CSI: Cell science investigators

Lesson plan

12–14

Thanks for downloading ***CSI: Cell science investigators***. Use this lesson plan with a class of 12-14 year olds to…

Recap on stem cell properties

Use real cell images to learn about cell damage in multiple sclerosis

Discuss how stem cell research might help treat diseases

Do an experiment showing how stem cells can be used to test new medicines

Learn how stem cells are used in treatments today

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Overview

A 60-minute lesson for 12-14 year olds on the potential medical applications of stem cell research, illustrating some key aspects of the scientific method. The lesson is guided by a simple PowerPoint presentation and is divided into a number of short sections, mixing group work with a class demonstration and a hands-on model drug testing experiment.

Cell science investigators follows directly on from ***Discover stem cells***, an introductory lesson on stem cells and their role in the body. Both lessons provide flexible resources for visiting scientists or teachers in the classroom. They were initially designed for delivery by two scientists visiting a school, but are supported by all the necessary information and materials to allow teachers to deliver the activities themselves.

This guide outlines how we have found the ***Cell science investigators*** lesson to work best, but we hope you will adapt the details to suit your own needs. Post your comments and experiences on the lesson pages:

1. Discover stem cells - http://www.eurostemcell.org/toolkititem/discover-stem-cells
2. CSI: cell science investigators - http://www.eurostemcell.org/toolkititem/csi-cell-science-investigators

Learning objectives

All students

- Know how stem cells may be useful in medicine and research
- Know an example of a disease that stem cell research may help in the future
- Know that a scientific experiment should be a fair test

More able students

- Know what a scientific control is
- Be aware that different types of stem cells may be useful in different ways

Required prior knowledge

This activity assumes that students have completed the lesson ***Discover Stem Cells*** or have equivalent knowledge, ie. know that stem cells can self-renew and differentiate, that there are different types of stem cells (tissue and embryonic) with different properties and know that tissue stem cells are important in the body. A short recap on stem cell properties is included in this lesson, but more time must be allowed if students have not previously been introduced to these concepts.

Materials and preparation

A materials checklist is provided at the end of this guide. Some preparation is needed:

Before the lesson

- Prepare indicator papers by soaking filter papers in red cabbage juice, and collect all the required equipment for the experiment, ***Using cells to look for medicines***. You can prepare the indicator papers up to a few weeks in advance as long as they are kept in a sealed container. Full instructions are included in the ***Using cells to look for new medicines*** task.
- Print worksheets for ***What goes wrong in MS?*** and ***Using cells to look for new medicines***.
- Read the guidance notes accompanying the PowerPoint slides within the ***Cell science investigators*** PowerPoint file. These notes give detailed guidance on how to run the lesson and tasks.
- Prepare an envelope containing a slip of paper with the message ‘Jump’!

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Lesson structure and timings

See the ***CSI: Cell science investigators*** PowerPoint for detailed guidance notes on delivery of each lesson activity.

Activity	Time needed	From...to… (insert times, e.g 9-9:05am)
Start: Students arrive and settle down.	5 mins	
Introduction and task 1: recap on stem cells (slides 1–4) Introduce who you are and what the lesson will involve. Use the recap worksheet and cell shapes to remind students of basic stem cell properties.	5 mins	
Presentation & demonstration: MS and nerves (slides 5–10) Introduce the symptoms and some key facts about the disease multiple sclerosis (MS). Use a line of students passing a message to demonstrate the job of nerve cells.	10 mins	
Task 2: What goes wrong in MS? (slides 11–12) Students work in groups to examine diagrams of healthy and MS nerve cells and to compare real images of nerve cells from the brain.	5 mins	
Presentation: How can stem cells help? (slides 13–18) Discuss possible ways stem cells could help with developing treatments for MS – study disease, test medicines, develop cell therapies – and the possible sources of stem cells for these purposes.	10 mins	
Task 3: Using cells to look for new medicines (slides 19–20) Students work in groups to plan and carry out a model drug testing experiment.	15 mins	
Wrap-up (slides 21–24) Describe cell therapies available today and highlight the time needed to develop new therapies. Summarise key messages. Students and teacher fill in feedback forms.	10 mins	
Total time:	**60 mins**	

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Materials checklist

Classroom equipment

- Computer with PowerPoint ❑
- Projector and screen, or interactive whiteboard ❑
- Desks arranged for working in small groups of approx 4 ❑

Presentation

- ***CSI: Cell Science Investigators*** PowerPoint slides ❑
- Envelope containing a sheet of paper with the instruction, 'Jump!' ❑

Task 1: Recap on stem cells

- 1 x worksheet per group of students (ideally laminated for re-use) ❑
- 6 x cut-out cell shapes per group of students (ideally on card and laminated for re-use) ❑
- Blue-tak or other quick method for sticking cells onto worksheets ❑

Task 2: What goes wrong in MS?

- 2 x worksheets per group of students ❑

Task 3: Using cells to look for new medicines

- Per group of 4 students:
  - 6-well plate or 6 x small containers ❑
  - 'cell culture' sample: indicator papers made using red cabbage (see task set-up and answer sheet for instructions) ❑
  - Test substances – 1 acid and 4 alkaline household substances, plus water (see task set-up and answer sheet for details) ❑
  - 6 x 1ml pipettes ❑
  - 1 x Beaker ❑
  - 1 x worksheet ❑
  - Gloves and safety goggles ❑

Wrap-up

- ***CSI: Cell science investigators*** feedback forms: teacher and student versions ❑

More information on Multiple Sclerosis

- EuroStemCell information on stem cell research and MS: http://www.eurostemcell.org/faq/what-multiple-sclerosis-and-can-stem-cells-help
- International MS Society Public Information Booklet on Stem Cells (pdf): http://www.eurostemcell.org/files/International_MS_Society_Public_Info_Booklet_on_Stem_Cells_0.pdf
- Young person's guide by the Multiple Sclerosis Trust: http://www.mstrust.org.uk/downloads/young_persons_guide.pdf

Additional activity suggestions

If you have more than an hour available or want to create your own workshop, here are some additional ideas to try out:

Cell protocols: methods for controlling cells

You could use a dressing up task as a fun way to illustrate the concept of cell specialization, aspects of scientific methods and possibly as an introduction to a careers-related discussion. Rather like stem cells, students have the potential to develop into specialists doing different types of jobs, depending on what information and skills they collect, and what influences their choices.

Students work in small groups. One student in each group is the 'stem cell'. Give each group a box containing a selection of clothing items and a description of a job, e.g. teacher, scientist, electrician, plumber. The description should include some key pieces of information about what a person needs to do that job. The group then has to dress their 'stem cell' appropriately. They must nominate a reporter to record each decision and action they take. They must then write up a 'protocol' or method for turning a student into a teacher/scientist/etc, giving enough detail for others to follow their instructions. If you have time, you could also swap the instructions over to see if each group can follow another's instructions correctly and end up with exactly the same result. The group following the instructions could be tasked with identifying any ambiguous instructions. Round up with a class discussion to reflect on what was difficult about the task (e.g could they have dressed their stem cell differently and still matched the information in the job description? How would they test whether they had made the right choices?). Discuss the importance in stem cell research of detailed observation, recording and testing to create a protocol that can be successfully repeated by others. You could also discuss research careers.

Chemistry extension

If the class chemistry teacher would like to follow up on how the colour change works in the experiment in this lesson, the BBC has two short video clips and a lesson plan on red cabbage and pH: http://www.bbc.co.uk/schools/teachers/bang/videos/lesson1_red_cabbage_indicator.shtml

Stem cell concepts

Don't forget our ***Discover stem cells*** lesson is designed to introduce basic stem cell concepts before you tackle ***Cell science investigators***. We also have a whole host of other resources and activities on stem cells in our toolkit. Get ***Discover stem cells*** and explore our other tools here: http://www.eurostemcell.org/toolkititem/discover-stem-cells

Acknowledgements and licensing

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Authors: ***CSI: Cell science investigators*** was created and developed by Emma Kemp and Ian Chambers, MRC Centre for Regenerative Medicine, University of Edinburgh.
Acknowledgements: Shona Reid, her colleagues and students at the James Young High School, Livingston, Scotland, participated in pilots and offered helpful advice and feedback. Gianvito Martino of the Division of Neuroscience, San Raffaele Hospital, Milan reviewed information about MS.
Picture credits: Sources of illustrations and images are given where the image appears. Where diagrams do not have a source identified, they were created by Emma Kemp for EuroStemCell.

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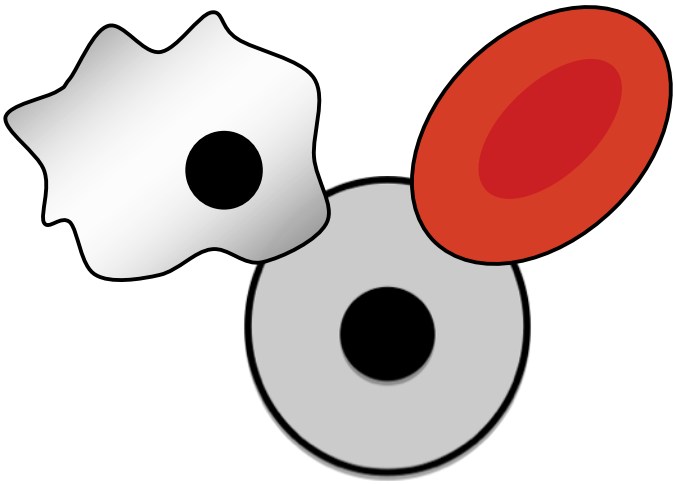
Recap on stem cells



A quick starter activity. Students work in groups to stick cells onto a worksheet in the correct positions to create a diagram showing the two key properties of stem cells: self-renewal and differentiation.

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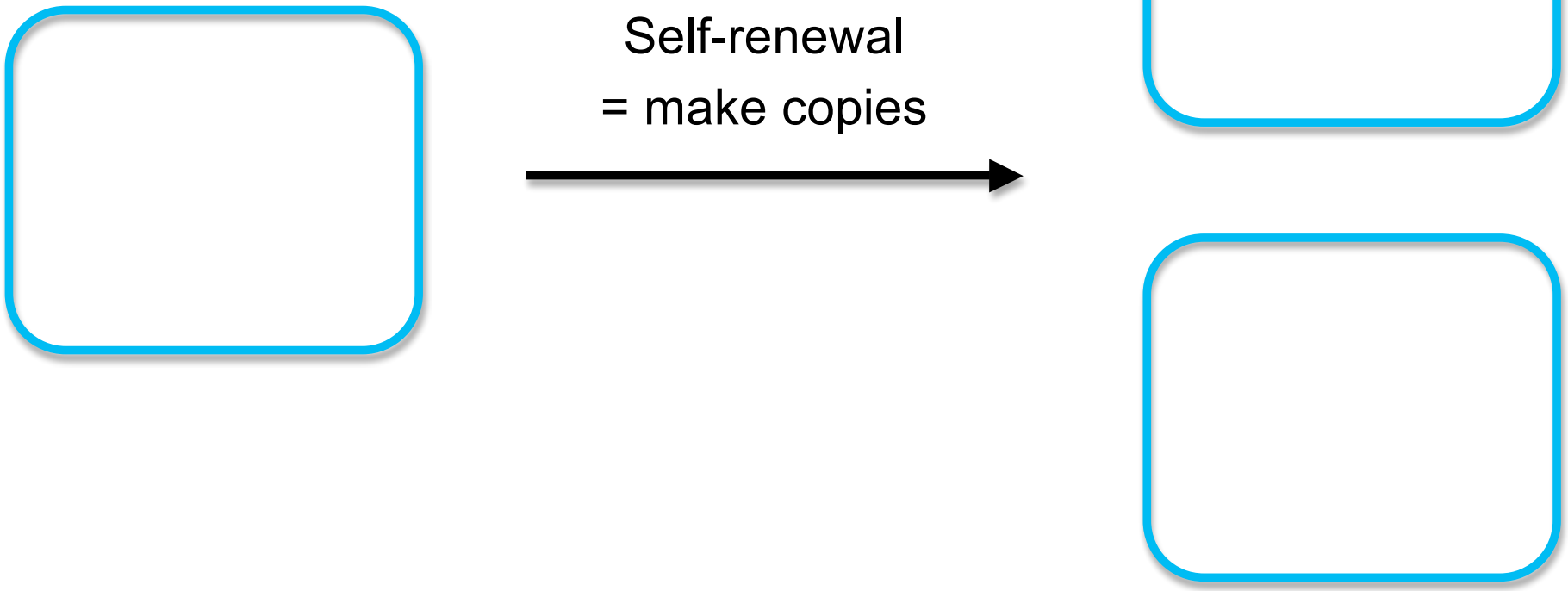
What can stem cells do?



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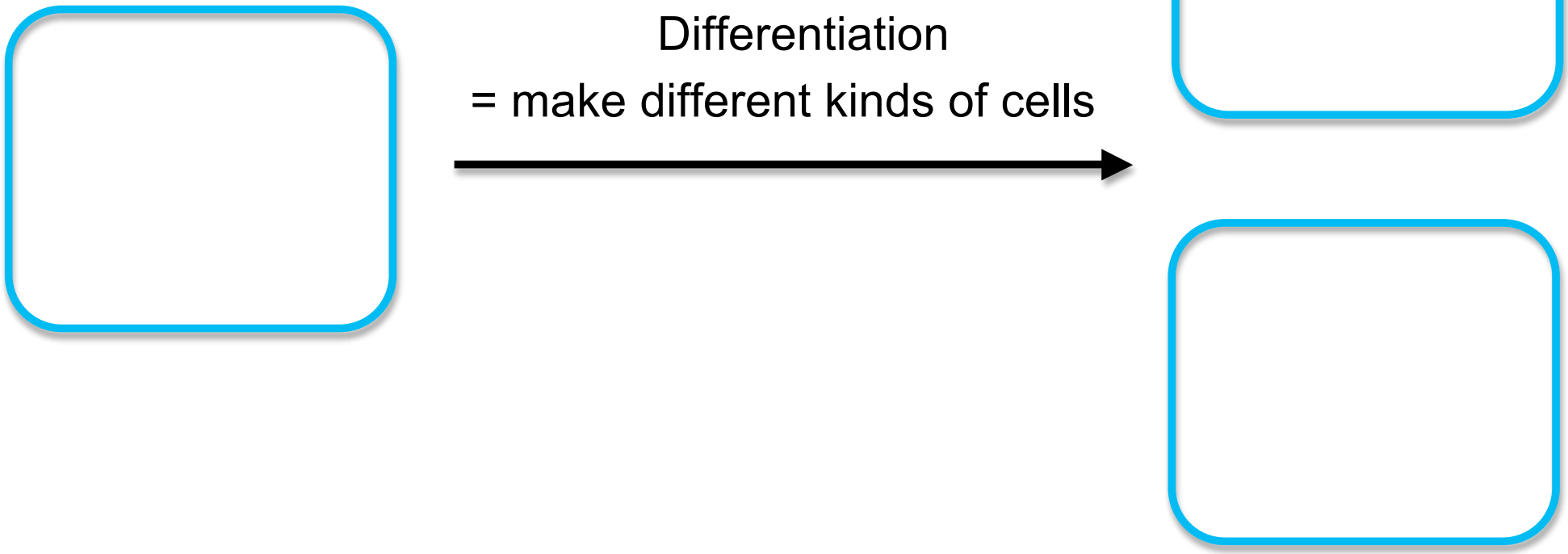
What can stem cells do?



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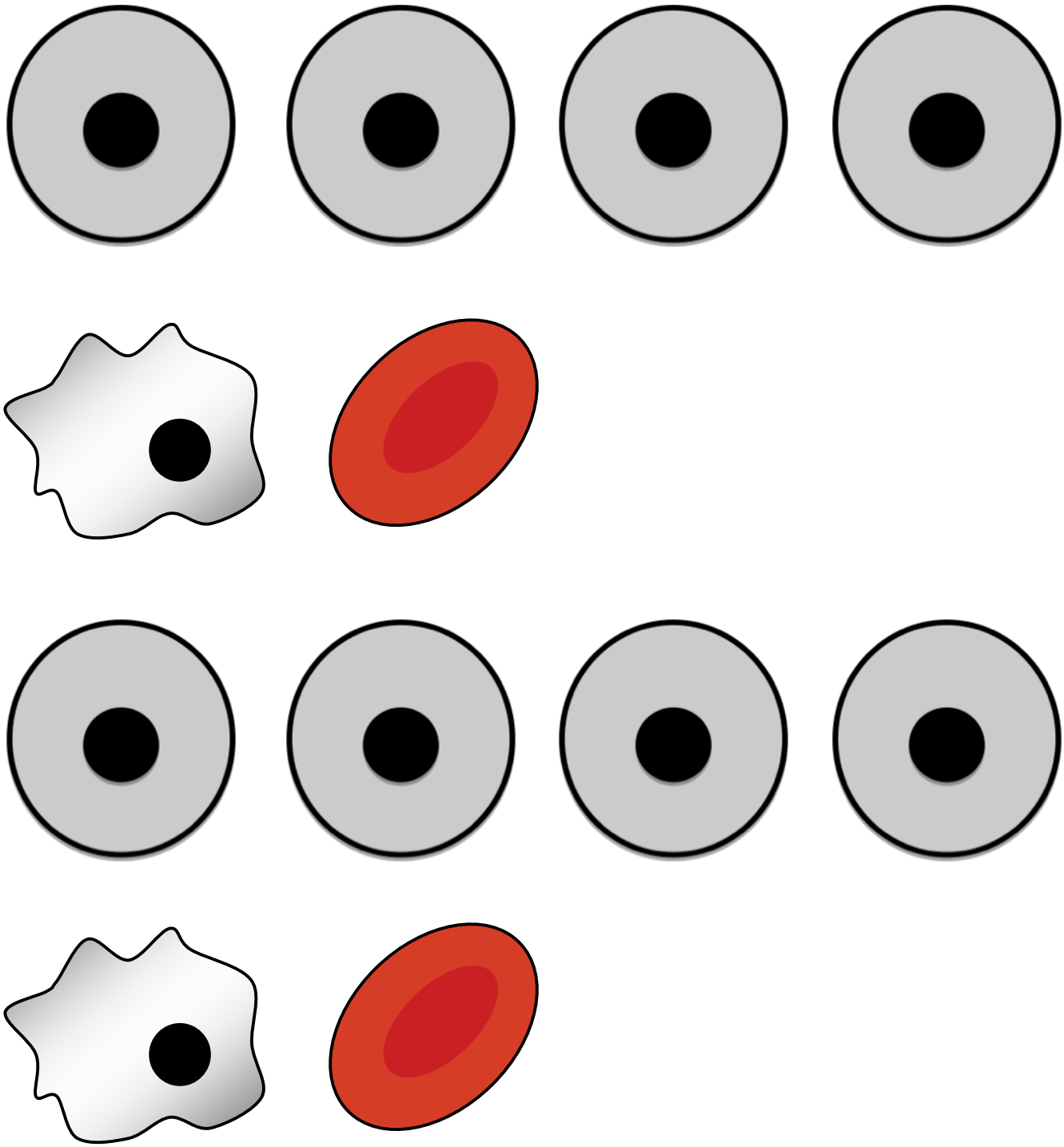
What can stem cells do? Cells to cut out

The cells below are sufficient for one class of students divided into six small groups (four or 5 students per group). Each group needs four round stem cells and two specialised blood cells.



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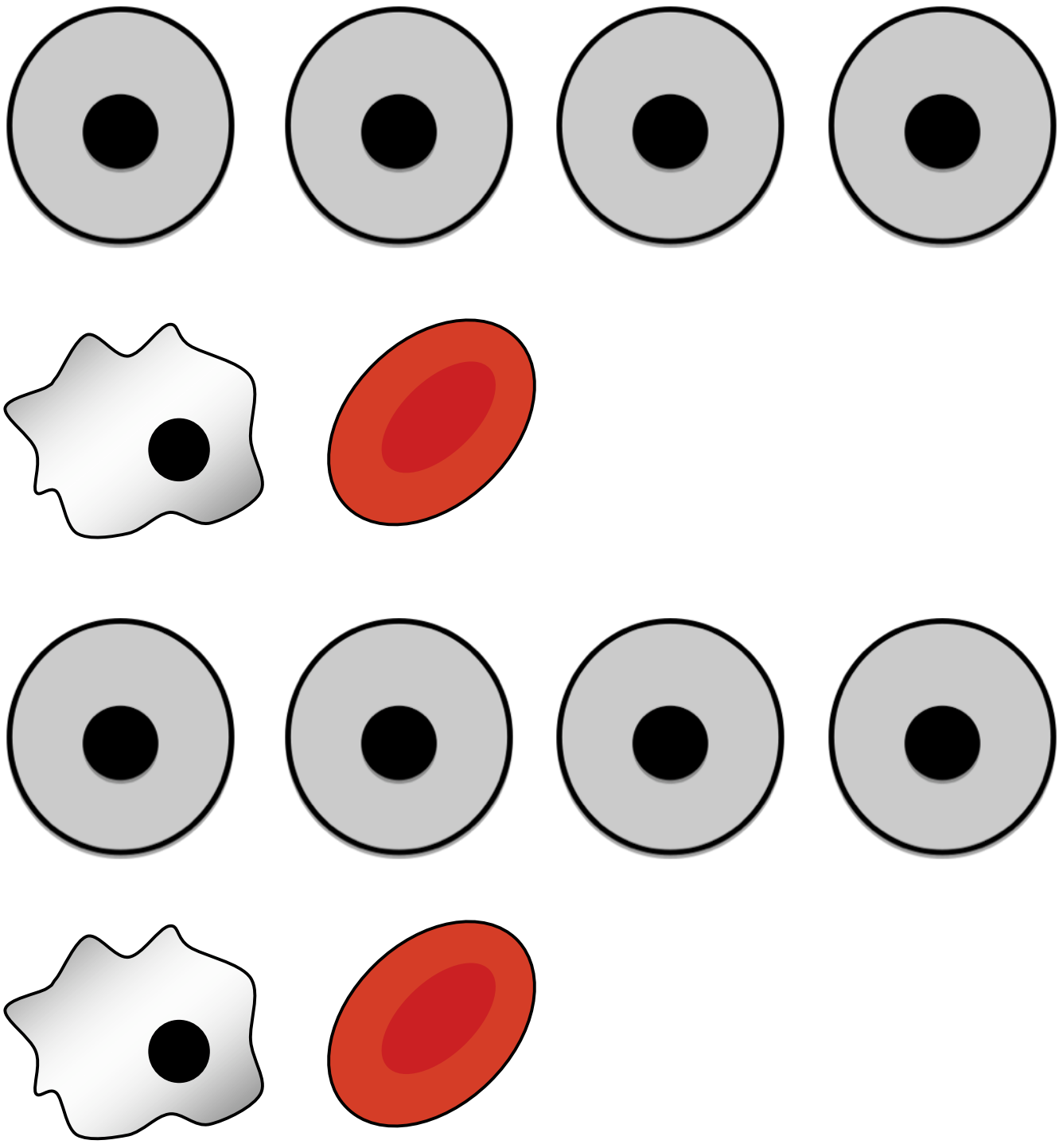
What can stem cells do? Cells to cut out



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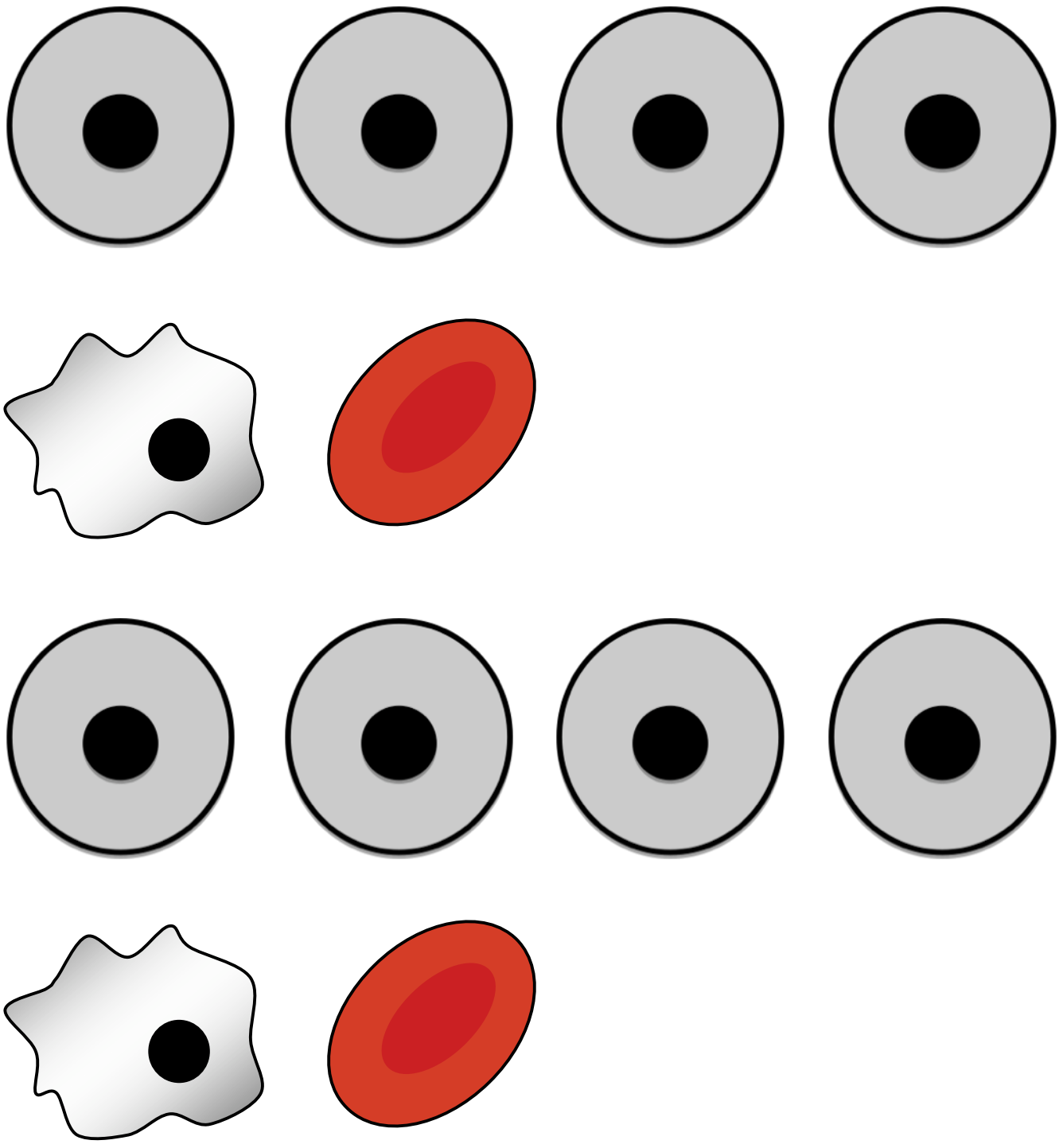
What can stem cells do? Cells to cut out



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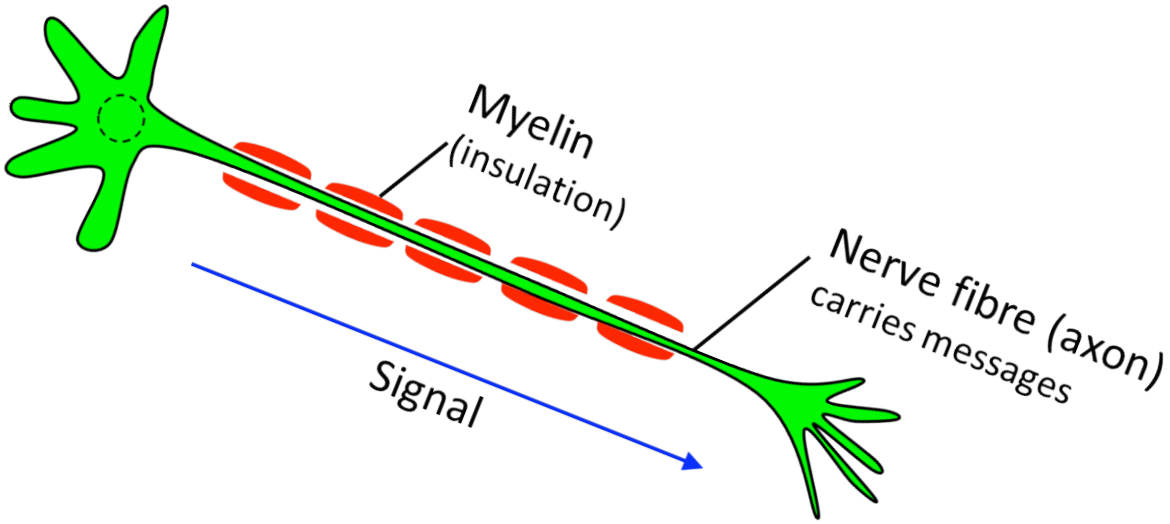
What goes wrong in MS?



Students work in groups to examine diagrams of nerve cells, determine the problems with MS-affected cells and apply that knowledge to looking at real nerve cell images.

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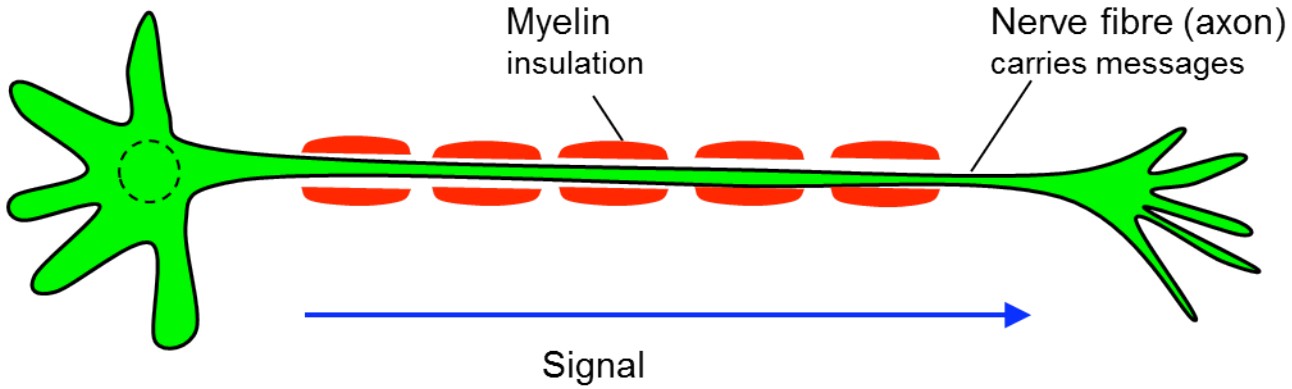
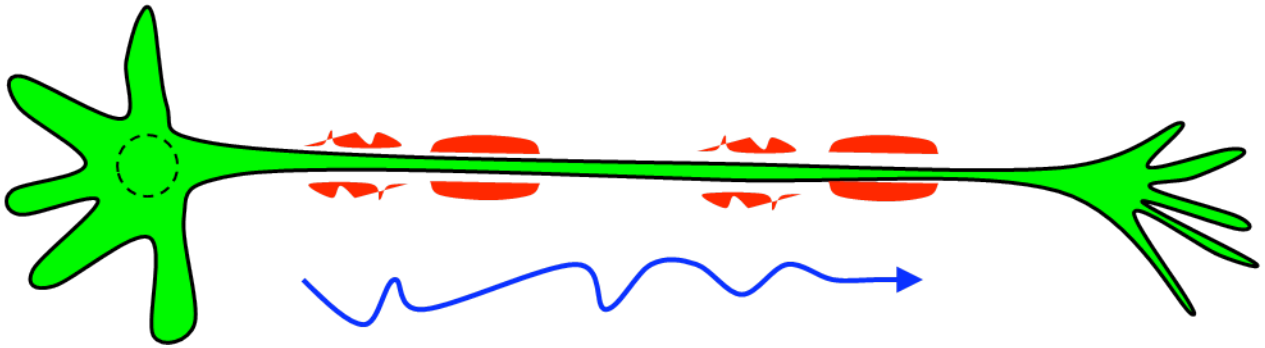
What goes wrong in MS?



Healthy nerve

This nerve cell can carry a signal very fast



What has gone wrong?

Label the problems on this damaged nerve

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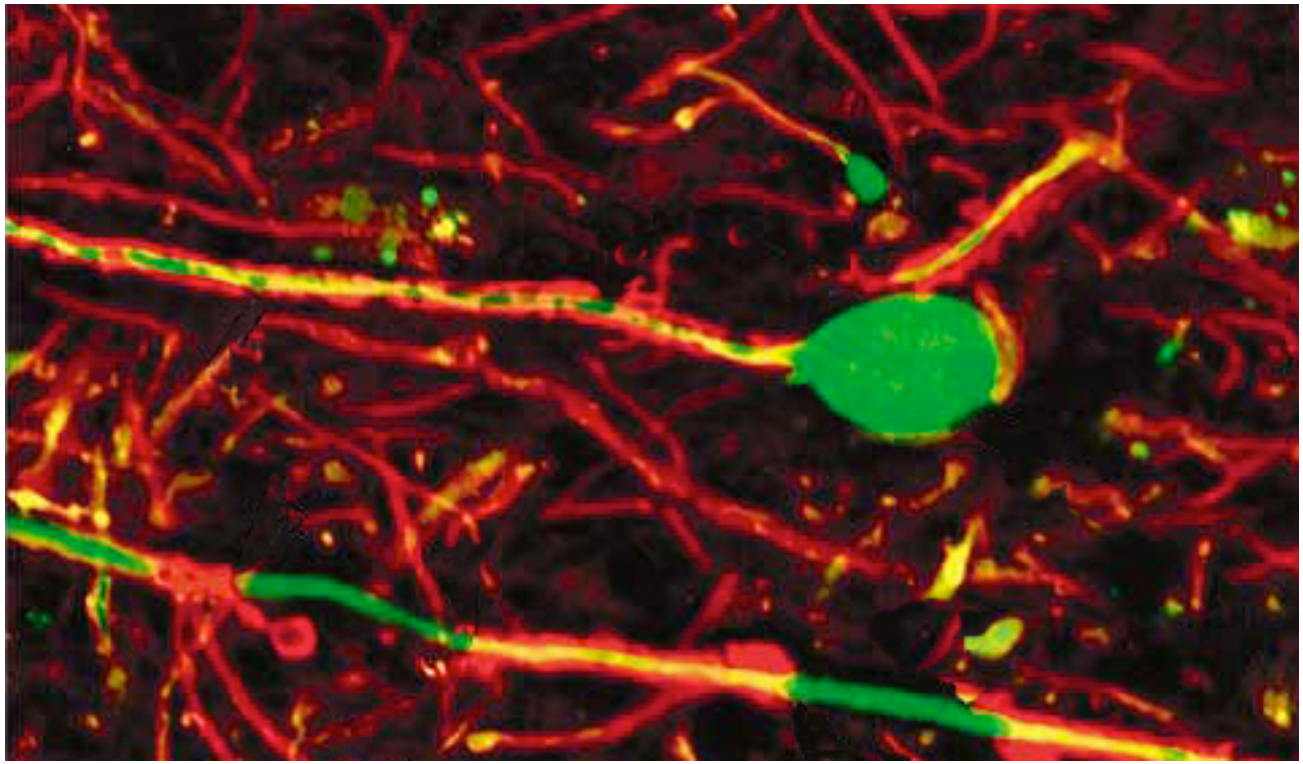
What goes wrong in MS?



Has this patient got MS?

Red = myelin

Green = nerve

Yellow = nerve + myelin

Image reproduced with permission from Bruce D. Trapp, Ph.D., John Peterson, B.S., Richard M. Ransohoff, M.D., Richard Rudick, M.D., Sverre Mörk, M.D., Ph.D., and Lars Bö, M.D. *Axonal Transection in the Lesions of Multiple Sclerosis*, N Engl J Med 1998; 338:278-285: http://www.nejm.org/toc/nejm/338/5/

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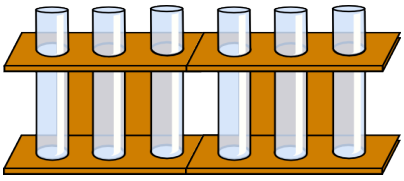
Using cells to look for new medicines



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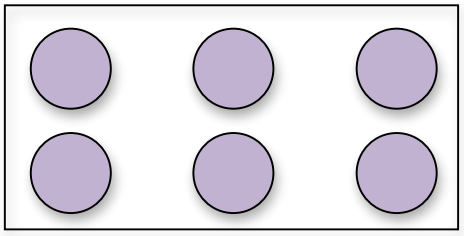

Substances to test

Model cell samples

An experiment in which students test five substances to identify one that could be sent for further research as a possible new MS medicine.

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Using cells to look for new medicines SET-UP AND ANSWERS

Equipment

Each group of 4 students will need a box containing:

- 1 x worksheet
- 1 x 6-well plate or 6 x small shallow containers for 'cell culture' samples
- 6 x 'cell culture' samples: indicator papers made by soaking filter paper in red cabbage juice (see below)
- Test substances in tubes labeled A to E:
    - 3 x alkaline household substances labeled A, C and E (e.g. liquid soap, surface cleaner, washing powder solution)
    - 1 x acid household substance labeled D (e.g. vinegar or flat lemonade)
    - Water in a tube labeled B
- 1 x labeled tube of water
- 6 x 1ml pipettes
- 1 x beaker
- Gloves and safety goggles

Preparation: making the indicator papers

Red cabbage juice can be used as a pH indicator. It is red at around pH 1-3, purple at pH 6-7, blue at pH 8-10 and green above pH 10.

Take one whole red cabbage and cut it into slices. Place in a pan and pour in enough water to cover the cabbage. Boil for half an hour, then turn off the heat and allow to cool to room temperature. Alternatively, pour boiling water onto the cabbage and mix in a blender or mash with a wooden spoon until you have deeply coloured purple liquid.

Cut up some filter paper into round pieces that will fit in the 6-well plates or in the sample containers you are using – make enough for your class(es) plus some spares. Place the papers into your red cabbage juice and leave to soak for approximately half an hour. Remove them from the juice and leave on a clean surface to dry. The papers can be kept in an airtight container for several months before the juice oxidizes and is no longer effective as an indicator.

Cautions

Never use dangerous substances. Do not use strong acids or bases. Do not put test substances in containers for food use (e.g. cups, juice bottles) because they could be mistaken for food or drink. Ensure all substances and containers are clearly labeled so that you can identify them. Students must wear safety goggles. Protective gloves are not essential for safety when using the substances suggested here, but students often enjoy the novelty of wearing them. If using gloves, do not use latex gloves. At the end of the experiment, empty and wash the beakers. Throw away used gloves and pipettes. Place the containers of any leftover substances you want to keep in a suitable place, out of reach of children and clearly labeled, with any hazards identified. A teacher should always be present during the experiment and you should carry out your own risk assessment before the lesson.

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Using cells to look for new medicines SET-UP AND ANSWERS

Method

Students should plan their own experiment using the worksheet provided. The aim is to test the substances A to E on their 'cells' (indicator papers) and use the results to select a substance for further research as a potential new medicine. Encourage students to think about making their experiment accurate and a fair test by:

- Using the same amount of each solution
- Using the water as a control. Note that they may not be familiar with the word 'control' but they do usually learn about 'fair tests'.
- Using a different pipette for each solution

Students may not be familiar with how to use pipettes to measure out solutions.

Colour changes

Cabbage indicator goes red at around pH 1-3, is purple around pH 6-7, blue at pH 8-10 and green above pH 10. Students are told:

✔ Red = myelin.
Your drug is helping the nerve cells.

✗ Green = bare nerve.
Your drug is damaging the myelin.

Results

Test solution	Substance	Expected colour
A	Liquid soap	Green
B	Water	No change (purple)
C	Dettol (or equivalent) surface cleaner	Green
D	Vinegar or lemonade	Red
E	Washing powder solution	Blue/green (changes to yellow if left to stand)
Water (control)	Water	No change

Conclusion

Students should select substance D for further research. Emphasise that much more research would be needed before this could be used as a medicine for patients.

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Using cells to look for medicines

Method

Plan and carry out an experiment to decide which substance might make a good medicine and should go for more research.

In your kit, you have:

- 5 substances to test
- A tray of nerve cells grown from stem cells in the lab
- Some water. Think about how you could use this to help make your experiment a fair test.

How will you know what works?

Look for a colour change:

✔ Red = myelin. This means the test substance is helping the nerve cells.

✗ Green = bare nerve. This means the test substance is damaging the myelin.

Method

Write down what you are going to do in your experiment in the box below.

Now turn over and record your results.

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Results

Test substance	Colour of cells after adding test substance
A	
B	
C	
D	
E	
Water	

Conclusion

We think test substance _____ should be researched more because

_____.

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Feedback forms

?

Forms to help you gather feedback on how the lesson went.

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Feedback form: students

12–14

1. Did you enjoy the lesson?

- ❑ I enjoyed it a lot
- ❑ I enjoyed most bits of it
- ❑ I did not like some of it
- ❑ I did not like any of it

2. Which part(s) of the lesson did you LIKE? Why?

3. Which part(s) of the lesson did you DISLIKE? Why?

4. How much did you learn in the lesson?

- ❑ I learned a lot of new things
- ❑ I learned quite a few new things
- ❑ I did not learn much
- ❑ I did not learn anything

5. Try to write down 2 things you learnt during the lesson.

6. What should we change to make the lesson more interesting?

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Feedback form: students

12–14

Circle the correct answers to the questions below.

1. What is a stem cell?

- A cell that can make copies of itself AND make different types of cell — A
- A cell that helps to fight against infections — B
- A cell that is specialized — C
- A cell that can produce all the cell types of the body — D

2. What do nerve cells do in your body?

- Keep you warm — A
- Give you blurred vision — B
- Help you grow — C
- Carry signals around your body — D

3. Multiple sclerosis is a disease that…

- Damages nerve cells — A
- Can be cured now — B
- Only harms very young children — C
- Damages the skin — D

4. Stem cells can be used to make specialized cells like nerve cells in the lab. This means scientists could use stem cells to help treat diseases by…

- Studying cells in the lab to understand how diseases work — A
- Testing new medicines on cells — B
- Making cells to give to patients to replace their damaged cells — C
- All of the above — D

5. What diseases are stem cells used to treat now?

- Nothing, there are no stem cell treatments yet — A
- All diseases can be cured with stem cells — B
- Some blood diseases, burns and eye damage — C
- None of the above — D

Thank you for your help. We hope you enjoyed the lesson.

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Feedback form: teachers

12–14

1. Which class(es) did you observe?

2. How would you describe the level of engagement of the students in comparison to their usual engagement level in lessons?

- ❑ Majority of students more engaged than usual
- ❑ A few students more engaged than usual
- ❑ Students all at their usual engagement level
- ❑ A few students less engaged than usual
- ❑ Majority of students less engaged than usual

3. Was the content pitched appropriately for the age and ability of the students?
If some parts of the lesson were more appropriate than others, please explain which parts were problematic and why.

4. We combined different formats of delivery. Was the balance of activity types appropriate? If not, what should be changed?

5. Was the content well matched to curriculum goals? If not, what should be changed?

Please turn over

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Feedback form: teachers

12–14

6. Would you consider repeating the visit, or suggesting to colleagues that they organise a similar event? Why/Why not?

7. Any other comments or suggestions for improvement of today's activities?

8. We want to make some downloadable educational resources on stem cells and regenerative medicine. Would you use today's resources yourself, or what would you prefer instead?

9. Do you look for teaching resources online, and if so, are there any particular sites or resources that you like ? (on any topic, not only stem cells)

Thank you for your time. Your comments will help us develop our activities and provide guidance for other scientists who wish to visit schools.

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