STEM CLUBS

NUMBER 1 FOR STEM

SURVIVAL STEM: SUITABLE FOR AGE 14-16

Save the world with STEM

STEM Learning activity resources

SUBJECT LINKS:

Science, mathematics, design and technology, computing.

SURVIVAL STEM: SUITABLE FOR AGE 14-16

Save the world with STEM

STEM Learning activity resources

Introduction

This programme of activity is provided by STEM Learning, the largest provider of STEM education and careers support in the UK. It has been developed in partnership with Club leaders.

Save the world with STEM

How can STEM help us survive and thrive? From thinking about how diseases are spread or contained, to building a better skyscraper that can withstand earthquakes, this programme of activities explores both the practical and the hypothetical. Students are asked to explore the big question: Can we save the world with STEM?

Key information

AGE RANGE: 14–16.

SUBJECT LINKS: Science, mathematics, design and technology, computing.

DURATION: Activities range from 20 to 90 minutes – at least 6 hours in total.

FLEXIBILITY: Complete the whole programme over a half term or choose individual activities to suit the needs of your Club.

RESOURCES: Each activity includes a list of the resources required and a comprehensive set of Club leader and student notes in the form of guides.

IMPACT MEASUREMENT: Each set of resources is designed to help evaluate and assess the progress of Club-based learning on Club members. A useful set of assessment tools is available at www.stem.org.uk/enrichment/stem-clubs.

ACHIEVEMENT: Students that successfully complete an entire set of activities can be rewarded with the downloadable STEM Clubs Certificate of Achievement. Students may be able to use these resources to work towards a CREST Discovery Award.

APPROPRIATE VENUES: Club leaders can run most activities in general spaces e.g. classrooms, halls, and outdoor areas. If not, suggested locations are marked clearly in the Club leader guide and in the table below.

SAFETY: Each activity includes details about significant health and safety considerations, such as appropriate eye protection, gloves, etc. Club Leaders should ensure that all equipment is handled with care, particularly sharp instruments. Advice and guidelines are available from CLEAPPS and SSERC, or see the STEM Clubs handbook (page 20). We recommend that practical activities are risk assessed before commencing and Club Leaders must follow their employer or organisations policies.

OTHER ACTIVITIES: Visit www.stem.org.uk/resources/stem-clubs/ for a wealth of ideas for STEM-related Clubs.

FURTHER SUPPORT: The STEM Clubs Best Practice Handbook includes comprehensive support for leaders of all STEM-related Clubs. It can be found at www.stem.org.uk/stem-clubs/getting-started.

Activities

1	**CAN WE SEE HOW DISEASES SPREAD?:** students design and carry out an experiment that models how a disease like Ebola spreads.	60 minutes	
2	**CAN WE RID THE WORLD OF DISEASE?:** students explore the topic of controlling disease and run a vaccine simulation to conclude how many people need to be vaccinated to protect the wider population.	60 minutes	
3	**IMAGINING THE FUTURE – MAKING PLASTIC OUT OF A POTATO!:** students create a bioplastic from potatoes and discuss the implications of replacing traditional plastics.	60 minutes	
4	**HOW CAN WE ENSURE HEALTH FOR ALL IN AN EMERGENCY?:** students discuss the challenges of keeping people healthy in an emergency, and run a hands-on session to create homemade antibacterial cream.	60 minutes	
5	**HOW CAN BIOLOGY AND CHEMISTRY FIGHT CLIMATE CHANGE?:** students generate and share ideas about how STEM can help solve a key challenge or answer a big question about the future, particularly as it relates to climate change. 60–90 minutes	60-90 minutes	
6	**HOW DO YOU SURVIVE A TSUNAMI?:** students simulate a tsunami and explore different ways to protect the shoreline e.g. bio barriers, walls and see which is most effective.	60-90 minutes	
7	**STURDIER SKYSCRAPERS:** students explore the science of forces and materials and identify some of the factors that make buildings earthquake-proof.	60-90 minutes	

STEM CLUBS

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CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

1 Can we see how diseases spread?

Objective

Students devise an activity that will allow them to model how a virus such as Ebola spreads through a community. They then use this information to generate and share ideas with the goal of answering the question: how can STEM help us to slow down or stop the spread of disease?

TOPIC LINKS

Biology: health and disease

TIME

60 minutes

RESOURCES AND PREPARATION

- 2 numbered test tubes for each student
- water
- milk
- starch
- iodine solution
- pipette
- permanent marker

1. Each student will need two test tubes – both labelled with the same number. Fill one with milk and leave the other empty. Label the empty ones 'before' (these will be used later to identify the original infected students before the experiment started).
2. Prepare the spiked 'Ebola virus' solution by dissolving starch in hot/boiling water, then adding 1ml to milk. Keep this 'virus' solution to the side as the positive control. Then 'spike' one of the student test tubes with starch as well.
3. Prepare one test tube with milk to use as the negative control.

DELIVERY

1. Introduce the background and the goal to the students. Explain that they are going to be designing and undertaking their own investigation in order to find out how just how quickly a disease like Ebola can spread through a population. The test tubes represent people, and the milk represents bodily fluids.
2. Show them how the positive and negative controls from the preparation react to the iodine solution and explain that the 'Ebola virus' only shows up after the iodine check. Mixing the 'bodily' fluids in the test tubes leads to a contraction of the virus.
3. Explain that it will be their goal to devise an activity that will allow them to model how the Ebola virus spreads through a community. Every member of the group will have their own test tube and at the start of the experiment the vast majority of the students should be 'healthy' (ie have milk in their test tube). Students should then walk through the room and swap half of their solution back and forth with someone else during round 1. Explain that if both students are healthy, there is no problem, however, there should be one or more infected students in the class who carry the 'Ebola virus' (i.e. milk and starch solution). As students go through more rounds, the virus will quickly spread – but this will only become apparent after the iodine test, so infected students will be unaware of the spread until the experiment is over.
4. Discuss the importance of the following points and how they will affect the outcome of the experiment:
   - the number of infected people at the start of the experiment
   - varying the amounts of solution
   - the number of rounds where bodily fluids are swapped
   - tracking and recording who they have swapped their test tube contents with.
5. Let the students devise their own experiment with the guidance of the Club leader or their student guide. Once the design is complete and checked, let the students gather their materials.

TIPS

- use one spiked test tube for 20 students. If there are more than 20 participants, another spiked test tube is recommended
- three to five rounds of liquid swapping are recommended
- to ensure the test is fair, it is recommended only the Club leader can hand out the solutions and the students do not know which students are infected (even if they do know the total number of infected students)
- the 90-second video in the Useful links section is a good starter or conclusion to this activity

6. Once the students have received their labelled test tube with their solution, let them transfer about half of the liquid into the empty test tube labelled 'before' (with the same number). These test tubes should be returned to the front of the room.
7. Once the experiment is completed, use a pipette to put 1–2 drops of iodine into each of the students' test tubes to find out how much the virus has spread. Compare these results to the 'before' test tubes.
8. Lead the students into a discussion which can include the following points:

   a. Can you work out which students were the source of the infection?

   b. What can you say about the transmission rate of this particular disease?

   c. What are the possible ways this disease spread (think about the implication of the swapping of the solutions)?

   d. If this disease was spread through physical contact, how could the spread of this disease be stopped?

EXTENSION IDEAS

1. Students can visit the websites listed in Useful links, or you can set this beforehand as a preparation activity.
2. Students create an information leaflet to inform people about the different ways the spread of disease can be limited.

DIFFERENTIATION IDEAS

Support: provide a partial or complete version of the practical for students to follow and ask them to focus on undertaking the activity rather than designing it.

Challenge: ask students to undertake their own designed activity and evaluate on their protocol and their results. How could their practical be improved? How accurately does it represent how diseases can spread in a community?

USEFUL LINKS

- The Science Learning Hub on spreading and preventing spread of infections
  https://www.sciencelearn.org.nz/resources/179-infection
- Similar experiment with different apparatus
  https://www.sciencelearn.org.nz/resources/192-spreading-diseases
- The crazy scientist behind one of the most-watched TED talks explains Ebola in 90 seconds
  http://www.upworthy.com/the-crazy-scientist-behind-one-of-the-most-watched-ted-talks-explains-ebola-in-90-seconds
- BBC – Ebola basics: What you need to know
  https://www.bbc.com/news/health-29556006
- BBC - Ebola outbreak: How Nigeria is beating the killer virus
  https://www.bbc.com/news/world-africa-29654002
- Battling Ebola: Tracking the Virus
  https://www.bu.edu/research/articles/battling-ebola-tracking-the-virus/

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

1 Can we see how diseases spread?

Your challenge

Ebola is a serious infectious illness which often proves fatal. It is a virus thought to have originated in fruit bats. The disease does not spread through the air, like the influenza virus. Very close direct contact with an infected person is required for the virus to be passed to another person. There is some evidence to suggest the virus can survive on surfaces (e.g. phones, pencils, door handles) for up to six days. You will design an investigation that will demonstrate how easily a viral disease can spread through a population, even if each individual only comes into contact with a small number of people.

How quickly can diseases spread in a population, and what can we do to prevent this?

MATERIALS

- 2 numbered test tubes for each student
- water
- milk
- starch
- iodine
- pipette
- permanent marker

WHAT YOU NEED TO DO

Using the materials listed above, plan a simulation to observe how quickly a disease like Ebola can spread through the classroom and create a pandemic. The start of such a pandemic can look like the example below:

In a group of 20 students, there is one student who has been infected with Ebola. This means that at the very start of the experiment, there are 19 test tubes with ONLY milk (healthy students) and there is one test tube with milk and starch (the sick student).

During round 1, the sick student mixes their solution with one other person, transferring the virus (starchy milk) to an unsuspecting victim. During round 2, the two sick students each pass the virus on to two more students.

1. Consider the following topics as you plan and design your experiment:
   - the total amount of infected people at the start of the experiment
   - the total amount of rounds in which bodily fluids are swapped. Should this be the same for every participant
   - how will each participant track who they have swapped their test tube contents with? Is it important to record this? Why
   - will you conduct a blind test (where the infected test tube(s) is/are handed out in such a way that no one knows who is about to cause the upcoming pandemic)
2. Once you have had your plan checked by your Club leader, you can undertake the experiment and gather your data.
3. Tip: once everyone has their own test tube containing the milk or starchy milk, transfer about half of the liquid into the empty test tube labelled 'before' (with the same number). These test tubes should be returned to the front of the room to be compared to the result at the very end of the experiment, using the iodine indicator to test how far the disease has spread.

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

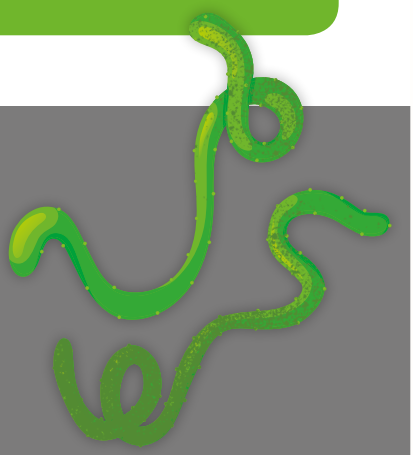
1 Can we see how diseases spread?

Discuss

4. What can you say about the number of sick people at the start of the experiment compared to those who have been infected over the course of the different rounds?
5. Can you work out who was the source of the infection in this experiment?
6. What can you say about the transmission rate of the disease?
7. What are the possible ways this disease spread (think about the implication of the swapping of the solutions)? Compare it to what you know of Ebola.
8. If this disease was spread through physical contact, how could the spread of this disease be stopped?
9. What are the symptoms of Ebola?
10. Which countries were involved in the most recent Ebola outbreak?
11. What is the fatality rate of Ebola?
12. What precautions could be taken?
13. Could the most recent outbreak of Ebola have been prevented? If so, how?

To find out more visit:

- **BBC – Ebola basics: What you need to know**
  https://www.bbc.com/news/health-29556006
- **BBC - Ebola outbreak: How Nigeria is beating the killer virus**
  https://www.bbc.com/news/world-africa-29654002
- **Battling Ebola: Tracking the Virus**
  https://www.bu.edu/research/articles/battling-ebola-tracking-the-virus/



FUN FACTS

1. In 2014, following the Ebola outbreak, Liberia's health minister advised people to stop having sex, shaking hands or kissing. The WHO says men can still transmit the virus through their semen for up to seven weeks after recovering from Ebola.
2. The incubation period (time from exposure to infection or apparent symptoms) is 2–21 days, but 8–10 days is most common.

STEM CLUBS

NUMBER 1 FOR STEM

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

2 Can we rid the world of disease?

Objective

Students investigate disease control through a vaccination simulation. They analyse their data and attempt to conclude what percentage of a population must be vaccinated in order to protect the majority of a community.

TOPIC LINKS

Biology: health and disease

TIME

60 minutes

RESOURCES AND PREPARATION

- computers with internet access
- three or six large sheets of paper and marker pens, fixed to the wall or on desks, labelled with 'reasons to think yes', 'reasons to think no' and 'interesting points'
- a large screen in case you decide to display the question and the sample perspectives from the student guide
- arrange the furniture to suit the discussion style below, or your preferred approach

DELIVERY

1. Introduce the question 'Can we rid the world of disease?' and give some background to students. Explain that they are going to use their STEM knowledge and imagination to explore the issues and possibilities and decide what they think the answer might be.
2. Some diseases can already be prevented if people are vaccinated against them. Introduce the topic of vaccination programmes and artificial immunity. Ask the students whether it would be necessary to vaccinate every member of a population to prevent a disease spreading. Is this even possible? (Consider reasons that not everyone can be vaccinated – ethical/religious reasons, allergies, financial limitations, etc.) How many people in a population would need to be vaccinated in order to protect those that can't be?
3. Explain that they will do an investigation using a computer simulation where they will investigate the topic of herd immunity as one way in which STEM can be used to help rid the world of disease. Their goal is to find out what percentage of the population needs to be vaccinated to protect the majority of the population.
4. Instruct students to follow the instructions in the student guide to run the simulation.
5. After the students have concluded their investigation, discuss their findings. Students can share their results and their conclusions.

TIPS

Make sure students write down their thoughts as short, legible sentences. Useful questions:

1. Are some diseases more important to eradicate than others?
2. Could we really help everyone on Earth?
3. Where should the money to do this come from?
4. Should we just continue to live with some diseases?
5. Might some diseases always be untreatable?

6. Move on the preparation for the discussion by reviewing the perspectives on the student guide together.
7. Deliver this second part of the activity using the writing walls approach below, or using your preferred approach.

   a. Students reflect on the three statements:

I. It's not realistic: diseases are always mutating, and our environment is changing as well. We'll never keep up.

II. It's possible: computers, artificial intelligence and medicine are advancing so quickly that one day we'll understand how every disease operates.

III. It depends: there's a big difference between knowing how, and having the will or ability to take action. It will all depend on getting the funding and the goodwill to make it happen.

b. Students organise their thoughts into 'reasons to think yes', 'reasons to think no' and 'interesting points', circulating in small groups to write their ideas on the large sheets of paper.

c. Invite students to read out the ideas on each sheet. Discuss each one and explore whether any of the 'interesting points' change any of students' reasons to think yes or no.

d. Explain that students have 30 seconds to decide on their final point of view. Hold a vote, asking each student to give one brief justification for voting 'yes' or 'no'.

EXTENSION IDEAS

1. Students can visit the websites shown in the Useful links section, or you can set this beforehand as a preparation activity.
2. Ask students to record a vox pop video of other students' opinions.

DIFFERENTIATION IDEAS

Support: if it is not suitable to write down ideas, split students into small groups and ask each group to think of three 'reasons to think yes', 'reasons to think no' and 'interesting points'. Give each group 30 seconds to share each of their sets of ideas.

Challenge: the second link in the Useful links section includes reasons why many diseases are considered not currently eradicable. Ask students to review this linked PDF and provide a strong justification for their ideas.

USEFUL LINKS

- **Techydad: vaccination programme simulation**
  http://www.techydad.com/Vaccinate/
- **BBC News article on 'Is it possible to eradicate all diseases?**
  http://www.techydad.com/Vaccinate/
- **List of diseases considered as candidates for global eradication**
  https://www.cartercenter.org/resources/pdfs/news/health_publications/itfde/updated_disease_candidate_table.pdf
- **Chan Zuckerberg initiatives**
  https://chanzuckerberg.com/initiatives

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

2 Can we rid the world of disease?

Your challenge

In 2016, Facebook founder Mark Zuckerberg and his wife Priscilla Chan announced the launch of a $3bn (£2.3bn) fund with the ambitious goal to 'cure, prevent or manage all diseases by the end of the century'.

XXXXXXXXXX

WHAT YOU NEED TO DO

Investigate: vaccination and herd immunity

Herd immunity describes a form of immunity that occurs when the vaccination of a significant portion of a population provides a measure of protection for individuals who have not developed immunity. You are going to use a computer simulation to model how vaccination programmes work. Your aim is to find out what percentage of the population you need to vaccinate to protect the majority of the community.

1. Go to the website: www.techydad.com/Vaccinate/ and follow the steps below:
2. Keep each of the settings the same (chance of spreading etc).
3. Set the 'randomly vaccinate' setting to 1 person.
4. In a table, record the number of people who stay healthy, the number of people who get sick but recover and the number of people who die. Repeat this twice more and take an average.
5. Repeat step 4 for a 25% vaccination rate, a 50% vaccination rate, a 75% vaccination rate and a 90% vaccination rate. Do each rate three times.
6. Put your data into a table. Make your data into a graph (think about the best way to present the data – e.g. could you work out a death rate or sickness rate?).

FUN FACTS

1. The only infectious disease to have been eradicated to date is smallpox. The last known case occurred in Somalia in 1977.
2. According to the Journal of Molecular Medicine, Ribose-5 phosphate isomerase deficiency, or RPI Deficiency, might be the rarest disease in the world. Only one case has ever been recorded.
3. The World Health Organisation lists ischaemic (coronary) heart disease (where the arteries to the heart become blocked) as the biggest cause of death worldwide.

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

2 Can we rid the world of disease?

Discuss: can we rid the world of disease?

Organise your thoughts into 'reasons to think yes', 'reasons to think no' and 'interesting points'. In small groups, write your ideas on the large sheets of paper to share and discuss.

Here are three perspectives to kick-start your thinking:

1. It's not realistic: diseases are always mutating, and our environment is changing as well. We'll never keep up.
2. It's possible: computers, artificial intelligence and medicine are advancing so quickly that one day we'll understand how every disease operates.
3. It depends: there's a big difference between knowing how, and having the will or ability to take action. It will all depend on getting the funding and the goodwill to make it happen.

To find out more visit:

- BBC News article on 'Is it possible to eradicate all diseases?
  https://www.bbc.co.uk/news/magazine-37433012
- List of diseases considered as candidates for global eradication
  https://www.cartercenter.org/resources/pdfs/news/health_publications/itfde/updated_disease_candidate_table.pdf
- Chan Zuckerberg initiatives
  https://www.chanzuckerberg.com/initiatives

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

3 Imagining the future – making plastic out of a potato!

Objective

Students make a polymer out of potato starch.

TOPIC LINKS

- Chemistry: making a bioplastic
- Design and technology: sustainability
- Biology: plastic pollution

TIME

60 minutes

RESOURCES AND PREPARATION

Per group:

- 100g potatoes or potato starch
- potato grater
- tea strainer
- distilled water
- pestle and mortar
- 100ml measuring cylinder
- 250ml beaker
- large watch glass
- Bunsen burner and heatproof mat
- tripod and gauze
- stirring rod
- propan-1, 2, 3-triol (glycerol) (may be harmful if ingested in large quantities)
- hydrochloric acid 0.1 mol/dm^3 (minimal hazard)
- sodium hydroxide 0.1 mol/dm^3 (irritant)
- optional: food colouring
- petri dish or white tile
- universal indicator paper
- eye protection
- electric balance
- 25 ml measuring cylinder
- 10 ml measuring cylinder

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

Lab coats and eye protection must be worn and long hair must be tied back.

Propan-1,2,3-triol may be harmful if ingested in large quantities.

DELIVERY

1. Introduce the topic of plastic pollution. It is possible to link this to fossil fuels, microplastics, and biodegradable plastics (the YouTube link in the 'Useful links' section provides interesting insights into this topic).
2. Explain to students that they will be making their own version of an eco-friendly plastic using potatoes. Guide them through the process of making their own plastic as much as is necessary.
3. Once the plastics have been finished (they will require about one day to dry and form), students can evaluate their product.
   - **a.** Which properties make their plastics useful?
   - **b.** What sorts of products could be made out of such bioplastics?
   - **c.** Which properties might make consumers choose 'regular' plastic over their bioplastic?
   - **d.** Was there a difference between the plastics that contained propan-1,2,3-triol and those that did not?

TIPS

- Students should work carefully when handling the food colouring as they can cause stains

EXTENSION IDEAS

1. Students can investigate if there are other materials from which they can make bioplastics (e.g. milk) and what the advantages/ disadvantages are between the different options.
2. Ask students to research some of the problems related to our current use of plastics (e.g. its impact on ocean life, human life, or problems related to recycling). How could STEM careers help solve the problem they decided to investigate?

DIFFERENTIATION IDEAS

Support: if extracting the starch from potatoes is too time-consuming it is possible to use ready-made potato starch instead.

Challenge: students can compare how two plastics with and without plasticizers (propane-1, 2, 3-triol) differ. Let them research the chemistry behind how the plasticizer affects the plastic.

USEFUL LINKS

- **SciShow YouTube clip: 'The truth about biodegradable plastic'**
  https://www.youtube.com/watch?v=g9OqQ1PaACg
- **Sustainable plastics: 'About bioplastics'**
  http://www.sustainableplastics.net/about
- **YouTube clip: Can We Make Plastic from Potatoes? - Bang Goes the Theory - Series 7 Episode 1 - BBC One**
  https://www.youtube.com/watch?v=Lhigu23NQlw
- **Similar activity to this one**
  http://www.rsc.org/Education/Teachers/Resources/Inspirational/resources/3.1.7.pdf

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

3 Imagining the future - making plastic out of a potato!

Your challenge

Have you ever wondered if there is a more environmentally friendly way to make plastic? Bioplastics (biodegradable plastics, derived from biological substances) are being researched to limit out reliance on crude oil as a raw material for plastics.

Make your own eco-friendly plastic of the future!

WHAT YOU NEED TO DO

PHASE 1 – EXTRACTING THE STARCH

1. Obtain 100g of potato and thoroughly clean it. Grate the potato using the grater.
2. Put the potato into the mortar and add 100ml of distilled water. Grind carefully.
3. Using the strainer, pour the liquid off the mixture. The potato should remain behind in the mortar. Then add 100ml of distilled water and use the strainer to remove it again.
4. Repeat step 3 so that the ground potato is rinsed three times in total.
5. Pour the mixture into a beaker, and leave it to settle for five minutes.
6. Decant the water from the beaker. You should have white starch left in the bottom. Add 100ml of distilled water and stir. Leave to settle again, and then decant the water one final time.

You should now have extracted the starch to make a plastic film.

PHASE 2 – MAKING THE POTATO PLASTIC

Safety note: lab coats and eye protection must be worn during this part of the experiment. Long hair must be tied back.

1. Pour 25ml of water into the 250ml beaker. Add 2.5g potato starch and 3ml hydrochloric acid.
2. Put the watch glass on the beaker and heat the mixture using the Bunsen burner. Carefully bring the mixture to the boil. Boil gently for 15 minutes, but be careful not to boil it dry – if it looks like it might, then stop heating.

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

3 Imagining the future - making plastic out of a potato!

3. Measure the pH. For this, dip the glass rod into the mixture and dot it onto the indicator paper. Neutralise the solution by slowly adding a small amount of sodium hydroxide solution and checking the pH with indicator paper. You will probably need to add about the same amount of sodium hydroxide as you did acid at the beginning (3ml). Keep adding until neutral.

4. Optional: add a drop of food colouring and mix thoroughly.

5. Pour the mixture onto your labelled petri dish or white tile. Smooth it over with your glass rod so that you have an even covering.

6. Label your mixture and leave it to dry out. This will take about one day on a radiator or sunny windowsill or two days at room temperature.

CHALLENGE:

Ask your Club leader if propan-1,2,3-triol is available for you to use. This is what is known as a plasticiser. Undertake phase 2 of the experiment, with one change to step 1 as follows:

1. Pour 25ml of water into the 250ml beaker. Add 2.5g potato starch, 3ml hydrochloric acid and 2 ml propan-1,2,3-triol.

FUN FACTS

1. Potato starch consists of long chains of glucose units that are strung together. The two polymers that potato starch contains are:
   - amylose – a straight chain of glucose units
   - amylopectin – a branched polymer of glucose units
2. Normal plastic bags remain toxic even after they break down. Instead of biodegrading, they photo-degrade. This means that the plastic breaks down into smaller and smaller toxic bits of itself, contaminating the environment.
3. A company from New Zealand called Potatopak makes disposable food packaging from recycled potato starch. Their products are designed to decompose within 30 days.

STEM CLUBS

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

4 How can we ensure health for all in an emergency?

Objective

Students generate and share ideas about how STEM can be used to help solve challenges related to providing food and healthcare during emergency situations. They produce their own antibacterial ointment to help treat small injuries.

TOPIC LINKS

- Biology: health and disease
- Chemistry: oxidation, separating mixtures

TIME

60 minutes

RESOURCES AND PREPARATION

For the discussion:

- paper and pens
- you may wish to display the question and the sample perspectives on the student guide on a large screen
- arrange the furniture to suit the discussion style below, or your preferred approach

For the antibacterial cream activity, each group will need:

- 4 tablespoons of beeswax (can be purchased at many health food stores)
- 100ml of coconut oil
- 100ml of olive oil, jojoba oil, or almond oil
- 15 drops tea tree oil (can be purchased at many health food stores)
- 10 drops lavender oil (can be purchased at many health food stores)
- 1 tablespoon witch hazel
- selection of dry herbs (e.g. chamomile, marigold, lavender, plantain leaves)
- optional: 1 tablespoon of honey
- double boiler (or a glass/metal bowl set over a pot of hot water)
- cheesecloth (or a coffee filter)
- mixing bowl
- hand mixer
- glass container

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

Eye protection is recommended. Students should take care when using the double boiler.

Instruct students not to use the antibacterial cream as a medical treatment. You should also check for allergies before using this activity.

DELIVERY

1. Introduce the question and background to students. Explain that they are going to use their STEM knowledge and imagination to explore the issues and possibilities and decide what they think the answer to the question posed in this activity might be.
2. Review the perspectives on the student guide.
3. Deliver this activity using the snowball approach below, or using your preferred approach. Adjust the number of students in groupings to suit.
   - **a.** Students generate initial ideas in pairs.
   - **b.** Ask each pair to join with another and briefly share their ideas. Each group identifies the two or three most interesting or promising ideas they have shared, and develops these further.
   - **c.** Ask groups to join with another to form groups of eight to share ideas and again further develop the two or three best ideas.
   - **d.** Finally, ask each group to share one or two of their most interesting ideas or viewpoints with the whole group.
4. During the discussion, different aspects of providing food and first-aid or survival kits are likely to come up regularly. In the hands-on activity students create their own antibacterial cream that could prove useful in treating small injuries during an emergency situation. Introduce the different ingredients they will be using during the activity and outline the properties that make them useful for us.

TIPS

Brief students that they need to generate, build, share and judge ideas quickly at each stage of their snowball. Useful questions:

1. What groups of people can be affected and what food or medical help might they need?
2. How will you decide which ideas are the most promising or interesting?
3. What innovations could improve what is provided to victims of a disaster?
4. What could transform how food and medical aid is delivered, so it gets to the right people in top condition?
5. What innovations could help improve sanitation, a massive problem after natural disasters?

5. After the discussion, refer students to the instructions in the Student guide to create their own antibacterial ointment.
6. Reflect on the ideas produced by the students and link back to their discussion. Are some of the ideas they came up with equally achievable or more challenging?

EXTENSION IDEAS

1. You could include the balm in the GCSE required practical looking at antimicrobial substances to test its effectiveness.
2. Students can visit the websites listed in the Useful links section, or you can set this beforehand as a preparation activity.
3. Ask students to research STEM careers in disaster response and emergency aid.
4. Ask students to create a labelled diagram or poster of their ideas and present in a 'dragon's den' style activity.

DIFFERENTIATION IDEAS

Support: give each pair one aspect of aid to consider, e.g. either food or medicine and healthcare. Ask pairs to snowball with other students working on the same aspect.

Challenge: ask students to consider the different aspects of the challenge: What do they think they need to improve? Product or service (what is provided)? Quality? Cost? Efficiency?

USEFUL LINKS

- **Article on the steady increase in natural disasters**
  https://www.accuweather.com/en/weather-blogs/climatechange/steady-increase-in-climate-rel/19974069
- **Guardian article: Is the world heading for catastrophe over natural disasters?**
  https://www.theguardian.com/global-development/2016/apr/24/world-heading-for-catastrophe-over-natural-disasters-risk-expert-warns
- **The International Federation of Red Cross and Red Crescent Societies (IFRC) article on Health in emergencies**
  http://www.ifrc.org/en/what-we-do/health/health-in-emergencies/
- **WikiHow: How to make an antibacterial ointment at home**
  https://www.wikihow.com/Make-Antibacterial-Ointment-at-Home

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

4 How can we ensure health for all in an emergency?

Your challenge

The number of natural disasters worldwide has steadily increased, especially since the 1970s, and this increase is driven largely by climate-related events.

How can we ensure food and health for all in an emergency?

WHAT YOU NEED TO DO

Share your ideas with a partner, then join with another pair to share and explore your thoughts. Keep 'snowballing' into bigger groups until you've all shared your ideas!

Here are a few questions to kick-start your thinking:

1. One key challenge is to get aid to where it's needed. How can your ideas make food or medical aid easier to deliver and store locally?
2. It's vital to reduce waste and inefficiency. What innovations could make food or medical aid more effective when provided?
3. Self-help can empower people to begin rebuilding their lives and allows aid workers to focus on the most vital tasks. How could victims use your solutions with minimal need for expert help?
4. What are some basic things that everyone needs to stay healthy? What are the most important things (e.g. tools, medical aid, food) you would you put in a survival kit for an emergency situation?

FUN FACTS

1. You can see live data visualisations online for some natural events like wind and lightning. Visit https://earth.nullschool.net/ or www.lightningmaps.org
2. The biggest natural disaster since 1900 is thought to be the China floods of 1931, in which as many as 4 million people died.
3. Our nutritional needs are given as Dietary Reference Values (DRVs) for energy and nutrients. They're a great way to make sure you're eating a healthy, balanced diet.

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

4 How can we ensure health for all in an emergency?

MATERIALS

- 4 tablespoons of beeswax (can be purchased at many health food stores)
- 100ml of coconut oil
- 100ml of olive oil, jojoba oil, or almond oil
- 10–15 drops tea tree oil
- 5–10 drops lavender oil
- 1 tablespoon witch hazel
- 5 tablespoons of up to two different dried herbs (your choice)
- optional: 1 tablespoon of honey
- double boiler (or a glass/metal bowl set over a pot of hot water)
- cheesecloth (or a coffee filter)
- mixing bowl
- glass container (e.g. empty jam jars)

PROCEDURE

1. Collect your materials.
2. In a double boiler (or a glass/metal jar in a pot of hot water) combine your base oils. Add your own selection of the dried herbs that are available to the oils.
3. Leave the mixture to simmer for 30 minutes. Be sure to keep an eye on it at all times!
4. After 30 minutes have passed it is time to remove the dried herbs from the mixture. Prepare a small bowl with a cheesecloth or a coffee filter and pour the mixture through to filter out the herbs.
5. Return your infused oil to your double boiler. Add 4 tablespoons of beeswax, and stir until melted. Optional: If honey is available, you can add this now as well. Stir carefully until everything is mixed well.
6. Turn off the heat, and let mixture cool.
7. When the mixture has cooled down, add your essential oils and witch hazel (if available) and stir.
8. You have produced your own antibacterial ointment!

To find out more visit:

- **Article on the steady increase in natural disasters**
  https://www.accuweather.com/en/weather-blogs/climatechange/steady-increase-in-climate-rel/19974069
- **Guardian article: Is the world heading for catastrophe over natural disasters?**
  https://www.theguardian.com/global-development/2016/apr/24/world-heading-for-catastrophe-over-natural-disasters-risk-expert-warns
- **The International Federation of Red Cross and Red Crescent Societies (IFRC) article on Health in emergencies**
  http://www.ifrc.org/en/what-we-do/health/health-in-emergencies/
- **Create your own antibacterial ointment**
  http://www.ifrc.org/en/what-we-do/health/health-in-emergencies/

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

5 How can Biology and Chemistry fight climate change?

Objective

In this activity, students generate and share ideas about how STEM can help solve a key challenge, or answer a big question, about the future.

TOPIC LINKS

- Biology: plant biology, respiration, photosynthesis, food webs
- Chemistry: carbon cycle

TIME

60–90 minutes

RESOURCES AND PREPARATION

For the hands-on starter:

- different plants (fern or basil plants might be appropriate as they have a low compensation point)
- dark plastic bag
- clear plastic bag
- thin rope or rubber band
- fluorescent lamp
- CO_2 sensor / datalogger OR bicarbonate indicator in a petri dish (change in colour would indicate change in amount of CO_2

For the discussion:

- you may wish to display the question and the sample perspectives on the student guide on a large screen
- arrange the furniture to suit the discussion style below, or your preferred approach

HEALTH AND SAFETY:

A suitable risk assessment using guidance from CLEAPSS and SERCC should be written and adhered to for this activity.

DELIVERY

1. Introduce the question and background to students. Students can brainstorm and generate ideas about climate change and how STEM can be used to fight it.
2. If it has not come up during the initial discussion, the Club leader can bring up the topic of plants, and their role in the carbon cycle. Ask students the question: 'Could plants help to slow the march of global warming?' This links to an activity (described in the student guide) which demonstrates how plants influence the atmospheric CO_2 concentration, the carbon cycle, and the greenhouse effect.
3. Once students have completed the activity, discuss their results together and use the students' findings to introduce key climate scientific principles. Do the students have enough information to answer the questions posed at the start of the activity? If not, what further research would need to be done? Reflect on the effects of increasing/decreasing the number of plants on Earth on global warming.
4. Explain that they are going to use their imagination to explore the issues and possibilities related to climate change and look at this from one or several areas of STEM. What can we do to fight climate change?

TIPS

Pay attention to timings while students think and discuss in pairs. Useful questions:

1. How can we break the challenge of climate change down into more focused problems to solve?
2. Are you going to apply ideas from Biology or Chemistry?
3. Are you trying to stop an effect, or to find a solution to the problems it creates?
4. Are you trying to help humans or other species?

5. Deliver this activity using the think-pair-share and 30-second circuit approach below, or using your preferred approach.

   a. Students think individually to generate ideas, then get into pairs.

   b. Pairs share ideas together, adding suggestions to build on each other's ideas.

   c. Finally, pairs form a large circle. Set the scene as a global conference in which students are taking part. Students take turns to spend 30 seconds each to explain their ideas to the group.

   d. List some key ideas and interesting points, to discuss once every pair has shared their suggestions.

   e. As time permits, discuss together whether students' ideas leave them feeling hopeful about how we will address climate change. What reasons do they have to feel hopeful or pessimistic? How can STEM help?

EXTENSION IDEAS

1. Students can visit the suggested links in the Useful links section, or you can set this beforehand as a preparation activity.
2. Ask students to prepare and present their ideas in more detail during a more fully-developed mock global conference.
3. Ask students to research climate-related STEM careers.
4. Ask students to use the web links, and their own research, to develop constructive ways to challenge people who choose to deny the reality of climate change.

DIFFERENTIATION IDEAS

Support: identify one or more focused problems to solve, for example ocean acidification or changes in crop yields, and focus students' thinking around this.

Challenge: ask students to explain in more detail the Biology or Chemistry subject knowledge and understanding they are drawing on when generating their ideas.

USEFUL LINKS

- YouTube video of climate change (explained in 60 seconds)
  https://www.youtube.com/watch?v=n4e5UPu1co0
- Web article: Scientists agree humans are the primary cause of global warming
  https://www.ucsusa.org/global-warming/science-and-impacts/science/scientists-agree-global-warming-happening-humans-primary-cause
- Guardian article: Seven megatrends that could beat global warming
  https://www.theguardian.com/environment/2017/nov/08/seven-megatrends-that-could-beat-global-warming-climate-change
- A series of experiments: 'Global warming and climate change – an experimental approach'
  http://www.carboeurope.org/education/CS_Materials/Bernd-BlumeExperiments.pdf

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

5 How can Biology and Chemistry fight climate change?

Your challenge

Over 97% of climate scientists agree that global warming is real and is largely caused by humans. The impacts on humanity, while uncertain, will be huge. Changing weather patterns and climate will affect food and water supplies and lead to many more climate-related natural disasters, while rising sea levels will displace millions of families.

How can Biology and Chemistry help to fight climate change?

WHAT YOU NEED TO DO

PHASE 1 – INVESTIGATE

1. Place the plant in a dark plastic bag and close the bag.
2. Through a small gap in the bag, measure the change in carbon dioxide air content with the CO_2 sensor every minute for a total of 20 minutes. Record the results in a table.
3. Now place the plant in a clear plastic bag and measure CO_2 concentration in the bag for 20 minutes as in step 2.
4. Create a graph to represent your data.
5. Describe the curves in your graph and try to explain them.

Questions for fast finishers:

1. Can you see a pattern for the amount of CO_2 present in each of the experiments?
2. What are the implications of your results when you link it to the topic of climate change?
3. Explain the term 'carbon sink'. Do plants qualify as a carbon sink?

FUN FACTS

1. More than half the world's population lives within 60km of a shoreline, with more than a billion people living in low-lying areas.
2. Climate change will have a disproportionate effect on people in developing countries, both due to the changes they will experience, and their ability to be resilient.
3. 47% of land mammals and 23% of birds have already suffered negative impacts from climate change.
4. Climate scientists call the processes which remove CO2 from the air 'sinks'. The oceans are one such sink.

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

5 How can Biology and Chemistry fight climate change?

PHASE 2 – THINK OUTSIDE THE BOX

Think up some great ideas, share them with a partner to help you develop them, and then present your ideas to the group in just 30 seconds!

Here are three perspectives to kick-start your thinking:

1. Climate change isn't caused by one thing and causes many effects. What specific aspect are you going to address?
2. How could you apply Biology or Chemistry to gather data on the effects of climate change, to help understand the scale and speed of change or to model future effects?
3. Do you want to try to slow down or reverse specific effects, or develop solutions that address the problems these effects create?

To find out more visit:

- **YouTube video of climate change (explained in 60 seconds)**
  https://www.youtube.com/watch?v=n4e5UPu1co0
- **Web article: Scientists agree humans are the primary cause of global warming**
  https://www.ucsusa.org/global-warming/science-and-impacts/science/scientists-agree-global-warming-happening-humans-primary-cause
- **Guardian article: Seven megatrends that could beat global warming**
  https://www.theguardian.com/environment/2017/nov/08/seven-megatrends-that-could-beat-global-warming-climate-change

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

6 How do you survive a tsunami?

Objective

Pupils simulate a tsunami and explore different ways to protect the shoreline e.g. bio barriers, walls and see which is most effective.

TOPIC LINKS

- Engineering: design and 3D modelling of barriers/walls
- Physics: wave motion; comparing effectiveness of barriers

TIME

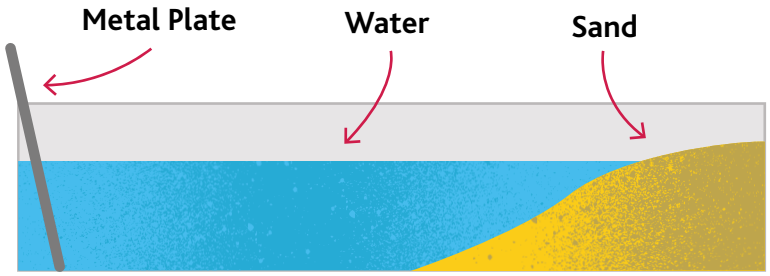
60–90 minutes

RESOURCES AND PREPARATION

- clear plastic or glass tank/ container (recommended minimum length is 50cm)
- measuring tape or ruler
- marker
- water
- sand
- metal plate/plastic tray
- access to a smartphone or tablet, camera
- materials to be used for the barriers: this could include plywood, clay, gravel/ pebbles, or other materials you have available

SET UP

- Fill the container with water to about 15% of its height and use a marker to make a line on the container where the water level is.
- Create 'land' on one end of the tank as is shown in the diagram below.
- In order to replicate a tsunami: push down on the metal plate, plastic tray or other solid object at the deep end of the tank, which replicates the sudden displacement of water. You could even use a large bowl (but take care not to submerge it completely).



DELIVERY

1. Introduce the topic, and clarify the concepts of tectonic plates, earthquakes, volcanoes and landslides.
2. Use the model to show how a tsunami is formed. Go through the steps of how the wave is produced in the model and illustrate that the height of the waves can be recorded using the ruler and the marker.
3. Explain that the students will be simulating a tsunami with the goal of designing the most effective barrier. For this, they will need to research structures and materials. A few points they must consider while designing and planning are:

   a. Materials: heavy versus light. Cheap versus expensive.

   b. Structure: should the barrier slope? If so, in which direction in comparison to the wave?

   c. Numbers/size: how many barriers/how big of a barrier will be able to stop the tsunami?

TIPS

- This activity can be messy, so we recommend using a tarpaulin or doing the activity outside. Remember to have plenty of materials available to clean up the water spillage.

4. After the design stage, students should be given plenty of time to build, test, and revise their designs.
5. Effectiveness can be measured using cameras to record the passage of the wave before the barriers are in situ and again when the barriers are in place. It would be helpful to draw a grid on the outside of one side the tank to assist the students in recording the height and speed of the waves.
6. Students should plot the height of the wave and the speed at which it travels on a graph using footage from the camera to help identify the height/speed of the wave at given points. Students should plot the passage of the wave both before and after the barriers are applied to help assess the effectiveness of the barriers and their placement.
7. Encourage students to test and refine their design and placement of the barriers to reduce the amount of sand that is 'washed away'. You could place a beaker in the sand, making sure it is always in the same place and protrudes out of the sand at the same height after each wave. Students can record how full of water and sand it gets before and after their barriers are used.
8. To help the students refine and perfect their designs you could set a target for them to achieve, such as reducing the amount of sand and water in the beaker by 75% or decreasing the speed and height of the wave after it hits the barrier.

EXTENSION IDEAS

1. Students can visit the suggested links in the Useful links section, or you can set this beforehand as a preparation activity.
2. Students can compare the results they achieve using different depths of water in the tank.

DIFFERENTIATION IDEAS

Support: provide several examples of simple barriers that allow the students to compare them between each other in terms of effectiveness.

Challenge: Students can progress the initial experiment of creating a tsunami by designing their own effective barriers reduce the effect of the tsunami. However, impose constraints such as limiting the materials that can be used for their barriers. For example: imagine they are in a part of the world prone to tsunamis, but where money is more problematic. What materials are readily available there?

USEFUL LINKS

- **Science NetLinks: 'Making tsunamis worse'. On loss of natural barriers against tsunamis**
  http://sciencenetlinks.com/science-news/science-updates/tsunami-barriers/
- **PBS News Hour Extra: How do you protect against tsunamis?**
  http://www.pbs.org/newshour/extra/daily-videos/how-do-you-protect-against-a-tsunami/
- **How to design for tsunamis**
  http://www.architecturerevived.com/how-to-design-for-tsunamis/
- **Teach Engineering Lesson: Tsunami Attack! Giant Wave Characteristics and Causes**
  https://www.teachengineering.org/lessons/view/cub_natdis_lesson06
- **Teach Engineering Hands-on Activity: Survive That Tsunami!**
  https://www.teachengineering.org/activities/view/cub_natdis_lesson06_activity1
- **YouTube video of a wave tank**
  https://www.youtube.com/watch?v=3yNoy4H2Z-o

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

6 How do you survive a tsunami?

Your challenge

While tsunamis cannot be prevented, STEM researchers can work together to protect against damage and to warn people in time for evacuation.

Use your creativity to save lives and decrease the destruction caused by tsunamis!

WHAT YOU NEED TO DO

PHASE 1 – RESEARCH AND DESIGN

Organise your ideas for your design of the barrier.
In small groups, write down your ideas, share and discuss.
Consider the following things while you design:

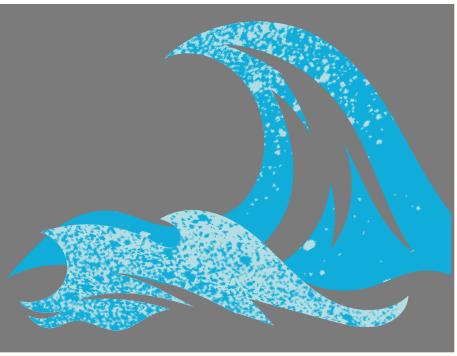
1. Materials: heavy versus light. Cheap versus expensive. Often, heavier and sturdier materials might work well against a tsunami, but is it feasible in terms of costs?
2. Structure: research the way the waves of a tsunami will hit the barrier. Should the barrier slope? If so, in which direction in comparison to the wave?
3. Numbers: will a double barrier work better than one (comparing it to natural barriers such as mangrove forests)?

To find out more visit:

- **Science NetLinks: 'Making tsunamis worse'. On loss of natural barriers against tsunamis**
  http://sciencenetlinks.com/science-news/science-updates/tsunami-barriers/
- **PBS News Hour Extra: How do you protect against tsunamis?**
  http://www.pbs.org/newshour/extra/daily-videos/how-do-you-protect-against-a-tsunami/
- **How to design for tsunamis**
  http://www.architecturerevived.com/how-to-design-for-tsunamis/

FUN FACTS

1. Tsunamis can travel at speeds of about 500 miles or 805 kilometres an hour: almost as fast as a jet plane.
2. Mangroves and coral reefs can act as natural barriers against tsunamis, saving lives and protecting property. Unfortunately, human activities are the cause of the loss of many such natural barriers – which ends up coming back to haunt us when the next tsunami hits.



STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

6 How do you survive a tsunami?

TIPS

- It might be necessary to repeat the simulation several times from different angles before everything is clear on camera.

PHASE 2 – CREATE AND TEST

Use the materials provided to create your barriers and trial them out in the simulation tank. You should record the passage of the wave before and after your barriers are used to help you refine the design and placement of your barriers.

1. Create a wave by pushing down on a solid object at the deep end of the tank, which replicates the sudden displacement of water. Make sure you record the wave on camera. Record how much water and sand is in the beaker.

2. Use the slow motion feature to watch the footage and observe carefully how the wave develops and travels towards the beach before hitting it. Plot the height and speed on a graph. You will use this information to help you place your barriers and refine the design.

3. Place your barriers in the tank, and recreate a wave, making sure you record the wave's journey. How much water and sand is in the beaker?

4. Use the slow motion feature to watch the footage and observe carefully how the wave develops and travels towards the barrier before hitting it. Plot the height and speed on a graph and compare the two waves. It should allow you to assess the effectiveness of your barrier more accurately.

5. Consider the effectiveness of your barrier:
   - did your barrier reduce the amount of sand and water in the beaker
   - did the wave deposit more water and sand elsewhere
   - did the barrier reduce the height or speed of the wave
   - how can you improve the design of the barrier
   - could the barrier be placed or angled differently

6. Use the information you've captured in slow motion and in your graphs to review the effectiveness of your barrier, keep redesigning and testing your product until you have a barrier that can protect against the tsunami effectively.

CLUB LEADER GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

7 Sturdier skyscrapers

Objective

Students explore the science of forces and materials and will need to identify some of the factors that make buildings earthquake-proof.

TOPIC LINKS

- Design and technology: building design
- Engineering: civil engineering

TIME

60–90 minutes

RESOURCES AND PREPARATION

For the starter, each group needs:

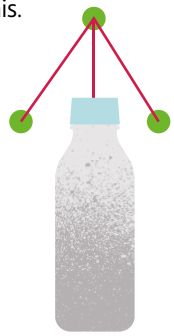
- empty drinks bottle with cap on
- 4cm BBQ skewer
- 2x BBQ skewer of longer length
- 3 wedges of plasticine

For the skyscraper activity, each group needs:

- cardboard
- masking tape
- straws (approximately 30 should be enough per building)
- paper clips
- pins
- 2 meters of string
- access to a shaking table (this link - http://teachers.egfi-k12.org/activity-earthquake-proof-structure/ describes how a shaking table can be constructed)
- access to 10–20 sandbags (250g each)

DELIVERY

1. Provide students with the drinks bottle and the short BBQ skewer with a wedge of plasticine attached to it. Ask them to get the skewer to balance on the bottle top, but without sticking the plasticine to the bottle top. (They probably will not be able to just yet.) Tell students there is a way to do this – no tricks, just science! Students should start thinking about how to do this.



2. Introduce how civil engineers have to think of ways to strengthen buildings outside of the actual material selected to make the building – by thinking about how the building is structured and weight is distributed. Add two more skewers with plasticine masses on each end to the original piece and show that by manipulating the centre of mass, the entire structure can balance on the BBQ skewer. It can even be pushed and will not topple.

3. The main task for the students is to construct a building using the principles and test its resilience. Students can undertake the necessary research before they design and create a prototype.

4. Divide students into working groups. Explain the rules and requirements of this building challenge. The goals and constraints for this activity can be set by the Club leader, but some examples are:

   a. Buildings must survive the earthquake test for at least 10 seconds.

   b. Buildings must be at least 3 levels high.

   c. Buildings must contain at least 1 triangle.

   d. Buildings must contain at least 1 square.

   e. Buildings must be able to hold a certain amount of weight (the sand bags) on each level.

   f. Create and hand in a construction drawing with measurements and analysis.

TIPS

Some pointers and discussion prior or during construction may include:

a. A description of trusses (https://skyciv.com/tutorials/what-is-a-truss/) and cross-bracing (www.youtube.com/watch?v=0-RDPHxvLmg).

b. The effect of a wide base or a narrow base on the stability of the structure.

c. How to secure the sand bags so that they don't fall off.

5. Demonstrate the testing procedures and show how the shake table works.
6. Show students some of the different methods (www.wikihow.com/Build-a-Straw-Bridge) for joining straws together without folding the straws and compromising their integrity.
   - Two straws may be pinned together with a straight pin.
   - A paper clip (https://classroom.synonym.com/build-out-straws-paper-clips-5233234.html) may be partly opened up and be slipped into a different straw.
   - Holes may be drilled with the pins and the string slipped through to tie straws together.
7. The shaking table can be used to simulate an earthquake. Students may test their prototype and to make adjustments to their design. Let students design and rebuild as many times as time allows.

EXTENSION IDEAS

1. Ask students to conduct their own research into the field of civil engineering.
2. Students can watch this video of an earthquake-resistant building model created for a final year civil engineering project.

DIFFERENTIATION IDEAS

Support: reduce the number of requirements and constraints for their model buildings.

Challenge: give students more requirements and constraints for their model buildings.

Wind is another factor that civil engineers need to take into account during the designing process. Ask students to investigate what can be done to protect skyscrapers from toppling over because of wind. Can they incorporate this information into their own designs?

USEFUL LINKS

- **YouTube clip: DIY Science Balancing Act**
  https://www.youtube.com/watch?v=MTc5uFif49M&index=7&list=PLw7lLwXw4H51zKplcw1sgdXbaKRzcE5Gu
- **PBS: Skyscraper basics**
  http://www.pbs.org/wgbh/buildingbig/skyscraper/basics.html
- **The Engineering Tricks Behind the World's Super Tall and Super Slender Skyscrapers**
  https://www.curbed.com/2015/9/24/9917752/the-engineering-tricks-behind-building-slender-taller-towers-and
- **New Scientist: Engineers take skyscrapers to new heights**
  https://www.newscientist.com/article/mg22029430-900-engineers-take-skyscrapers-to-new-heights/
- **Seismicity and earthquake hazard in the UK**
  http://www.quakes.bgs.ac.uk/hazard/Hazard_UK.htm
- **Lesson: Skyscrapers: Engineering Up!**
  https://www.teachengineering.org/lessons/view/duk_tower_tech_less
- **Constructing earthquake-proof buildings**
  http://www.discoveryeducation.com/teachers/free-lesson-plans/constructing-earthquake-proof-buildings.cfm
- **Activity: Build an Earthquake-proof Structure**
  http://teachers.egfi-k12.org/activity-earthquake-proof-structure/

STUDENT GUIDE: SUITABLE FOR AGE 14-16

Save the world with STEM

7 Sturdier skyscrapers

Your challenge

Civil engineers face many challenges in their quests to build ever-taller skyscrapers. They need to consider centre of mass when designing buildings, so that buildings are able to withstand strong winds, and even minor earthquakes.

Design, build and test your own earthquake-resistant skyscraper!

WHAT YOU NEED TO DO

PHASE 1 – RESEARCH AND DESIGN

Conduct research into this topic.
Some sources to get you started:

PBS: Skyscraper basics – http://www.pbs.org/wgbh/buildingbig/skyscraper/basics.html

The Engineering Tricks Behind the World's Super Tall and Super Slender Skyscrapers – https://www.curbed.com/2015/9/24/9917752/the-engineering-tricks-behind-building-slender-taller-towers-and

New Scientist: Engineers take skyscrapers to new heights – https://www.newscientist.com/article/mg22029430-900-engineers-take-skyscrapers-to-new-heights/

Seismicity and earthquake hazard in the UK – http://www.quakes.bgs.ac.uk/hazard/Hazard_UK.htm

In your group, draw and design what you would like your skyscraper to look like. Consider some or all of the following points during this process:

1. How many levels will your building have?
2. What can be done to make the structure stronger?
3. Where does the centre of gravity lie for your design? How can you test this?
4. What features are important when designing the foundation of your building?
5. What must be done to prevent the building from toppling over each time you add a level?
6. Can you use any knowledge you acquired from the bottle balancing act?

PHASE 2 – CREATE AND TEST

Test how well your building can withstand the earthquake simulation. If necessary, make changes to your product to make it safer.

Once you have finished your building according to the constrictions and goals set by the Club leader, complete a structural analysis of your skyscraper. Include clear and complete answers to the following questions:

1. During construction:
   - **a.** How did you test the strength and stability of your structure?
   - **b.** What strategies and materials did you use to strengthen the weaker areas? Explain fully.
2. What are the strongest parts of your building? Explain fully.
3. What are the weakest parts of your building? Explain fully.
4. If you had five more straws, where would you add them? Why?

FUN FACTS

1. 3D computer models allow engineers to build increasingly taller buildings that are sturdy and safe. These computer models take information about a building's size, shape, weight, and the forces it will exert and have exerted on it, and give engineers details about the minimum amounts of materials they should use.
2. You might think that a skyscraper would be in more danger of toppling during an earthquake than a smaller building, but in fact, the opposite is often true. Because shorter buildings are stiffer than taller ones, a three-story apartment house is considered more vulnerable to earthquake damage than a 30-story skyscraper.

Notes

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