine.

At the start of this experiment the mixture of starch and amylase will turn iodine blue/black; however, when the starch is broken down to glucose the iodine should stop changing colour.

Equipment:

Electronic water baths set at different temperatures
Starch solution
Test tubes
Glass rod
Stopwatch
Thermometer
Iodine solution
White spotting tile
Amylase solution
Paper towels

Method:

1. Use a dropper to add one drop of iodine to each well on the spotting tile.
2. Label a test tube 'Starch'; add starch solution to the tube and place the tube in the water bath of the first temperature to be tested.
3. Label a test tube 'Amylase'; add amylase solution to the tube and place the tube in the water bath of the first temperature to be tested.
4. Add the amylase to the starch and stir the mixture. Using a glass rod, transfer a drop of the starch/amylase mixture to the first well of iodine and observe any colour change. Immediately start the stopwatch. Wipe the glass rod.
5. Every minute stir the mixture using the glass rod and transfer a drop of mixture to a drop of iodine on the spotting tile. Wipe the glass rod.
6. Repeat step 5 for 10 minutes or until the colour of the iodine remains unchanged.
7. Repeat steps 1–6 using water baths at different temperatures.

5 Cells to Systems
Breathing volumes

KS4 National Curriculum WS link

3. *Analysis and evaluation*
   b. translating data from one form to another
   c. carrying out and representing mathematical and statistical analysis

Resources:
Task sheet 5: 1 each

Time:
Activity: 10 minutes
Discussion: 5 minutes

Notes

- **Suitable for:** extended Starter or Plenary, or a Main or Homework activity
- Volumes are approximate to 100 cm^3 due to scale on Y axes.
- **Keywords/concepts:** Lung capacity, measurements and names of volumes when breathing

Suggested answers

Fill in the table below using the information on the graph (volumes +/– 100 cm^3).

Name	Definition: The volume of air…	Volume (cm^3)
Total lung capacity	in the lungs after maximum inhalation	5800
Tidal volume	inhaled and exhaled in one normal breath	500
Inspiratory capacity	that can be inhaled after a normal exhalation	3500
Inspiratory reserve volume	that can be inhaled after a normal breath in	2800
Expiratory reserve volume	that can be exhaled after a normal breath out	1200
Vital capacity	that can be exhaled after maximum inhalation	4600
Residual volume	that remains in the lungs after maximum exhalation	1200

Extension suggestion

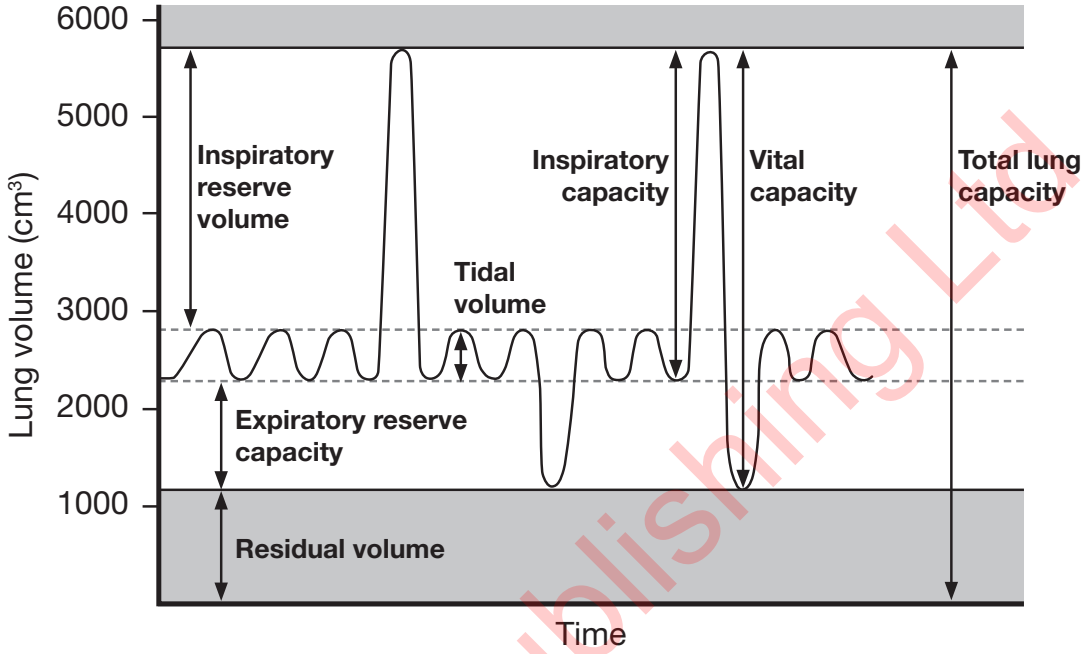
Suggest the factors that will affect tidal volume and vital capacity.

Cells to Systems

Breathing volumes

5

The graph below shows the volumes of air that are inhaled and exhaled. The volumes of air inhaled and exhaled during normal breathing and when breathing at maximum capacity have specific names.



Task

Fill in the table below using the information on the graph.

Name	Definition: The volume of air…	Volume (cm^3)
Total lung capacity	in the lungs after maximum inhalation	5800
	inhaled and exhaled in one normal breath	500
	that can be inhaled after a normal exhalation	3500
	that can be inhaled after a normal breath in	2800
	that can be exhaled after a normal breath out	1200
	that can be exhaled after maximum inhalation	4600
	that remains in the lungs after maximum exhalation	1200