21st Century BioChallenges

FACILITATOR GUIDANCE NOTES

Royal Society of Biology

21st BioChallenges

BIOCHEMICAL SOCIETY

CONTENTS

ABOUT this pack

The Royal Society of Biology and the Biochemical Society have put together this activity pack around the themes of health and food security. Our aim is to provide opportunities to share exciting cutting edge science with a wide audience, while also giving the public the chance to discuss and debate the ethical and social challenges it poses. We hope these activities enable you to place current research in to context in a fun and engaging way.

Ten activities

This booklet contains guidance notes for 10 activities to be used at science fairs; many also have suggestions for how they could be used in a workshop or classroom setting. The required kit for all activities can be found in the 21st Century BioChallenges box.

Five topics

There are five topics, each with two activities – one for over 12s and one for under 12s. These age groups are just a guide; the complexity of all activities can be varied depending on the expertise and confidence of both facilitators and participants.

Storytelling

Storytelling is key! Each activity has guidance notes for setting the scene; these narratives can be embellished as much as you wish. During trialling, we found that ice-breaker questions work well when introducing activities. A few are included in the notes, but feel free to try out your own introductory spiel. Think about the age and background of participant(s) and how they will relate to the topic. The best way to find out what works is to try out a few different ways and gauge from participant responses which work.

Preparation

There is some background science provided for each, but it is important that you first familarise yourself with the activities. It will give you greater confidence when delivering each activity.

Competition

Where possible, try to incorporate a competitive element. For example, the whiteboards (or perhaps a large flip chart) could be used to keep a participant leader board. Encouraging the use of team names is also fun. Small prizes, such as the branded pens included in the box, or sweets, could be used as an incentive.

Also included is a competition form. This can be a useful way of keeping momentum throughout the day, and an easy tool with which to quantify how many participants use an activity.

ANTIBIOTICS 1: Antibiotic resistance

SUGGESTED AGE: under 12

TIME: 10 mins

SET UP: Moderate; reagents are already made up, but you will need to add water and food colouring to make the 'urine' samples.

SYNOPSIS: Participants test 'urine' samples for a bacterial infection, prescribe a course of antibiotics, and then test the same patient's samples at daily intervals during the course.

The aim is for participants to understand that antibiotics treat bacterial infections, and that not taking the full course can result in antibiotic resistance.

You will need

- 1 x dropper bottle with 'urine' sample, labelled 'Patient X'
- 1 x dropper bottle with reagent, labelled 'Bacteria Test'
- 5 x universal pots with glucose solutions, labelled 'Day 2', 'Day 4', 'Day 6', 'Day 10' and '2nd Course'
- Stirrer
- Infection reference chart
- Filter papers
- Glucose test strips (note: throughout the activity, you are pretending to test for bacteria in urine, so don't show participants the packaging and don't refer to these as 'glucose' test srips)
- Plain white paper
- Lab coat, goggles and gloves
- Blue roll
- Bin and/or bin bags

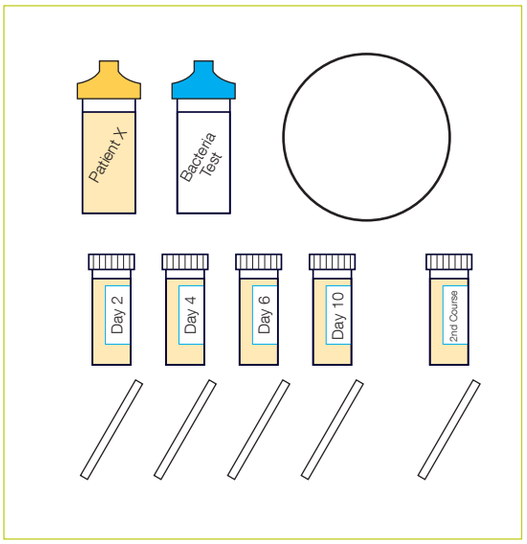
Setting up

Make sure there is enough space to lay everything out without getting knocked over or spilled. You will need some blue roll and a bin bag or bin nearby to mop up any spillages and dispose of used filter papers and test strips.

You should wear a lab coat, gloves and goggles, and have spares nearby for the volunteer to wear.

Place the *infection reference chart*, urine sample pots, reagents, filter papers and glucose test strips on the workstation.

Be aware that the Bacteria Test solution contains 1 mol HCl [LOW HAZARD].



Running the activity

Invite participants to test urine samples for bacterial infections. Once you have a volunteer, provide them with a lab coat, goggles and gloves. Set the scene, for example:

You are a scientist in a hospital lab and have to work out if this patient has a bacterial infection. How can we investigate whether a patient has an infection? What samples can we take from a patient? Blood, urine, faeces, saliva. Introduce the idea that biological samples are useful. You could use major sporting events, such as the Olympics, as an example of testing biological samples.

Explain that they will use a spot test to check whether the patient has an infection – they add a reagent to the urine and see if there is a colour change.

Part 1

Guide the participant through these steps:

1. Add one drop of Patient X's 'urine' onto a piece of filter paper.

2. Add one drop of the Bacteria Test reagent.

3. Look for a colour change.

Note: they should use just one drop of each – you may need to show them how to add liquids dropwise.

There should be a colour change. Explain that this means the patient has an infection in their urine.

Ask them to use the *infection reference chart* to work out what infection the patient has, and what antibiotic will treat it.

Part 2

Explain that the patient was given a 10 day course of antibiotics (he was told to take two tablets every day for 10 days). He provided urine samples during that time.

Show them the samples, labelled Day 2, Day 4, Day 6 and Day 10.

Guide the participant through these steps:

1. Dip a glucose test strip into Day 2. Lay it on a piece of white paper.

2. Repeat for Day 4, using a different glucose test strip. Place it on the paper next to Day 2.

3. Repeat for Day 6 and Day 10, using a different glucose test strip each time.

4. Compare the four glucose test strips.

Talk through the results, inviting questions and suggestions as you go:

The colour change should be light green in Day 2 – this indicates a high level of bacteria in the urine. The colour change should be darker green in Day 4 and darker still in Day 6 – this indicates that there is less bacteria present, so the antibiotic is working. But at Day 10, the colour change is light green again, as it was in the beginning. Why?

Explain that, after Day 6, the patient stopped taking antibiotics because they felt better. However, the bacteria weren't all gone – they started to multiply and, by Day 10, he felt ill again.

The doctor prescribed another course of antibiotics but, a week later, the patient still felt ill so gave another urine sample. Show participants a fifth urine sample, labelled '2nd Course'. Perform the indicator strip test – it should turn light green, as in Days 2 and 10. Explain that, even though the patient started taking antibiotics again, the medicine didn't work anymore. Why? Because the bacteria has learnt how to fight off the antibiotics by changing its DNA. This is why it's really important we take a full course of antibiotics to prevent the bacteria learning how to do this.

Hints, tips and extension

Young participants may be easily distracted! You may need to ask them to put their equipment down before you explain the next step, in order to maintain their attention. The more you can make of the story, the more your participants will engage with the activity. Detecting urine in bacteria will most commonly be for urinary tract, bladder or kidney infections. Blood is more commonly used for detecting systemic infections. A photo or model may be useful to show where, for example, the kidneys are located. Don't be afraid to ask questions of your participants! Some may be more willing to answer than others, so it's best not to put any shy people on the spot. In a classroom situation, consider involving all the students in the testing, both with the initial urine test and with the week-by-week urine test.

Some background science

Antibiotic resistance remains one of the biggest biological challenges of the 21st century. Globally, antibiotic resistance is a prominent issue in politics and research, and the subject has recently received more attention in the press. Antibiotics work by killing bacteria. As they divide and grow, bacteria often make mistakes in copying their DNA. These mistakes are called mutations and can cause bacteria to become resistant to antibiotics. Antibiotic use selects for resistance in several species of bacteria at the same time because the drug affects both harmful and helpful species. While most are killed off, the mutated bacteria survive and grow unchecked. Numerous strains are now resistant to antibiotics; some *Staphylococcus aureus* strains (most commonly cause skin infections) are resistant to methicillin and some *Neisseria gonorrhoeae* (gonorrhoea – causing bacteria) strains are resistant to sulfonilamides, tetracyclines, penicillin and fluoroquinalones. The pharmaceutical industry has not been successful at introducing new antibiotics for the past 30 years, but recent research breakthroughs are uncovering new mechanisms of targeting bacterial growth and delaying resistance – perhaps even avoiding it altogether.

More information

- www.nhs.uk/Conditions/Antibiotics-penicillins/Pages/Introduction.aspx
- www.cdc.gov/drugresistance
- www.who.int/topics/drug_resistance

About the urine and reagents

Urine samples and reagents have been made up for you. If more are needed, these are the solutions:

- Patient X's urine sample: 100 cm^3 water + ~50 drops of methyl orange indicator solution*
- Bacteria Test reagent: 100 cm^3 1 mol dm^{-3} hydrochloric acid
- Days 2 and 8, and 2nd Course urine: 20 µg glucose solution (glucose powder dissolved in water)
- Day 4 urine: 150 µg glucose solution
- Day 6 urine: 1000 µg glucose solution
- For all urine samples, add ~1 drop of yellow food colouring to make the solution look like urine

The first two will need to made up in a laboratory, but the glucose solutions could be made in bulk using approximate amounts and a little trial and error.

If making up new solutions, ensure you carry out a risk assessment first.

**Exact quantity of methyl orange indicator solution will depend on concentration used. A 0.04% solution required ~50 drops to give an obvious red colour upon contact with HCl. Allow time for some trial and error before commencing the activities if using alternative methyl orange solutions. You may need to top up the indicator solution, as it has been known to 'go off'.*

ANTIBIOTICS 2: Combining antibiotics

SUGGESTED AGE: over 12
TIME: 15 mins
SET UP: Simple

SYNOPSIS: Participants play a demonstrator-led game about bacteria and antibiotics, using individual whiteboards and board pens. The aim is for participants to understand that, sometimes, several antibiotics are needed to treat bacterial infections, and that not taking the full course of antibiotics can lead to resistance.

You will need

- Four A4 laminate strut cards (to be used as whiteboards)
- Four whiteboard pens of various colours
- One black or brown whiteboard pen
- Four pieces of blue roll

Setting up

Make sure there is enough space for four volunteers to each hold a whiteboard, and make it clearly visible to other participants and people watching.

Running the activity

What is an infection? How can people get an infection? What medicine can treat bacterial infections? These questions can be used to get a captive audience thinking, or to get the attention of passers-by. Enlist a few participants to play the bacteria game with you. You need a minimum of four participants, but it will suit larger groups as well. Ask for four volunteers. Give each vounteer a whiteboard, a different coloured pen and a piece of blue roll.

Set the scene

Imagine there's a patient (ask for a name which you can use throughout) who isn't very well. He comes into hospital and the doctor suspects he has a bacterial infection. It's important to stress here that antibiotics – the medicines which treat bacterial infections – are tightly controlled by hospital scientists. Doctors have to make strong cases for using antibiotics, and they will only be given out when strictly necessary. (This is due to antibiotic resistance, which you may/may not wish to mention at this stage.)

Establishing the game

On arriving at the hospital, the patient is tested for bacteria. Instruct the four volunteers to each draw three dots on their boards (they need to be large, clear dots but with enough room to add more).

The dots represent bacteria; different colours represent different types of bacteria.

The volunteers' blue roll represent the antibiotic that can treat the type of bacteria on their board.

Explain that the test reveals four different types of bacteria that could be causing the patient's symptoms. The doctor treats the patient with ONE type of antibiotic, every day for one week. She has a choice of four antibiotics; each antibiotic treats one type of bacteria. Choose one volunteer to use their antibiotic.

Week 1's test results are in!

Depending on which antibiotic was selected, ask the volunteer to wipe off one dot from their board. Tell the other volunteers to double the number of dots on their boards. Explain that, although the antibiotic has started to treat one type of bacteria, the other types have had time to multiply.

Increasing the dose

The patient is feeling worse! The doctor decides to try a different antibiotic and to double the dose. Choose a different volunteer to use their antibiotic.

Week 2's test results are in!

Depending on which antibiotic was selected, wipe off HALF the dots from the appropriate board, but again double the dots on the rest of the boards.

Combining antibiotics

Explain that the doctor is now rather concerned. After talking with the hospital scientists, she decides to use a combination of antibiotics to treat the patient – she gives all four antibiotics every day for one week. (Note: you could ask participants for suggestions about what the doctor should do, and lead them to the idea of combining antibiotics.)

Week 3's test results are in!

Ask the volunteers to wipe off all but one dot from each of the four boards. Success.

Explain that the patient feels so much better, he leaves hospital. He is given another week's dose of the combined antibiotics, with instructions to take them every day.

Non-compliance and antibiotic resistance

A few weeks later, the patient is back in hospital – feeling more ill than ever! (You could ask why this might be, or wait until the next stage of the activity.) The doctor ran another test.

New test results are in!

Ask three of the volunteers to wipe off their remaining dots and put away their boards and blue roll. Their bacteria have been successfully eradicated.

Then, using the black/brown pen, colour over the fourth volunteer's remaining dot and add five or more black/brown dots.

Explain that, since the patient felt better, he didn't take his last week of tablets.

Three types of bacteria were – fortunately – killed off. But the fourth strain changed – the bacteria mutated against the antiobiotic and became immune to it.

Take away the remaining volunteer's blue roll. Explain that the patient took his tablets a few days later, but it was too late. They didn't work anymore. The bacteria had become RESISTANT to the antibiotics.

Ask participants why they think hospital scientists control the use of antibiotics so tightly (to minimise resistance, made worse by cases such as our patient).

We don't yet have many effective ways of treating antibiotic resistance.

Discussion

Reinforce the following concepts:

- Certain antibiotics treat certain bacteria and many antibiotics treat more than one type of bacteria.
- Some infections involve more than one type of bacteria, and need to be treated by combining antibiotics.
- Bacteria exposed to antibiotics, but not sufficiently treated, can become resistant to the medicine.

Hints, tips and extension

There is a great deal of flexibility and numerous scenarios that could be played out here, depending on the knowledge and confidence of both the facilitator and volunteers. If you have a good knowledge of this topic, feel free to play around with scenarios as you see fit.

Depending on the knowledge level of volunteers and other partcipants, you can explain that bacterial DNA randomly mutates, and therefore evade the action of the antibiotic. It is a bit of a crude simplification to say that bacteria *learn* to avoid antibiotic treatment, but the concept of DNA and mutation may not necessarily be familiar to this age group.

Some background science

Antibiotic resistance remains one of the biggest biological challenges of the 21st century. Globally, antibiotic resistance is a prominent issue in politics and research, and the subject has recently received more attention in the press. Antibiotics work by killing bacteria. As they divide and grow, bacteria often make mistakes in copying their DNA. These mistakes are called mutations and can cause bacteria to become resistant to antibiotics. Antibiotic use selects for resistance in several species of bacteria at the same time because the drug affects both harmful and helpful species. While most are killed off, the mutated bacteria survive and grow unchecked. Numerous strains are now resistant to antibiotics; some *Staphylococcus aureus* strains (most commonly cause skin infections) are resistant to methicillin and some *Neisseria gonorrhoeae* (gonorrhoea causing bacteria) strains are resistant to sulfonilamides, tetracyclines, penicillin and fluoroquinalones. The pharmaceutical industry has not been successful at introducing new antibiotics for the past 30 years, but recent research breakthroughs are uncovering new mechanisms of targeting bacterial growth and delaying resistance – perhaps even avoiding it altogether.

More information

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- www.cdc.gov/drugresistance
- www.who.int/topics/drug_resistance

CANCER AND OTHER DISEASES 1: DNA whispers

SUGGESTED AGE: under 12

TIME: 10 mins

SET UP: Simple

SYNOPSIS: Participants play a game to learn about DNA replication errors. The aim is for participants to understand that mistakes can occur when DNA is being made, and that these mistakes sometimes cause cancer.

You will need

- Pen and paper
- Whiteboard or flip chart and whiteboard pen

Setting up

You'll need enough space for a few participants (at least five, preferably 10 or more) to stand comfortably in a semi-circle or line.

Write three sentences onto three pieces of paper. For example:

1. DNA is a chemical in our cells
2. DNA tells our bodies what to do
3. Everyone's DNA is different

Note: you could choose to use different sentences, or ask volunteers to come up with their own. The sentences could be about anything – but simple sentences about DNA may help with the explanations later, and might introduce some new vocabulary to the participants. You could use different expressions for 'cell' and 'DNA', such as 'tiny body compartments' or 'your own personal instructions that tell your body how to grow and what you should look like'.

Running the activity

Invite a group of participants to take part. You need at least five, preferably 10 or more people. Arrange participants in a semi-circle or line, depending on space.

Show the first sentence to the participant at one end of the line. Ask them to pass the message on, along the line to the last person. The last person tells the facilitator what they hear, and he/she writes it on the whiteboard.

Repeat with sentences 2 and 3.

You should have three sentences written on the board; they may or may not contain mistakes – it's likely that they will!

Explain that, in the same way the group passed the messages along, a tiny body part inside our cells 'reads' a long chemical message, in order to make DNA. DNA is really important because it tells our bodies what to do – how tall we should grow, what colour our eyes are etc.

If there are mistakes, go back down the line asking each person what they heard, to see if you can discover when the sentence was first misheard (the mistake was made).

Explain that because a mistake was made, you ended up with the wrong message written on the board (reassure participants that it's fine if they make a mistake – in fact, that's what the activity is all about!) Just as some people misheard, so the body can sometimes misread the individual letters that make up the chemical message during DNA production. Normally, the body is very good at spotting any mistakes and correcting them. But, sometimes, mistakes can get through. Misreading the chemical message means that faulty DNA is made. People with faulty DNA are more likely to get ill in the future so they need special attention from their doctor. Depending on the age/level of participants, you could specify some types of illness (cancers, other genetic abnormalities, and so on).

Hints, tips and extension

The messages above are just an idea to get you started. Depending on the knowledge/literacy level of the group, you can make the messages easier or harder as you see fit. Remember, some of your participants may be very young!

This is easy to replicate in the classroom. You could make it a competition – how many words can you add to the message before a mistake is made?

Some background science

Cancer is caused by the uncontrolled growth of cells containing damaged DNA. One of the reasons it's so difficult to treat is because many established methods of killing cancer cells can severely injure normal cells too. So finding new and more targeted treatments for cancer is one of the biggest biomedical challenges in the UK currently. We're now at a stage where as many people survive cancer (for at least 10 years) as die from it, but with around 200 different types of cancer, there's still a lot more research to be done.

More information

- www.macmillan.org.uk/Cancerinformation/Cancertreatment/Treatmenttypes/Treatmenttypes.aspx
- www.bbc.co.uk/science/0/22028516

CANCER AND OTHER DISEASES 2: Urine test diagnoses

SUGGESTED AGE: over 12

TIME: 10 mins

SET UP: Simple

SYNOPSIS: Participants observe chemical reactions in 'urine' and determine their significance from a reference chart. The aim is for participants to undertake a short practical exercise that mimics the basis of chemical diagnostic testing. Participants will carry out spot tests, and should appreciate that multiple tests may be required for differential diagnoses where disease symptoms overlap.

You will need

- 4 x dropper bottles with reagents, labelled W, X, Y and Z
- 4 x dropper bottles with 'urine' samples, labelled U1, U2, U3 and U4
- Urine test template on A4 tray
- Disease reference chart
- Lab coats, goggles and gloves
- Blue roll and bin bag

Setting up

Make sure there is enough space to lay everything out without getting knocked over or spilled. You will need some blue roll and a bin bag or bin nearby to mop up and spillages. You should wear a lab coat, gloves and goggles, and have spares nearby for the volunteer to wear. Place the urine test template and disease reference chart on the workstation and line up all the dropper bottles.

Running the activity

Invite participants to test patient's urine samples and diagnose disease. It's not really urine – but it adds to the theatre if you pretend it's real!

Once you have a volunteer, provide them with a lab coat, gloves and goggles.

Explain that we can find out a lot about a patient's health by analysing the contents of their urine. For example, if a patient is taking medicine, we can identify what this is by analysing breakdown products of the medicine in their urine. Urine colour can tell us how hydrated a patient is and the presence of some molecules can indicate certain illnesses.

Explain that urines U1, U2, U3 and U4 belong to patients who are having a routine check up. It's up to the participant to diagnose what – if anything – is wrong with them.

Guide them through the following steps.

1. Have a look at the four urine samples. Do any of them look unusual? What might this indicate? Have a look at the *disease reference chart* and see if you can predict what disease the patients might have.

   Sample U1 is cloudy; could be a urine infection.

   Sample U2 is dark orange; could be liver disease or dehydration.

Samples U3 and U4 look fairly normal, although one is quite pale and the other quite dark, which might indicated different levels of hydration.

So, just by looking we have some idea about the health of these patients.

But that's not enough for a diagnosis. Let's test the samples…

2. Using the laminated *urine test template*, add one drop each of urine samples U1, U2, U3 and U4 to the relavent boxes for each.

   Explain that reagent W tests for bacteria: no change is positive, change is negative. X tests for high levels of bilirubin: colour change (to red) is positive, no change is negative. Y tests for protein: colour change is positive, no change is negative.

3. Add one drop each of reagents W, X and Y to the three boxes.

4. Observe any changes and use the *disease reference* chart to diagnose disease.

   Sample U1 tests positive for bacteria; the patient is likely have a bacterial infection.

   Sample U2 tests positive for high levels of bilirubin, which suggests problems with the liver – you send the patient to see a specialist.

   Samples U3 and U4 appear to be the same. Explain that the *disease reference chart* indicates that they could have one of two problems: high blood pressure or diabetes, as these both show the presence of protein in the urine.

   So, they will need to carry out an additional test.

   Introduce reagent Z, which tests for glucose (sample turns intense blue/green if glucose is present).

5. Add one drop each of urine samples to the (U3,Z) and (U4,Z) boxes.

6. Add one drop of reagent Z to the (U3,Z) and (U4,Z) boxes.

   Sample U4 tests positive for glucose, so they are likely to have diabetes.

   You suspect high blood pressure for sample U3, so send for further tests.

The full set of spot test results

	U1	U2	U3	U4
W	NO CHANGE	**GREY/WHITE PPT**	**GREY/WHITE PPT**	**GREY/WHITE PPT**
X	NO CHANGE	**RED COLOUR**	NO CHANGE	NO CHANGE
Y	NO CHANGE	NO CHANGE	**TURNS RED/PINK**	**TURNS RED/ ORANGE**
Z			NO CHANGE	**INTENSE BLUE/ GREEN**

Discussion

Explain to participants that this is quite a simple set of chemical tests. In hospitals and research laboratories, a technique called chromatography is often used to detect different components in a patient's sample, even if present in very small quantities.

In reality, lots of different types of tests are available, such as imaging (such as X-ray, CT, PET), electrical (such as ECG, EEG) and physical (such as lung capacity test).

It's not just urine that can be tested either. Blood samples are commonly taken, and sometimes other samples like saliva, tissue (biopsy) or even faeces may be needed.

Depending on time and the knowledge level of participants you could do a quick 'show-of-hands' to see if anyone has heard of X ray, ECG, etc, and if anyone knows how they work.

Hints, tips and extensions

This is a very simple test. In the classroom, students could research and present other types of diagnostic tests, including screening tests for common diseases such as cancer.

In the past, doctors occasionally used a taste test for urine – it might be fun to have an extra 'urine' sample (warm apple juice) which the facilitator drinks from.

Some background science

There are many types of diagnostic test – chemical, electrical, physical, imaging techniques and more form an arsenal of tests used to identify disease in patients. Following successful sequencing of the human genome in the early 21st century, the focus on early stage diagnosis has grown with possibilities for pre-symptom screening according to individuals' disease risks. This expanding field shows particular promise in the management of life threatening diseases such as cancer.

One rapidly expanding method of chemical diagnosis is biomarkers – proteins or other bio-chemicals present in the body, whose presence, in greater or lesser quantity, correlates with certain disease states. From heart conditions to kidney disease, biomarkers are commonplace in the diagnostic tool box. For example, the blood of patients suspected of having an under active thyroid will be checked for levels of thyroid hormones, which can indicate thyroid problems.

More information

- www.macmillan.org.uk
- www.bbc.co.uk/science/0/22028516

About the urine and reagents

Urine samples and reagents have been made up for you. If more are needed, these are the solutions:

- W: 100 cm^3 0.1 mol dm^{-3} silver nitrate solution
- X: 100 cm^3 1% w/v solution of dimethylglyoxime in 95% ethanol
- Y: 100 cm^3 1 mol dm^{-3} hydrochloric acid
- Z: 100 cm^3 0.1 mol dm^{-3} iron(III) chloride solution
- U1: 100 cm^3 water + 2 drops of milk + 1 drop of red food dye + 4 drops of yellow food dye
- U2: 100 cm^3 water + 1 drop of red food dye + 6 drops of yellow food dye + 1 g sodium chloride + 0.2 g nickel sulfate-6-water
- U3: 100 cm^3 water + ~50 drops of methyl orange indicator solution* + 1 g sodium chloride
- U4: 100 cm^3 water + ~50 drops of methyl orange indicator solution*+ 1 g sodium chloride + 0.2 g potassium (or sodium) hexacyanoferrate(II)

These will need to be made up in a laboratory. Ensure you carry out a risk assessment first. You may need to top up the indicator solution (U3 and U4), as it has been known to 'go off'.

EPIGENETICS 1: Kitten conundrums

SUGGESTED AGE: under 12
TIME: 5 mins
SET UP: Simple

SYNOPSIS: Participants complete an outcome quiz called Kitten conundrums. The aim is for participants to understand that environmental factors can affect a cat's genes, and the genes of its kittens.

You will need

- Internet access and a computer, laptop or tablet

Setting up

Ensure this website is loaded: tinyurl.com/kittenquiz

Running the activity

Invite people to take the quiz and provide the scenario: A cat has given birth to a litter of kittens; they are all genetically identical. Your job is to raise one of the kittens, and see how it turns out compared with the others. How will you look after your kitten? What affect could this have on its future generations?

Help participants to get started (and keep a close eye on the computer to ensure it doesn't get stolen or damaged). You could use a tablet and walk around the exhibition, inviting people to take part.

The questions include factors involved in metabolic, as well as epigenetic regulation. Epigenetics is a complex topic (particularly for the under 12s), but it may still be worth discussing the difference between the environmental effects on the kitten, and the possible effects on the kitten's kittens.

Hints, tips and extension

In the classroom, pupils could investigate further what genes are and where they exist in the body. They could have a go at making their own epigenetics quiz, using free software such as www.qzzr.com

Some background science

Epigenetics is the study of the chemical reactions that label our genes to be active or inactive. Active genes produce proteins responsible for carrying out the plethora of genetic instructions within our DNA – what colour to make our eyes, how tall we should be etc. As well as having a genome that is a unique combination of mum's and dad's genes, we all have a unique epigenome which is a set of these gene labels. Because the epigenome controls patterns of gene expression, changes in the epigenome can change how our body interprets genetic instructions without our DNA being effected. Scientists now understand that environmental factors – both within and above our control – can cause changes to both our epigenome and the epigenome of our offspring. Things such as smoking, diet and level of exercise have been shown to alter the chemical reactions responsible for gene labelling.

More information

- www.epigenome.org/index.php
- biochemicalsociety.wordpress.com/2013/01/15/epigenetics-beautiful-science

EPIGENETICS 2: Dice roll choices

SUGGESTED AGE: over 12
TIME: 10 mins
SET UP: Simple

SYNOPSIS: Two participants or teams play a dice-rolling game to see how different identical twins can look throughout their lives, depending on lifestyle choices. The aim is for the participants to understand that environmental factors, such as smoking – brought about by either choice or circumstance – can change the expression of genes in people with the same genetic makeup.

You will need

- Dice
- 2 x twin templates
- Set of Epigenetics choice cards

Setting up

There needs to be enough space for two participants or two small teams to play the game (small teams work best, as they can confer when arranging the cards on the template). Arrange the pack of cards, face down.

Running the activity

Invite two teams to play a dice rolling game to learn about epigenetics.

Give each team a twin template. Ask them to name their twin (it helps to have a name when providing explanations later on).

To play the game, you must ask them five questions (shown below).

After each question, the participants roll the dice. Whichever team rolls the highest number takes the corresponding red card; the other team takes the green card.

The teams place them in the correct box on their template. Depending on the age/ability of the participants, they can work out what the body part is and where it goes, or you can help them.

The five questions

Q1: When your twin turns 15, she is offered a cigarette. Does she smoke it?

Q2: When your twin turns 18, she is offered an alcohol drink at a party. Does she drink it?

Q3: Your twin goes to the gym but, as she enters her 30s, she goes less frequently and enjoys eating out at restaurants. What sort of food does she usually choose?

Q4: When she's 40, your twin goes for a promotion at work; it pays well, but is a really stressful position. Does she get the job?

Q5: As she enters her 70s, your twin finds it harder to be active. Does she sign up to a pensioner's fitness class, or accept that she's getting old and stop exercising altogether?

Once all five questions are asked and the templates are complete, explain that the dice roll (or lifestyle choice) for each question led to a physical consequence, even though their genes are the same. You may wish to go through each question again, explaining how each lifestytle choice led to each physical consequence.

You can then provide further explanation about epigenetics, such as:

But the decisions the twins made don't only affect them – they may affect their children too (and, potentially, their children's children, and so on). Explain that, even though the twins genes were EXACTLY the same, some lifestyle choices put labels on or took labels off particular genes. You inherit your genes from your mum and dad, but most gene labels are taken off during reproduction, so the baby can acquire its own labels unaffected by mum and dad. Sometimes, though, gene labels slip through to the next generation. So, drinking too much and getting liver disease could affect the health of your child as a result. These gene variations in gene labelling are called EPIGENETIC CHANGES.

Epigenetic changes don't just happen in twins. They happen in all humans, animals and plants.

Epigenetic changes aren't always bad, they occur very frequently in our bodies and most of the time we might not notice any difference.

Note: during trialling, some children had difficulties understanding where the changes actually occured; this may be worth exploring further.

Hints, tips and extension

Some participants may not know what a gene is: it might be best to describe genes as the body's instructions. Deciding to smoke, or to do exercise can change the way your body interprets its instructions and this makes identical twins (with identical body instructions) look different.

With the more able/engaged participants, you could spend a few minutes explaining where genes are in the body, using the whiteboard and pens.

In the classroom, students could match up genes, DNA, chromosomes and cells to appropriate descriptions and draw a diagram of DNA within a gene, within a chromosome, within a cell.

Some background science

Epigenetics is the study of the chemical reactions that label our genes to be active or inactive. Active genes produce proteins responsible for carrying out the plethora of genetic instructions within our DNA – what colour to make our eyes, how tall we should be, etc. As well as having a genome that is a unique combination of mum's and dad's genes, we all have a unique epigenome which is a set of these gene labels. Because the epigenome controls patterns of gene expression, changes in the epigenome can change how our body interprets genetic instructions without our DNA being affected. Scientists now understand that environmental factors – both within and above our control – can cause changes to both our epigenome and the epigenome of our offspring. Things like smoking, diet and level of exercise have been shown to alter the chemical reactions responsible for gene labelling.

More information

- www.epigenome.org
- biochemicalsociety.wordpress.com/2013/01/15/epigenetics-beautiful-science
- epigenetics.jhu.edu
- thenakedscientists.com/HTML/podcasts/show/20121209
- tinyurl.com/ofmyx5b

GENETIC MODIFICATION 1: GM jigsaw

SUGGESTED AGE: under 12
TIME: 5-10 mins
SET UP: Simple

SYNOPSIS: Participants complete a jigsaw puzzle showing real life examples of genetic modification and selective breeding. The aim of the activity is to introduce the concepts of selective breeding and genetic modification, and to illustrate the concept behind genetic modification with real life examples.

You will need

- GM jigsaw puzzle
- Timer, whiteboard and pen (if introducing a competitive element)

Setting up

The work station must have enough space for one participant, or a small team, to work comfortably.

Running the activity

Participants may work alone or in groups of two or three. The jigsaw shows some real life examples of genetic modification and selective breeding. Depending on the age/ability of the participant(s), you can help by showing a picture of the complete jigsaw as well – there is a factsheet which can be used as reference and given away after particpiants have finished. Try asking some introductory questions around the images, such as "What animal is this? How does it look different to other cows you might have seen?" or "Why do you think a scorpion and a cabbage might be genetically modified?" After the jigsaw is complete, discuss some of the fundamental differences between genetic modification and selective breeding. For example:

Selective breeding: Pick animal/plant for breeding depending on desirable traits – what they look like, how they behave – so the offspring has the best intended traits.

Genetic modification: Change the genes (the instructions) of the animal/plant, so the offspring has new or altered traits for which there is a gene available.

Discussing different breeds of dog may be a useful context for relating the concept of selective breeding to participants' own lives. Similarly, bovine insulin production may be a useful context for genetic modification.

What's on the completed jigsaw?

Enviropig: Normal pigs can't digest 'phosphates', which are found in their food and are vital for pig growth. It means their poo can be toxic; it can wash into waterways and be harmful to the environment. So, scientists have inserted genes from mice and *E.coli* bacteria into pig DNA to create a pig that can digest phosphates. This is an example of genetic modification.

Belgian blue: Farmers have chosen the most muscular animals to breed with each other. Some cows and bulls have a natural mutation in a muscle gene which means their muscles don't have a 'stop' signal; they grow and grow! Belgian blues have a higher muscle-to-fat ratio, so their meat is lean. This is an example of selective breeding.

Killer cabbage: Androctonus australis Insect Toxin (AaIT) is a nuerotoxin created by *Androctonus Australis Hector* scorpions. Scientists put scorpion venom genes into *E.coli* bacteria, and then insert these into cabbage cells as a vector for AaIT. This could mean farmers using less chemical pesticides, which harm the environment. This is an example of genetic modification. Note: this example has yet to make it past the research stage; as yet, it is not a commercial product. It may be worth discussing with participants that lots of research is carried out on GM – much of which is reported, sensationally, in the news – but only some projects become a (commercial) reality.

Bananas: In the wild, bananas are small and oval with thick tough skin peppered with large and hard seeds. But over time people have selected seeds from the thinner, less seedy, sweeter bananas to breed better bananas for human consumption. This is an example of selective breeding.

Fish oil seeds: Omega-3 oils offer health benefits, such as helping to protect against heart disease. But because our own body can't produce the oil, it's recommended that we eat two portions of fish a week to get enough. But fish don't actually produce the oil themselves; marine algae produces omega-oil, and fish – such as salmon – accumlate it by eating smaller fish that eat marine algae. So, farmed fish have to be fed on wild-caught fish. Research scientists have genetically engineered the *Camelina sativa* plant by introducing a set of seven synthetic genes – based on those found in marine algae – that allow the GM crops to produce the omega-3 oils. The crops can be used to make food for farmed fish. This is called metabolic engineering – a type of genetic modification.

(See: www.rothamsted.ac.uk/news-views/first-gm-oilseed-crop-produce-omega-3-fish-oils-field)

Hints, tips and extensions

You could add a competitive element by timing participants and adding names/times to a leader board.

You can download and print a PDF of the jigsaw, cut it up and use it with larger numbers of pupils.

You may like to engage the parents/guardians in more detailed discussions of the examples on the jigsaw, and of selective breeding and genetic modification as concepts, whilst the children are occupied with the activity.

Some background science

Genetic modification has been around for decades in various forms, but is still a controversial topic. With increasing pressure on worldwide food supply because the population is growing while the space to farm is not, the potential for genetic modification to add beneficial characteristics to organisms in the food supply chain is being considered as a possible solution to the problem. By changing the genetics of livestock and crops in the right way, food production could be made more efficient, more sustainable, and less damaging to the environment.

More information

- www.who.int/topics/food_genetically_modified/en
- www.nature.com/news/kept-on-a-leash-1.16750
- www.thenakedscientists.com/HTML/podcasts/show/20121209
- tinyurl.com/ofmyx5b

GENETIC MODIFICATION 2: Fish oil debate

SUGGESTED AGE: over 12

TIME: 5-10 mins

SET UP: Moderate (time required to familiarise yourself with characters)

SYNOPSIS: Participants consider four characters' opinions about GM – more specifically, about genetically modified algae and omega-3 – and make decisions about who they agree with and why. The aim of the activity is to provide an opportunity to discuss and debate a specific case involving genetic modification, and to illustrate the various – often contrasting – opinions and arguments about its use.

You will need

- 4 x A3 character boards
- 1 x A3 introduction board, plus print outs of the A4 scenario information
- Sticky notes and/or sticky dots
- Pens
- Optional: Accessories for the participants/demonstrators to wear, such as hats or badges

Setting up

Set up the character boards and introduction board in an area where they are clearly visible, can be accessed by many and where there's space to mill around. The scenario sheets should also be visible.

Make sure sticky notes/dots and pens are available nearby.

The level of facilitator involvement can vary with this activity – if you are working alone, you should familiarise yourself with each character and their arguments so you can engage with participants. If there are a number of facilitators, then you could each choose and assume the role of one character.

It might be useful to write a few opinions on sticky notes and add them to the display, so that participants aren't nervous about being the first.

The four characters are:

Maria, a doctor and dietician: "Foods rich in omega-3 are good for the heart and the brain, so ensuring a constant supply of these foods – whether they're genetically modified or not – is important."

Oliver, a vegetarian and climate change activist: "Scientists should spend their time and money researching non-animal food to deliver omega-3 into people's diets, rather than the unethical use of farmed fish."

Charlotte, a PhD student researching biotechnology: "This project could open the door to other uses of GM algae – for example, biofuels."

Daniel, a biosecurity expert and lecturer: "I'm not convinced that we should be growing genetically modified marine algae. What if the GM algae leaked into the ocean? What are the long term effects of GM algae feed on marine ecosystems?"

Running the activity

On the most basic level, participants read the scenario and the four characters' opinions, and then add a sticky dot to the one they agree with most strongly – or they may choose more than one opinion. They can choose to write down their own reasoning on a sticky note if they wish. This will quickly give a visual indication of which opinion is shared with most people at the event. As more participants view the display, they can read other sticky notes to help them decide; some may even revisit and change their minds, or add additional comments and thoughts. If they are undecided, suggest that participants put a sticky note in the centre.

But you can become more involved and make the activity more engaging if you wish…

Invite participants to debate GM; try to get a small group gathered. Ask a few icebreaker questions about the topic, for example "have you ever been told we should more oily fish?" and "did you know that fish can be farmed too?"

Present the scenario.

Ask for suggestions from participants about the use of GM algae and fish farming.

Introduce the four characters on the display – or introduce yourselves if you are role playing.

Facilitate discussion and debate between the characters' points of view – ask challenging questions, encourage participants to consider various sides to the arguments.

Ask participants which character(s) they agree with most. Ask them to write some thoughts or arguments of their own on a sticky note, and stick them on the relavent quadrant(s).

If there is enough time, challenge some participants on why they've sided with their character.

Hints, tips and extensions

If there are more than four demonstrators available, having someone act as a news reporter would be helpful to do the introductory narrative and interview the characters.

Why not ask some participants to take on the role of news reporter, or one of the characters?

Most people have heard about genetic modification, but they may not necessarily understand what it is. You may want to come up with a few simple explanations for different age groups.

Same background science

Genetic modification has been around for decades in various forms, but is still a controversial topic. With increasing pressure on worldwide food supply because the population is growing while the space to farm is not, the potential for genetic modification to add beneficial characteristics to organisms in the food supply chain is being considered as a possible solution to the problem. By changing the genetics of livestock and crops in the right way, food production could be made more efficient, more sustainable, and less damaging to the environment.

As well as being a subject of genetic modification, other scientists are interested in algae as a potential biofuel (see www.ncbi.nlm.nih.gov/pmc/articles/PMC3152439). Though these two uses may not be linked in any way, often one research pathway can stimulate the idea for another. For more information on genetically modifiying algae, visit www.rothamsted.ac.uk

More information

- www.who.int/topics/food_genetically_modified
- www.nature.com/news/kept-on-a-leash-1.16750

STEM CELLS 1: Lego™ cells

SUGGESTED AGE: under 12

TIME: 15 mins

SET UP: Simple

SYNOPSIS: Participants build different stem cell types with Lego™. The aim is for participants to understand that stem cells are the precursors to all other cells, and that they are various – some types can turn into many different cell types, some can't.

You will need

- Box of Lego™ (150 pieces)
- A4 tray
- Two plastic boxes and sets of labels
- Timer
- Whiteboard (or flip chart) and pen

Setting up

Make sure there is space for two-three participants to stand around the A4 tray. Empty the Lego™ into it. Place two boxes nearby, each with three labels inside (totipotent at the bottom, multipotent in the middle, and unipotent on the top). Keep an eye out for spilt Lego™.

You will need to make three simple Lego™ models to show to participants:

- Two pieces (same colour, same shape). This represents a unipotent stem cell.
- Two pieces (different colour, same shape). This represents a multipotent stem cell.
- Two pieces (different colour, different shape). This represents a totipotent stem cell.

Running the activity

Invite two participants (or small teams) to have a go at making stem cells from Lego™.

Introduce the topic of stem cells. For example:

Who knows what we're made of? Answer: cells – but be aware that the concept of cells may also require explanation depending on your participants. You can include all living things (plants and animals) in your explanation.

Where do cells come from?

Explain that, although there are hundreds of different types of cells, they all come from a basic cell called a stem cell (it will help if you give some examples of types of cells).

Pass around the three models and ask participants to identify the difference. Note: uni-, multi- and toti- may be complex terminology; remember that the aim is for participants to understand the concept of stem cells and their different types so you can simplify as necessary (for example, you call rename the categories 'one', 'several' and 'lots' if it helps).

Explain that different types of stem cells can make different numbers of cell types – unipotent stem cells can only make one type of cell, multipotent stem cells can make a few different types of cell, and totipotent stem cells can make any type of cell in the body. These are represented by the three Lego™ models.

Try asking some questions such as 'Have you ever cut yourself?' and talk about skin repair from unipotent skin stem cells. You can introduce multipotency by asking them to identify different blood cells, and explaining that they all come from the same stem cell. Totipotent cells exist right at the beginning of life. Explain that, when you were only one cell, that cell needed the potential to turn into any type of cell, in order to make the rest of you.

Ask participants to identify which Lego™ model represents which type of stem cell.

Challenge the participants to make as many different unipotent stem cells as they can in 30 seconds, adding them to their box when they have done so. Count them up and note the number, judging if they're correct.

Ask them to disassemble their models and challenge them to make as many different multipotent stem cells as they can in 30 seconds.

Repeat for totipotent stem cells.

Write their names, or team names, and numbers of models on the whiteboard. This is the leader board: challenge new participants to beat the best score.

Alternatively, participants can work against each other to see who can make the most of each model on each round. (You can emphasise the competitive element by reading out running total scores after each round.)

If participants want to find out more, you could discuss how stem cells are being used to treat disease.

Hints, tips and extensions

Keep the Lego™ in the box and/or on the tray.

Some background science

Stem cells are the precursors to every cell in your body. Their regenerative potential has made stem cells an attractive tool for research into regenerative treatments. From neuronal disorders to cancer, stem cells have a wide potential remit. The ethics surrounding sources, combined with the limited supply of donations and the plethora of science still to be understood around stem cells goes some way to explaining why there are currently used only in research, and are not yet a standard medical treatment option.

More information

- www.ukscf.org
- www.eurostemcell.org

STEM CELLS 2: Stem cell card matching

SUGGESTED AGE: over 12
TIME: 5-10 mins
SET UP: Simple

SYNOPSIS: Participants play a card matching game. The aim is to explain that stem cells are the precursors to all other cells, and that they are various – some types can turn into many cells, some can't. The activity also introduces the importance of stem cells as a tool for regenerative medicine.

You will need

- Set of 12 stem cells cards (4 x cell types, 4 x cell jobs and 4 x related stem cell facts)
- Timer
- Whiteboard and pen

Setting up

Lay out the 'cell type' cards, face up. Ensure there is enough space to lay out the remaining cards as participants match them.

Running the activity

Invite participants to play a stem cells card matching game.

Briefly explain the cell cards. Take suggestions about where different cells live and what they do. Provide an explanation, mentioning that different cells have different functions (give examples) but all cells originate from precursors, called stem cells. Explain that, because of their potential to become any cell in the body, stem cells are useful treatments for ailments where cells die and need replacing. Explain that, for each of the stem cells on the template, there are cards containing corresponding information

The simplest exercise is to lay out the 'cell type' cards, face up, and ask the participants to match the 'cell jobs'. It can be made more challenging by then asking participants to match the 'related stem cell facts' cards. Alternatively, you could place a different set of cards face up to start the game. For example: show the 'related stem cell facts' cards and ask participants to match the 'cell types'.

You could challenge participant to match all the cards as quickly as possible. Using the timer, record the number of seconds each group/particpant takes to correctly carry out the activity. Add their name, or team name, to a leader board.

Go through the correctly-placed cards and discuss (or invite questions) about the use of stem cells as outlined on the cards. You may wish to draw on your own knowledge of other uses of stem cells, including those currently used in research.

More info about 'how can stem cells help'

People with leukaemia can be treated with drugs (chemotherapy). But these drugs kill healthy blood cells as well as cancerous ones, so patients don't have enough blood cells left to fight infections. Stem cells are given to replace the healthy cells that are killed.

Stem cells can be used to grow new skin to help people who have been burned. A common way of replacing burnt skin is with a skin graft, but this is sometimes rejected by the body as foreign. Stem cell

therapy can grow new skin without it being rejected by the body's defence system.

Dementia is mainly caused by neurones dying. Unlike other cells, neurones don't divide so a dead neurone is not replaced. Researchers think stem cells can replace the dead neurones in a dementia patient's brain and help the brain to keep working.

Researchers think stem cells can replace cells in someone's liver that have been killed by liver disease, for example from drinking too much alcohol.

Hints, tips and extensions

This activity lends itself to families/groups with a mix of adults and young people, as the cards contain quite a lot of information, and participants will probably need to confer. Older participants may be able to aid younger participants.

Demonstrators can vary how much assistance they give, and how much they explain, dependent on the engagement of the group as a whole.

Some background science

Stem cells are the precursors to every cell in your body. Their regenerative potential has made stem cells an attractive tool for research into regenerative treatments. From neuronal disorders to cancer, stem cells have a wide potential remit. The ethics surrounding sources, combined with the limited supply of donations and the plethora of science still to be understood around stem cells goes some way to explaining why there are currently used only in research, and are not yet a standard medical treatment option.

More information

- www.ukscf.org
- www.eurostemcell.org

Here are links to the Sciberbrain resource, produced by the Biochemical Society:

- www.sciberbrain.org/ (home page)
- www.sciberbrain.org/standard-level/stem-cells (stem cells specifically)

Here you can find further activities, discussion topics and quizzes to confirm understanding. For example, students could use the site to prepare for a classroom debate on the ethics of stem cells.

Competition form

Event:

Date:

Title of activity:

Your name...
Your school and town...
Time taken to complete activity...

One word or sentence to describe the activity...

Hazards and risks

There is no over-arching risk assessment for these activities, as risk assessments depend upon location. It is the demonstrators' responsibility to create a risk assessment approrpoate for the specific environment. (See *generic risk assessment template*.)

Potential Hazard	Suggested way to manage risk of hazard
Reagents and 'urine'	Advise participants that none of the equipment is edible and to inform you immediately if anyone swallows any reagents or equipment; advise participants to wear a lab coat, goggles and gloves when handling reagents; closely supervise the participants' contact with the reagents (though damage to skin from reagents is highly unlikely).
Wet practical equipment	All bottles and pots are plastic rather than glass (to minimise shattering) – do not add any glass equipment to the box; closely supervise the participants' contact with the equipment.
Slips from spillages	Blue roll is provided in the activity box, make sure this is available and within reach at all times; be vigilant of spills and attend to them as soon as possible.
Whiteboards and pens	Supervise the use of board pens; make sure the whiteboard/(s) are appropriately positioned to avoid injury.
Lego (choking hazard)	Supervise participants at all times, particularly the younger ones; this activity is unsuitable for participants under three years of age.
Over-crowding; jostling	Ensure all information (e.g. debate character boards and information board) is at a height where all/most participants can see without straining or having to lean against one another.

General Considerations

- identify any cables crossing the floor and highlight them appropriately
- know where a trained first aider is at all times and how to contact them
- have access to a chair or two around your table for participants who may be less able to stand

Generic risk assessment template

Date assessed:	Assessor:
Event / Venue:	

		Risk evaluation			
Hazard identified	Person(s) at risk	(A) Severity*	(B) Likelihood*	Risk level (A x B)	Control measures

*Scale: Low = 1 – 8, Medium = 9 – 12, High = > 12

RISK ASSESSMENT MATRIX					
Likely injury	Very unlikely	Unlikely	May happen	Likely	Very likely
None	1	2	3	4	5
Minor	2	4	6	8	10
Major	3	6	9	12	15
Fatality	4	8	12	16	20
Multiple fatality	5	10	15	20	25

What's in the box?

Facilitator guidance (this document)

Giveaways

- Classroom activity ideas booklet × 200
- Factsheets (five types) × 200 of each
- Box of 21st Century BioChallenges branded pens × 100

Wet practical kit (Antibiotic resistance & Urine test diagnoses)

- Plastic clip-box with:
    - ¬ Reagents: W, X, Y, Z, Bacteria Test (2 × each)
    - ¬ Fake urine samples: U1, U2, U3, U4, Patient X (2 × each)
    - ¬ Sample pots: Day 2, Day 4, Day 6, Day 10, 2nd course
    - ¬ Filter paper sheets (1 pack)
    - ¬ Glucose test strips (1 pack)
- Lab coats (4 × adult/teenager; 1 × child ~11-13yrs)
- 1 × box of nitrile gloves
- Goggles (1 × adult; 1 × child)
- 1 × A4 tray with laminated urine test template
- 1 × A4 disease reference chart
- 1 × A4 infection reference chart

Combining antibiotics

- 4 × A4 laminated whiteboards (strut cards)
- 5 × whiteboard pens (four different colours + one black or brown)

Stem cell card matching

- Set of 12 x A6 stem cell cards

Lego™ cells

- Box of Lego™ (150 pieces, 10 different types)
- 6 × stem cell labels (two of each type: uni-, multi- and totipotent)
- 1 × A4 tray
- 2 × small plastic boxes

Epigenetics

- 2 × dice (one for game, one spare)
- Set of epigenetics choice cards
- 2 × epigenetics twin templates

DNA whispers

- Note pad

GM Puzzle

- A3 acrylic jigsaw puzzle

GM Debate

- 4 × A3 character boards
- 1 × A4 introduction board
- 10 x A4 scenario sheets
- Sticky notes
- 2 × sheets of sticky dots

Other bits and bobs

- 2 × A3 card/whiteboards to use as leader boards
- Stopwatch
- Pen pot (to put giveaway branded pens in)
- Extra pack of glucose test strips
- Blue roll
- Bin bags

21st BioChallenges

The 21st BioChallenges project, activities and resources are supported by the Royal Society of Biology and the Biochemical Society.

Royal Society of Biology

BIOCHEMICAL SOCIETY

All activities and related resources were devised, written, trialed and designed by 4science
www.4science.org.uk