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Camera obscura and lenses

Physics: Peering at the outside world through a lens.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Camera obscura lens in cardboard sheath, should be packed carefully to avoid scratches
- Wooden board painted white
- Ray box and 2 colour filter light boxes
- Power supply for lights
- Lenses ((i) "eye" lens, (ii) corrective lens(es)), should be packed carefully to avoid scratches
- Sheets of A4 white paper to go under ray boxes
- Sheet of A4 paper to act as screen for ray boxes
- Poster showing cutaway diagram of eye

Explanation

Overview

This is a large experiment with 3 parts.

1. A glass camera obscura lens in the side of the darkroom tent, and a wooden board. If you hold the board in the correct place inside the darkroom then an upside down image of the outside world will be projected onto it through the lens.

2. Ray boxes and lenses on a table. This is essentially a 2d representation of the camera obscura which you can use to explain it. You can show: why the image is upside down; why the lens is important; what focussing does; and how corrective lenses work in the eye.

3. Poster showing cutaway diagram of eye. Allows you to link in the bio factors, talk about the parts of the eye, nerves etc.

Set Up

- Position the darkroom, and the camera obscura lens, such that it is looking out on a brightly lit, active area with, if possible, plenty of depth for varying focus. Ideally it's a good idea not to let people (parents/ demonstrators) congregte just in front of the lens... out of focus legs blocking most of the picture aren't very exciting!

- Cut a hole for the lens at about child's eye level (or find a suitable hole), and tape the lens and sheath in place.

- Set up the ray box and light boxes on the table, and check they work. They should have switches on them.

[image1]

- Get the 2 sheets of paper showing the eye with/without corrective lenses and tape the light boxes in the correct place.

[image2]

- Tape up the poster of the eye somewhere

Demonstrating

(This is one approach to demonstrating this experiment. It's quite long so it might be wise to split it between 2 people.)

1. The camera obscura

1a. Encourage children to look through camera obscura lens from various distances, observing that they can see what's outside, but blurry and possibly upside down.

1b. Either holding the white board yourself, or getting the children to hold it, position the board so that the image is in focus on it. Ask them what they can see and get them to realise it's an image of outside.

1c. Ask them what's wrong with the image. Eventually they'll get that it's upside down. Try turning the board over and show that it doesn't make a difference. If one is wearing a white T-shirt, try getting the image focused on them, if not, use your arm... make it clear there's nothing special about the paper- it's the light coming in.

1d. Move the board around and show that the image is blurry unless it's in the right position.

2. The eye

(This seems to be well received by everyone, and is fairly interactive but not hands-on. There's loads you can talk about: cameras, eyes, shutter speeds, focussing, digital cameras, nerves. This is one approach).

2a. Say that this is how your eye works. Shock horror. DON'T move over to the eye poster yet - it seems to distract them and it's pretty dull. Instead, talk about it while you're holding the camera obscura board and point with your arm to where the eyeball would be.

2b. Start by talking about the pupil - "what's in the middle of your eye?" - most people know what its called and what colour it is so this is a good starting point. Then say its a hole that lets light into the eye, just like the hole in the side of the tent. Again, point with your arm to where the eyeball and pupil would be in the tent, relative to the board that you're holding.

2c. A hole isn't much use by itself, its the glass thing that does the work. You've got one in your eye too. Yes really. What's it called? A lens. What's it made of? Glass. How do you make glass? Heat sand to high temperatures. So can you do this in your body? No. So your body uses jelly to make the lens instead.

2d. Ask them what the eye is filled with. The eye is filled with clear jelly liquid. does light go through water? Yes. So (pointing with your arm again) the light goes through the hole into your eye until it hits the other side of the eye.

2e. So the light goes through the hole into your eye until it hits the other side of the eye. What happens on the other side of the eye? You get an image upside down, just like on the wooden board for the camera obscura.

2f. That's great but you still can't see. The neat trick is to cover the board at the back of the eye with electrical sensors that sense what colour light is hitting each point on the board. So here they say "yellow", here they say "red", etc. All this gets sent down wires to the brain so you can see.

2g. Now move over to the poster of the eye diagram and show them that it's all true. The orientation of the cutaway diagram isn't obvious at first so you have to help them with this.

2h. So, on to these wires. What're they called? Nerves. Have you seen wires in the house? What're they made of? The middle bits made of metal. It conducts. Do you think wires in the body are made of metal? No. What else conducts? Salt water. So the body uses salt water instead. What about the plastic? It insulates. Do you have plastic in your body? No. So use fat instead.

3. Ray boxes

(Younger children tend not to receive this part very well - they just don't grasp the correspondence between the 3d camera obscura and the 2d ray boxes. However there's still some mileage in shadows and light going in straight lines. If you've been talking to them for ages already it's better to get someone else to demonstrate this bit otherswise they tend to get bored.)

3a. Move to ray-box table, tell them we're going to explain why the image is upside down. Ask if they have any thoughts about it.

3b. You could show light travelling in straight lines- talk about shadows- caused because light can't go round corners, etc.

3c. Now with the lens in place, compare the system you have to the camera obscura - eg "we have the light coming in on this side, and here's the lens, etc...". Hold a piece of white paper up as "the board".

3d. Point out that the image is upside down - on one side of the lens, the red light is at the top and the green light is at the bottom, but on the "board" the reverse is true. Get them to work out that the lights cross over inside the lens, so the red light starts out at the top and goes to the bottom, and vice versa for the green light.

3e. Compare this back to the camera obscura, where light from the ceiling ends up at the bottom of the board and light from the floor ends up at the top of the board. The light crosses over inside the lens.

3f. Talk about focussing the light to a point by moving the "board". Relate this back to moving the board for the camera obscura.

3g. If they're already familiar with how the eye works then you could take them through corrective lenses. Use a mishaped eye (squashed black circle on white paper) with one lens and show that the light doesn't focus properly on the edge of the circle. Now add a corrective lens in front of that lens and show that it now focuses properly. Get them to relate this to contact lenses and glasses.

Camera obscura and lenses Risk Assessment

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DESCRIPTION	Using a lens in a dark room to project an image of what is going on outside
RISKS	1. Glass lens may break, and glass shards may cut people. 2. If lens is positioned in direct sunlight, then the focused sunlight can cause retinal damage and burns.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Make sure the lens won't fall on floor, eg. by using tape. Clear up broken glass immediately. 2. Demonstrator to make sure that the lens is not positioned in direct sunlight.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in the event of injury.

DESCRIPTION	Use ray boxes to observe light paths through variety of prisms
	• 1. Electrical hazard • 2. Bulbs become very hot when in use, box may become hot over time

RISKS	• 3. Prisms, lenses and bulbs may shatter if dropped on floor - possibility of cuts. • 4. Trip hazard from cable.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Use low voltage equipment (3V). Power supply should be PAT tested, as per the elecrical parts RA • 2. Some bulbs are enclosed in plastic case. Do not remove case. Do not touch bulbs. Bulbs not in plastic cases have been tested to ensure they do not get too hot. Turn box off when not in use. • 3. Discourage rough handling of lenses and prisms. • 4. Keep the cable to the ray box out of reach if possible. If cable is somewhere it might present a trip hazard, ensure it is taped down.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Disconnect electrical supply, then call first aider in event of injury • 2. Call first aider in case of injury • 3. Clear up broken glass immediately and keep people away while doing so. Call first aider in event of an injury. • 4. Call first aider in case of injury

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation • 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper).

ACTION TO BE TAKEN TO MINIMISE RISKS	• 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

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Hot Air Balloons

Physics: Making hot air balloons with plastic bags and a toaster.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Bottle with balloon attached to the top (thinner balloons that expand more easily work better, check that there are no holes in the balloon near the neck of bottle).
- Toaster with cardboard shield to fit around it.
- The "balloons": Various white bin liners, with bits of gaffa tape attached to the bottom of them.
  (NB: The box won't shut properly as the toaster is too big, so don't waste too much time trying to make this happen...)

Explanation

This is a neat experiment which kids often find quite exciting, particularly in a large room (preferably away from any outside doors on windy days, even small amounts of wind are a pain for this one). It's best when combined with the vacuum demonstrations (which show that air is not massless and leads in nicely to the beginning of hot air balloons).

Bottle with balloon

I usually start by asking the kids what is in the bottle (lots of kids will say nothing, this experiment is a good way of seeing that air isn't nothing!), and what will happen if we heat it up (the balloon expands). Depending on how old they are and how much they know you can talk about the following while you do the heating:

- Air is a gas (some children will be confused by this as they think it's a mixture of different gases which is not relevant here, but can be something to talk about if they're interested).
- Gases usually expand when they get hot.
- What this means in terms of particles, ie they gain energy, move faster so fill up more space. A reasonable analogy is that of a class of children all walking round past each other needing less space than the equivalent class running.

Heating is best done by running it under a hot tap, then you can cool under the cold tap, but you can use the toaster if you don't have a sink (for obvious reasons don't do a mixture of the two!). If using the toaster, you need to hold it a good distance away (at the top of the shield) to avoid melting the bottle.

Balloons

I sometimes get kids to think of something powered by hot air (many get it straight away, some need a remarkable amount of prompting and loads say aeroplane...).

To make a balloon fly:

- Put the cardboard shield around the toaster, it's easiest if you turn it on first.
- Put the bag over the shield, pull it all of the way down to the bottom.
- Let the air inside heat up and off it goes.

You can get sensible kids to do this themselves.

Things to talk about include:

- What is at the bottom of a hot air balloon? Aside from the basket with people in, there is a burner that heats the air, and gives it more energy.
- Pretend that the bag is air tight (actually not far off being true, very little air escapes out the bottom), thus it only has a finite amount of air in it, which initially weighs the same as all the surrounding air. When heated the gas expands, which can be seen as the balloon puffs up slightly (although the effect is subtle sometimes) and hence there is the same amount of weight spread over more volume, so each "bit" of air i.e. fixed volume element, weighs less than it did before, thus less than the surrounding air and the balloon experiences buoyancy.
- Now pretend like air is loss. Where does the air go when it expands? It fills up the bag then escapes out the bottom. This makes the bag lighter, so it floats up to the ceiling. N.b. either explanation works, the first is more thorough but the second may be more intuitive especially for younger children. They are both in part true, though I'd guess at the first being dominant.
- If they all say "it rises", you can explain that we're trying to understand why it rises, or hold the bag down and say that it can't be rising because there's a bag in the way!
- Why do we have the bits of tape on the bottom? They are weights helping the bag go up in a straight line, if it gets tipped over sideways a bit then the weight pull it back straight again (hold the bag over your arm and tip it to demonstrate this). Some kids will know that real hot air balloons carry sand bags as ballast, this is more to help them control their height than to stop tipping, the weight of the basket/passengers is enough for this. You can try launching a bag without any weights, you should find that it tips over and falls back down quite quickly, though you need a relatively high ceiling to see this.
- How can we make it go higher/faster? Heat up the air more at the beginning by holding down the bag. Be a bit careful doing this, you can melt the plastic bag quite easily and it all gets quite hot. Different sizes of bag would be an option as well, though I don't think there are any in there at present.

Further discussion:

- What difference does the temperature of the room make?
- Will the balloon stop going up? Would this balloon work in space, why not? What would happen as it approached space? (tip: as it rises density of surrounding air drops until the weight of displaced air = weight of balloon and it stops rising)
- How does this relate to buoyancy in water? Can lead into some great discussions about how fish and submarines change depth (by expanding and contracting their volume, one way or the other)

(If you have the vacuum chamber as well, then you can use that to show that air does have some mass, so the bag does really get lighter when you lose some air, this will surprise most children and their parents. With good groups I think this is best done after the balloons, though less attentive children may lose interest once they've seen the exciting bit. Vacuums can however be used to start off the theory and lead into the idea of gas particles.)

Hot Air Balloons Risk Assessment

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DESCRIPTION	Making hot air balloons out of bin liners fly in a room. The air is heated using a toaster at the bottom of a card tube over which a bin liner is placed.
RISKS	• 1. Heat causing burns. • 2. Heat causing tube or crumbs to catch fire • 3. Heat causing bin liner to melt • 4. Electrical hazard. • 5. Cable presents trip hazard. • 6. Bag suffocation.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. The tube is made out of card which isn't very conductive and will not melt and stick to people. -Use a cool-wall toaster which will therefore not get too hot. -The tube should make it very difficult to put fingers in the hot parts of the toaster. -The tube is supported so it can't fall over easily • 2. Are using a toaster that hasn't been used to toast bread so there are no crumbs. -The card is white so will go brown before it burns - if it goes brown turn it off. -**If there are burning smells turn it off!!** • 3. Do not hold bin liner over toaster for longer than a few seconds • 4. Use a new or PAT tested toaster. • 5. Ensure cable is either positioned where people will not be walking or taped down. • 6. Make sure spectators are not stood too close where the bag could land on their heads, and try to catch before it can land on them.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	In case of burns run under a cold tap. Call first aider in case of injury.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 13/02/2017 - 00:56

Spinning Chair

Physics: Use a freely spinning chair, some masses and a bicycle wheel to see some unintuitive physics.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- spinny chair *(Heavy - be careful when lifting)*
- masses - 2 small and 2 large (bags of rice covered in gaffer tape)
- bicycle wheels with handles (one big & one small), with spokes covered in cardboard to minimise finger trap risks
- clear plastic bottle half full of water
- Sticks with streamers.

Explanation

Overview

By using a spinning chair, weird effects due to conservation of angular momentum can be felt. Have a go before demonstrating, but beware - it's difficult to concentrate when your head is spinning!

Set up:

- Try to make sure the chair is level, there is more than a metre of clear space around it in all directions, and the floor is something that won't graze anyone who lands on it (e.g. carpet).
- Find somewhere convenient to keep the bits of kit so that people don't trip over them.

What can you do with it?

Masses:

- By holding the masses at different distances from the body, the speed of spinning changes. For small children, it's enough to get them to just stick their arms and legs out.

Wheels:

- Before sitting on the spinny chair, hold the bicycle wheel between two hands and spin it. Turn your arms so that the wheel is horizontal. There is a pull in the opposite direction.
- Stopping the wheel while it's spinning. For a child standing, stop the wheel so that they feel a twist in their feet. For a child on the chair, if they are stationary, start the wheel spinning then stop it. They will start to spin.
- Turning the wheel over while sitting on the spinny chair (initially stationary) so they move in one direction then the other.
- Demonstrating the precession of a wheel while hanging from a string due to the moment caused by gravity.

Other things to talk about

Artificial satellites use gyroscopes to orient themselves without wasting reaction mass.
Stable rotation axes - important for satellites.

Gyros are used in ships for navigation, by pointing to True North (not Magnetic North) as determined by the rotation of the Earth, which is more useful for navigation. Also, magnetic compasses can be affected by the steel in ship hulls, whereas gyrocompasses are immune to this effect.

Spinning in trampolining or ice-skating: to go faster, trampolinists and ice-skaters bring their arms and/or legs in.

A very brief explanation

- Change of rotation speed: Explaining angular momentum can be very difficult as it's very unintuitive (the entire reason this experiment is fun, that and the spinning) but there are some simple approximations you can make by just assuming children are point masses in a vacuum, but don't tell them that.

If you ignore the mass of the children, but not of the bags of rice, then by conservation of angular momentum you would expect the rice bags to move with constant velocity (for a point mass m at distance from axis r and angular speed w, velocity v = rw and angular momentum L= mr^2w is conserved, therefore v is conserved). You can show them, by spinning around on foot with the masses in your hands, one arm outstretched the other bent, that the mass on the outside is moving further in the same amount of time, thus must be going faster. Alternatively use the streamer sticks to show that air is passing the sticks faster when held out at arm's length compared to close in.

But we know that masses should not change speed (can explain via some rudimentary newtons first law, rather than angular momentum), therefore the only way to conserve linear speed is to change angular speed, and speed up or slow down the chair.

If they understand this you can then explain that human beings, much like rice bags, do also have some mass and therefore some effect, and for the really keen ones, there are nice discussions about the limits of the speeds if they were massless, if the masses were at an infinite distance, or at a distance approaching 0.

- Gyroscopic effects: Pixies
(or see below)

Tips for Demonstrating:

- There is some potential for slipping off the chair and landing badly. Get people to sit well back on the chair - that way they have good contact with the seat, and they can easily adjust their centre of gyration by leaning forwards. Small children need to be lifted onto the chair.
- Some of the more spindly kids can build up an impressive amount of spin as they pull their arms and legs in, heavier kids will tend to slide off the chair, while with adults there is a risk of toppling the chair. Use only moderate speeds. Alternatively, always start the kids with their arms and legs / weights close in to them. You can then start them spinning and all that can happen when they move is their angular velocity decreases.
- Some kids like to experiment with how dizzy they can make themselves - best to stop this before it gets out of hand with a lecture on how the semi-circular canals in the inner ear detect rotation, and why they are getting dizzy. Slosh the water in the plastic bottle to show how the fluid in the inner ear moves around.
- The wheels are heavy, and when spinning move in unexpected ways. This has lead to a couple of minor abrasions where the rim has rubbed against the bare arms of the person holding it. Test the child's ability to hold the weight of the wheel before starting it spinning - remember that they will also need to hold it up for a while, and have some spare strength to resist its gyration.
- The kids will almost always notice the spinny chair, or have seen people on it earlier, but it's often best to talk about what you're going to do first before anyone gets too dizzy.

Basic Procedure and Explanation:

"Who wants a go on my spinny chair?"

In Depth Explanation:

Talk about pushing something to make it move, and what determines how hard you need to push.
Give them the masses and set them spinning with a gentle push on the arm. Two masses, one in each hand, arms out sideways is most effective (add legs up forwards too, if the child is heavy)
For smaller children, you don't often need the masses: they will be able to feel themselves speeding up and slowing down. However, the masses do make it more obvious for the people watching.
Get them to experiment with bringing the masses in to their bodies and away again (concentrating and distributing their mass). Miming the actions as you say them helps communication here.
Stop them spinning then ask first what happens when the masses are in different places, then ask why it happens.

Get them to observe the paths the masses are moving along (repeat experiment if necessary). The idea is: it is a shorter distance around a small circle than a large one, while the masses want to keep the same speed, so get around the smaller circle quicker.

Hold one weight close in to your body and one far away whilst you are sat on the chair. Ask which is going fastest. Kids are often quite bad at this so get them to work out which goes furthest, , then propose a race around a circle, where one person is close to the centre and the other is further away. Who has to go fastest if you get around in the same time? Now think about the weights, as they come in they are going 'too fast' for the distance out that they are so they get ahead of your spin. This drags you forwards until you're going a bit faster. As you allow them to go further out they're going too slowly for how far out they are, so they drag behind and slow you down.

Momentum can be difficult to explain, especially with younger children, although it can sometimes be done. Often talking about loaded shopping trolleys is a good way to start: once you get them moving, they will carry on going until they are stopped. Amount of spin, or spinniness helps in the explanation of the spinny chair, then angular momentum can be introduced as "what scientists call it".

To give them a feeling for how moment of inertia varies with mass distribution you can get on the chair yourself with the two large masses, and get them to spin you slowly, first with concentrated mass, then distributed.
What happens to all the extra effort they put in to spin you in distributed configuration when you make yourself concentrated? (True - the extra angular momentum they supplied is conserved, and you did start with more energy, but you do work too when you pull the masses in) (Warning: it can be hard to demonstrate when your head is spinning...)

Using the wheel on the chair:

Spin the wheel slowly on one side, ask which way it is spinning, turn it over. Which way is it spinning now? We can change the way the wheel is spinning just by turning it over. It is often worth giving the wheel to a couple of the kids before putting anyone on the chair, even if it's just so they can see how funny it feels- ask them how their feet feel. Make sure you have explained what you're doing and be careful they don't scrape the spinning wheel against themselves.

Get them on the chair, spin up the wheel and get them to hold it up-right, one hand on each side. Stand back and let them experiment with turning the wheel (slowly!) onto one side and then the other. Sometimes they don't know which way to turn the wheel, so maybe show them what you mean before-hand. Observe directions of rotation, and if you think they will follow, talk through the conservation of angular momentum about the vertical axis (transfer to the earth!).

You can also do the same thing just by starting the wheel spinning and getting them to stop it, and then feeling the force acting on them.

Using the string

Suspend the wheel from the string, hold it with the axis level and ask what will happen if you leave go. They should say that it falls down, but they'll expect you to be asking because it doesn't, so you may surprise them when it does. Now get it spinning and do the same thing again, the wheel stays up (as long as it's spinning fast enough). Ask why and see where they get. With more confident kids, talking about what made it fall over before and what that force is doing now is often a good way to start: it keeps the idea of something pushing it around.
Remind them that earlier the wheel when turned could start them spinning, and ask what it can start spinning now. If there's nowhere to put your spin you can't lose it.

Additional Background (If you read the above then you're good to go on demonstration, read the below if you have more time. Don't expect to get anywhere near precession with normal kids though, and don't go further than you know confidently, kids can smell fear):

Angular momentum is an odd concept. The conservation of angular momentum can be derived from the symmetry of the laws of physics with respect to rotations of the reference frame (c.f. classical mechanics). Or you can ignore it and stick to point masses with negligible structure (or things that are built up by summing or integrating over such masses). That way the symmetry will seep into your calculations through the geometry, and you will still automatically conserve angular momentum.

It is only when you begin to leave out large chunks of a problem's geometry (treat an extended body as a 'thing' rather than the sum of its parts) that you need to make angular momentum explicit in a calculation. Looking at it more positively, angular momentum is the only aspect of the dynamics of the extended body that you need to retain - so you can discard a lot of irrelevant detail at the start of a calculation rather than waiting for it to cancel out at the end.)

It is the tendency of people's intuition to leave out geometry (to apply their experience of large non-rotating objects to the wheel), but not replace it with a-m that makes this seem so weird.

My normal approach to the spinny chair is to begin by working in terms of point masses, showing how this gives rise to angular momentum (although I shy away from the technical term, and just call it spin) - trying to get people to add these ideas to their intuition. Then if they stick it out all the way through to the precessing gyroscope, I try and pick that apart in terms of point masses and centripetal forces.

For the 'ice-skater' experiment, to bring the weights onto a smaller circle in the lab frame, you have to give them some radial velocity in addition to the tangential velocity they already have. You don't get to take this velocity away again when the weights reach the desired radius. To see this, consider applying the delta v as a single inward radial impulse, then turn off the centripetal force until the desired radius is reached. The minimum impulse that can be applied to achieve a given radius will make the mass's velocity tangent to a circle of that radius, so that when the minimum radius is reached there is no radial velocity to reclaim.

In the original rotating frame, the particle begins by moving radially inward, but gets increasingly ahead of the rotating frame (in the lab frame it is taking a short-cut across a chord of the circle), so its path curves in the direction of rotation. This is the fictitious Coriolis force.

To move to a larger radius, first turn off the centripetal force, then apply the impulse once the new radius is reached. This time the angle between the radial impulse and the particle's velocity is obtuse, so we can extract energy from the particle. This is not straightforward to explain to children. You might be able to say something about how, when the masses are spiralling inward, the inward pull is no longer purely sideways to their paths. Also, they might accept the conservation of energy argument as they will have really been able to feel the work they do to pull the masses in. This could be confusing though as in the person's instantaneous rest frame, radius acts like height for potential energy.

[image2]

The Angular Momentum Version:

A-M is not constant, but its magnitude remains the same because the plane of the couple is always at right-angles to the current plane of rotation (because the . Say the wheel is spinning in the x-z plane, while the couple is in the y-z plane - the wheel precesses so that it is spinning in the y-z plane (you can only spin around one axis at a time). But the couple is still 90 degrees ahead... (or use axial vectors if you prefer.)

My Gyroscope Explanation

Standing on the ground, let them hold the wheel with one hand on each handle.

(Be consistent in which way you spin the wheel for this part of the experiment - it is harder to get lost in your explanation if you always do it the same way). Twist opposite handles of the wheel up and down, feeling the pushes and pulls on the handles (in and out in alternate arms). Hold the handles level, and rotate whole body from side to side (i.e. twisting the wheel sideways without bashing it against arms), again feeling the forces (up and down in opposite hands).

Get their observations and help them summarise them while you thread the string through the end of one of the handles. With the wheel not spinning, hold the string in one hand and keep the handles level with the other, get them to predict, then release so that you are only holding the string. Describe this motion as a twist. Try for predictions of what will happen when we try the same thing with a spinning wheel, then demonstrate it. Once released, push the handle without string around in the direction of precession a little so that the wheel sits up and looks even weirder.

The key to picking apart what is happening here is to realise that things can only spin round in one lot of circles at a time, if you try make it something spin two ways at once its component particles are doing something much more complicated.

Talk about how things move in straight lines unless they are being pulled sideways. Go back to shopping trollies, conkers on strings, (drop blue-tac onto the rim and show how it flies off?).

Discuss how when wheel is rotating only one way, forces are all towards the middle, and all balance out, so are not felt in the handles. Twirling a conker, forces don't balance. With the handles level, and the wheel spinning top towards you while precessing around anti-clockwise (when looked down on), think about the motion of its consitiuent particles, and the forces required to generate that motion (and thus supplied by the hands). The bit of the wheel that is at the top would just come towards you, but as you are forcing the wheel to precess round, you are making it curve sideways to your right. Likewise the bottom of the wheel needs a sideways force in the other direction to make it curve to your left. These forces are opposite, but don't line up, so they are a twist. You can feel your hands supplying this push as you force the wheel to precess, or you can hold the handles only at one end and balance out the twist this generates with the precession force.

(This seems to add up correctly to a linear dependance of the force on the angular velocity of the wheel: as it goes faster, the curves become straighter, but the mass flows around them faster, /and/ at a greater rate.) If drawing a diagram of this, follow the path of the top of the wheel for a few more revolutions - projected on the horizontal plane this will be a complicated epicyclic curve (see glowstick photo) - it is all the sideways curving that is generating the odd forces.

Nutation:

The more I think about nutation, the less sure I am that I understand it. This link shows you how complicated you can make it. At some point I intend to try and translate some of that into english... (Anyone with brain-cells to burn is welcome to try and beat me to it.)

http://mitpress.mit.edu/SICM/book-Z-H-40.html#%_sec_Temp_261

Spinning Chair Risk Assessment

Last updated: 13/02/2017 - 00:56

DESCRIPTION	Kids spin round sitting on a rotating chair holding bags of rice of different sizes at different distances. They can also use a rotating bicycle wheel as a gyroscope, both on and off the chair.
RISKS	1. Falling off chair 2. Instability of chair 3. Hitting someone while spinning 4. Heavy chair and bags of rice, can be dangerous in transport 5. Rotating bicycle wheel could hurt fingers. 6. Chair may be incorrectly assembled, causing it to be unstable. 7. Bicycle wheel is fairly heavy, and could damage things/people if dropped.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Demonstrator must maintain control of the chair and should not allow it to spin at speeds at which there is a significant risk of the child falling off. Make sure that the chair is placed on a flat floor, or grass which is sufficiently flat to ensure stability, with no corners or edges to fall against. If there is an area of flat grass or carpeted or wooden floor, this should ideally be used. Avoid placing the weights, and other hard objects on the floor haphazardly near the chair, which could injure children if they fall off. 2. Stop kids getting too violent - do not allow them to spin too fast. Ensure chair is on flat ground. Tell children to step off if it is spinning too fast. Stop the chair if it gets out of control. Make sure other children stand away from the chair whilst it is spinning. Use chair with stable base. 3. Keep viewers back. Encourage people not to spin too fast. 4. The person carrying the equipment should be strong enough to do so, or get someone to help carry it. 5. Bicycle wheel is covered in stiff plastic to stop fingers being inserted between spokes. Be ready to help child with rotating wheel if it gets out of control. 6. Demonstrator to ensure the chair is correctly assembled (all parts are labelled). 7. Demonstrator should assess the size/strength of a child before getting them to hold the gyroscope. If the child cannot hold it comfortably in both hands, with arms horizontal and the wheel easily not touching them then they are too small and/or weak (remember they will have to hold it for a while, and not drop it when it feels like it's fighting them). The demonstrator ought to be ready to take the wheel back if required, and take some time to practice and get a feel for how it moves before demonstrating it to the public (it's not hard to do, but it's difficult to think of why people might drop it if you've not had a play yourself). Ensure that people (particularly smaller children) don't have the string around their wrist whilst holding the wheel so that it doesn't sprain/damage the wrist if dropped. Another dropping risk comes from dangling it on the end of a piece of string. This is a good bit of the demo to do, but make sure that the string is both well tied, and not frayed, before doing this.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• If injury occurs call first aider

Air Streams

Physics: Balancing balls on upward streams of air, and looking at aerodynamics.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Small scale stuff:
- Bendy straws (consumable), must have reasonably wide holes.
- Ping-pong balls
Large scale stuff:
- Big Blower (too big for box, needs 2 people to lift)
- Stream stabiliser for the big blower (a hollow box open on one end and with a grid on the opposite end)
- 'Small' blower (in box)
- 2 x variable power switches for blowers.
- beach balls
- Screwdriver with haztape streamer (for showing streamlines)
- Paper
Wind tunnel stuff:
- Aeroplane wing

Explanation

In a nutshell

Show how flowing air acts on object in or next to it.

How to set up the experiment

Note: The big blower is not necessary but makes a nice show. It may cause the circuit breakers to go off, so check first so that you don't cause a power outage a the beginning of the session.

Place the blowers on the ground. Make sure they are not in anyone's way. Put the stream stabiliser on top of the big blower. Plug the cables to the power switches and to the grid.

Note: The switch for the big blower gives full power for a few seconds after switched on. Afterwards you will be able to regulate it.

Blow up the beach balls and have the straws pingpong balls and aeroplane wing handy.

How to proceed

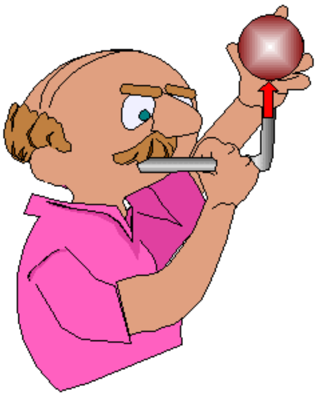
This is a suggestion on how to proceed with the demonstration. The demonstrator should encourage the kids to try and figure parts of explanation out by themselves by asking the right questions, so that they stay focused. There's a lot in here: you may not explain all of it!

Straws and pingpong balls

Take a straw and bend it in right angle. You can start by asking the kids if they can think of a way to balance the ball on top of the short end (not holding it by hand). Two ways are quite good: sucking and blowing. (Simple balancing it is possible but very hard.)

If you suck the air from under the ball, the air pressure from the outside will hold it in place. You can tell them about the air pressure and that we are constantly pressed everywhere and that suction occurs when we reduce the pressure in an area (eg the inside of the straw). (The concept might be hard to grasp so consider the age of the children.) They might already have some knowledge of it if they have seen the Vacuums experiment.

If you blow into the long end and hold the short end upwards, you are able to balance a pingpong ball on the stream. (The straw end needs to be vertical and you have to blow quite hard.) It requires a bit of practice. Let the kids have a go at it. Give each a new straw and dispose of them afterwards to avoid spread of infection. Demonstrating what goes on is easier with the blowers. It's the same on a larger scale.



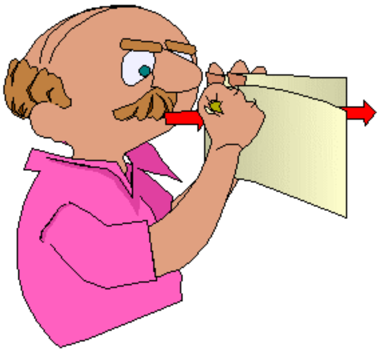
A bit of theory - what are forces

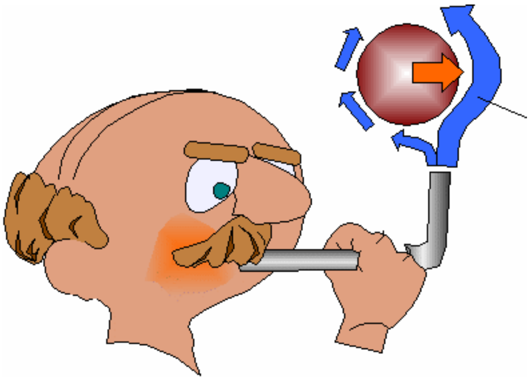
Hold a ball in mid air and ask them what is going to happen if you let go. Show them that they are right. Now ask them why the ball falls down. You should get to gravitational force. Explain what a force is. That it is what makes things move, for example pushing, pulling, gravity, magnetic force, friction. Explain that if something isn't moving, the forces must be balanced (they are pulled down by gravity but pushed up by the ground).
Tell them about Newton's third law - action and reaction. If you push or pull something, you get pushed/pulled yourself. You can demonstrate by letting them push/pull your hand.

Blowers and beach balls

Preferably use the big blower for this. If you place the ball in the air stream it will balance on it and not fall off. You can demosnstrate that it always balances at the same height. If you hold the ball at the edge of the stream you can feel how it is pulled in. You can let the kids to feel it too. You can use the screwdriver with haztape to demonstrate the direction of the stream.

Explaining why the ball doesn't fall directly down is easy and the kids might tell you that on their own. The tricky part is why is it pulled to the middle of the airstream. There are two ways to go about the explanation. The first is using Newton's third law. When you look at the airstream around the ball when it is at the edge of the stream, you will see that it is bend around the ball. After passing the ball, the stream is not strictly vertical (it is going a bit sideways). That means that the ball effectively pulls the passing air towards itself. The equal and opposite reaction on the ball then is that it is pulled inside. The other way of explaining it is using the Bernoulli's principle - the fact that the pressure is lower where the air has greater speed. (You can demonstrate it by blowing between two parallel sheets of paper hanging vertically next to each other.) So there is atmospheric pressure on one side of the ball and lower on the side of the airstream. The difference in pressure results in a force towards the stream.





A bit on stability

By the time you're reading this we should have a few beach balls of various sizes in the box, if not shout at Zephyr...

Using these we can do a brief discussion on stability of systems and how they will tend to rearrange themselves in the most stable form.

If we put two balls of different sizes into the air stream at once, the most stable configuration is the smallest on the bottom and the largest on top. This is because each ball effectively blocks some of the air hitting it from getting to the ball above (though by no means all, as seen with the bigger at the bottom) and hence there is less upward force on the higher ball.

Thus with the smaller on the bottom, enough air still reaches the second ball to hold it up, whereas the other way up little air makes it to the smaller, higher ball and it is likely to 'fall' off the side of the stream.

Why the quotation marks? Well, if you're lucky (/careful with the settings) the second ball rarely actually escapes the stream, instead the larger ball barges it's way past and then the smaller slots back into place under it. I.e. the system seeks out the most stable configuration.

That said, the smaller ball on top is still an equilibrium state, just less stable, and for more advanced audiences you can talk about the differences between equilibrium and stability.

Note, there is another effect with very small balls, like the ping pongs balls, where they are so light that the force they experience hugely outweighs the difference in amount of air hitting them, so make sure that the balls are of roughly comparable mass, or the lightest will just fly off!

Aeroplane wing

When you tilt the small blower so that the stream of air is horizontal, you can demonstrate the forces acting on the aeroplane wing. Children should be able to feel the air pushing the plane upwards when it is held horizontally. The wings are designed to maximise the upward thrust (which means they push down air significantly) while the backward thrust is minimised (we don’t want the wings to slow down the plane too much). Tilting the wing in the airstream results in greater upward force but also greater backwards force. Let the kids feel it but be careful so that the wing doesn’t fly off and hit them in the face.

Two possible explanations you can use:

One way to think about this is again with Newton's Third Law. The curvature of the wing means that the wing pushes the air blowing at it downwards, and so the air pushes the wing upwards. The size of the force depends on how fast the air is moving, and therefore how much air it is pushing down - you can show this by adjusting how hard the fan is blowing. This means that a plane has to travel VERY fast to get enough lift to keep it in the air (commercial airliners travel around 500mph).

Or using air pressure to explain: When the plane moves forward it pushes air out of the way, over and under the wing. As the top of the wing is curved more than the bottom of the wing, the air has to go further to get over the top and so it has to move faster. Bernoulli's principle says that the pressure is lowered when the air speeds up, so the air pressure above the wing is lower than the pressure below it, and the wing (and plane) is pulled upward (ie the same way things get sucked into a vacuum), opposing the gravity pulling it down.
[note: this doesn't explain *why* the air has to move faster over the wing - the air stream moving over the top of the wing has to move through a narrowing space due to the curvature, but with a constant volume per time (like water through a tube that then gets narrower).]

Bits from older explanation

*** OTHER THINGS TO TALK ABOUT ***

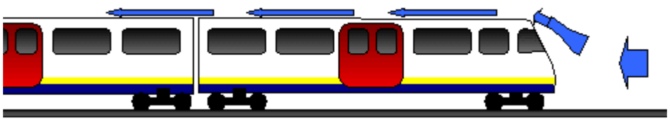
Have you ever noticed your ears going pop as your train goes through a tunnel?

For the train to move forward the air in front of it has to get out of the way, normally there is lots of space for it to do this, but in a tunnel there is just a little gap around the side, which the air has to squeeze through really fast.

This fast moving air sucks some of the air out of the train, which then sucks on your eardrums, making them go pop!

Why do you think they go pop again when you leave the tunnel?

The air isn't going as fast outside so the pressure goes up and the pop back inwards again.



You may notice the ball is spinning sometimes - think about where the air must be flowing to stop the ball falling off.

This happens when the straw is at an angle so the ball drops down a little and the air stream is faster over the top which is what is holding it up.

Try moving your hands across the blower, just above the grill. This will cause the ball to 'dance' as you are changing the air stream so the beach ball adjusts its position to remain in equilibrium.

Air Streams Risk Assessment

Last updated: 25/01/2017 - 23:03

DESCRIPTION	Try to keep ping-pong ball suspended in air by blowing upwards alone and by blowing upwards through a straw. Keep beach ball and balloons in air stream of several different air conditioning generators. Model wing in air stream of air conditioning generator.
RISKS	1.Finger hazard in blower. 2.Risk of long hair getting sucked into intakes. 3.Heavy object. 4.Electric risk + tripping over wires. 5.Slip hazard from ping-pong balls. 6.Transmission of illnesses via saliva on straws. 7. Risk of child injuring mouth from falling over with a straw in his/her mouth. Also, children are liable to run across people's paths after escaped ping pong balls, which can lead to accidents 8. Model wing can be blown quite hard, e.g. out of a young child's hand. Straws may be blown towards face or eyes. 9. Risk of dizziness from blowing too hard
	1.Have designed guards so it is not possible to get a finger of any size into the danger area. 2.Keep children with long hair (and animals if applicable) away from intakes.

ACTION TO BE TAKEN TO MINIMISE RISKS	3.Keep air conditioning generator on floor. Make sure that it is stable in the mount. Take care when moving it. 4.Tape wires to floor and lay sensibly (not across the middle of the room). If necesssary, attach something brightly coloured so that cables are clearly visible. Follow electrical parts RA. 5. Keep track of where the ping pong balls are and do not leave them on the floor. 6.Give every child a fresh straw. 7.Get the kids to sit down when playing with the ping pong balls so that they don't run around with the straws in their mouths and fall over. Encourage them not to chase balls. Do not allow young children to take straws away with them after experiment. 8. Make sure model wing is held securely - do not let small children hold unassisted when blower at full power. Discourage dropping of straws into air streams. 9. Warn before blowing into the straws not to blow too hard and to stop if dizzy.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1.Turn off electricity. 2.Call first aider in event of injury. 8. Call first aider in event of injury. 9. Call first aider in event of injury.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 02/02/2017 - 00:43

Vegetable oil and pyrex

Physics: Using the refractive index of vegetable oil to make a glass bowl 'disappear'.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- 2 pyrex bowls (1 big, 1 small)
- Vegetable oil (note: works less well/not at all if other types of oil are used)
- Paper towels
- Sodium polyacrylate spheres - optional
- Pure water - optional
- Coffee jar with pre-prepared spheres - optional

Explanation

What to do

1. Fill the large bowl with oil.
2. Parts of the smaller bowl which are fully surrounded by the oil become invisible - you can either pull the bowl out of the oil, or put a bowl in, the effect is the same.

Why this works

Glass is see-through, so how come we can see things made of glass at all?

It's all down to the fact that light travels through glass and air at different speeds. [1] When light moves from one material to another, it changes direction (refraction). When we look at a glass object, we don't see the glass itself, we see the bending of the light from objects behind it. [2]

Light travels through vegetable oil and pyrex glass at the same speed: they are said to have the same *refractive index*. When the Pyrex bowl is surrounded by oil, light passing though them doesn't change speed, and hence doesn't change direction, as it moves into the different materials. You don't have any way of seeing the smaller bowl, you only see the edge of the oil or the outer bowl.

Why does the light bend

If the wavefronts of the light hit the interface at an angle, then one end ends up moving more slowly than the other end. This makes the light bend.

Go and see the water-tank experiment for a hands-on demonstration of refraction.

(For a better explanation, take a look at the Making Pyrex Invisible experiment on the Naked Scientists).

If the balls have been prepared ...

The same effects can be observed using sodium polyacrylate spheres in pure (de-ionised/distilled) water. Sodium polyacrylate is a super-absorbent polymer which can absorb a few 100 times its own mass in water - hence it effectively has the same refractive index as water. The spheres take a few hours to absorb the required quantity of water so this part can only be done if the spheres have been pre-prepared.

In a non-cross linked form the polymer absorbs water much more quickly but sadly isn't transparent. This form is used in baby nappies.

[1] The "speed of light" is defined in a vacuum; in denser materials it travels slightly more slowly.
[2] And any impurities in the glass - this is why most glass is green if you look at it side-on. Optical glass (for optical fibres, etc) is much higher purity.

Vegetable oil and pyrex Risk Assessment

Last updated: 02/02/2017 - 00:43

DESCRIPTION

Putting a pyrex bowl into vegetable oil. Since they both have the same refractive index the pyrex bowl will disappear.

RISKS

1. The oil is very slippery, and could cause a nasty slip hazard.
2. If the pyrex bowls broke they would be sharp.
3. Children eating sodium polyacrylate spheres and spheres bursting.

ACTION TO BE TAKEN TO MINIMISE RISKS

1. Be very careful to minimise the chance of this happening, probably use a towel on top of a plastic sheet to contain any small spills if it is done inside. Mop up any spills carefully.
2. Check for cracks before starting demonstrating. If the Pyrex does break, dispose of it carefully. Be especially careful of any pieces that are in the oil as they will be INVISIBLE, so it is better to pour the oil out rather than fishing for them.
3. Ensure only one child is 'investigating' the spheres at a time so that they can be monitored. If they burst the sphere ensure that they don't rub their eyes and that they wipe their hands.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT

Call first aider in case of injury.

Last updated: 13/02/2017 - 01:04

UV (Fluorescence)

Physics: Looking at how materials fluoresce in UV light.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Short blue box containing:
Shrouded UV lamp
White paper
Washing powder tablets
Glowsticks
Highlighters
Sun cream
Board coated with glow in the dark paint
Also useful:
Paper money, driving license (anything with UV security markings)

Explanation

In a nutshell..

Show kids that there's more to light than the colours that they can see- and how this can explain why some ordinary things glow in "black light"

How to set up the equipment

This is best set up on the floor so that you don't look directly at the bulb. Put the lead and switches of the box towards you, with the flat side of the box towards your audience. The experiment is better in a dark corner/ in a dedicated dark room area. See the Risk Assessment for more details, but do thing about avoiding trailing wires in the dark! Also, there should be a power lead for the light box with this kit- please don't pack it with the main box of extension cables! There's lots of extra things in the box- if you keep them in the empty blue box when you're not using them it's easier to find them in the dark/ helps people avoid tripping over them!

What does the box do?

Turn over the box **with both lights switched off**, and show the kids the two bulbs. One is for "ordinary/normal" white light. The other bulb is a UV bulb- a kind of light human eyes can't see. There is a switch for each on the back. Turn it back over as soon as you're done with this to avoid UV directly into people's eyes.

See Risk Assessment for more details, but briefly: this particular UV light is pretty safe- it's not that far into the UV, so isn't as energetic/ dangerous as some other sources. You should hopefully spot that it gives off weak visible light too. It's also fairly weak - but *don't use it while it is facing up* just in case!!

What is light/ UV light?

The light most of us are really familiar with is white light. But that's actually a mixture of different colours. Most of the time we can't tell that, but sometimes we can see these colours split up, like in a rainbow.

Do you know the colours of the rainbow? Ask them to tell you!
[Red -> Orange -> Yellow -> Green -> Blue -> Indigo -> Violet (basically purple!)]

It turns out that there are more kinds of light than our eyes can see. Some kinds of light are "redder" than red is - we call that kind of light "infra-red" (there's another CHaOS experiment about this- check it out!). You might have seen images from cameras that can detect this kind of light, perhaps watching animals at night on TV, or police chase criminals with helicopters. At the other end of the rainbow there are other kinds of light that we can't see. These are more blue/ more purple than violet, and we call this kind of light "ultra violet".

It's weird to think that there's kinds of light we can't see, but not all kinds of eyes detect the same light. For example, some people can't tell red and green apart, which is called "colour blindness". Another example: some insects, such as bees, can see UV light. Some types of flowers have extra patterns in UV, so this helps them find the nectar in the middle of a flower! (How cool is that?!)

But what about wavelength/ spectra?

Add this extra level of detail with caution: it can be too much detail to take in if they've never thought about UV/ IR before, and you can overwhelm them. You can come back to this later on once you'rve showed them some of the cool things that glow!

EM Spectrum: we call all the kinds of light (including UV, IR, visible) "electromagnetic radiation". One way of understanding this is to say that all these kinds of light have different sizes of wavelength. There's some charts in the box that you can point at when you explain this. Start with the rainbow: Red light waves are wider/longer than blue light waves. Following on from that, infra-red has longer waves than red light; UV has a shorter waves than blue. If you go further outside that you can see microwaves (that you can cook with) and radio waves (which can hold information. like music). These have a longer wavelength, much longer than infra-red. If you go the other way you get to X-rays- these have smaller waves than UV!

Energy: Another way of viewing the light is as a stream of particles. We call them photons. They are like small balls travelling at the speed of light. And photons of different colours have different energy. Blue photons have more energy then red ones and ultra-violet ones have even more energy. This if why UV can cause damage to your skin. (You can use analogy with a light and heavy ball. The heavier has more energy and can harm you more if thrown upon you.) It causes damage to the cells (which can cause cancer if it goues really bad). When you get sun burned you have absorbed too much of UV. So wear suncream to prevent this!
(And X-rays have even more energy and do not stop on your skin - they can go through your body so you can use them to see what is inside. But they are also more harmful and that is why it is used as little as possible.)

Some things glow if you put them under UV light

Put an object from the box under the UV light. Boring old white paper works- though pretty patterns on driving licenses/ credit cards/ banknotes are a good start if you have them! Either way, this first item should glow! Here's a way of explaining this...

1) Turn on the UV light
2) Place a (fluorescent) object underneath it - it should glow.
3) What's happening? How can we see glowing if we can't see UV?
4) It's fluorescence! (Use this word! Here's a simple explanation- let us know if you have an alternative!)

The object absorbs or takes in light that we can't see- UV light. The object can then change the light from UV to a kind we can see. The energy in the UV light is being converted into a different visible form, and things that do this are called fluorescent.

Wikipedia has a more precise explanation, but it depends on understanding lots of other technical words!
"Fluorescence is the emission of light by a substance that has absorbed light or other electromagnetic radiation. It is a form of luminescence. In most cases, the emitted light has a longer wavelength, and therefore lower energy, than the absorbed radiation."
(From http://en.wikipedia.org/wiki/Fluoresce)

Where are UV lights used in everyday life?

In shops, to check if money is fake! (See markings on banknotes)

Ask if they've ever seen notes being checked in shops.You can ask parents if they have a five pound note you can borrow briefly. If you look at the note, there are all kinds of features visible to the eye (metal strip, watermark etc.) but if you put the note under the UV light, you can see extra information, like the value of the note. This is useful in preventing forgery because printing with UV sensitive ink is difficult and expensive. Again, the UV gives the special inks energy so they give out light. Don't forget to give the fiver back

In discos, to make white things look super bright!

You might have seen this!

Fluorescent objects in the box

Highlighters:

Fairly boring in white light, but spectacular under UV. Draw on white paper or non-fluorescent card, on even a smiley face on the back of your hand!

Glowsticks:

- show them glow sticks in the UV - which will glow. Glow sticks get their energy from a chemical reaction rather than UV, if you give them energy from UV they will still glow though

Tonic water

This is probably the brightest fluorescence in the box, so I usually leave it until last. It's quinine that's causing the glow- this compound is more famous for helping to kill malaria parasites when it was added to tonic water. In the past it was in much higher doses than it is now.

For more info on tonic water visit: http://en.wikipedia.org/wiki/Tonic_water

Washing powder

Residual powder makes your clothes look whiter by helping balance out the yellower colours of sad old white clothes.
This gets everywhere, need to replace blocks!!

Phosphorescent things in the box

Phosphorescence is very like fluorescence a chemical in the paint absorbs energy from the UV light, but instead of releasing it again in miliseconds, it releases it slowly over minutes.

Glow in the dark stars:

As above!

Glow in the dark paint: tube (not presently available)

Apparently this stains, so don't open the tube! (There is some phosphorescent paint, this does the same thing as fluorescent dyes but releases the energy much more slowly -> glow in the dark stars etc. NB: this should be well wrapped in plastic (whilst being non-toxic it is very staining) - you can often see it glowing through the container.)

Glow in the dark board

There is also a board coated with the phosphorescent paint - put it under the UV light for 10 seconds (or more - doesn't do any harm), then turn the light off and let them see how the board carries on glowing. Turn the light back on and invite them to put their hands on the board. Make sure they keep their hands in the same place for at least 10 seconds, and see if they can guess what the board will look like after they take their hands away - the effect will be most long-lasting if you turn the UV light off at almost the same time as they take their hands off the board. Some parents may want to take photos!

Why is there sunscreen in the box?

- UV light from the sun (not this box, so it's safer than sunlight!) has lots of energy. This damages your skin (or cells, and ultimately, the DNA) when you absorb/ take in too much of this.
- If you use sun screen it can absorb the UV/ block it from reaching your skin, which reduces the damage the sunlight can do
- See this in action: spray a white sheet of paper with a bit of sunscreen. Predict what will happen (should look black). Try it under the light.
- Try drawing with the sunscreen- you can write hidden messages!
- Combine this with highlighter pens- you should be able to block fluorescence.
- Try not to use too much sunscreen -it's pretty expensive...

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Bits of an old explanation- should all be in section above!

I start off trying to get the idea across, that UV is a colour, but you just can't see it..

What colours are there in a Rainbow? -> ROYGBIV..

Have you thought that there might be some other colours that you can't see? If they are older ask them if they have heard of infra red, microwaves, radio waves, X-rays, UV -> they are all colours of light that your eye can't see

Explain that the tube gives off UV and show them what happens when you put the paper in the UV. This is because when UV hits the paper it gives it some energy, which it can release as blue light...

Do you know what UV does to your skin? normally they don't

What happens to your skin if you stay out in the sun too long -> sunburn -> Due to UV
Sun cream

What do you put on to stop you getting sunburnt? -> sun cream

What do you think it does to the UV? -> Stops it

What do you think will happen if we put sun cream on the paper? Quite often they work out that it won't glow

Get them to draw stuff on the paper with the suncream then put it in the UV light -> dark lines. Which I was impressed with the first time I tried it.

It's always more striking if you do the drawing-on-the-paper-with-suncream in the light (take them outside the darkroom) and then bring the paper in... in the darkroom it's harder to see how little difference the suncream makes to visible light. Which I (and lots of parents) think is really cool... sometimes I manage to convince the kids, too.
If you've got a group working round the darkroom experiments it's worth being aware what they've already had demonstrated to them, as if they've seen, say, polarised light, they should (OK, might) have some idea about what (you want them to tell you) light is.

Fluorescent things

Get them to play with the highlighter pens (they are much more impressive on paper or cardboard that doesn't glow)
Glow sticks get their energy from a chemical reaction rather than UV, if you give them energy from UV they will still glow though
Paper money and driving licences (security marking)!
Driving licences also have patterns only visible in UV.

UV (Fluorescence) Risk Assessment

Last updated: 13/02/2017 - 01:04

DESCRIPTION	Use UV light to observe effects of suntan lotion and other samples
RISKS	• 1. Electrical hazard • 2. UV light • 3. Trip hazard • 4. Broken tube including mercury • 5. Risk of ingestion of washing powder sample, or getting it into eyes. • 6. Some people have an allergic reaction to suncream. Avoid getting in eyes. • 7. Risk of ingestion of split glow stick - chemicals can cause irritation to skin and eyes and vomiting if ingested.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Use covered tube. Set up of box keeps lamp off possibly wet floor. Ensure has passed PAT test. Read separate electrical parts RA. • 2. Use soft UV - our UV tube was on sale to the general public so the wavelength is at the safer end of the UV spectrum. The experiment is set up so that it is not easy to look directly at the uv light. Warn users not to look directly at it. Avoid prolonged skin exposure. • 3. Place wires sensibly (not across middle of room), and put the UV light in a place it is not likely to get trodden on. Tape down if necessary. • 4. Tube is inside the light box to protect it. • 5. Washing powder to be kept in a sealed clear plastic bag. • 6. If children want to put suncream on their skin, first make sure that they've previously used suncream without allergic reaction. • 7. Don't let children repeatedly play with and bend glowsticks
ACTION TO BE TAKEN IN THE EVENT	• 1. Call first aider in event of injury. • 2. Call first aider in event of injury. • 3. Call first aider in event of injury. • 4. If lamp becomes broken, keep the public well away from the area, and ventilate area where breakage occurred. Take usual precautions for collection of broken glass. Do not use a standard vacuum cleaner for cleaning up dust; instead, pick up pieces/dust with a damp cloth or damp paper towels. Place materials, including the cloth/towels, in a sturdy closed container to avoid generating

OF AN ACCIDENT	dust. After you have picked up all that you can, then vacuum the area. Finally, ventilate the room where the breakage ocurred. • 5. Call first aider in event of injury, who may perform an eye wash if trained and confident to do so. • 6. Call first aider in event of injury, who may perform an eye wash if trained and confident to do so. • 7. Make sure anyone in contact with the glow stick washes their hands immediately and clear up spillages before continuing. Call first aider in event of injury.

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation • 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well

	(dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Near IR webcam

Physics: Use a modified webcam to see into the near infrared.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Laptop
Small grey box containing:
Webcam (modified)
Lights (Incandescent and compact fluorescent)
Coke
CD
Shaver (blades removed)
Paper with CHaOS logo written with different pens
small white remote control

Explanation

What it it?

Take a normal webcam, remove the IR filter and replace it with crossed polars or a piece of exposed colour film and hey presto you have a near IR camera. Practical point:- the webcam has a focusing ring in front of the lens, which may be turned during an event, causing the image to become blurred. If this happens, ask a committee member to show you how to focus it (there is a knack, and if you it wrong you can jam the focus).

What is light/ IR light?

The light most of us are really familiar with is white light. But that's actually a mixture of different colours. Most of the time we can't tell that, but sometimes we can see these colours split up, like in a rainbow.

Do you know the colours of the rainbow? Ask them to tell you!
[Red -> Orange -> Yellow -> Green -> Blue -> Indigo -> Violet (basically purple!)]

It turns out that there are more kinds of light than our eyes can see. Some kinds of light are "redder" than red is - we call that kind of light "infra-red" . You might have seen images from cameras that can detect this kind of light, perhaps watching animals at night on TV, or police chase criminals with helicopters. At the other end of the rainbow there are other kinds of light that we can't see. These are more blue/ more purple than violet, and we call this kind of light "ultra violet".

It's weird to think that there's kinds of light we can't see, but not all kinds of eyes detect the same light. For example, some people can't tell red and green apart, which is called "colour blindness". Another example: some insects, such as bees, can see UV light. Some types of flowers have extra patterns in UV, so this helps them find the nectar in the middle of a flower! (How cool is that?!)

But what about wavelength/ spectra?

Add this extra level of detail with caution: it can be too much detail to take in if they've never thought about IR/UV before, and you can overwhelm them. You can come back to this later on once you'rve showed them some of the cool things you can see with the IR camera!

EM Spectrum: we call all the kinds of light (including UV, IR, visible) "electromagnetic radiation". One way of understanding this is to say that all these kinds of light have different sizes of wavelength. There's some charts in the box that you can point at when you explain this. Start with the rainbow: Red light waves are wider/longer than blue light waves. Following on from that, infra-red has longer waves than red light; UV has a shorter waves than blue. If you go further outside that you can see microwaves (that you can cook with) and radio waves (which can hold information. like music). These have a longer wavelength, much longer than infra-red. If you go the other way you get to X-rays- these have smaller waves than UV!

What do I look at with the camera?

Firstly, plug the *new* camera into a laptop and use VLC player (open up the video devices settings and select USB input owtte).

Things to look at:

Coke is transparent, as are some plastics (shaver casing, sample of smoked glass).

Bank notes have lines. Try looking at the Queen's head on a £5 (old ones or new polymer ones both have the same effect!) or £20 note.

CD can be used as a diffraction grating to produce a 'rainbow' - shifted position.

Incandescent vs compact fluorescent - about the same luminosity in visible, former is much brighter under IR (Note: This looks more convincing if you give the fluorescent bulb 30 seconds or so to reach full brightness).

Different materials - some black clothing appears white under IR, often patterns on clothing disappear.

On the paper with the CHaOS logos, one shows up in IR and the other doesn't (written in different pens) - there is also the Normal/IR vision one with the same effect.

The laptop screen appears blank.

Remote control- uses IR, point at the camera while pressing buttons. Many camera phones lack IR filters so can test this on parents phone use it to see light from the end of the remote control.

There are lots of cool things to look at according to this:
http://www.hoagieshouse.com/IR/

Near IR webcam Risk Assessment

Last updated: 01/02/2017 - 19:25

Using a webcam sensitive to near infrared light to look at various objects.

Risks:

* 1. Bedside lights contain glass bulbs.
* 2. Incandescent light gets hot if left on.
* 3. Compact fluorescent bulb contains (very small) quantity of mercury.
* 4. Lightbulbs can appear very bright when just switched on in dark room. Eyes are not used to that brightness.
* 5. Electrical cables present trip hazard
* 6. Coke is out of date.

Actions to control risks:

* 1. Take reasonable level of care with lamps.
* 2. Do not allow children to touch lamps, do not place too near the darkroom wall, or any flammable object.
* 3. Ensure lamp is stable and not easy to knock over.
* 4. Warn childen/visitors not to look directly into the lamps when you switch them on.
* 5. Try to keep cables out of thoroughfare. If cables must be placed somewhere people are likely to be walking, tape them down.
* 6. Do not let children drink the coke.

What to do if an accident still occurs:

* 1. In the event of broken glass, move public away and clear up mess carefully as soon as possible. In the event of injury, call first aider.
* 2. In the event of a burn call first aider. In the event of fire, follow procedures in venue RA (raise alarm, evacuate,...).
* 3. If lamp becomes broken, keep the public well away from the area, and ventilate area where breakage occurred. Take usual precautions for collection of broken glass. Do not use a standard vacuum cleaner for cleaning up dust; instead, pick up pieces/dust with a damp cloth or damp paper towels. Place materials, including the cloth/towels, in a sturdy closed container to avoid generating dust. After you have picked up all that you can, then vacuum the area. Finally, ventilate the room where the breakage occurred.
* 4. This is not really a major risk, tell first aider if child seems too dazzled about light.
* 5. In the event of injury, call first aider.
* 6. In the event of drinking, call first aider,

Darkroom Risk Assessment

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Last updated: 01/02/2017 - 23:37

Polarisation

Physics: Discover how polaroid filters block light as you turn them round

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Blue light box
- Two polaroid filters.
- Some bits of clear polythene
- Rulers, set squares etc, for bending.
- Some pieces of calcite
- A partially dismantled LCD screen

Explanation

*** OVERVIEW ***

Demonstrating the use of polarisers with crossed polars, polythene strips, plastic rulers and a light box.

Possible activities:
- Demonstrate how crossed polars work by rotating two pieces of polaroid with respect to each other and looking through them to see how the light changes.
- Looking at stressed plastics under polarisers.
- Demonstrate the colour change when a strip of polythene is stretched when viewed under the polariser material.

Other things to talk about:
- LCDs and how they work.

Tips for demonstrating:
- Let the children experiment with different objects under the polarisers as this will keep their interest.
- Use paper strips with waves drawn on to help to demonstrate how polaroid filters work.

*** BASIC PROCEDURE AND EXPLANATION ***

1. Show them the light box and the polarising filters

Top tip: scroll down if you're reading this online- there's photos of the various bits of kit!

- The box gives out "normal" white light. Experiment generally works best if set on the floor/ somewhere low enough that everyone can easily see from directly above.
- Take the top piece of polariser and give it to them, get them to look at it in the light. What does this look like -> grey piece of transparent plastic.
- Put the polariser on the light box the way round so light can get through. Still look normal?
- Get them to rotate the polariser around, and see what happens... This normally gets their interest. Get them to turn it upside down.
- Ask what is happening: looks almost black one way round, turn it 90 degrees and it looks bright again

2. Introduce the idea of light as a wave

Do they know what a wave is?

- Ask them what types of waves they know about: sound, water, etc.
- Can they make a wave along their arms? (An awesome dance move if you can pull it off!)

Light behaves like a wave, this wave can be in all directions

- Explain that light is a wave using a wave sketch on a bit of paper
- Light can wobble in different orientations - polarisations. It can wobble up-down, side-to-side, and everything in between
- You can imagine this as a 2D wave like the one sketched on the paper
(Yes, we know that there's a second component of the wave, but if you consistently talk about the same component of the wave the explanation is right..)

Polarising filters are like grills that let light through in only in some directions

- Using your fingers as a grill demonstrate what the polariser looks like. Get them to try and get the piece of paper in the through the grill parallel and perpendicular to the grill, i.e. in the two different polarisations.
- Only half the light can get through - this is why the plastic looks slightly darker normally.
- Then add another grill parallel to the first which will allow the light from the first grill to get through. Rotate it by 90 degrees to demonstrate that light can't get through with any orientation. This makes the polariser look black.

- You'll have lots of hands available, you can show the effect of as many twice as many polaroid filters as you have people! You can show that if the light passes through the first filter if it stays at that orientation it can't get through the second one.

3. Twisting the direction of the light

Demo with the filters

- Ask them what you would have to do to the light (wave drawn on paper) between the crossed polars to get it through. They normally tell you to twist it.
- You can introduce a third polar at 45 degrees to do this (current kit only has two though, unless you use the sunglasses)

Polythene (bags) can twist light

- The polythene normally doesn't affect the light but if you stretch it, it will twist the light.
- Let them have a go at stretching the polythene strip in the light box under the polaroid filter (this can take a while as they find it fascinating!). You should see many colours.
- The different colours twist the light by different amounts. So pick a red bit (best as they know what colour you get if you mix blue and green). You may rotate red by 90deg so it will get through, blue by 180deg so it won't, and green by 360deg so it won't...
- Now get them to look at a red bit while you turn the polariser through 90deg - it should now look turquoise... Now the polars are parallel so red is twisted 90deg so it doesn't get through, blue is by 180deg so it does... -> turquoise light gets through.

Plastic rulers can twist the light

- Put a ruler between crossed polars, you should see lots of colours. These are because they are made by injection moulding, so the plastic is effectively stretched in manufacture.
- The place where the most stretching happens is where the plastic was squirted in - you should be able to see this and you can probably see the rough bit where the sprue was attached.
- There are some rulers that have been cooked, and you should see the shape has changed most in the place where there was the most stress.
- You can also bend the ruler and see stress. A ruler with a crack in it should concentrate stress.

Calcite crystals can twist light

- The crystals of calcite twist light as it travels through, so can appear lighter or darker than the background when placed between the crossed polarisers.

4. Uses of polarisation

Possible uses of polarisation - polaroid sunglasses, measuring stress on equipment, analysing substances, etc.

3D cinema glasses (there's some in the box) use circular polarisers. More info:
http://en.wikipedia.org/wiki/Polarized_3D_system#Circularly_polarized_gl...

5. Extension: LCD screens- how they use polarisation

The black object with a window and several buttons is an LCD which has had the polarisers removed (and the wiring completely mangled) so you can see that they work through polarisation. Look at it in normal light, then in between the crossed polarisers.

The display consists of two pieces of glass with a 'liquid crystal' in between. This consists of long rod shaped molecules which move around at random like a liquid, but are all aligned like a crystal. There are lines scored on the glass and the liquid crystals tend to align along them, the lines on the top are at 90 degrees to those on the bottom, so the molecules twist as you move through the liquid crystal.

If polarised light passes through the liquid crystal the light rotates by 90 degrees, however if you apply a voltage between the two glass plates by pressing the buttons, the rods rotate so they are end onto the light and stop rotating the light.

So by applying a voltage you can turn on and off the rotation of the light, which with 2 polarisers means you can make it go from clear to black, and by patterning some wires on the glass you can produce a display. which are used everywhere from watches to TVs. This is why if you look at a monitor through a polariser the image can disappear by rotating it.

Polarisation Risk Assessment

Last updated: 01/02/2017 - 23:37

DESCRIPTION	Using a light box with a crossed polars, polythene strips, and plastic rulers.
RISKS	1. Cuts from broken objects (such as rulers) 2. Trip hazard if placed on floor 3. Electrical hazard
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Do not allow children to bend items to point where they are likely to break. Remove items which are broken. 2. Make sure equipment is safely and securely placed, at the side of the dark room out of the way of where people are walking. Do not allow the power cable to run across a walkway. 3. See electrical parts RA
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation • 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Seeing Sound

Physics: Use an oscilloscope and slinky spring to see how sound travels

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Box in which is mounted a signal generator and audio amplifier, with cables.
- Loudspeaker
- Oscilloscope
- Microphone + battery box
- Concertina, recorder, etc.
- Antiseptic wipes (to clean the recorder)
- Slinky spring

Explanation

*** OVERVIEW ***

Seeing Sound uses a signal generator and loudspeaker to make sounds, as well as various musical instruments. There is a microphone and oscilloscope to `see' the sound, to allow kids to learn about what sound waves are and some of their properties. If the oscilloscope isn't working, a reasonable alternative is to download a free mobile app instead. If doing this, keep you phone in your possession at all times.

Possible activities:
- Explaining what sound is, and how you can hear things, using the signal generator and loudspeaker.
- Looking at your voice on the oscilloscope when you say different words and vowels etc.
- Comparing the voices of different people looking at pitch and volume.
- Looking at how simple musical instruments work.

Other things to talk about:
- How sound travels through the air.
- How the oscilloscope displays a sound wave.

Tips for demonstrating:
- Get the whole family to talk into the microphone so that you can look at the different pitches and volumes of their voices.
- Get the children to try different vowel sounds, low sounds, and high sounds etc.
- There's a lot which can be done in this experiment; you don't have to do it all, and you don't have to follow the order below...

*** BASIC PROCEDURE AND EXPLANATION ***

- Start by explaining how we can hear things. Ask the children if they know anything about waves - water waves, sound waves etc.

- When sound travels through the air, it is in the form of a wave, a little bit like the waves that you get on the surface of water (although longitudinal compression wave rather than transverse).

- Use the slinky to show how longitudinal waves travel. Normally we can't see these waves in the air, but our ears can pick them up.

- Using the signal generator and amplifier, get the loudspeaker oscillating at 10-20 Hz and get the kids to notice this. If they are careful they can touch the speaker gently to feel it move.

- Then turn up the frequency so you can hear it (make the connection between the wobbling and the sound) and can still feel it 50-80Hz. Get them to feel the air above the speaker they should be able to feel it moving. Say that the air wobbles above the speaker, and then wobbles all the way to their ear (you could use the slinky to demonstrate this - a picture of an ear and loudspeaker may help here too) and your ear hears the wobbles as sound.

- Turn up the frequency again, and get the kids to make the connection between speed of vibration and pitch.

- Explain that you can't see sound, because the air is transparent and it's moving too fast anyway. Then introduce the microphone and oscilloscope and look at the sound from the loudspeaker. (**As of mini-tour 2016 the Oscilloscope started smoking so use should not be attempted unless it has clearly been replaced. There are free mobile phone apps make a reasonable alternative if your battery can hold out. The following explanations still hold though!**) The children can also make some simple noises into the microphone. Vowels are good for this. Explain that each sound has its own particular shape - saying the alphabet can prove invaluable here. A long vowel sound should create a quite stable wave on the 'scope.

- Ask the child to sing a quiet note and a loud note, and see that the picture drawn gets taller with volume.

- Get child to sing a long note moving from a high note to a low note (dads may be useful here for very deep notes), and show that the wiggles on the screen get further apart the lower the note, and closer together the higher you go. This is a measure of increasing frequency - when things vibrate faster, we get a higher note (e.g. car accelerating).

- They can also feel their larynx vibrate when they talk - easier with lower sounds.

- Now for the musical instruments! Let them try to make different notes with recorder and concertina, and with the big pan pipes from the resonance experiment. Look at how different pitches, different volumes, and different timbres (types of note) appear on the oscilloscope.

*** OTHER THINGS TO TALK ABOUT ***

- Introduce the idea of wavelength with long wavelengths corresponding to low frequencies and vice versa.

- A couple of features of the oscilloscope can be explained. You can explain that the microphone converts the air wobbling into an electrical wobble which makes the dot on the screen wobble up and down (you can show this by turning the freq very low on the oscilloscope and you should be able to see the dot going up and down). Speed the dot up again a bit and kids can normally work out that fast wobbles make short wavelengths on the screen, and from stuff earlier they should be able to work out that high pitch makes short wavelengths too.

- You can go into more detail of the biology of hearing, or use this point to encourage them to go onto the biology experiments afterwards!

- You can think about why the ear and loudspeaker are the shapes they are, and why these are quite similar. This is also quite like an amphitheatre.

*** SCIENCE BACKGROUND FOR DEMONSTRATORS ***

Sound is a longitudinal (compression and rarefaction) wave through the air. The signal generator produces an oscillating electrical signal, made bigger by the amplifier; the loudspeaker contains a coil of wire which acts as an electromagnet, so that the speaker cone oscillates at the same rate as the signal. We hear because the sound wave makes our eardrums vibrate: the vibration is passed on through a series of bones which amplify its magnitude to the cochlea, where tiny hairs inside the fluid-filled tube pass a signal through the auditary nerve to the brain when they resonate with the vibrations. (The action of these hairs is complex, and only recently becoming understood.)

The microphone is capacitative, so needs a battery and resistor (in the little box) to produce a voltage signal for the 'scope.

Recorders (and suchlike) produce standing waves of air in the tube. The concertina is a free reed instrument: air is blown past a tongue of metal, which vibrates at a rate determined by its length and mass, in such a way that the air going past is caused to vibrate too.

Seeing Sound Risk Assessment

Last updated: 30/01/2017 - 16:21

DESCRIPTION	Microphone joined up to oscilloscope. Play recorder and observe trace on oscilloscope. Use slinky to demonstrate waves. Demonstrate how loud speaker works with amplifier
RISKS	1. The oscilloscope is heavy and could be dropped or knocked off table. 2. Electrical hazard. See Electric Parts RA. 3. Spread of infection via recorder mouthpiece. 4. The amplifier can be quite loud.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Keep oscilloscope away from edges of table. 2. See Electric Parts RA. 3. Clean mouthpiece of recorder with antiseptic wipes between uses. 4. Take care not to have amplifier on too loud.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Switch off oscilloscope. Clear up broken glass. Call first aider in case of injury. 2. See Electric Parts RA. 3-4. Call first aider in the event of injury

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation

	• 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 02/02/2017 - 12:27

Water rockets

Physics: Launching lemonade bottle water rockets with a foot pump.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Pump.
- Bung with hole or with valve.
- Rope
- Launching base.
- A selection of lemonade (or other fizzy drink) bottles
- Lots of water in a large container.
- Preferably another bucket for filling the container.

Explanation

Setup

Set up the rope running from the launch area to a higher point (raising the launch area, e.g. blocks, can keep the rope above head height) - run the rope through the tube attached to the bottle. Jam the bung in the bottle and get kids to pump until the rocket launches up the rope. Hopefully it should come back down to somewhere you can grab it. Keep people out of the area where the rope is so that they don't get hit by the rocket or walk into the rope!

As a further point - it can very occasionally be done without the guide rope pointing vertically upwards, or without a guide rope at all. This is suitable in large sports halls or outside only. Here care needs to be taken that a large enough area is cordoned off so that it does not hit anyone when it returns to Earth. If a guide rope is not being used, it can still be helpful to attach a rope to the rocket, in order to limit its range (such as to avoid hitting people) or to aid retrieval.

Explanation

Water rockets are great fun. Everyone wants a go, from 3 to 13 - and the teenagers and adults too, if they are brave enough to admit it. The does mean that you'll always have a queue and so an interactive discussion is difficult to achieve: on the upside, they'll be back for another try. I always try to remember the faces to keep a line of questioning going from launch to launch. I question them before every launch on a couple of points and while questioning I always keep their rocket in my hand, it keeps their attention and stops a rocket from flying up your ass.

As a first question I always ask: "So how do you think it works?" Which is always a good starter and that gives you your level. If it's not a terribly bad explanation, generally I don't try and correct it or improve it and I let them launch their rockets. Each time they come back a couple more questions maybe a little demo. They very rarely listen to the children ahead of them, which is kind of stupid, but there you go.

Then I suppose I start to refine their understanding of how it works and try and get them to experiment. Trying the bottle, full, empty; the bung in hard, or soft - you have to fiddle this one as it is difficult to control. Indeed you have to fiddle the empty bottle too, you want it to go about 5 feet and catch it, otherwise it can go almost as high as with water.

You've got a couple of lines of questioning. Pressure is always a good one. You can relate it to the pump. As a kid I could never pump up my bicycle tyres, because I didn't push the plunger very far. That sort of inspires me down this line. You can put your thumb over the valve and get them to push down on the plunger, the further they push down the harder it gets. When they let go the air may push it up a little. So that's your basis for explaining what pressure is, how you raise the pressure in the bottle and how it pushes the bung out. Don't use density.

Older kids and adults may talk about molecules. When your talking about molecules you can raise the concept of molecules inside the bottle hitting the inside of the bottle. I quote how fast an air molecule moves, about 500 ms^{-1}, so even though it's light it packs a punch. I crush the bottle, put the bung in and then pump some air in. The bottle comes back to its original state, so the air molecules hitting the wall have pushed it back into shape. Then invite an assistant to squeeze the bottle, it's soft, but as you pump more air in it gets harder and harder, because those air molecules are pushing back at you. It's not a way people generally see the world so it's kind of a fun thing to do.

As part of fully explaining how it works you need the water there to push the rocket up. Every reaction has an opposite but equal reaction. I put the question: "when you lean on a wall and push on it, does it push you back?" All ages generally say no. So on to the demo, lean forward and get an assistant to push on your hand as your wall; "Now, I'm pushing against him and he's pushing against me and I'm going nowhere, what do you suppose happens if he's stops pushing against me." Your assistant stops pushing and you pretend to fly forward. "So if you're pushing against a wall, it must be pushing back."

The more water you've got in the bottle the harder the air pushes it down and the bottle up. So the more water the higher it goes. Sometimes getting them to imagine throwing a tennis ball versus a boulder can help.

Next is the energy. Where is the energy stored? This can lead on nicely to all sorts of questions about conservation of energy and what forms of energy are being converted from lunch to launch. So the more air the higher it goes.

There seems to be a catch 22 situation. Of course it means there is an optimum and this is an important scientific concept in itself. Remember the heavier it is the lower it goes as well. This is all worth expanding on, especially with adults and at this point I may sweeten the pill by saying that on tour "we" settled down to try and work out what the optimum amount of water is, four sides of maths later we still hadn't solved it. The mathematics of how these bottles launch is more complicated than NASA rockets as the thrust changes over time.

The next bit is the bung. This is what really makes it go high or low. "If I push in the bung really hard will it go higher, lower, or not make a difference?"

I even ask the tots questions. I push some air into the bottle and say, "What are these?" Bubbles. "What's in a bubble?" Air, relate to blowing a balloon, what is in a blow? Indeed what's air?

These are just some of the themes I question on and there are plenty more so you shouldn't get bored. Remember, be a bastard hold that bottle 'til you've got some science into, or out of, them.

Practicalities

Let them fill their bottles some way away, though you may want another bucket to make your own adjustments to the amount in the bottle. The area around the launch site gets very wet, so move on occasionally. Stay away from roads, people and roofs. Keep the queue back and make sure the rocket isn't angled towards their, or your, face. Bottles may get stuck in trees, that's half the fun.

If you're launching along a rope, you can engineer your setup so that most of the water goes back into the bucket on launch. This will save you some walking!

The more taut the rope is, the less friction the rocket will experience and the further it will go, so tie it to something strong and tie it tight!

Water rockets Risk Assessment

Last updated: 02/02/2017 - 12:27

DESCRIPTION	Build water rockets out of lemonade bottles by pumping air into bottle which is partially full of water.
RISKS	1. Slip hazard 2. Bottle exploding (slim risk) 3. Hitting people with the bottle 4. Walking into or tripping on the rope
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Do the experiment outside on a surface that can take water. If done indoors or on a surface which can get slippery, keep a mop close to hand and cordon off the area. 2. Check bottle for cracks and other damage before use. Any damaged bottles should be cut or marked to show they cannot be used if they cannot be disposed of immediately. Only use 2L "fizzy drink" bottles (coke, fanta, etc) not bottles for still drinks which are not (always) suitable for pressurising. 3. Keep the range clear, and cordoned off if necessary, and make sure the launching platform will not fall over. Ensure that the person pumping the water rocket does not lean over it (try to keep the pump as far away from the rocket as the hose will allow - we have lengthened the hose to make this job easier). Locate the experiment sensibly - bear in mind roads etc and wind direction. The rope can be used to limit the range of the rocket, even if a guide rope is not used. 4. As with (3), ensure visitors are kept away from the rope. Any trailing rope ends should be tucked away and kept off the ground if possible.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in event of injury

Last updated: 15/01/2017 - 16:50

Air Rockets

Physics: Launching lemonade bottle air rockets along a rope

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

* Pump
* Bung with hole or with valve
* Rope
* Lemonade (or other fizzy drink) bottle with tube attached for the rope to run through (something with low friction so that the bottle will come back down again and fly further).
* Launch stand

Explanation

Launching lemonade bottle air rockets along a rope (going up at an angle of 20-30 degrees) - this is a less messy version of the water rockets experiment which can be done inside in a suitably large hall.

Setup
Set up the rope running from the launch area to a higher point (raising the launch area, e.g. blocks, can keep the rope above head height) - run the rope through the tube attached to the bottle. Jam the bung in the bottle and get kids to pump until the rocket launches up the rope. Hopefully it should come back down to somewhere you can grab it. Keep people out of the area where the rope is so that they don't get hit by the rocket or walk into the rope!

As a further point - it can very occasionally be done without the guide rope pointing vertically upwards, or without a guide rope at all. This is suitable in large sports halls or outside only. Here care needs to be taken that a large enough area is cordoned off so that it does not hit anyone when it returns to Earth. If a guide rope is not being used, it can still be helpful to attach a rope to the rocket, in order to limit its range (such as to avoid hitting people) or to aid retrieval.

Explanation and Demonstrating

Like the water rockets, everyone likes to play with the air rockets... and they can't fail to notice the experiment since it makes a bang every time the rocket goes off!

If you want to explain the experiment, you'll probably find it best not to let the kids get onto the launch platform until you've talked to them a bit. It's generally best to ask a question first to see what they know already.

There's quite a lot of physics you can explain with the experiment. Firstly the idea of pressure - you can talk about the pump - put your finger over the valve and get them to push down on the pump - they'll find it gets harder as they push down and increase the pressure. So we have the idea that as we pump the bottle up, we increase the pressure and this pushes the bung out. If they understand (ask them to explain it again!) you can talk about molecules. The molecules move at about 500 ms-1, so even though they are light give a good push on the walls of the bottle when they hit (plus obviously there are > 10^23 of them!). So, as you pump up the bottle, adding more molecules, there is a harder push against the wall and the bottle gets harder.

So what happens when the rocket launches? We've said that the bung gets forced out by the pressure in the bottle (what pressure it reaches depends on how hard you jam the bung in each time, and varies, and thus does the height the rocket gets to). You probably don't want to talk about conservation of momentum with the kids - the bung flies out backwards with a certain momentum, and thus to give the overall system zero momentum the bottle gets equal and opposite momentum, sending it up the rope. You can talk about equal and opposite reactions, though. Think about leaning on a wall - does it push back on you? Most kids probably think not. However, if you get one of them to push on your hand, and you push back, you both stay where you are. If you ask them to stop pushing, then you fall forwards (or at least pretend to!) - so leaning against the wall, the wall must be pushing against you! Going back to the rocket - when you pump up the bottle the air is pushing against the bung - when the bung pops out it's like stopping pushing against your hand, so the rocket flies forward. You can show this with throwing a bag of rice; as you throw it it pushes you back.

You can also talk about energy - where does the energy for launching the rocket come from, and where is it stored? The more pumping you do, the higher the rocket goes (all else being equal).

Kids will keep coming back to have another go, so each time ask them something about it to see what they've remembered!

N.B. A good trick with families or other groups is to challenge them to get the rocket as far as possible along the string (maybe with only one attempt!) little do they know that the distance pretty much only depends on how tightly you put in the bung, and thus the meekest among them can be the mightiest!

Air Rockets Risk Assessment

Last updated: 15/01/2017 - 16:50

DESCRIPTION	Fly air rockets up a rope by pumping them up with a bicycle pump.
	1. Hitting people with the bottle

RISKS	2. Bottle exploding (slim risk) 3. Walking into/tripping on the rope which the rocket travels on 4. Slipping on wet floor if indoors.
ACTION TO BE TAKEN TO MINIMISE RISKS	1a. Keep people away from the rope (which the rocket travels on) by blocking off any area where the rope is below head height with chairs, hazard tape or similar. Make sure the person launching the rocket doesn't lean into its path. Also locate the experiment sensibly, bearing in mind walkways that people will want to use in the venue. 1b. If done without a guide rope, cordon off sufficiently large area to ensure it lands within it. Check prevalent wind direction as well by test firing the rocket before people come. 2. Check bottle for cracks and other damage before use.If a cracked or damaged bottle is found, it should be cut or marked to show that it is not for use if it cannot be disposed of immediately. Only fizzy drinks bottles should be used, as still drink bottles may not be suitable for pressurising. 3. The provisions for (1) ensure that visitors are kept away from the rope. Keep rope ends tucked away and off the ground if possible. 4 Cordon off area under rope, and keep mop close to hand.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in event of injury

Last updated: 29/01/2017 - 16:37

Electromagnetism

Physics: Making electricity, and using it to spin a motor.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

1. Generating power
- Small ammeter and coil. Bar magnet of some sort that fits through the hole
- Green rotating generator. Clamps to attach it to a table.
- Wooden box with bulbs/handle/generator

2. Dropping magnets
- Metal 'coin drop' setup, separate wooden base (base in box, the rest is separate)
- Two pipes, one copper, one plastic.
- Green 'iron filing' paper.
- Selection of coin magnets (don't get more than a couple out an once).

3. Motors etc.
- Motor
- Power pack (stored in separate power pack box)
- Real motor (non-functional)
- Magnet/wire with 'indicator lights'
- Nail with coil of wire.

Explanation

There are lots of things to do, there are 2 nice stories, going through the generation and motors stuff, and some extra odds and ends. You shouldn't usually attempt to get through all of this in one go!

1. Generating Power

There are 3 different power generating bits, in increasing level of usefulness.

Magnet, coil and ammeter

This has a coil of copper wire attached to a small ammeter. When you wave a magnet through the hole in the middle of the wire you get a reading on the wire. Some things to talk about/do with it are:

- What are the objects? Coil is made of copper wire, this is a good electrical conductor. The setup as a whole is an electrical circuit (components linked together in a circuit). The meter looks like it might measure something (cf weighing scales), it measures the amount of electrical current (or just electricity) going round the circuit.
- Do we get more electricity by moving fast or slow? Does it work if we're not moving at all?
- Is this very much electricity? The scale on the ammeter is microamps (the funny squiggle is the Greek letter mu), talking (or asking questions about) millimetres, metres and kilometres is a good warm-up to explaining that microamps is a small unit. Older kids might know that fuses have amp ratings on them.
- What do the positive/negative readings mean? It tells us which way the electricity is going round the circuit, notice that it changes if we move magnet in a different direction, or swap north/south poles.
- How can we get more electricity? Good ideas are moving faster (and moving in circles is easier than up/down), stronger magnet or more coils.

This then leads nicely onto the next bit...

Rotating generator (green)

This has most of the improvements suggested above (show to them the larger magnet, more coils), and if you spin the handle fast enough it will give you enough electricity to light a bulb. Things to talk about:

- The faster you spin it, the brighter it is.
- Does it matter which way round you turn it? No.
- [more advanced]If the bulb is an LED rather than a filament bulb then it will only light half of the time, with frequency=rate of turning the handle. This is because the current is alternating ('going backwards and forwards') and it only lights when the current is going one way.

Generator in a box

This is a better version of the previous one, but it's all hidden in a box which means visitors can't see what is going on as well. There are two bulbs that can be switched on or off, and also a voltmeter/ammeter. Things to do:

- Start someone off turning the handle and then increase the wattage of bulbs turned on gradually. They will find that it gets harder to turn as you do this. Talk about needing to put extra energy in to get more light out (the energy is coming from them, **not** from the magnet/coil which just convert kinetic/moving energy into electrical energy)
- Power generation: How many watts are the bulbs you have at home? If it's this hard to turn a handle to make 10W of bulbs light, how hard would it be to power all the bulbs in your house? How about all the bulbs, TVs,... in town X? This is really where our power comes from, what better ways

are there of turning the handle (wind farms are the easiest example for small kids)
- [More advanced]Look at the ammeter/voltmeter. When a bulb is fully lit how do those readings compare to the wattage of the bulb (P=IV).

2. Dropping magnets

This uses the last part to do a neat trick.
The three columns in the coin drop are made of plastic, aluminium and metal ???. None of these are magnetic, but a coin magnet will fall more slowly through the metals.

This is because the moving magnet is inducing an electrical current in the metal (like the magnet past the coil in part 1). There are two ways to explain why this causes it to slow down:

1. [easier]Some energy is needed to make the electrical current (like turning the handle before). This time the energy comes from the falling magnet, and when it loses kinetic energy it slows down.
2. [harder]Eddy currents of electricity are formed, and these create an electromagnetic effect opposing the motion of the magnet, hence it slows down.

You can also do this with the perspex and copper pipes (get a volunteer to hold the pipe, with their other hand below it to catch the magnet), the slowing effect with the copper pipe is really huge.

There is also green 'iron filing' paper, which shows up the movement of a magnet through it. You can use this to 'see' the movement of the magnet inside the copper pipe.

3. Motors etc

There are various bits here, you probably won't want to do all of them. This is the opposite of what we have been doing so far. Now we are using electricity to make magnets, or electricity and magnets to make something move.

Compasses around a magnet/wire

Show what a magnet/current carrying wire do to a compass, compare the two.

Electromagnetic Nail

Wrap wire around a nail attach it to a power supply and see how it affects paper clips, with and without the power, try picking up a matchbox car as a use for electromagnets.

Jumping Wire with indicator lights

Put a current through the wire on top of the magnet, you should notice the wire is pushed by the magnet. If you reverse the direction of the current the direction of the force reverses.

Simple motor

This is a simple toy motor. There are two commutators one which keeps the polarity the same - you can show that you can get some movement but not rotation, and one which swaps the polarity, that will make it turn nicely.

-Have a look at the motor there are a load of wires near some magnets, so there will probably be some forces going on from the Jumping wire experiment.

-Using the first commutator, you need to keep swapping the polarity as when the motor gets half way round the direction of the current has essentially reversed (you are using the other half of the coil), so it gets pushed back again. You can get it to keep turning, by reversing the current. This however gets a little tedious...

Luckly the second solves the problem, everytime the motor turns halfway round the two contacts swap, so it keeps turning. This is how all DC motors work, some AC ones use the changing direction of the voltage instead of a commutator, so have fixed speeds.

Tricks: It works best on the 7.5V range with the motor wired from the +ve side to the -ve side. The brushes should be touching the commutator, on either side (top and bottom won't work)

There is a real motor in the box too, which you can compare it to.

Electromagnetism Risk Assessment

Last updated: 29/01/2017 - 16:37

DESCRIPTION	Lots of experiments about magnetism and electromagnetism
RISKS	• 1. Overheating of coils/wire -> burns • 2. Powerful magnets shattering • 3. Rotating motor could be dangerous • 4. Visitor or demonstrator catching fingers in generator as they turn the handle on the generator • 5. Motor connections can short-circuit and get hot. • 6. Copper pipe hitting people in face. • 7. Heavy Generators and Motors could fall and hit someone.

	• 1. Do not put too much current through a coil/wire, if it is getting hot, turn it down
	• 2. Warn visitors if you give them a magnet.
	  ◦ Use the minimum number of free magnets
	  ◦ Keep the magnets under control
	  ◦ Cover with tape to reduce impact, and contain any shards
	  ◦ Pad edges of magnet to reduce finger trap
	• 3. Keep kids' fingers away - if it needs pushing it should be done on the axle, not the armature
	• 4. Place generator on flat surface so visitors can't catch their fingers underneath so easily.

ACTION TO BE TAKEN TO MINIMISE RISKS	• Tell visitors to hold only the rotating part of the generator handle and not the entire handle. • Keep control of the visitors at all times and don't let them get overexcited while turning the handle • 5. Demonstrator to turn off power supply to motor when not in use • 6. Demonstrator should hold pipe for younger kids and monitor use for others. • 7. Use clamps to keep generators and motor firmly attached to table.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. If there is a burn, run under cold water for ten minutes, call a first aider • 2. Call first aider in case of injury • 3. Call first aider in case of injury • 4. Call first aider in case of injury • 5. Turn off electricity at mains. Call first aider in case of injury. • 6. Call first aider in event of injury. • 7. Call first aider in event of injury.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Resonance

Physics: What is the link between earthquakes and cello strings?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

For earthquakes (large blue box):
- Earthquake table (wooden box with handle)
- Sections of tower for the above, made of perspex, magnets and springs.
- Dog on a swing.

For the cello (green lidded box):
- Folding mock cello, with removable string
- Bow and rosin
- Signal generator
- Power supply
- 'Cello driver amplifier
- Assorted cables for the above

Optional:
- Set of giant pan pipes

Explanation

It's a collection of experiments illustrating resonance: the Earthquake Table lets you build towers and see what happens to them when vibrated near the resonant frequence, the Dog On A Swing gets across the basic idea of resoanance, the Giant Pan Pipes show how resonant air makes music, and the 'cello is a string driven by an oscillating electromagnet, which gets excited at resonance.

*** OVERVIEW ***

When you shake things too quickly or slowly, nothing much happens, but if you shake them at just the right rate - the rate they naturally shake at if you push them - the shaking builds up and builds up.

Possible activities:
- Trying to make the tower fall over by wobbling it at just the right rate.
- Comparing this to pushing a dog on a swing.
- Making the 'cello string resonate by adjusting the frequency on the frequency generator.
- Looking for the fundamental, first harmonic, second harmonic etc, and talking about stringed instruments.
- Hitting or blowing across the pan pipes to make a noise.
- Putting your ear to the pan pipes - they make a noise even when not hit or blown.

Other things to talk about:
- Building design to withstand earthquakes.
- Seismic waves.
- How wind instuments work
- Resonance in cars, taps etc.

Tips for demonstrating:
- Everyone enjoys turning the handle on the earthquake table. Try to make people, even little children, take turns. The 'cello is better for older kids, especially those who seemed to understand what was going on with the tower...
- The experiment links well with Seeing Sound, and can share equipment and demonstrators.

*** BASIC PROCEDURE AND EXPLANATION ***

- Start by getting someone to turn the handle of the earthquake table slowly. A tower three blocks high works best. It shouldn't shake very far. Then ask what they think it will do if they shake it much faster. Will it wobble more?

- It doesn't (or, at least, not much). Now get them to try an intermediate speed. It should be possible to get the tower shaking a long way at jusrt the right speed. You may need to practise doing this to show unconvinced children with poor handle control.

- Try to explain why this happens. The swing is useful here: to make someone swing higher, you push them once every time they come past, so that they build up a little bit more each time. Get the kids to do this to the dog. Also show them that pushing at the wrong rate means that you're sometimes speeding him up and sometimes slowing him down, which is why it doesn't work properly. Then show them that it also works when you wobble the base of the swing: just the right rate makes the dog swing high.

- The kids may then be able to explain why the tower seings most at a particular frequency, and might want to talk about designing buildings to withstand earthquakes.

- The pan pipes make a sound if you blow across (not into) the ends, or hit then with bats or bits of card. Explain that this is the air inside shaking inside, and link in with the Seeing Sound experiment if it's about. It's possible to use the slinky spring to get across the idea of a standing wave.

- The pan pipes also make a sound when you put your ear next to the end and listen. This is becasue any sound in the room at the right frequency is magnified by the resonant pipes.

- Introduce the 'cello, showing that it makes a sound when plucked or bowed, just like a real one. Then start the driver at a very low frequency, so that the string can be seen to be moved up or down.

- Get the kids to play with the frequency control, and explain that the magnet on the string can be moving so fast that it looks blurred. See if they can find the right frequency for the string to shake a lot. As before, explain that this is the frequency at which the string likes to vibrate if it's plucked. You may need to find it for them, or at least point them to the right range.

- This was the fundamental frequency. See if you can find the first harmonic, where one side of the sting is going up, one side is going down, and the middle (called a node) is staying still. You should be able to see the shape by eye. Then there's the second harmonic, and so on.

*** OTHER THINGS TO TALK ABOUT ***

- All sorts of things can resonate, and we'd often rather they didn't. Many people will have heard about the millenium footbridge in London, which wobbled as people found themselves walking in step with the wobbling. It had to be closed, and was fixed by fitting damping, which is also the way a car's suspension tries to avoid resonating. Going further back, the Tacoma Narrows bridge failed catastrophically due to resonance with the wind.

- The 'cello's driver does the job of a pick-up in an electric guitar, but in reverse, and works in much the same way.

- Serious string players can get harmonics to sound on a string by putting a finger lightly where they want the node to be. A little of the harmonics is excited each time the note is played, though, along with the fundamental, and the exact pattern of harmonics determines the timbre of the note.

- The first harmonic is an octave above the fundamental, and the second harmonic a perfect fifth above the first. This may make sense to musicians, though they might object that the intervals aren't quite right, which is because of the distortion caused by the mass of the magnet and the position of the driver.

- It would be nice to see the 'cello string in slow motion, which can be achieved by a stroboscopic light. There are safety issues in using certain strobe lamps, but it may be possible to tune the 'cello string to resonate at a frequency close to that of mains fluorescent lighting. Explaining the stroboscopic effect is fun with brighter kids.

*** SCIENCE BACKGROUND FOR DEMONSTRATORS ***

Anything that you know about resonance will come in useful for this experiment. Most things can be modelled as damped, driven harmonic oscillators, yielding a second-order differential equation with a sinusoidal right-hand side and a familiar set of solutions. Trying to go into mathematical detail with little children is a mistake, though. Even the words `resonant frequency' can be off-putting.

You may like to note (so to speak) that the pan pipes are tuned to a pentatonic scale.

Resonance Risk Assessment

Last updated: 01/02/2017 - 23:51

DESCRIPTION	Using various models to explain the concept of resonance. There's a box, which shakes a model tower (held together by magnets) when a handle is turned. There's a model swing with a dog, a set of large plastic tubes on a piece of wood, and a 'cello string attached to some electronics which drive it at different frequencies.
RISKS	• 1. Falling box or tower blocks could hit children on the head, hands or foot. • 2. Finger trap between the handle of the box and the table on which it's mounted, or between magnets. • 3. Finger trap in folding cello • 4. Cello string breaking, and hitting someone • 5. Cello bow poking someone in the eye • 6. The board that the pan pipes are on is heavy and may fall on children
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Tape the box to a table, and not so high that falling tower blocks could hit children on the head. • 2. Mount the box with the handle far enough clear of the table that there's no possibility of a finger trap. Collect any magnets which work loose from the model, so that they're not played with. • 3. Be careful when setting up/packing away. • 4. Don't use string if obviously damaged The cello string shouldn't be tensioned very high, and use a wire wrapped string so it won't fail spectacularly • 5. Supervise children carefully and make sure no one is standing where they could be poked • 6. Ensure that the pipe-board is positioned carefully and taped down where appropriate.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1-6. Call first aider in case of injury.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show

ACTION TO BE TAKEN TO MINIMISE RISKS	that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Vacuums

Physics: Various demonstrations using a vacuum pump.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Vacuum pump (belongs to Dave)
- Green vacuum chamber
- Magdeburg hemispheres.
- Balloons.
- Various other bits.

Explanation

There are lots of different bits to this experiment, and there is probably too much to do with any given group of people. Here are some of the things that can be done:

Particle Theory

A good way to start (I think, depends on the age group) is often good to ask what the surroundings are made of, solids liquids gases etc, and introduce the idea of particles (kids, even young ones may have heard of atoms or molecules). You can talk about how particles behave in each state of matter, and then start to focus on the air around you. Many kids will know the names of the gases that make up the atmosphere, so that's a nice question to ask, then you can explain that you get lots of these gas particles zooming around, but that you can't normally feel them. Example, wind blowing you backwards. You can also explain that many, many particles bump into you each second, but because you're used to it you don't notice (and your body has evolved to deal with it, if they're old enough to know about evolution). Maybe make a comparison, such as a bag of flour (1kg) on an area the size of a postage stamp (1cm^2).

Weighing Air

Does air weigh anything? Most kids (and adults!) will answer no to this question when asked it straight off, it links in quite nicely with the hot air balloon experiment where we argue that it floats because some air gets forced out of the bottom of the balloon making it lighter. Have a discussion about the difficulties in weighing air. A good analogy is a swimming pool; if you try to lift someone in the pool they feel much lighter than in the air. There may be a plastic pint glass on a piece of string in the box; so if you have a bucket of water you can test the weight of a glass when it is:

1. Empty, hanging above the water.
2. Full, hanging above the water.
3. Full, hanging in the water.

Get a volunteer to say heavy/light in each case. This should get across the idea that when you weigh something the surroundings matter. Now you can measure the weight of air itself. Take the plastic Vacuum chamber and put it on the scales. You can tare them to zero if you want, but this leaves you with a confusing negative mass measurement. Attach on the tube and then get someone to read the mass off, make sure no-one is touching it/leaning on the table too hard! Turn on the pump and (hopefully) they should see the mass go down by around 10g. (be very clear about what the pump is doing...lots of kids will be confused and think it's pumping air in rather than out!) Talk about how heavy this is, try weighing a marker pen/bunch of keys for comparison. So air really does weigh something!

Expanding balloon

Put a partly inflated balloon into the chamber. Evacuate the air from the chamber and see the balloon expand. Open the tap and it will shrink again (and if you do it too fast, it will shred into lots of pieces to the amusement of all). Talk about why this happens. No air can get in or out of the balloon, there are always the same number of particles inside it. Can talk about particles bashing against the inside and the outside of the rubber, when you remove them from the outside the balloon can expand more easily. You can even use a child tapping the palm of your hand on either side to demonstrate the point that if the tapping on one side gets taken away your hand moves. For a cheap "urgh!"; what would happen if I put you into a Vacuum chamber?

How strong is the Vacuum?

The other two experiments will have got across the idea that a Vacuum sucks things. Can talk about how this links in to Vacuum cleaners, which use pressure differences to suck up dirt (this is probably the only place they will have heard the word Vacuum before). Don't let them try to pull the lid off the plastic chamber (though they can put fingers on the end of the tap to feel the sucking effect!), but we have a metal Vacuum chamber that they can pull at hard! Evacuate it and let everyone have a go at pulling it apart. Can talk about the fact that you're fighting to pull against the millions and millions of air particles all bashing against the outside pushing it together.

Vacuum Bazooka

This leads nicely into the Vacuum bazooka experiment, which has a separate explanation/risk assessment (and can't be done in confined spaces!).

Vacuums Risk Assessment

Last updated: 02/02/2017 - 12:02

Pumping on vacuum chambers to see what happens when you evacuate various things.

Risks:

1. The chamber could implode, throwing things out.
2. The pump will produce oil mist in the exhaust.
3. Risk of falling over when two people trying to seperate metal vacuum chamber by "tug of war" method (especially if unexpectedly successful)

Control Measures:

1. Use a polycarbonate dessicator as the chamber, as polycarbonate doesn't shatter. Check chambers for damage before using them. Only put a rubber balloon inside the chamber.

   Can also use a metal vacuum chamber as this will not implode
2. The exhaust from the pump is fitted with an air filter.
3. Don't allow "tug of war" in a confined space/area with risk of bumping into sharp objects/other hazards, sometimes best to make both parties sit down first. If group is (showing signs of becoming) over excited best for demonstrator to hold one end of the chamber to maintain control

In case of accident:

Call first aider in case of injury.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 02/02/2017 - 12:12

Water Fibre Optics

Physics: Constraining light in a stream of water, making it work like an optical fibre.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Large bucket
- Lemonade bottle with a hole drilled in it
- Torch (the more powerful the better)

Explanation

Borrowed from Dave's Naked Scientists explanation: http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/water-...

In a nutshell

A stream of water is used to bend light and demonstrate how fibre optics work.

What to do

1. With the bottle empty, ask where they expect the light to go when the torch is switched on. Most will say in a straight line. Show them they are correct - it's useful to have a wall to point the torch at.
2. Put your finger over the hole and fill the bottle up with water.
3. Shine the torch through the bottle at the back of the hole.
4. Remove your finger from the hole and move it down the stream of water, showing how the light no longer travels in a straight line.

If you can, put a short straw into the hole - you'll get a smoother flow of water than just through the hole alone.

You should notice a spot of light on your hand while it is in the stream of water even though it must have gone around a corner to get there. It tends to work best when the water comes out quite slowly.

What you need to know during the experiment

To understand what is going on here it helps to do another experiment. Fill a transparent bowl with water, put something in the bowl and then look upwards at the bottom of water.

If you look at the bowl from the top you can see the spoon at the bottom.

Looking upwards in the bowl of water you see a reflection of the spoon at the bottom of the bowl in the surface. The water is behaving like a mirror.

So light will reflect really well off the inside surface of water at a relatively small angle.

This means that if you shine the light into a tube of water whenever it meets the side it is reflected so the light stays within the water until it hits your hand lighting it up. This happens even if the water goes around a corner.

Want to know more?

Why do you get such a good reflection from the surface of the water?

Light goes more slowly in water than in air and whenever light changes materials and the speed changes it will be bent (refracted). When it moves from a slow material (like water) to a faster one (like air) it is bent towards the surface.

Optical Fibres

If instead of making the tube out of water you use very very pure glass and pull it to a thin flexible fibre, when you shine light in at one end it will come out of the other. By getting the right design of fibre the light can travel through up to 50 km of fibre and still be detectable. You can then send signals through the fibre by flashing the light on and off again a bit like morse code, and if you can flash the light very fast you can transfer huge amounts of information. The record is now (Dec 2011) nearly 200 gigabits per second down a long-distance optical fibre connection (http://www.bbc.co.uk/news/technology-16174972). Because they are so good at transmitting data optic fibres move most of the data around the world (internet traffic, phone calls etc.) and you are almost certainly reading this via one.

If you make the tube out of plastic rather than glass it is more flexible and safer, and you can use it to make the artificial Christmas trees with the tiny pin pricks of light.

Water Fibre Optics Risk Assessment

Last updated: 02/02/2017 - 12:12

DESCRIPTION

Pouring water out of a lemonade bottle with a hole in it shining a torch into it and looking at where the light ends up.

RISKS

1. There is quite a lot of water involved, so if a surface is vulnerable to getting slippery when wet it could be a slip hazard.
2. If using the large bucket of water, note that it is very heavy to carry.
3. Electric shock risk with water.

CONTROL MEASURES

1. If the floor is vulnerable to slipperiness, clear up any spills. It may be worth laying down newspaper in the area around the bucket.
2. Take care when carrying the large bucket of water, and seek assistance if necessary.
3. Electrical torch to be well insulated from water - protect bodywork and bulb area.

IN CASE OF ACCIDENT

Call a first aider.

Last updated: 02/02/2017 - 00:20

Spinning Eggs

Physics: How to test if an egg is uncooked or hard boiled.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Eggs, a mixture of uncooked and hard boiled (you'll probably want more hard boiled ones, as they tend to crack).

Explanation

Basic experiment
Spin an egg, either cooked or fresh.
Stop the spin with one finger for a moment, then let go.
The fresh egg will start spinning again because the inside of the egg will carry on spinning when the outside stops and will cause the outside to accelerate again. The cooked egg will stop dead.
It's probably nicer to get people to try to think of ways to tell the cooked and uncooked eggs apart before you show them how to do it! After you have explained why the uncooked eggs carry on spinning get the kids to spin a random egg and tell you whether they think it's cooked or uncooked.

Other stuff to talk about
You can also ask them what would happen if you filled an egg with syrup and spun it and stopped it? Would it spin for a longer time or a shorter time than an uncooked egg? It should spin for much less time than an uncooked egg as it is very viscous and therefore the momentum diffuses much faster through it (don't use words viscous, momentum or diffuses though).

You could also try explaining why it's harder to spin an uncooked egg then a cooked egg. I found it a bit complicated to explain but if you talk about the fact that when you spin the egg initially only the egg shell and the fluid very close within the egg (in the boundary layer of the fluid) actually spins and then more and more of the fluid starts to spin but this slows down the fluid that was originally spinning (this is due to momentum diffusion with the fluid).

If you're feeling brave...
Apparently if you spin a hard boiled egg fast enough on a very smooth surface it will start tipping upwards and spinning around its axis of symmetry rather than lying flat (not unlike those toys you can't knock over I suppose). That is, at fast enough speed the stable orbit becomes the upright one rather than the flat one. Not sure how easy this is to make work in practice though...

Spinning Eggs Risk Assessment

Last updated: 02/02/2017 - 00:20

Spinning and stopping fresh and cooked eggs

Risks:

1. If dropped on the floor eggs may smash, causing a slip hazard.

2. Some people are very allergic to (especially raw) egg.

3. Salmonella risk from raw eggs.

Control Measures:

1. Spin eggs in a shallow tray to reduce risk of dropping them.
Have equipment available to clear up broken eggs

2. If an egg is broken ensure it is thoroughly cleared up, keep visitors away from area until area has been cleaned.

3. Only perform this experiment with Lion Mark eggs (from chickens vaccinated against salmonella). Wash hands after handling raw eggs and ensure visitors do likewise.

In case of accident:

1. In case of injury call first aider

2. Anyone with a level of allergy which might cause a major issue should be carrying appropriate drugs etc and they (or their carer) will know what to do. Risk is no greater in this case than going into a supermarket.

3. We won't know that someone has salmonella poisoning until well after an event. We might wish to warn people of the salmonella risk in the event of contact with a raw, non-Lion-marked egg, but really the risks are substantially lower than those incurred in baking a cake.

Last updated: 02/02/2017 - 00:07

Slug Bubbles

Physics: Does a tube of water drain more slowly with a bung in the top?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

3 tubes of different diameters but similar lengths held vertically on a board.
A frame to which the board is bolted to keep it upright.
A tray to catch water underneath the tubes (this is now a box with the board mounting permanently affixed)

Plugs that fit the tubes (and thumbs for those tubes for whichyou are missing plugs!)
A small pile of straws.
A bucket or two to hold replacement water.
A jug for filling tubes.
A couple of differently sized funnels for filling tubes.

Explanation

This experiment uses perspex tubes which are clamped to a board, and can be filled with water. When the bung at the bottom of a tube is pulled out, it empties. If there is a bung in the top, it empties much more slowly, as the air has to get in the bottom (a 'slug bubble').

What to do.

Put a bung in the bottom of a tube.
Fill it up with water using funnel and jug. Kids really want to help fill them up, and this is a good way of getting them involved.
Ask what they think will happen when the bung is removed: does the water rush out, drip out slowly, stay in etc.?
Ask if they think it'll come out fast enough to get their shoes wet.
Then ask if they're willing to test their hypothesis in reality, or take a few steps back and remember where their shoes were at the time (I normally look at the parents for confirmation of feet wetting next!)
Count down and remove the plug. SPLASH :-)
What happened?
Water rushed out etc...

Why?
Gravity pulled the water towards the ground and when the water came out of the tube, and air replaced it from the top. (Notice the subtle hint for the next stage.)
Get it filled it up again, but this time put a bung in the top as well.
WARNING: Make sure you hold the bottom bung on when you put the top bung in as water is not particularly compressible, and you can easily force the bottom bung out by pushing the top one in.
Now ask them what'll happen.
Then demonstrate - you can ask one of them to remove it this time :-)
Did they see the bubble go up the tube? Get them to try to explain what was going on. My explanation is just that for water to come out of the tube, air has to get in, as there can't be nothing in the tube (vacuum) as the high air pressure around will not allow it. However, it did not all stay in there because the hole at the bottom was nice and large allowing air and water to swap. You can see the air going in - it goes up the middle in the form of a big bubble, called a 'slug bubble'. The water flows out down the sides.

Next we have a race...
Fill up all the tubes, put bungs in both ends, and recruit some help to get it started. (You will probably have to loosen off the bungs in the bigger ones, as they are quite difficult to remove.
Which one is going to empty fastest? Why? See what each spectator thinks - often people have different views. They can be encouraged to argue it both ways: perhaps the big tube will empty faster, as there is more space at the bottom, perhaps it will empty more slowly, as there is mor water to come out, or perhaps these effects will cancel out and they will empty at the same speed.

Ready, steady, Go!

The biggest one empties fastest. Why did it do that?
A smaller hole at the end means that there is even less space for the water to swap over, so it comes out much slower. The more space there is for the air and water to squeeze past one another, the faster it can come out.

If you like, you can then move onto some straws, saying that straws are exactly the same, but they have even smaller holes at the bottom.
Straw under water, thumb on the top. Remove from water, remove thumb. A straw has such a small hole that the surface tension of the water cannot be broken.

An interesting addition
[Stolen from the Independent (2/8/06)]
Poke a hole in the side of a cup, cover the hole, fill with water, uncover the hole: water comes out Repeat, only this time drop the cup at the same time as uncovering the hole: water stays in, so you can talk about gravity acting on water and the cup, and things falling at the same speed etc. Probably not a tremendously exciting addition, but maybe something to talk about with very interested people, or something... [Plastic cups tend to shatter when dropped on concrete, and are a pain to make holes in, so maybe paper would be better.]

Slug Bubbles Risk Assessment

Last updated: 02/02/2017 - 00:07

DESCRIPTION	Perspex tubes are filled with water, attached to a board. Remove the bungs from the bottom to let air in. Watch different bubbles produced.
RISKS	1. Instability of the board 2. Slip hazard due to spilt water 3. It is conceivable, although highly unlikely, that a child could drown in the trough of water.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Ensure that the board is properly bolted to the frame. 2. Use the tray to catch the water. Clean up excessive spillage. Do the experiment outside. 3. Demonstrator to reduce risk of trips/falls (see #2) and monitor experiment at all times.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1-3. In the event of injury call first aider.

Last updated: 02/02/2017 - 00:36

Sunset Model

Physics: Why is the sky blue and the sunset red?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Perspex Tube
Light box stand to sit the tube on
Milk powder
Jug
Power Pack (from the power pack box)

Explanation

A perspex tube filled with a jug of water mixed with about 2-3 pinches of milk powder. Light is shone up the tube, and the colours of the sunset can be seen down the tube at different depths of water, and the blue sky can be seen in the side. The experiment needs to be in the darkroom. This probably works better in schools than in a public venue as it does take 10-15+ mins to get all the way through..

The solution works better if it is left to stand for a couple of hours before you start, so if you can pre-mix some the night before that is great.

The kids need to be able to see down the tube, so it works better with the tube on the floor.

This can work brilliantly especially with older kids, here is the way I do it:

This experiment is quite unusual for ChaOS in that it can actually be done as an experiment rather than purely as a demonstration though with a large group the experiment has to be quite directed by the demonstrator to stop kids getting bored.. I like to start by essentially saying - "I want you to to find out what happens to the colour of light as it gets shined through a dilute milk powder solution".

You then get them to fill the tube with the pre-made solution, look at the colour of the light through different depths of liquid, and make a table of depth vs colour.

This could take forever, but if you feed depths to them you can speed it up a lot. You want to distribute them something roughly along the lines of 0cm, 3cm, 6cm, 12cm, 24cm, 40cm.

You should find that the colour of the light bulb (It is worth making it clear that you mean the bulb and not the murk at large depths) goes from white, to yellow to orange, to a dark reddy orange or if you are very lucky red.

If you then get them to tell you what colours of the rainbow there are in white light -> all of them, then start from the bottom of the table and work out what colours are in each colour they have observed (this is of course a simplification as all the colours will work on exponential decays but it works well enough).

You should add these colours as an extra column on the table. and end up with a table looking like:

Depth of liquid	Colour Observed/td>	Colours of the Rainbow
0cm	White	R, O , Y, G, B , I, V
3cm	Whitey Yellow	R, O , Y, G, B , I
6cm	Yellow	R, O , Y, G, B ,
12cm	Yellowey orange	R, O , Y, G,
20cm	Orange	R, O , Y,
30cm	Reddy Orange	R, O
40cm	Red	R

You can then ask which colours you loose first from the light -> the purples and blues

Where are they going? --> if you look in the side of the tube from low down at the bottom you should see a bluey tinge to the light coming out.

They are scattering off the little lumps of fat in the milk powder.

You can then go onto ask if they have seen any lights which change from whitish to red, possibly up in the sky... eventually you may get the sun as a response

Explaining this is a lot easier with a diagram, and it works better if you draw it as you go along. Try to get the kids involved in this as much as possible, by asking them to tell you what to draw, or if they are competent and you have time get them to draw it.<./p>

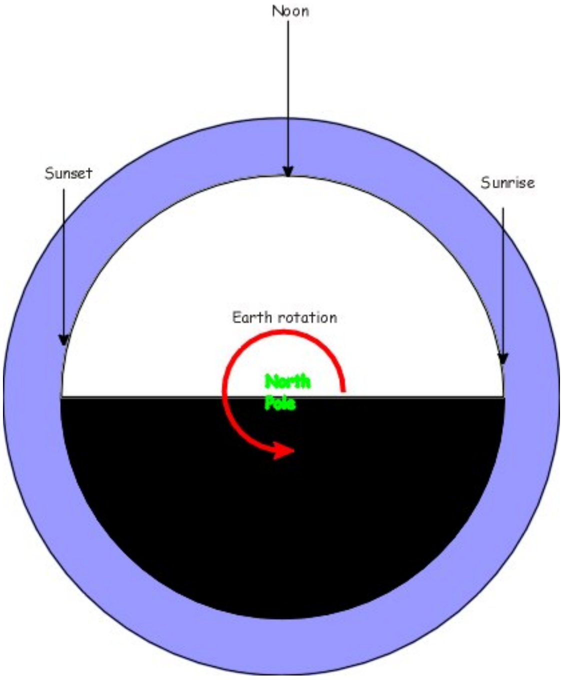
- Draw the earth, from the top (so north pole in the middle)
- Draw the sun off to one side

Ask them what could be getting between you and the sun to change its colour -> Air

- Draw on the atmosphere - it should be relatively thin in reality as thick as the skin on an apple
- Draw the half of the earth in shadow
- Mark on sunrise sunset midday and midnight.
- Draw a light beam going to someone standing at midday, and draw a little blue light scattering out
- Draw a light beam going to someone at dawn or dusk through lots of atmosphere-> draw all the blue light scattering out -> leaving the red -> red sunset just like in the tube

Draw someone near this light beam who looks toward the beam going past - what colour will they see? -> Blue. What colour is the sky? -> blue. Wy is the sky blue? -> cos you are seeing the scattered blue light

If you can get this final response it makes up for all the labour up to then!



A bit more background detail

The scattering in the sky is actually mostly from oxygen and nitrogen molecules not dust.

You might like to know that the process by which the scattering occurs is called Rayleigh scattering (or the Tyndall effect). The scattering cross-section (in effect, the amount of light scattered) is dependent upon (wavelength)^(-4). This is a very strong wavelength dependence, which explains why the blue light (short wavelength) is scattered more than the red (long wavelength).

Historically, Tyndall and Rayleigh thought that the scattering was due to small particles of dust and water vapour in the atmosphere. However, this is not the case - the scattering takes place from nitrogen and oxygen in the air. If scattering took place off dust, the colour of the sky would be much more variable. Water droplets in clouds tend to scatter all wavelengths of light equally, which is why clouds are white.

Why is the sky blue not violet (since violet is even shorter wavelength)? This is to do with our eyes, which are more sensitive to blue than violet, hence the pale blue colour of the sky.

Other Interesting Scattering-related phenomena

Dust in the atmosphere can enhance they effect, so harvests are often associated with good sunsets due to the dusk kicked up, and after the bunsfield oil depot fire there were some wonderful sunsets in the south east.

Mountainous regions are often famous for their blue haze. This stronger than usual scattering of blue light is due to aerosols of terpenes from the vegetation, which react with ozone in the atmosphere to form particles of size ~200nm which scatter blue light well. Forest fires or volcanic eruptions can cause the opposite effect - they can put particles with a size similar to the wavelength of red light into the atmosphere, which causes the red light to be strongly scattered (scattering is best when the particles are the same size as the wavelength of the light). Therefore we can get effects such as the blue moon (which is rare!), where the moon appears blue because the red light has been scattered out.

There is no atmosphere on the moon, so it has a black sky (nothing for light to scatter off). Mars has a red sky, not due to scattering but because of dust storms disturbing the red dust. If there has been no recent bad weather, the sky should be blue, but darker than the earth's daytime sky because the atmosphere is thinner so less scattering occurs.

Sunset Model Risk Assessment

Last updated: 02/02/2017 - 00:36

DESCRIPTION	Perspex tube filled with water and milk. Light shone in at one end and scattering observed.
RISKS	1. Slip hazard 2. Tube could topple and spill water, which could come into contact with electrical equipment. Also see Electrical Parts RA.
	1. Clear up any spills promptly

ACTION TO BE TAKEN TO MINIMISE RISKS	2. Use 7.2V light only. Demonstrator to place power supply/transformer above the surface on which the tube stands. Keep transformer off ground and away from experiment and possible spills. All surrounding mains voltage electrical equipment must be kept clear of the ground, or in a place where it will not be compromised in the event of a major leak. When setting up experiment, pour water into tube away from unprotected electrical equipment (over the low voltage, splash-proofed light box is OK) Demonstrator must carefully inspect the light box before starting to ensure no damage has occured which would affect the waterproofing (for example cracking of the light window).
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Call first aider in event of injury. 2. Turn off electricity at mains. Call first aider.

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation • 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased

ACTION TO BE TAKEN TO MINIMISE RISKS	(unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 02/02/2017 - 00:13

Sounds from an oven shelf

Physics: Get very strange sounds from an oven shelf.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Oven Shelf
String
Something to hit the shelf with

Explanation

Get very strange sounds from an oven shelf. Hang it from two pieces of string, wrap string around your fingers, put your fingers in your ears, hit the oven shelf. It will sound like big ben!

Why does it happen?

First of all we have to understand that sound is all about vibrations. When somebody speaks, their voice box vibrates, and this makes the air around it vibrate. These vibrations carry information about what someone has just said. When these vibrations reach your ear, they make your eardrum vibrate and this is processed by your brain as sound. The amount of energy (or the volume of the sound) that manages to make the journey from voice box to ear depends on what the sound is travelling through and what kind of sound it is.

In the case of speaking to a friend or when you listen to the oven shelf, the vibrations must travel through air. Air is really sloppy, fluid and not very stiff. Water is quite similar - if you put your hand in water and slowly move it around, the water feels very soft and fluidic. However, if you slap the water then it suddenly feels very hard and stiff. This is because the water doesn't have time to get out of the way so it has to form waves. Although it is not quite so obvious, this is the same for air. If you move something through it very quickly, the air feels stiffer and it's much harder to move through it, so high frequency vibrations will transfer more energy into the air.

The ability of sound to reach someone's ear also depends on the ability of the air next to the ear drum to vibrate. In the same way as a high frequency (pitch) vibration can transfer more energy to the air from the oven shelf because it has less time to get out of the way, a high frequency sound will transfer more energy from the air to your eardrum so the sound is loud. Low frequency sounds vibrate the air much more slowly, and so the air seems relatively more sloppy and doesn't transfer energy so well so they sound much quieter. So both low and high frequency sounds are produced by the oven shelf but it's only the high frequencies that vibrate the air by your ear drum much so the shelf sounds tinny and high pitched.

In order to hear the low frequencies, you need to create a stiff connection between the oven shelf and your ears. The string wrapped around your fingers provides this connection. The string is taut and stiff and can transmit both high and low frequencies. When you add the high and low frequencies together, the oven shelf suddenly sounds like a gong.
What about in the real world?

This is why your voice sounds different to everyone else and when you hear it recorded. Everyone else just hears you though the air, but you hear yourself through the bones in your skull as well, so different pitches will reach your ears than other people's.

For more see:
http://www.thenakedscientists.com/HTML/content/kitchenscience/exp/the-se...

Extra information
In case someone of a more mathematical background is asking, it's the impedance mismatch between the shelf and the air that filters out the low sounds (acting as a high pass filter). We could get those sounds to the air better if we passed them through a series of media with different impedances instead of a big jump. The string has an impedance much closer to that of the shelf (being a solid and all) so there is less of a mismatch and better transmission.

Sounds from an oven shelf Risk Assessment

Last updated: 02/02/2017 - 00:13

Hanging a vibrating oven shelf from two pieces of string wrapped around your knuckles, which are put in your ears.

Risks:

Minimal, but if fingers are pushed into ears with long nails it could cause some minor damage.

Control Measures:

Encourage children to put their knuckles, not their fingers, in their ears.

In case of accident:

Call a first aider.

Last updated: 29/01/2017 - 16:06

Colour mixing

Physics: Dimmable, focussed red, green and blue lamps for experimenting with light colour mixing

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

3 lamps with LED bulbs and focussing optics
Bench power supply (6V MAX PLEASE)

Explanation

The three lamps in this experiment each contain an LED focussed to produce a tight, reasonably even circle of light that can be projected onto different surfaces. The lamps each produce a different colour (red, green, blue) and can be individually dimmed. This allows you to play with producing different colours by adjusting the intensities of the different lights.

Suggestions for explanation:

- Mixing a colour – get the children to choose a colour and let them work out how to make it.
- Demonstrating how the primary and secondary colours (of light) are produced – space the three colours so they slightly overlap to produce three circles of red, green and blue, with cyan, magenta and yellow where two colours overlap and white where all three do
- Fooling the eye – LEDs are fairly monochromatic – their spectrum is not very widely spread about the peak wavelength. Because we expect light to appear as it does from a 6500K light source (the sun), it is possible to confuse the eye when dealing with monochromatic light. For example, mix the lights to produce a white(ish) colour, then put a brightly primary coloured object such as a tomato underneath. Because, the surface will directly reflect a large proportion of one colour, it will appear unexpectedly bright.
- Funky shadows – shine the lamps at a wall or other white surface from some distance away. Observe the multiple shadows of different primary and secondary colours that can be seen. This works best with a wide separation between the lights.
- This is a new experiment – if you think of something interesting to talk about, please write it below!

Colour mixing Risk Assessment

Last updated: 29/01/2017 - 16:06

Using 3 focussed, dimmable LED lamps in red, green and blue to investigate colour mixing

Risks:
1. Light from LEDs can be intense.
2. Power is dissipated by electronics. Lamp and base may become slightly warm in use and hot if excessive input voltage is used (6VDC MAX)
3. Lamps may topple if knocked
4. Electrical cables present trip hazard
5. Circuit is designed to operate from a 5V supply and is not designed to handle more than 15V under any circumstances. There is no electric shock risk from this low voltage circuit, but it should not be operated outside its specifications to avoid possible overheating.

Actions to control risks:
1. The majority of LEDs are considered to be class 1 and do not pose a risk to sight ("safe under all conditions of normal use"). These lamps use 3W Philips Luxeon III LEDs, widely used in a range of consumer products. Whilst the beam is focussed to about 10 degrees, the lumen output is much lower than more modern devices and considerably more powerful and focussed devices are readily available in products such as bicycle lights. The lamps should not, therefore pose a risk to sight even if someone were to look directly into the source.
Do not allow people to look directly into the beam. Natural aversion should be sufficient in most cases, but demonstrator to keep control of lights and if necessary switch off power.
2. Children warned that the lamps may get hot, and instructed to handle lamp at base if moving it about. The correct voltage MUST be used.
3. Lamps are modified desk lamps. Some base weighting was removed in construction, but the modified lamps are not required to support the weight of a bulb. This does not greatly reduce stability but does mean less effort is required to knock them over than may be expected. Conversely, should the lamp be knocked over, damage or injury is unlikely – the plastic LED and lens assembly is practically indestructible in normal operation. Lamps should be used on a flat, level surface.
4. Try to keep cables out of thoroughfare. If cables must be placed somewhere people are likely to be walking, tape them down.
5. To avoid overheating, lamps should not be covered during operation. A 5VDC (nominal) input voltage should be used, maximum 6VDC. UNDER NO CIRCUMSTANCES MUST MORE THAN 15V BE APPLIED TO THIS CIRCUIT.

What to do if an accident still occurs:
1. In the event of a person being dazzled by lights, switch off lights and get them to sit down until they have recovered. Check they are ok before letting them walk around in case they walk into something!
2. In the event of a burn call first aider. In the event of fire, follow procedures in venue RA (raise alarm, evacuate,...)
3. In the event of injury, call first aider.
4. In the event of injury, call first aider.
5. If the circuit is damaged during use (abuse, misuse, overvoltage etc.), switch off all power immediately and do not use again until it has been checked by a competent person.

Darkroom Risk Assessment

DESCRIPTION	This experiment is one of a range of experiments that are best carried out in the dark, either in our purpose built darkroom (constructed from a gazebo frame and black plastic sheeting), or in a suitable other dark location.
RISKS	• 1. Fire risk • 2. Heat exhaustion • 3. Unseen drop (e.g. if a stage is used as a dark room curtain wall may mask edge of stage) • 4. Risk of child abuse allegations if alone with a child/children in the darkroom.
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. We have tested fabric for flammability. The tent walls can be lifted/detached quickly to allow exit. Keep all electrics away from fabric and off the floor if there is a risk of moisture getting into the electrics. Keep fire extinguisher in dark room. Check carefully behind tent for heaters etc. • 2. All demonstrators to have drinks bottles. Ensure demonstrators change round regularly, and that people visit dark room to check everything's okay. Use fans and make sure the chimneys are providing some ventilation • 3. Where possible leave a gap between a drop and the edge of the dark room. Clearly mark sides next to drops (e.g. hazard tape along inside). If possible site experiments to block access to drops. • 4. Always ensure a minimum of two demonstrators are present. If this is not possible the darkroom should be closed. NB. There is a risk of accusations of child abuse being made if you are ever alone in the dark room with one or more children. Always ensure two demonstrators are working in the dark room at any time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Evacuate area. Tackle fire with extinguisher if safe. Call emergency services if necessary. • 2. Remove victim to fresh air and cool area. Give plenty of fluids and rest. Call first aider if necessary. NB: You should only attempt to move someone if you are trained to do so. • 3. Call first aider if necessary. • 4. Close darkroom until two demonstrators are avaliable.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency.

OF AN ACCIDENT	• 3. Call first aider in case of emergency.

Last updated: 01/02/2017 - 23:41

Phase Game

Physics: Game introducing the phases of matter and phase changes

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Some method of marking a playing area. Some playgrounds have markings, otherwise cones etc. Inside a hall, the entire room may be used

Explanation

When you have a large number of children to entertain for an unknown period of time, who do you call? Phase busters!

This game is designed to be run in schools or on jamborees when there are a large number of children who need entertaining

The principles of the game are simple. You yell a phase, or a phase transition, and the children act in a manner akin to molecules in that phase.

Basic calls :
Solid: The children stand still, with their hands by their sides. Some huddling may be encouraged, but isn't necessary.
Liquid: The children walk slowly, I generally also bring my hands up, palms together, wiggling in front of me to worm around. They should probably come close together too.
Gas: Walking (or running if they seem trustworthy) as far apart as possible, bouncing off the edges of the container.
Melt: Transition solid to liquid
Evaporate: Transition liquid to gas
Condense: Transition gas to liquid
Freeze: Transition liquid to solid
Sublimate: Transition solid to gas
Deposit: Transition gas to solid

Other call options:
Oxygen or Nitrogen: Children are a gas in pairs (holding hands with a partner)
Ozone: Children are a gas in 3s (have some demonstrators there to make up to a multiple of 3 if necessary)
Neon: Children are a monatomic gas, as per the previous gas description
Benzene: Children are in rings of 6
etc. (make up as you like)

Spiel:
To start with I introduce that we're stood in a beaker (or something similar) and that the children are the molecules. Maybe some discussion here of what molecules/atoms are; don't need to go too complicated. See if they know what the molecules do in a solid, liquid and gas. Then start making some calls and get them to do the appropriate actions. This is a good time to gauge how well the group is behaving and point out that those misbehaving/pushing/running everywhere may have to go stand with a teacher. Use solid to stop them for more instructions.
More Q&A. How do we get between phases (or states, or types, whatever they can handle)? If you hold ice in your hand what happens? What's that called? Try a few out, remember you can still call solid to get them all to stop. I'd only stick with what they're likely to have heard of at this stage.
Trickier now, sublimate and deposit are added. See if anyone knows the word, maybe get them all to say it back. Examples include dry ice (solid carbon dioxide), pieces of ice in cold dry conditions, formation of snow and frost.

Variant:
Knock out game (maybe once they're getting tired, or from the start because you're bored of running the other one. Don't make it knock out for a bit so that they get the hang of it and all get a chance to do something. Use the alternative calls, sometimes people won't have a full group. These people (or the last group formed) are out. They can cheer on their compatriots as they play on or be gradually siphoned off to home time etc. For example:
14 children in room, call "Benzene", two rings of 6 form, other children out.
12 children in room, call "Ozone", last ozone to form is out.
9 children in room, call "Nitrogen", lonely child out.
8 children in room, "Benzene" again, 2 spare children out.
6 children in room, "Ozone" again, last ozone formed is out.
3 children in room, call "Neon", they all look confused as no one is out.
3 children in room, call "Nitrogen", lonely kid is out, other 2 children are winners.

Phase Game Risk Assessment

Last updated: 01/02/2017 - 23:41

EXPERIMENT	Explore the phases of matter in an exciting game
RISKS	• 1. Falling over • 2. Running into each other/static objects
ACTION TO BE TAKEN TO	• 1. Children should be asked be careful and to be aware of falling over risk. The speed of the game should be limited to a safe one (get them to walk instead of run if they are behaving dangerously). Over excited children should be asked to stand out for a round or two, there should be teachers on hand who can deal with that sort of thing. Make sure that the floor isn't slippery before starting (wet

MINIMISE RISKS	hall floor, leaves outside, wet grass etc.). • 2. Clear away or keep the game away from any static objects likely to cause danger. Use area markers which are not dangerous to run into. As for falling over risk, limit the excitement of the game as required and make the children aware of the risk ("Be careful not to run into each other, ok?").
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Call first aider in event of injury. Stop experiment if required. • 2. Call first aider in event of injury. Stop experiment if required.

Last updated: 02/02/2017 - 00:42

Scale of the Solar System

Physics: By comparing sizes and distances we can scale our solar system all the way up from the Earth and the Moon, up to our nearest star, and you might be surprised how far that actually is!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Golf ball - Moon
Globe - Earth
Marbles - Earth/Sun on different scales
Red foam ball - Jupiter
Card with pin-prick hole - Sun/Solar system on bigger scales

Explanation

For globe earth:
Golf Ball moon - at a distance of 4m
c=6ms-1

For 2m (roughly demonstrator height) Sun:
Earth marble
Jupiter ball
c=1ms-1 (GUESS!?!)

Sun marble
Earth 2m away
Jupiter 10m
Neptune 60m

Sun 1mm (pin prick hole in card)
Neptune 4m
Alpha Centauri 29km

Solar System (sun to neptune) 1mm
Alpha Centauri 10m

Scale of the Solar System Risk Assessment

Last updated: 02/02/2017 - 00:42

Potential risk:
1) Tripping or falling
2) Ball rolling off and getting underfoot
3) Small balls used in some parts of the experiment being swallowed

Solution:
1) Demonstrator must emphasise that children must walk, should stop everyone walking to actually do explanations
2) Must be made very clear to children that they may not kick or throw the balls ever
3) Do not use small balls parts of experiment for audiences of very young children

Last updated: 13/02/2015 - 18:12

Exoplanets and Alien Biology

Physics:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Explanation

Looking at other planets, animal under extreme conditions and extrapolating this to some first guesses about what life on other planets might be like.

Exoplanets and Alien Biology Risk Assessment

Last updated: 13/02/2015 - 18:12

DESCRIPTION	Apart from lots of pictures of planets, and maybe the inclusion of the orrery (separate RA) my expectation of the experiment will be that it contains some skulls and other paraphernalia of animals who live under extreme conditions, hence I've just copied in the RA of animal skulls below
RISKS	• Some skulls may have sharp teeth or beaks. • If dropped, skulls may fall on feet or shatter, causing cuts and other injuries. • Possible infection risk from bone if skin is cut by touching the bone
ACTION TO BE TAKEN TO MINIMISE RISKS	• Remind children to handle skulls carefully; in particular, be careful not to pinch fingers/hands in the jaw. • Again, remind children to be careful, and demonstrator only have a few skulls present at a time to minimise risk of children picking up or playing with skulls. Demonstrator to keep an eye on anybody holding skulls. If a skull smashes, clear it up immediately with dustpan and brush. Any skulls with sharp edges may need to be smoothed off or replaced. • We have boiled the skulls we found in bleach for a few hours to sterilise them. Please note, however, this does not necessarilly mean that the skulls are sterile now.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• In case of injury call first aider. • Warn parents of the possibility of infection if a child does cut him/herself on the skull; Advise parents to take child to a doctor if the cut looks infected.

Last updated: 11/02/2016 - 11:57

Wave Phase Tank

Physics:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Explanation

Y shaped wave tank that allows two children to make waves that then combine in or out of phase.

Wave Phase Tank Risk Assessment

Last updated: 11/02/2016 - 11:57

DESCRIPTION	Y shaped wave tank that allows two children to make waves that then combine in or out of phase.
RISKS	• Spillage of water from over-zealous children or leaks causing slip hazard.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Instruct children not to make waves that are near to overflowing the tank. Before demonstrating check for leaks. Have tissue paper on hand to mop up any small spillages, keeping an eye out for water on work surface and floor.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• In case of injury call first aider.

Last updated: 09/02/2017 - 15:03

Rod Climbing

Chemistry: A polyacrylamide solution, which "climbs up" a rod when it is rotated in the solution

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Pot of pre-made polyacrylamide-in-glycerine. (x2)
Stirring rod (plastic)
Box of string "spaghetti"
Fork

Explanation

In a nutshell
Twisting a rod in the polymer solution causes long molecules to wrap onto the rod and creep slowly upwards (like spaghetti on a fork).

How to set up the experiment
The premade solution is polyacrylamide (between 0.5 wt% and 1 wt%) dissolved in glycerine (same thing as glycerol) with food colouring, which goes with the rod. The fork and spaghetti can be used to demonstrate how a polymer behaves when it moves.

What you need to know during the event
1) Get the kids to twist the rod in the slime. Wait for them to notice that it's doing something weird...
Explain that all materials, like the slime, are made of molecules. The slime molecules are really long and thin, like spaghetti...,The slime contains a polymer called polyacrylamide. The solution has some properties of a liquid, for example it finds its own level in a container, and some of the properties of a solid, for example it is elastic.

2) Let them have a play with the spaghetti-string and fork, and see that the string climbs up the fork.
Encourage them to see how the length of the molecule makes the spaghetti get tangled, creating a viscous solution. Explain what's going on - as the string wraps onto the fork out of the mixture, it pulls more string with it. As it pulls tight, some of it gets forced up over the surface, pushed out of the way as more string wraps on. This is what's happening with the polyacrylamide, but on a much smaller scale so we can't see the individual "strings". *Demo only works with the prongs of the fork on the plate as otherwise the spaghetti is squashed out the bottom (which is preferred because of gravity)*.
This occurs due to the circular flow of the liquid around the rod becoming sheared, which causes the forces perpendicular to the surface (upwards) to become much larger than those effects causing the circular motion, leading to the liquid rising up onto the rod. This effect (called the Weissenburg effect) can occur in any liquid capable of shear (think batter or similar things in baking partially rising up the whisk when mixed), but as the rising is due to shearing effects, this will become magnified for more viscous liquids, such as the polyacrylamide. Also, note that this effect just requires some rotational motion, and if this can be achieved without the rod, a bump will still form around the vortex formed by the stirrer. As seen in this youtube video:
https://www.youtube.com/watch?v=tK2ajzCfNBU

What kind of molecule do they think might pour much more easily? (e.g. water, sand, sugar which are small and round molecules instead of chains).

Sometimes they will ask why it forms a 'blob', and doesn't just rise up, this is because of this effect falling off as the width of the 'blob' decreases (less shearing can occur), and so gravity pulls the layers down until a blob is formed

3) Try lifting the rod out of the slime or touching the surface of the slime lightly with the rod. The solution has a very high extensional viscosity (resistance to flow when pulling as opposed to pushing, which is how we usually think of viscosity). Imagine trying to pick up one strand of cooked spaghetti from a huge pile – it's the same thing (except that you're pulling out hundreds, if not thousands of strands of spaghetti).

Tips for demonstrating
Don't let them put their fingers in the slime
1) Acrylamide (the monomer) is harmful, but there is none of this in the solution. The slime (POLYacrylamide) that we're using is non-toxic. The degree of polymerisation (the length of the chains) is so high that even the shortest is several thousands of monomers long.
2) It is also very sticky and if it starts getting on people's hands, then we'll lose it all very quickly.

Want to know more?
Polyacrylamide is a polymer; this means that the molecules (the smallest parts that are still polyacrylamide) are very long and thin like cooked spaghetti, lengths of string or long hair. Polyacrylamide is used to thicken foods.

Polymers behave elastically due to the different states they can adopt - extremes being the coiled and extended states. In the coiled states, there are lots of different conformations which come about from molecule rotating in different parts along its length, but only one that makes it straight. That means that the coiled state is much more likely (this is entropy!), and so the polymer tries to go back to it if stretched.

The glycerine that the polyacrylamide is dissolved is used as a cough mixture and is also added to icing to keep it soft.

Rod Climbing Risk Assessment

Last updated: 09/02/2017 - 15:03

DESCRIPTION	Weissenberg effect. If rod is rotating fast in a polymer solution the polymer will climb the rod.

RISKS	1. Eating polymer (note: polyacrylimide is non-toxic). 2. Slip hazard.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Stop kids from eating polymer. If you are using polyacrylimide, use a very high molecular weight so there are no monomers. Children must not handle the slime during the activity! 2. Clear up any spills.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Polyacrylimide is non-toxic. Advise parents what has been ingested and to see their GP should illness develop 2. Call first aider in event of injury

Last updated: 06/02/2017 - 19:23

Mini Explosions

Chemistry: Exploding film canisters with lemon juice and bicarb.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Lemon Juice (and maybe vinegar)
Bicarb
A couple of washing up bowls
Teaspoon or similar for scooping bicarb
Clear plastic box with the hinged lid
Green tray to catch any leakage from clear plastic box (doesn't live in blue box)
(All of this lives in a large blue box with white lid)

Explanation

In a nutshell.....
Acid + Carbonate -> Salt + Water + Carbon Dioxide
Production of carbon dioxide in a sealed container to produce explosions.

How to set up the experiment
Initially, mix lemon juice (about 1/4 fill the cannister) and bicarb (1/4 of a teaspoon) in the film cannister with the lid off, so that the kids can see it frothing up. Ask them where they think the bubbles are coming from/ what's in the bubbles (space for a bit of a discussion of different gases here, many of them will have heard of CO2).

Get them to think about what lemon juice is like (sour), and what else is sour (vinegar, other citrus juice..) and discuss that any acid can let out the gas that's "trapped" in the powder. Possibly also discuss use of bicarb in baking - heating it up releases gas, which puts bubbles in your cakes.

The bubbles should froth well over the top of the cannister, point out that if the lid were on the gas wouldn't be able to get out. Ask them to predict what will happen if you put a lid on (does the gas have anywhere else to go?)

Now try it and see if they're right! With older kids you can discuss how molecules create pressure, ask them to push their hands against each other a bit to demonstrate reaction forces.

Some children ask why there is no 'fire' if it is an explosion. It can be worth explaining that an explosion is simply a rapid expansion of gases and release of stored energy, often with heat being produced, though this is not a necessary condition. Sealing the cannister causes the pressure to build up, which stores energy, until the lid can no longer resist the force of the trapped gases. The stored energy is then released rapidly when the lid pops off and gases expand, causing the explosion.

There are 2 slightly different approaches:

Method 1

Put some lemon juice in the cannister, put a piece of tissue paper over the top of the cannister with bicarb on top of that, push the lid on so it hold the tissue paper. The bicarb is now held at the top of the pot away from the lemon juice.
Put the cannister upside down in the clear plastic tank and shut the lid (it's often a good idea to have the lid partially shut before you invert the cannister to reduce the risk of it getting off you). The bicarb and lemon juice will mix and the pot will explode upwards.

Method 2

Put some lemon juice in the cannister, press bicarb into the well in the centre of the lid. The bicarb is now held at the top of the pot away from the lemon juice.
Put the cannister upside down in the clear plastic tank and shut the lid (it's often a good idea to have the lid partially shut before you invert the cannister to reduce the risk of it getting off you). The bicarb and lemon juice will mix and the pot will explode upwards.

It's usually a good idea to try both methods and see which one works better for you and the type of film cannister you happen to have.

Some film cannisters explode better than others, so it is worth trying different ones to make sure you are using the right lid. The oval ones work really well.

Other things to think about: vinegar (acetic acid) is a stronger acid than lemon juice (citric acid); if using vinegar expect this reaction to be quite quick...

Mini Explosions Risk Assessment

Last updated: 06/02/2017 - 19:23

DESCRIPTION	Lemon juice and bicarbonate mixed in a film cannister. Top pressed on. Explodes off in box.
	1. Slip hazard

RISKS	2. Explosions could get out of box, (or occur before the cannister has been put in the box) and get into eyes 3. Eating the reaction Irritant to eyes Irritant in cuts
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Clear up spills if on a slippery floor. Do experiment outside if possible 2. Do experiment in a clear lidded fish tank so kids are not peering over the top to see what is happening, keep lid opening faced towards demonstrator. Ensure the top of the tank is not at eye level (it is possible for a small volume of the reagents to be propelled through the crack between the top of the tank and the lid). Run a length of plastic tape along the hinged side (which should be closest to your audience) to prevent splattering. 3. Do not let the kids do the reactions themselves or leave them alone with the experiment. It is important to keep the kids under control. Try to keep control over at least one of the reagents, so the kids can't just do it themselves Don't let the kids peer over the top We have eyewash in the safety box- the demonstrator must ensure he or she knows where it is but not adminster it unless they have been trained. Tissue paper may be used as a "fuse" to increase the time taken for the reactants to come into contact with each other - this gives more time to get the cannister into the tank. Lemon juice is usually better than vinegar, as it reacts more slowly, so again, there is more time to get the canister into the tank. In addition, eye protection should be provided for demonstrators to minimise possible risk of solution splashing into demonstrator's eyes.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Call first aider in case of injury 2. Call first aider. Use eyewash to wash out of eyes if trained and confident to do so, if solution or reactants have entered eyes. 3. Advise them that the reactants are all edible but to seek medical attention if they start to feel very bad as experiment has been in cupboard for unknown amount of time.

Last updated: 23/01/2017 - 18:44

Cornflour

Chemistry: Explore the remarkable properties of cornflour mixed with water.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

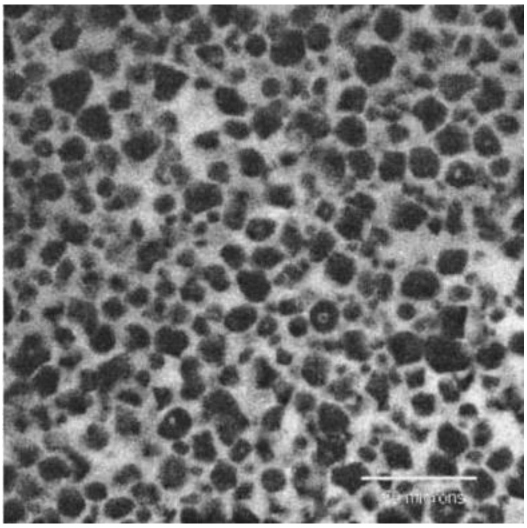
1. Washing up bowls 3-4
2. Cornflour 3kg min
3. Water
4. Laminated cornfour picture

Explanation

In a nutshell
You and the children play with the gooey cornflour/water mix, exploring the concepts of solids, liquids and substances that have properties of both.
Cornflour is lots of irregular shaped particles that are separated by water normally so are lubricated and can move. If you squash them together it will push the water sideways a little bit and let them touch - now they lock together and behave as a solid.
The picture shows cornflour under a confocal microscope, which takes a 2-D slice through an image rather than looking at the surface.

How to set up the experiment
Slowly add water to cornflour until it works - ask a committee member for help if you're getting stuck. A ratio of 2.5 parts flour to 1 part water is suggested, but the ratio may vary.

What you need to know about the experiment
(1) Cornflour is shear thickening. This means the higher rate of shear, the higher the viscosity (i.e. the thicker it is). (Note: Shear can be explained by considering 'layers' of cornflour particles sliding past each other.)
(2) Try asking them whether it is a solid or a liquid. You may want to get them to come up with definitions of the terms solid and liquid - e.g. "what do we call hard things / things that flow...?" Cornflour is like a solid and a liquid - Acts as a solid under stress and a liquid otherwise
(3) It's like a room full of people and when you try and make it move quickly, everyone tries to move at once (while also moving closer together) and they all get in each other's way and so no one can move anywhere. And when you do stuff to it slowly, everyone has time to move out of the way and file out.



(file here) (Bromley & Hopkinson reference here)

Want to know more?
Shear thickening is a problem in the oil industry, as when they are drilling they are getting rock fragments in the mud coming back up, if there are too many they behave similarly to the cornflour, with catastrophic results to pumps.
Some people are talking about making liquid body armour using this effect, to make the body armour more comfortable.
The opposite of shear thickening is shear thinning. Many substances are shear thinning because the higher rate of shear can break up interparticular interactions and reduce the viscosity - e.g. shampoo, toothpaste - when you shear them by squeezing them out of the tube, it flows, but when there's no shear, it sits quite happily on the toothbrush without flowing anywhere.

Explanation warnings
THICKENING SOUPS IS DIFFERENT: the cornflour grains open up when heated and release long starch molecules that tangle together forming a gel-like substance.
THIS IS NOT THIXOTROPY, which is concerned with time related effects. Thixotropy is a long word and shouldn't be used with children. Adults should be politely and gently explained the difference! The longer you shear a thixotropic fluid the lower the viscosity (the thinner it becomes) - e.g. paint - as you progressively break up interparticular interactions. Many fluids that are shear thinning are also thixotropic. Rheoplexy / Anti-thixotropy is the opposite - i.e. the longer you shear a fluid the higher the viscosity (the thicker it becomes). Xanthan gum might do this under certain conditions, but it's very rare for

substances to do this.

Cornflour Risk Assessment

Last updated: 23/01/2017 - 18:44

DESCRIPTION	Cornflour and water mix in a washing up bowl.
RISKS	1. Powder may trigger asthma attack. 2. Minor slip hazard. 3. Irritant to eyes. 4. After a while, the mixture accumulates some dirt, which is not recommended for consumption.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Clear up spilt powder. Where possible, do the experiment outside. Do not allow children to help to mix in new powder without first checking that they do not suffer from asthma. 2. Clear up spills promptly; if the floor is smooth, ensure that a mop is available for this. 3. Avoid contact with eyes. 4. Encourage children to wash hands after use.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Move child out of area and sit them down. Call first aider. 2. Call first aider in event of injury. 3. Rinse with eyewash supplied if trained and confident to do so. Call first aider.

Last updated: 09/02/2017 - 14:15

Electrolysis

Chemistry: Splitting water into hydrogen and oxygen, and using the recombination of these to launch ping-pong balls.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Electrolysis tower (~ 6' tall, white cover, don't drop it - you will need 2 people to move it)
0-15V variable power supply OR Power pack of doom
Small red box (approx. contents): Water models, small air blower, $MgSO_4$, deionised water, funnels etc. power connectors, piezo-electric sparker, silencer, ping-pong balls)

Explanation

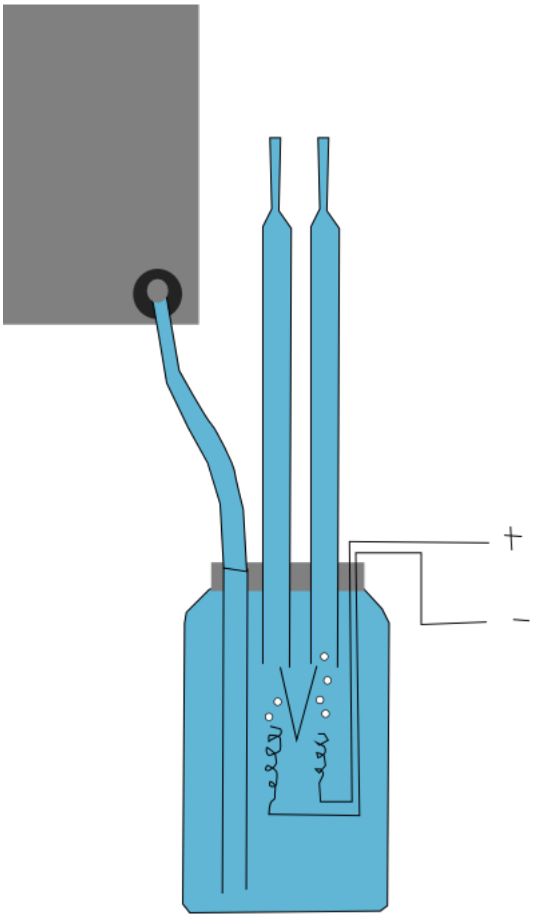
In a nutshell
Water is split into hydrogen and oxygen, which are then recombined explosively at different concentrations to launch a ping pong ball into the air. This means that you can investigate energy conversion, stoichiometry, what is an explosion, etc. etc..

Setting up Electrolysis
Note: Please do not attempt to set up or pack up electrolysis unless you have been shown previously how to do it and are confident you know how (one of the committee members at the event will be happy to show you what needs to be done) - if you get tap water in the electrolysing chamber you will get some very strange results (mainly due to metal oxide formation removing the oxygen as you make it), and the chamber may need to be cleaned.
(1) Ensure the tower is secure and won't fall over. There is a sound muffler in the box that fits over the ignition chamber. It is strongly advised that you use it if you are going to be demonstrating this for any length of time/are indoors.
(2) Attach the power cable to the current controller
(3) The wires are connected (those with tape on inserted first, and the sparker can have its wires go in any way around, for the electolysis apparatus itself, connect red and red, and black and black)
(4) Ensure that the apparatus on wet ground (if outside use separate upside-down trays for the appartus, and for the power supply and sparker)
(5) Use a funnel to pour the MgSO4 solution into the back chamber (such that it goes to the electrolysis chamber), ensuring that no water enters the sparking chamber
(6) Use a gravity siphon (use plastic tubing to suck some water to insert the tap water into the front (mixing) chamber, again ensuring no water enters the sparking chamber

How to set up (and run) the experiment
Note: Please do not attempt to set up or pack up electrolysis unless you have been shown previously how to do it and are confident you know how (one of the committee members at the event will be happy to show you what needs to be done) - if you get tap water in the electrolysing chamber you will get some very strange results (mainly due to metal oxide formation removing the oxygen as you make it), and the chamber may need to be cleaned.
(1) Ensure the tower is secure and won't fall over. There is a sound muffler in the box that fits over the ignition chamber. It is strongly advised that you use it if you are going to be demonstrating this for any length of time/are indoors.
(2) Pass current between the platinum wires in the reaction chamber at the bottom, this splits water into hydrogen and oxygen, which are collected by two inverted burettes. ***Do not use too much voltage for the water splitting, as you may start causing some strange by-reactions.***
(3) Holding the mixing chamber valve shut, release hydrogen and oxygen from their burettes in an appropriate ratio into the mixing chamber.
(4) Release the mixing chamber valve to let the gas mixture into the explosion chamber, then use the piezo igniter to fire it (some off the gas will vent out around the ping pong ball - this is ok).
(5) The electrodes that make the spark are now wet; if you need to repeat the explosion quickly the air blower may be used to dry them more quickly - in practice by the time you've done the introduction again the electrodes may be dry.

Video set up guide here:

What you need to know about the experiment
Water is H_2O and, if you apply enough energy (needed to break bonds), it can be split into its constituent parts (there should be some models).
You should be able to see that there is twice as much hydrogen as oxygen.
You can get the energy back out rapidly -> heat ->expansion -> acceleration of the ping pong ball.
The sparking electrodes a become wet: you've made water!
A detonation is an explosion which travels at supersonic speeds (you should hear it!), and hydrogen and oxygen will detonate at the right concentrations.



Want to know more?
The main point to get across is that water is made out of hydrogen and oxygen and these are gases. But as you go on you can also describe the energy in -> energy out aspect, stoichiometry and molecular structure and also relate it to how we would have to make hydrogen for cars.

In starting the explaining at the bottom of the apparatus you can ask what the children can see in the bottle at the bottom. Water and wires. I then go on to say I'm going to put some electricity in the wires, now what can you see? Bubbles. What's in the bubbles?

I then explain how were are turning water into what it's made out of. So what's it made out of? Excellent if they can answer this. Otherwise, do you know another name for water? It's surprising how many kids get H_2O. Why is it called H_2O? Because it's made out of hydrogen and oxygen - "Hydrogen times 2, H_2 and oxygen O."

Once that's settled, you can go for the molecular models. Breaking them up into two H_2 and one O_2 molecules. While this is in I explain what we're going to do next in recombining the molecules back to H2O giving them a good shake. Random collisions aren't a bad model for a chemical reaction.

Now is also a good time to talk about the energy in/out business if you're going to. Though for years 6 up really. Energy from electricity is used to split the O and H and is then stored in the O_2 and H_2 molecules. When they recombine the energy is released as heat. Cycling up a hill is the clear analogy, I always like pointing out that as you come down the hill you think that it's "speed for free" but it's not really, you're getting the payback for all the effort you put in cycling up the hill.

We then try some logic and I turn the power off and draw their attention to the bubbles at the top of the tubes. One is twice the size. Which one is the Hydrogen? Next explain how you're going to mix the gas and arrange your volunteers and check the trigger works.

As you mix the gases you can say, if we need 8 ml of hydrogen, how much oxygen do we need? Then we're pretty much onto the pop. Once that's gone grab the ball quick. With luck there should be some water on the bottom. Show them this, as this is your opportunity to hit home. "Can you see that? You've that made water!" Which is cool.

Parents and teenagers will be interested in the hydrogen cars angle. With this audience I probably would have started with the hydrogen cars. Anyway, you can be a bit environmental pointing out we have to use energy to make hydrogen, and it is only ever an energy store. you can also burn the hydrogen in an internal combustion engine (like at the top) or in the exact reverse of what happens on the electrodes at the bottom, to make electricity right out of the hydrogen and oxygen in a fuel cell, then driving a motor.

Electrolysis Risk Assessment

Last updated: 09/02/2017 - 14:15

DESCRIPTION	Separating Hydrogen and oxygen and then recombining them ignited by a spark to fire a ping pong ball into the air.
RISKS	1. Explosion in the electrolysis chamber 2. Explosion in the mixing chamber 3. Evolution of chlorine 4. Loud explosion - more of a problem for the demonstrator, because of the repeated nature 5. Being hit by ping pong ball 6. Increased hazard from mains electricity due to presence of high ionic strength solution
	1. Designed so any excess gas vents to the outside, so even if the power is left on there will be no major build up of gas. The chamber is made out of a tough plastic (PET) that won't shatter

ACTION TO BE TAKEN TO MINIMISE RISKS	There is a polycarbonate blast shield in case something does go wrong 2. The valve at the top of the mixing chamber is designed so it defaults to be open, so gas won't build up when you are not paying attention. The explosion is separated from this chamber by water so it shouldn't ignite The explosion occurs behind a blast shield 3. Use deionised water (chloride ions have been removed), and use $MgSO_4$ as an electrolyte as this will not decompose before the water. Experiment must only be set up by a demonstrator familiar with the apparatus and the solution required. 4. Ignition is by modified kitchen lighter. Is on the end of a long wire, allowing everyone to stand well clear of the explosion (energy dissipates as r^2). A sound muffler can be attached to the top of the column. 5. Make the explosion chamber quite high, so you can't look in the top. Ball is very light and would not hurt much. 6. Ensure that apparatus is secure before filling (also prevents risk of tower falling). Do not fill/top up apparatus whilst power unit is nearby. Keep power unit raised above level of base of apparatus See electrical parts RA
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Call first aider in event of injury 2. Call first aider in event of injury 3. Turn off power, remove any casualty from area, call first aider 4. Contact GP if there is a problem 5. Call first aider in event of injury 6. If solution splashes onto power supply turn off immediately at mains and close experiment. In case of injury call a first aider (and turn off power if safe to do so).

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 09/02/2017 - 14:59

Red cabbage

Chemistry: Making a natural pH indicator.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Red cabbage
Knife/grater/rolling pin or other masher
Large Bowl for grated cabbage
Cups
Vinegar
Bicarbonate
Water
Absorbent white paper

Explanation

*** OVERVIEW ***

Cabbage juice is used as a pH indicator to demonstrate the concept of pH. Paper stained with cabbage juice will change colors when dipped in an acid (vinegar) or base (bicarb).

Possible Activities:
1) Dip the paper (with cabbage juice as indicator) into the acid and base to show the kids how it changes color.

Other things to talk about:
1) What are other examples of acids/bases?
2) What is pH?
3) Why does the juice change color in acids/bases?

Tips for demonstrating: If the kids want to, let them take home the pH paper!

*** BASIC PROCEDURE AND EXPLANATION ***

Before Event:
1) Cut up half a head of red cabbage and grate it.
2) Crush it using a rolling pin. Strain the liquid into another beaker, and you should have a bluish/dark purple liquid – this is your basic universal indicator. When added to acids it should go pink, and in alkalis or bases it should go blue/green.

At Event:
3) If the cabbage still needs to be crushed/strained into a cup, ask the kids to help you.
4) Dip a piece of paper into the juice and explain that this juice will act as a pH indicator – in other words it will tell us whether something is acidic or basic.
5) Ask them if they know what pH is?
-tailor your explanation to the age of the child
-pH scale is a logarithmic scale defined by $pH = -log10[H+]$ – for older kids
-pH is a number that tells you how acidic or basic something is [neutral substances, such as water, have a pH of seven, acids (vinegar/lemon juice) have a pH of less than seven, and bases (sodium bicarbonate) have a pH of more than seven.]
6) Ask them if they can name some acids/bases. (Lemon juice, bicarb, vinegar, orange juice, etc)
7) Explain that the cabbage juice will turn blue/green when dipped in a base and pink when dipped in an acid
8) Show them your two “mystery” liquids (vinegar and bicarb/water) – ask them to use the indicator paper to determine which one is an acid/base.

*** OTHER THINGS TO TALK ABOUT ***
1) How can the cabbage juice act as an indicator?
-red cabbage contains coloured pigments called “anthocyanins” which have antioxidant properties
-in acidic conditions they lose an –OH group, and gain it in basic conditions
-most indicators gain an $H+$ in acidic conditions and lose in again in basic conditions
- This change in the physical structure will change the wavelength of light reflected off it, and so it changes colour
2) What would happen if we dipped the paper into water?
-Explain the concept of neutral substances.

Red cabbage Risk Assessment

Last updated: 09/02/2017 - 14:59

DESCRIPTION	Cut and grate red cabbage before the event. Then mash, eg. using a half rolling pin, to give pH indicator solution. Paint onto paper and observe colour change when lemon juice/vinegar or bicarb solution is added.
	1. Sharp knives and grater may cause cuts

RISKS	2. Lemon juice/vinegar and bicarbonate of soda irritant to eyes 3. Children eating/drinking bicarbonate, lemon juice or vinegar.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Only demonstrators to use knives or graters to cut cabbage. Knives and graters to be kept concealed and out of reach for the duration of the experiment 2. Only use small amounts. Do not squirt. 3. Don't leave children with experiment unsupervised.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Call first aider in case of injury 2. Wash with emergency eye wash provided if trained and confident to do so. Call first aider if necessary. 3. Advise parents that reactants are all edible, but to seek medical attention if child is feeling unwell as reactants may have been in box for unknown amount of time.

Last updated: 09/02/2017 - 14:17

Fire Extinguishers

Chemistry: Demonstrating the power of a carbon dioxide fire extinguisher.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

NB: this experiment does not have a box
Candle (Tea light)
Matches
Deep walled heat-proof container (e.g. ceramic mug)
Plastic beaker
Bicarbonate of soda
Vinegar
Cloth (useful to be able to wipe-up spillages)

Explanation

Setup note
This experiment will only work in very still conditions (somewhere not too draughty indoors) since if there is any wind the carbon dioxide will blow away rather than extinguishing the flame.

Experiment
Light a tea light (small candle in a metal holder).
Mix vinegar and bicarb in a film cannister.
Carefully, without spilling any of the liquid, pour the carbon dioxide over the candle. The flame should go out.

Explanation (NB, some kids will have seen the mini explosions experiment and so will have more idea what's going on than others)

Light the tealight.
- Discuss burning. What is needed for something to burn? Fire triangle- fuel, heat, oxygen.
How can we put out a fire?
(Kids may talk about fire extinguishers... if they do, can draw that into how different extinguishers work- CO_2, water, powder.)
Take away the fuel (like turning off a gas flame on a hob).
Take away the heat (cool things down, part of how water puts out fires... takes energy to heat the water so less is available to carry on the fire).
Take away oxygen (smothering the flame, what we're going to do here).

We're going to try putting out a fire by depriving it of oxygen using a gas called carbon dioxide which is heavier than air, and in which flames can't burn (used in fire extinguishers).
Make carbon dioxide by reacting vinegar (like on chips) with sodium bicarbonate/bicarbonate of soda/bicarb which they may have used for cooking.
Discuss where the CO_2 comes from (locked up in carbonate in solid, let out by vinegar or lemon juice (acids), or by heating as in cake baking). Reaction is: Acid + Carbonate -> Salt + Water + Carbon Dioxide

Pour CO2 over the flame... it should go out (will work better if candle has burnt down a bit in the holder, as it will hold some CO2). If it doesn't try again, you could discuss the effect of draughts on mixing oxygen back into the carbon dioxide.

Fire Extinguishers Risk Assessment

Last updated: 09/02/2017 - 14:17

DESCRIPTION	Vinegar and bicarb mixed and CO2 produced and used to put out a candle (tealight).
RISKS	1. Fire risk 2. Risk of burns 3. Vinegar could get into eyes * Irritant to eyes * Irritant in cuts
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Use a tealight rather than a more standard candle: short, stable candle contained within metal holder. Make sure tealight is on a ceramic plate or something that will not burn. Do not leave lit candle unattended. Keep tight control of matches. Ensure no flammable materials are near the lighted candle. Know where the nearest fire extiguisher is. 2. Don't let kids get hold of candle. 3. We have eyewash in the first aid box. The demonstrator must know where the eyewash is located.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. In case of fire follow local procedure. 2. In case of burn run affected area under cold water for at least ten minutes 3. Call first aider in case of injury

	Call first aider. Use eyewash to wash out of eyes if trained and confident to do so

Last updated: 09/02/2017 - 15:10

Thixotropic sand and fluidised bed

Chemistry: Looking at floating and sinking using a bed of sand

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Sand - about 2.5cm in a washing up bowl
fluidised Bed
reversible hoover - small variac
Fluidised bed sand (finer and more uniform than normal)
Things of a range of densities that can be floated/sunk in the dry sand, similar set to go in water/thixotropic sand.. wood, rocks
Dustpan and brush
Container of water

Explanation

Thixotropic sand

Just add water to sand until it is thixotropic - this is a bit more of a challenge than the cornflour, but if the surface is actually wet it normally works.

Get the kids to build a sandcastle, then shake the bucket and the sand should slowly liquefy

Explanation:
Because the sand is much heavier it squashes the water from between the grains just by its weight, so the only way you can get the lubrication back is to shake them apart so the water can get in between.

Uses:
The ground liquifying is a big problem during earthquakes, and can often cause more damage than the shaking itself, eg in a 1964 Niigata earthquake in Japan.

Fluidised bed:

Fill bed with sand, attach hoover in blow mode (attach pipe under cover in the middle). The hoover is a bit powerful, so it is a good idea to vent some of the air out the side to avoid blowing all the sand everywhere, we should have a device for doing this, but something may have to be manufactured using gaffer tape.

Get them to feel the sand without air, then get them to feel it as you turn the air on. It will suddenly feel light, will flow easily and almost behave like a liquid - you can float and sink things in it - you should be able to float things in it that won't float in water.

You can get the child to bury things that float in it, then blow air and they will float up, and vice versa

Explanation:
Basically the sand particles can't move past one another normally as they are touching, but if you blow sand between them the bounce around and can joggle past one another. You can look at it like a blown up model of a liquid with all the particles joggling around so it will flow.

Uses:
It is used to move things like flour around (which is why you can transport it in tankers.) Also as a way of doing reactions where you need a large surface area eg burning things well.

Fluidised beds are used for burning coal in power stations, as you get a really large surface area, and you can add Sulphur and Nitrogen Oxide scrubbers as lumps in the fluidised bed.

This also has a similarity to quicksand, if you have a (water) spring under sand, it can fluidise the sand which you can sink into (the water acts like the air in this demonstration). This is particularly dangerous in big sandy tidal flats, as when the tide comes up, you can get water trapped under an impermeable layer, and when you walk over the top you can release this, liquefying the sand you are standing on, which will then solidify again, leaving you stuck in the sand with the tide coming in!

Thixotropic sand and fluidised bed Risk Assessment

Last updated: 09/02/2017 - 15:10

DESCRIPTION	Blowing air through sand, making it flow like a fluid (and allowing more/less dense items to sink/float through it).
RISKS	1. Blowing sand into people's eyes/faces. 2. Sand on a hard, smooth surface can be a lubricant/trip hazard 3. Slip hazard if water is spilt

	4. CHaOS committee adding water to electronic components may cause a hazard 5. Wet Sand from fluidised bed getting transferred to childs hands then into eyes 6. Explosion due to pressure drop across container
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Set up carefully, using blower on low power, work out correct air flow rate for amount of sand used. Less sand needs lower flow, important to work out correct settings on set-up (without the public sticking their heads over the bed) and to make sure if anything changes (for example some of the sand is tipped out) 2. Use play-pit type sand (less dusty) 3. Sweep up any spilt sand/mop up any water immediately 4. Do not pour water into the electrical equipment 5. Ensure experiment is set up near sink to wash hands in afterwards, Demonstrator ensure children wash hands after demonstration 6. Check for cracks before use
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Call first aider in event of injury. If sand gets into eyes, discourage rubbing (sand may scratch), sterile eye wash should be used to flush it out 2&3. Call first aider in event of injury. 4. Unplug, disassemble and put on a radiator 5. If sand gets into eyes, discourage rubbing (sand may scratch), Call first aider. sterile eye wash should be used to flush it out, only administer if trained and confident. 6. Treat as 1.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 06/02/2017 - 20:51

Molecular models and Periodic table

Chemistry:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Periodic Table of elements
Molymod kits - general, graphite, diamond
Sample of Graphite (pencil lead), maybe some others

Explanation

Start of by discussing the periodic table, and how the valency of a compound can be determined from this.

Introduce Covalent, Ionic and metalic bonding. Using the diagrams provided in the kit. Also refer to the samples of each provided. i,e metals ductile as structure can rearrange and electron cloud can move with it. Whereas covalent bonding is directional so if broken snaps. Metals conduct electricity as deloacalised electrons in the sea of electrons. Ionic compounds form strongly bonded salts, can explain solvation and why they dissolve in solution.

Then introduce the diamond and graphite structures. Ask them what they know about diamond, most should know it is the hardest material on earth. Ask them from looking at the structures to say which they think it is and why. Explain that it clearly isn't the graphite as the layers easily slide over each other. Then introduce graphite as pencil lead, so say this is how it writes layers of graphite slide over each other some onto the paper. If people still follow talk explain that there is a free electron from each C between the layers. These are delocalised so can conduct electricity. Next take a piece of graphite and show that you can put charge through it.

Molecular models and Periodic table Risk Assessment

Last updated: 06/02/2017 - 20:51

DESCRIPTION	Use Molymods and periodic table, along with samples of materials to explain the properties of various materials.
RISKS	1) Choking on small parts 2) Electric charge through graphite
ACTION TO BE TAKEN TO MINIMISE RISKS	1) Watch carefully over children, use preassembled models so fewer small parts 2) Use small charge
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1) Encourage child to cough, call first aider

Last updated: 09/02/2017 - 14:13

Alloys

Chemistry:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Alloy Model
Cutlery, cheap stainless set more expensive stainless set
Magnet
Shape memory springs
Normal steel spring
Kettle or at least access to one
Glass mug
Other lumps of metal could be good needs more thought

Explanation

What is an alloy? A metallic, which is a metal mixed with something. More rigorously: A metallic solid or liquid that is composed of a homogeneous mixture of two or more metals, or of metals and nonmetal or metalloid elements, usually for the purpose of imparting or increasing specific characteristics or properties.

Say that you can tell how expensive someone's cutlery is from whether it is magnetic. Good stainless steel contains Cr and Ni, the Ni stabilizes austenite phase which is not magnetic. Bad stainless steel contains just Cr, this means the ferrite (magnetic) phase is stable and therefore cheap cutlery is magnetic. The proportions are usually 18:10, 18:8 or 18:0 Cr:Ni - the higher the Ni content the higher the quality. Show that the good John Lewis stainless steel is non-magnetic and the cheap Asda stainless steel is magnetic. The result of this means the Asda cutlery marks more easily.

(Look at other properties. Ask if they know the difference between hardness and toughness? Most won't, toughness is a measure of the amount of energy it can take before fracturing, whereas hardness is a measure of its how hard it is to permanently deform. Have two bits of metal, one martensite, one pearlite phase. Show that martensite can scratch the pearlite but not vice versa. Then try to bend the samples, can easily bend pearlite, martensite would just fracture.)

Care necessary here, if springs are stretched too far then they won't reversibly return to the correct length.

Finally, shape memory alloys. Allow them to slightly deform the normal and shape memory spring. Ask them what they think would happen if it was put in warm water. Put it in water straight out the kettle. One will return to original shape, normal spring won't. Explain that when load applied layers slide out, then when heated it shifts to the austenite phase before crinkling to matensite when cooled. See diagrams in box.

Alloys Risk Assessment

Last updated: 09/02/2017 - 14:13

DESCRIPTION	An experiment to demonstrate properties of alloys, and different effects alloying can have.
RISKS	1) Hot water, can scald 2) Stabbing self with cutlery 3) Skin getting caught between cutlery and magnet 4) Potential splinters from wood/sharp ends of wire in atomic structure model
ACTION TO BE TAKEN TO MINIMISE RISKS	1) Use only a little water at bottom of mug, heat only when needed 2) Use relatively blunt cutlery, no properly sharp knifes 3) Use weak magnet so won't cause harm if occurs 4) Atomic structure model has wood sanded/wire ends protected/ends not exposed
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1) Encourage to run scalded area under cold tap for at least 10 minutes. Call first aider. 2) Call first aider.

Water densities, food colour sugar water oil miscibility

Chemistry:

Read before you demonstrate

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Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Food coloring - range of colors
Sugar
Water
measuring cylinder or something equivalently long and thin
Vegetable oil
Other containers for mixing

For ice part
Plastic measuring cylinder
Dyed ice cubes
Castor oil

Explanation

Here's How:

(Line up five glasses. Add 1 tablespoon (15 g) of sugar to the first glass, 2 tablespoons (30 g) of sugar to the second glass, 3 tablespoons of sugar (45 g) to the third glass, and 4 tablespoons of sugar (60 g) to the fourth glass. The fifth glass remains empty.
Add 3 tablespoons (45 ml) of water to each of the first 4 glasses. Stir each solution. If the sugar does not dissolve in any of the four glasses, then add one more tablespoon (15 ml) of water to each of the four glasses.
Add 2-3 drops of red food colouring to the first glass, yellow food colouring to the second glass, green food colouring to the third glass, and blue food colouring to the fourth glass. Stir each solution.) - might want to prepare the solutions before, depends how long this actually takes. If making or replenishing solutions while demonstrating, you can get children to stir (watch they don't eat it!).
Now let's make a rainbow using the different density solutions. Fill the last glass about one-fourth full of the blue sugar solution.
Carefully layer some green sugar solution above the blue liquid. Do this by putting a spoon in the glass, just above the blue layer, and pouring the green solution slowly over the back of the spoon. If you do this right, you won't disturb the blue solution much at all. Add green solution until the glass is about half full.
Now layer the yellow solution above the green liquid, using the back of the spoon. Fill the glass to three-quarters full.
Finally, layer the red solution above the yellow liquid. Fill the glass the rest of the way.
The sugar solutions are miscible, or mixable, so the colours will bleed into each other and eventually mix.
If you stir the rainbow, what will happen? Because this density column is made with different concentrations of the same chemical (sugar or sucrose), stirring would mix the solution. It would not un-mix, like you would see with oil and water.

Do they know about dissolving things? Especially if making the solutions with them, you might want to talk about salt in the sea and sugar in tea - how you can no longer see the bits of sugar but it's still there, just broken into smaller bits and surrounded by the water.

Explain that dissolving more sugar in the water leads to it being more dense. Ask if they know what that means, more mass per amount of volume, could say that adding more sugar to the water makes it have more mass but doesn't change how much space it takes up. Makes sense that the lighter ones will sit on top of the heavier ones.

It might be beneficial to show what happens if you add a more dense solution on top of a less dense one to see what happens (they just mix)!

Now repeat with oil and water, try stirring and see them separate out after a while. (You don't need a lot of oil to see this). See if they have any idea why we cannot mix the water and oil, hopefully some will same something like this is because they are unmixable. From here it will probably depend on audience how much you can explain but should try to explain what makes them not miscible, ie that one is polar and that the other is none polar, these terms will need explaining. MODEL FOR THIS.

Ask them to tell you what they can tell about the oil because it sits on top of the water. Encourage them to think about the sugar and water earlier. Hopefully some should be able to tell you that it is less dense.

Other ideas:
A measuring cylinder filled half with castor oil, half with water, with blue ice cubes floating on the top. The ice melts and the blue water drifts down through the castor oil to sit on
the meniscus.

Tips:
Try to avoid using gel food coloring. It is difficult to mix the gels into the solution. Darker colours eg. black can also cause problems when they bleed into the other colours so you can't see the rainbow.

Water densities, food colour sugar water oil miscibility Risk Assessment

Last updated: 09/02/2017 - 15:11

DESCRIPTION	Mix waters of different sugar conc, and so density, with different food colourings in and show they sit on top of each other in density order. Show water and sugar solution don't go back if stirred whereas oil and water does separate. Watching coloured ice melt and sink through castor oil.
RISKS	1) Solutions getting in eyes 2) Drinking of solutions 3) Slip hazard from spillage 1) Children may try to eat ice cubes (choking hazard) or drink water/oil. 2) Water from experiment may come into contact with electrical parts.
ACTION TO BE TAKEN TO MINIMISE RISKS	1) pour solutions carefully 2) watch children carefully, don't allow them to do experiment unsupervised. 3) keep solutions in secure locations 1) Explain to children that they must not eat/drink anything used in any experiment. Watch small children, and don't let them handle the ice. 2) Set up experiment away from experiments using electrical parts. If any electrical parts are nearby, place them above the cylinder filled with water.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1) Call first aider in event of incident. Use eyewash to wash out of eyes if trained and confident to do so. 2) Advise them that the reactants are all edible but to seek medical attention if they start to feel very bad as experiment has been in cupboard for unknown amount of time. 3) Clean up any spillage straight away. Call first aider in event of injury. Call first aider in case of injury.

Last updated: 13/02/2017 - 01:08

Tendon Hammer

Medicine: Using a tendon hammer to show and explain some strange reflexes

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Tendon hammer

Explanation

ACTIVITIES
-try to demonstrate some common reflexes

THINGS TO TALK ABOUT:
- what is a reflex? (see below)
-why do we have reflexes (here you could talk about reflexes in general i.e. blinking) - reflexes are there to protect us
-Why would we want to test reflex action? By testing reflexes, doctors can find out if there is nerve damage etc.

TIPS FOR DEMONSTRATING:
It is often difficult to show the reflexes on the kid. A good idea is to try it out on yourself first. If all else fails, you could try to demonstrate some other reflexes; i.e. demonstrate blinking; demonstrate the pupil reflex (get one kid to close their eyes for a bit and then open them; does the pupil size change?)
- you can have one kid doing it whilst the others watch and then swap, so everyone gets to see them

BASIC PROCEDURE AND EXPLANATION:

- Getting the reflexes to work can often be tricky. Try to find them on yourself/one of the other demonstrators first. (Hitting a bit harder often also helps.)
- If in doubt, ask a committee medic to show you how to elicit different reflexes.

These are some of the reflexes you could try:

- Do they know where any of the reflexes are?
- Get them to relax and try to elicit the reflexes:

A Arm:
1. Biceps: put your thumb on distal bicep tendon and tap that.
2. Supinator: Put your finger their forearm (distal radius over the supinator muscle) and tap it.
3. Triceps: bend their arm and tap distal tricep tendon.
4. finger: Lay their fingers over your index finger and tap your index finger.

B Leg:
1. Knee: get them to cross their legs and tap the patella tendon.
2. Ankle: Sit them on high ledge (if you have one), dorsiflex the foot and tap the achilles tendon.
3. Babinski's: if they've got shoes that are easy to take off, run your finger up the lateral side of their sole.

Most of these won't work in kids, because they don't relax. You could try reinforcement.
i. Upper limbs: get them to grit their teeth.
ii. Lower limbs: Get them to clasp their fingers together and pull.
iii. NOTE: reinforcement only works for a very short period of time so you must do it at the same time as you bang the reflex.
d. If you can't get a reflex there's no point bashing away at the same limb, because your chance of getting decreases each time -; try the other limb.

EXPLAIN WHAT A REFLEX IS:

a. Start with nerves: wires that carry messages from body to brain (SENSORY) and brain to body (MOTOR). If the kids are small, you can say it's a bit like a telephone line - messages travel from one phone to another.

b. There are some things we need to do so quickly that we haven't got time to send messages to and from our brain.
- Can they think of any?
- Use the example of blinking when something goes near eye.
- We also have reflexes in our arms. What do we need those for?
- Ask them if they've ever touched anything that's very hot.
- We also need reflexes in our legs, why?
- Ever stepped on something sharp.
- So we have reflexes to protect us
- Balance?
- Posture - what keeps us upright? Lots of muscles! If we sway forwards some of our muscles pull us back without us having to think about it
- (Also note in both cases the reflexes stop the tendons being stretched too far)

OTHER THINGS TO TALK ABOUT:

This usually works better if the kids are a bit older:

- why does a doctor want to test your reflexes
-get them to think about nerve damage and how you could assess that
-usually asking is a good idea (i.e. can someone feel something, see if they can move their arm etc.)
-however, what do you do if someone can't talk and doesn't move (i.e. in an accident when someone is unconscious)
-can then test if reflexes still work (i.e. doctors have pocket lamps; they can test the pupil reflex in an unconscious patient)

Tendon Hammer Risk Assessment

Last updated: 13/02/2017 - 01:08

DESCRIPTION	Using a tendon hammer to show reflexes
RISKS	• One end of the hammer tapers to a point - risk of getting into eyes • Risk of bruising if used with excessive force
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children use tendom hammer without supervision, don't let them get boisterous and over-excited with the tendon hammer • Use medics who have been taught how to use the hammer, or someone who has been shown by a committee medic how to use the hammer. • Do not use tendon hammer with excessive force
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury

Ear model

Medicine: Anatomical model of the ear, with removable parts.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Anatomical model of an ear.
Water filled plastic tube to demonstrate the semicircular canal.

Explanation

ACTIVITIES- EAR MODEL:
-show the model; it's important to orientate them; i.e.the white bit is the skull; get them to think about that the majority of their own ear is actually inside the skull
-take model apart; look at/identify individual bits - what might they do?

ACTIVITIES- SEMICIRCULAR CANAL DEMONSTRATION
-point out semicircular canals on the anatomical model; show them the water filled circular tube and say that that's what they look like inside
-get them to spin the water filled tube- the pink bits move- so the fluid moves as well (for things to say please see below)
- what else is important for balance: get them to stand on one leg and let them close their eyes; is it easier or harder with their eyes closed? (for things to say please see below)

TIPS FOR DEMONSTRATING:
If the kids are a bit older, they will often know quite a bit about how hearing works. However, they often know very little about balance, so it's good to talk about that a little more.
If the kids are really interested and know a lot already, you could talk a bit about soundwaves.

BASIC PROCEDURE AND EXPLANATION:

EAR MODEL:

What ears are for?
- All our senses, ears, eyes etc there so we can get information from outside into our brains. In the case of ears we want to convert sound into something we understand, music, speech or whatever.

Sound:
- The outside bit of ear's a funny shape, helping it to collect sounds and tell us a bit about where they are coming from. Sound makes the air vibrate, different sounds make it vibrate different amounts. This causes our ear drum to vibrate.
-If you've got the direction-swapping device (ear defenders with crossed tubes and cones) to hand, you can use this to explain how we locate sounds according to which ear they arrive at.

Ear drum:
- Lots of kids have heard of this. I'm often asked about grommets (lots of kids have these): They are
small tubes that can be put through the eardrum to help drain fluid and allow air to circulate in the middle ear.

Bones in the ear:
- Inside the ear we have the smallest bones in our body. Think how much bigger this model is compared with our ears. The bones join the ear drum with the inside bit of our ear, they vibrate as well. They help make sure that as much of the energy from the sound outside gets passed into the inner bit of our ears as possible. There are also tiny muscles attaching to them that can help protect our ears against sounds that are too loud.

Inside the ear:
- This is really clever and quite complicated (!). Tiny little cells with hairs on can detect the vibrating. We have nerves taking messages from our ears to our brains to tell us about the type of sound we're hearing, they're a bit like electrical cables so these tiny cells convert the vibration into an electrical message.
- Compare ear model to skull to see where all this is going on.

What happens in people who are deaf?
- The message is lost somewhere along the way. Maybe the sound cant get to the eardrum because we have wax in our ears. We can get infections inside our ears behind our eardrums where the little bones are, if this gets filled with fluid the bones cant vibrate properly. Or the cells with hairs on or the nerves can be damaged so the message can't get from our ear to our brain.

BALANCE:

Do we use our ears for anything else?
- They help us to balance too, so even if we close our eyes we still have some idea of which way up we are. Get them to stand on one leg and close their eyes or something. What happens when they close their eyes? It's more difficult, so we need our eyes for balance, too.
- There are little tubes filled with liquid at different angles. When we move, the fluid moves (bit like a spirit level?!). We can sense the fluid moving-that's how our brain knows that we're moving - can then help us balance movements. What happens when we get dizzy? We spin around lots so the fluids move round the tubes (use model), when we stop the fluid keeps moving for a bit after. So our ears think we're still moving, our eyes say we've stopped and our brains get confused. Similar idea in car sickness - when you look down at a book, your eyes start to think you're not moving, but your ears still think you are, so brain get confused again.

OTHER THINGS TO TALK ABOUT:

Ever noticed ears going funny in tunnels/on aeroplanes?
- Get them to breathe out, and then swallow while pinching the nose shut and with the mouth closed. There's a tube between our ear and throat that is normally closed but is opened when we yawn or swallow. It helps us by equalising the pressue in the inner ear and in the outside world, because if the air pressure (or better explain pressure without saying the word somehow!) around us is different to inside our ears our eardrum gets pulled in or pushed out, and opening the tube equalises the pressure, allowing the eardrum to return to its normal position. This is why sucking sweets helps when you go up in aeroplanes - I think because the sucking and swallowing causes the tube to open so the pressure difference is equalised frequently and so your ears don't 'pop'.

What is sound?
Sound travels in waves. It's like when you throw a stone into a lake- waves travel from it. The stone is the sound (i.e. a word we say), and our words/music etc. can make waves in the air, just like the stone can make waves in water; the eardrum in our ear can then pick up the waves; our ear converts these waves into signals, they travel to the brain, the brain interprets them as words/music

Ear model Risk Assessment

Last updated: 10/02/2017 - 15:58

DESCRIPTION	Various medical models.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes • Note the functional ear model is only filled with a few mls of water and is not a risk if it bursts
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down or taped over to be as safe as possible
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Larynx model

Medicine: Functional model of the larynx

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Model of the larynx
Laminated endoscopy images of vocal cords and pathologies.
We also have a plastic medical model of the larynx, which can be used in conjunction with the functional model.

Explanation

ACTIVITIES:

- use the model to generate different pitches/ how do get low/ high tones (ensure the children are gentle with the model - they usually want to hit the pump as hard as possible to make a loud noise, but this will break it and you can't change the tone unless you press the pump gently).
- use the pictures to illustrate how the larynx works + things that can go wrong with it...
- get the kids to feel their own thyroid cartilage/hyoid bones (could show Adam’s apple if they are accompanied by an older male sibling/their fathers)

THINGS TO TALK ABOUT:

- What is the larynx? Where is it? What does it do?
- How do we generate high/ low pitch (use model)
- Things that can go wrong (cancer, polyps etc.)

BASIC PROCEDURE AND EXPLANATION:

What is the larynx/ voicebox and where is it?

- Get the kids orientated- let them feel their own thyroid cartilage + use the pictures- so the voicebox is the entry to the airways (You could also show them the Adam’s apple if they are accompanied by an older male sibling/ their father)
- What is it made off? Well, it’s hard when you feel it, so it’s made out of something similar to bone... Do they know anything besides bone that is hard? Cartilage...
- However, cartilage is not the only thing that makes up your voicebox- also contains muscles, membranes, mucous membranes... (For older kids, use the anatomical pictures to illustrate this, but don’t go into details...)
- So on top of the larynx sits the epiglottis- it acts like a “lid”, closes when you swallow to protect the airways – Why is this important? Ask them what happens when they eat and talk at the same time- you “mis-swallow” and have to cough - don’t want food to get into airways; vocal cords can also close to protect the airway
- So is the larynx always closed? No, of course not- it needs to be open so that the air can get into the lungs (that is why you have cartilage- it’s a strong material, it helps to keep the entry to the airways open!)

What are the vocal cords and how do they function?

- Use the model to generate different pitches (The kids should really enjoy this), try to get them to figure out what they have to do to get a higher or lower pitch (i.e. do the vocal cords get longer or shorter for higher pitches?)
- so this is how our vocal cords generate sounds- cartilage is moved by muscles (i.e you use your hands (“muscles”) to move the plastic bits (“cartilage”) to lengthen/ shorten the yellow balloon bits (“vocal cords”))
- What else do you need? Air!!!! This is what the pump is for! Show them that it does’nt work if you don’t use the pump
- So when we breath out, air travels from the lungs through the wind pipe and gets to the vocal cords- they can then vibrate and this generates sound
- Do we need anything else for speech? Talk about pharynx, tongues, mouth, teeth, lips, i.e. they all help to “shape sound”

OTHER THINGS TO TALK ABOUT:

- Things that can go wrong: use the pictures- can they find anything that looks funny? Talk about cancer, polyps. What causes them? Cigarette smoke!!! (Your larynx is pretty much the first thing that is exposed to cigarette smoke...)

Another approach:
I was running this model alongside the lung model, so after asking them why you need to breathe (it appears that quite a lot of the general public believe we can extract carbon dioxide from the atmosphere......) I then asked them to try to talk without breathing out, and used that to introduce the idea that breathing out enables us to talk. I got them to put their hands on their throats and hum, then asked if they could feel anything, and explained that the buzzing was their 'voice box' and vocal cords. I then showed them the model, using the lung model to orient it, and explained that in place of bits of balloon we have flaps of 'skin'/membrane in our throats, and that when we speak we force air up between them. I then let the kids play around making noises with the model, getting them to work out how to change the pitch/volume etc. Finally I tried to relate this to how we make sounds by asking them to talk to me without moving their lips or their tongue - the sounds they made were very similar to the 'honking' of the model, so I could explain that the actual sound and how high or low it is is produced by the 'voice box' , but to form words we use our mouth/teeth/tongue/lips/etc. The sound of the model is also quite similar to babies crying, which again is noise made without fine control of the mouth etc.

Larynx model Risk Assessment

Last updated: 13/02/2017 - 00:24

DESCRIPTION	Larynx models: standard medical model and additional functional model.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes • The functional larynx model has moving parts, in particular the narrower end of the air pump is a finger pinch hazard.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down to be as safe as reasonably possible • The sharp metal parts of the pump should be covered with tape. • Reduce the finger-pinch hazard by ensuring the pump is placed on a flat surface (table/floor) and only allowing children to press the pump gently with the hands. Ensure fingers are free from the narrow end of the pump and do not let children hold the pump with both hands.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Last updated: 12/02/2017 - 23:53

Jaw model and giant teeth

Medicine: Anatomical model of the half jaw, parts can be removed to show structure of the teeth.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Anatomical model of the half jaw and three giant teeth

Explanation

ACTIVITIES:
-show whole model- what do they think it is? Let them point to their own jaws
-take the model apart; any ideas what individual bits are?

OTHER THINGS TO TALK ABOUT:
-losing teeth; getting new ones (especially when the kids are at that age)
- teeth are different- why do you need different shaped teeth? If we've got the animal skulls out, you could get them to go and have a look at those afterwards and think about why different animals have differently-shaped teeth.
- toothache- look at nerves coming into teeth- that's how you can feel pain

TIPS FOR DEMONSTRATING:
-focus your explanation on the age of the audience; if you have 6/7 year olds that are just getting their adult teeth, talk about that; if you have teenagers, you could talk about braces etc.

BASIC PROCEDURE AND EXPLANATION:

- Compare model to skull so they know what they're looking at. How the jaw bone fits onto the skull so we can open and close it to speek, eat etc. Feel the joint on themselves putting their fingers on the sides of their head just in front of ear, moving their jaw around. Explain how it can slide forward so we can open our mouths further.

- Different types of teeth have different functions. Flat ones at the front for cutting things, pointy ones for tearing/ripping, flat big ones at the back for grinding. When do we get new teeth? baby ones, adult ones, wisdom teeth. Look how deep the teeth go into our gums, can see on skull xray too.

- See where the blood vessels and nerves go to teeth. Think about what nerves are doing, funny that they go to bones. When do we know about them being there...toothache. Why might we get it? Protection covering teeth damaged, sugar, bacteria and stuff.

OTHER THINGS TO TALK ABOUT:

- medical procedures on teeth: fillings, braces, dentures; the idea is to get them thinking about what could go wrong and how they would fix it if they were a dentist

Jaw model and giant teeth Risk Assessment

Last updated: 12/02/2017 - 23:53

DESCRIPTION	Various medical models.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down to be as safe as reasonably possible
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Heart Model

Medicine: Anatomical model of the heart to show how the heart works.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Anatomical model of the heart. Has removable bits to show the structure of the heart.

Explanation

ACTIVITIES:
-let the kids take the model apart and let them figure out how it all fits together

THINGS TO TALK ABOUT
-What is “circulation” and why do we need it (see below)
-Structure and function of the heart
-Things that can go wrong (valve defects, heart attack etc)

TIPS FOR DEMONSTRATING:
It is quite surprising how little most people know about circulation. It is therefore very important to find out how much the kid knows already and work from that. I have included a very basic script for explaining circulation below- you would obviously have to adapt that to the age of the kid and to what he/she knows already.

BASIC PROCEDURE AND EXPLANATION

A) BASIC CONCEPTS

Look at the whole model. Ask the kids what it is (heart) and what it is used for (they will usually say that it pumps blood). Now comes the tricky bit: Why does the heart pump blood? It is quite surprising that many kids (and parents) have no idea about why we might want to pump blood through our body. If this happens, here is an explanation you could use to explain the basics of circulation (I have used a very simple one that even young kids can understand- you would have to adapt that for older kids/parents):

- Our body is made out of loads of little building blocks called cells. Each cell is like a small factory and it needs two things
- get the kids to think about what these two things may be; i.e. why do we breathe (to get oxygen); why to we eat (to get food/nutrients)
-so the factories in our body need food and oxygen
-where do they get that from? Ask them where the food they eat goes (stomach); similarly, the air they breathe in goes to the lungs
-so if the food is in the stomach and the oxygen is in the lungs, how can it ever get to all the “factories” that make up the brain, your toes etc.
- you need something like a street- these “streets” are your blood vessels
-you also need something to transport the food and oxygen, i.e. a lorry –this “lorry” is the blood
-so our blood transports food and oxygen to all the cells in our body
-but there is a problem- blood is a liquid- ask them what happens when you pour water/get water from the tap (water always “goes down”- so if this happens to our blood as well, it would all end up in our toes).
- so you need something that makes the blood go to the cells in the brain as well; i.e. you need an engine to drive a lorry or in other words, you need the heart to pump the blood through your body

B) STRUCTURE OF THE HEART

Let them take the heart apart and get them to think about what the individual bits may be and what they might be used for. Here are some things you could point out:

-can they see the big blood vessels (“streets”) that come into and out of the heart; get them to think where they might come from and where they may go to; i.e. some go to/come from the lungs and others go to/come from the body (having explained circulation beforehand helps; i.e. the blood has to go to the lungs to pick up oxygen); let them guess which ones might be the vessels that go to the lungs and which ones are the ones that go to the body

- The heart has chambers –can they see them? How many are there?- how does the blood travel through the heart?

- do they think that the blood can go back to the chamber it just came from? No; point out valves; if the kids are older, get them to figure out why this “one way” system is important

- the heart is a muscle; it contracts, when it contracts, the chamber gets smaller, this squeezes the blood in that chamber into the next chamber/ into the body/ to the lungs; valves prevent backflow

C) OTHER THINGS TO TALK ABOUT

- Can they see the small blood vessels going into the heart itself (coronary arteries etc)? Why is this important? – the heart is a muscle, that has to work all the time for all your life- it needs a lot of food and oxygen, too!!! What do they think happens if you block one of these vessels?
Ischaemia, angina, heart attack (Parents are usually quite interested in this)

-What can you do when this happens? Open up vessels (stents), make vessels bigger (drugs; vasodilators); but most importantly, remove anything that can block those vessels- this is why a healthy diet, exercise and stopping smoking are so important!

-Other things that can go wrong: Valve defects, heart failure

-When the heart pumps, it makes a noise- this is what you can hear with a stethoscope; refer them to the stethoscope experiment

Heart Model Risk Assessment

Last updated: 11/02/2017 - 12:48

DESCRIPTION	Various medical models.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down to be as safe as reasonably possible
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Giant intestine model

Medicine: Functional model of the intestine

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Model of the intestine, which can be used to explain the digestive process to children.
May also include tube made from chopped-off tights and a smooth plastic ball.

Explanation

ACTIVITIES:

- show the model to kids, let them feel it and ask them to guess what they think it may be
- illustrate the length of the intestine: get a kid to stand up and use the model to illustrate how long the intestine actually is (you can hide it in the bag and give the child one end to gently pull out and walk across the room until the whole thing is stretched out, if there's enough space and the child is sensible about it) Get them to imagine that such a long tube is actually rolled up within the small space of their tummies...
- get them to feel the inside- there are ridges. You could use this to discuss surface area (i.e. “what would happen if all these ridges were smoothed out?”)
- Use the plastic ball as a bolus of food and squeeze it through the tights tube to describe peristalsis.

THINGS TO TALK ABOUT:

- basic theory of digestion, i.e.”what happens to the food once we’ve eaten it?”
- what you need to make digestion effective: surface area of the intestine; how to increase surface area (ridges, length of intestine- use model to demonstrate)
- Things that can go wrong: diarrhoea, constipation, etc.

TIPS FOR DEMONSTRATING:

The idea is to get the kids involved as much as possible. The best way to do this is by using the model as much as possible when you explain things. Let the kids play with it as well- and get them to figure out things for themselves.

BASIC PROCEDURE AND EXPLANATION:

What do we use our intestines for?

- Our body is made up of loads of small factories, called cells
- What do they think these factories need? – Food (That’s why we eat...)
- However, the food we eat is very big and these cells are really small (so small that you can’t usually see them with the naked eye!)- so the food needs to be broken down
- What do they think breaks down the food? Talk about teeth, stomach, also your intestine
- The pancreas secretes a special liquid that breaks down the food (If the kids are older, they will often have heard of enzymes, so you can expand on this point as much as you- and they - like...)
- So, once the food is broken down, how does it get to cells in the body? Via the blood (for young kids: the blood is a bit like a lorry- it can pick things up and bring them somewhere else)
- The intestine is the place where the food gets taken up into the blood (for older kids, talk about absorption etc.)
- How does food move through the intestine? Use the ball and tights tube to explain peristalsis - there are muscles in the intestine walls that contract to squeeze the food along (use your hands to represent the muscles)

What makes the intestine so good at what it does?

This point is all about absorption and how you can increase the latter by increasing the surface at which it can occur.

For young kids:

Get them to imagine how long the intestine is by using the model. Can they imagine that such a long tube is actually folded up within their tummies (see activities)? So there is a lot of space for the food to get into the blood...

For older kids:

Talk about the length of the intestine as before. Also get them to feel the ridges inside- what do they think would happen if they were all smoothed out? Just for reference, the surface area of the small intestine in an adult person is about 250 square meters – that’s about the same size as a tennis court! How can such a large area fit into our tummies- by folding it up (so all the ridges are folds of the intestinal wall...)

What happens to the food we don’t absorb?

It moves through the intestine and leaves our body as poo- small kids often find this strangely fascinating.

OTHER THINGS TO TALK ABOUT:

- There are two types of intestine (small and large)- they have different functions (parents may ask you about this.)
- Things that can go wrong: diarrhoea, constipation, malabsorption, inflammatory bowel disease etc... see below for ideas:

Diarrhoea – ask who knows what this is?! It's watery, frequent stool. Very important to kids in developing countries especially – losing so much water (and you can lose blood too – this is called dysentery, which happens with Shigella and Amboebiasis) can be fatal. With cholera you are losing so much water so quickly that it is pretty much literally a battle to give the patient enough water. Common agents – E. Coli 0157 (the E Coli K we have on display is entirely safe though), Salmonella. Both are bacteria. Protozoa (one-celled, primitive, parasites in this case) – eg. amoeba and giardia, are much commoner in the third world. Viruses can cause disease, most commonly in kids, rotavirus being a common one. Norwalk virus causes diarrhoea and vomiting on cruise ships, calling for impeccable hygiene standards.

Older kids might understand the principal of isotonic drinks for rehydration – the ions are needed because so many are being lost, and the water enter cells more quickly due to osmotic attraction and as some ion channels co-transport water. Explain that ions are chemicals like sodium, chlorine, and potassium, and that they spread themselves out in the body into all the cells, with water following them. Ask them if they think it's important that you keep your cellular ions at a constant level. Ions are lost into the intestine because inflammation at its mucosal surface makes it leaky.

Malabsorption – What if a surgeon cuts out half your small intestine because it got damaged in a skiing accident or whatever? Do you think your intestine will work as well? What do you think happens if your villi are destroyed? This is what happens in celiac disease – it is an inappropriate immune reaction to gluten in the diet. The patient (usually a child) becomes thin and malnourished, slows down their growth and can become deficient in micronutrients, eg. vitamins, which are usually absorben in the small intestine.

Villi are also destroyed in Inflammatory Bowel Disease (these diseases are Crohn's disease and Ulcerative Colitis). Ulcerative colitis tends to affect the large bowel almost exclusively, decreasing its ability to absorb water. Therefore someone with Ulcerative Colitis will get watery stools. The tissue gets so inflamed (or I guess you could say "attacked" to younger kids) that it bleeds, which can be noticed in stools. Crohn's can affect the small intestine and cause malabsorption of lots of nutrients, carbohydrates, and lipids.

We mentioned that the pancreas makes enzymes – I like to describe them as being like tiny scissors which chop up the smallest nutrients up into a form which they can just nicely be absorbed into villi. If someone's pancreas isn't working properly (eg. it gets clogged up in cystic fibrosis, or if they have a gallstone obstructing its outflow) they can't absorb a lot of things like lipids, proteins and fat-soluble vitamins (A, D, E, K).

Giant intestine model Risk Assessment

Last updated: 10/02/2017 - 16:03

DESCRIPTION	Giant Model of the Intestine
RISKS	• Risk of strangulation if model/tights tube is wrapped around neck. • Risk of tripping and falling if the child runs across the room to stretch the intestine out (especially if stopped suddenly by reaching the end of the intestine) or from using the model as a skipping rope • Risk of tripping on escaped plastic ball.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Supervise children carefully and do not allow them to wrap model around neck. • Supervise child carefully, only allow them to walk (not run) across the room and do not allow it at all if there is insufficient space or the room is busy. • Only have one ball out at a time and keep an eye on where it is. The ball is large enough not to be a choking hazard
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider.

Last updated: 10/02/2017 - 15:53

Exercise and Heart rate

Medicine: When you exercise your heart beats faster!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Stopwatch.
(When done on tour, this experiment is often integrated with the Stethoscopes experiment. The Stethoscope experiment requires stethoscopes and antibacterial wipes/disinfectant and tissue, and also lives in a small blue box, often with the stopwatches. If using the stethoscopes, ensure you read the separate risk assessment for Stethoscopes).

Explanation

Check for asthma. If child is asthmatic, check with parents about severity, and if the child can do five minutes of fairly heavy-impact exercise. If they can do it, ensure they have an inhaler, and ensure they don't push themselves too far.

Take child's pulse (radial side of forearm), and write it down.

Make child run on the spot 3 mins and then do starjumps for 3 mins or any other combination of the above.

Check pulse again.

There should be a difference. If not, it's an anomaly, and you can make them do the experiment again.

If you're doing this experiment by taking the radial pulse, you need to start by asking questions (like "Have you had your pulse taken before/seen it done on TV?" and "Why do doctors take your pulse?" to make sure they know that your pulse reflects your heart rate, and if they don't, make sure to explain it before carrying on!

So, why does your heart rate go up?

What is the heart for?
-They will usually say say pumping blood around the body/beating. My favourite question after this is "What is blood for?", to which the answer is always "It keeps you alive". You can then progress from here by asking why (which they often will not know, even in surprisingly old children), and then explaining why we need blood. I usually go along the lines of "What do we need to do to stay alive?", get them to work out that we need to breathe, eat and drink, then think about where air and food go into our bodies, and then how might we be able to transport these things from your lungs/stomach to wherever they're needed, like your muscles to jump around or your brain to think - and then you have ended up working out what blood does! (You can use the analogy of lots of lorries (blood cells) driving along roads (blood vessels) carrying cargo (oxygen/food). You can go further into the idea of cells needing energy from glucose and oxygen with older/interested kids.)

- With older/interested children you can then develop the idea by talking about the heart as a double pump and the pulmonary and systemic circulatory systems. This works well if you've got the heart model to hand (on tour), or if someone else has just explained the heart model to them!

-Then you can talk about how your muscles are more active when you're doing exercise so they need more 'fuel' (oxygen and glucose), therefore you need to get more blood to them in a shorter space of time, therefore the heart beats faster!

-You can also talk about breathing rate (are they panting?) and recovery times and fitness if you wish to. You need to breathe at a higher rate and more deeply to get more oxygen into your lungs, and then move it to the muscles more quickly, because they need more energy and so are using up oxygen faster.

(N.B. I find this experiment is quite useful with groups of lively children, as provided you can get them to be reasonably sensible and you have enough space, they can jump up and down until they're quite tired and then they will often sit down calmly and listen to the explanation afterwards!)

Exercise and Heart rate Risk Assessment

Last updated: 10/02/2017 - 15:53

DESCRIPTION	Heart rate before and after up to 6mins of exercise
RISKS	• 1. Asthma attack • 2. Child running into things/people • 3. Physical injury eg. falling
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Check child's asthma status with parent or with teacher (or with child itself if old enough) before doing experiment. Do not allow child to exercise if asthma is severe, and DO NOT ALLOW AN ASTHMATIC CHILD TO DO EXPERIMENT IF THEY DO NOT HAVE AN INHALER. • 2. Make sure exercise area is clear, use on-the-spot exercise e.g. star jumps if space is limited • 3. Demonstrator to ensure floor area is clear and dry. If area becomes wet, locate a mop and dry the area.
ACTION TO BE TAKEN IN THE EVENT OF AN	• 1. Sit child down, keep them calm, locate inhaler for child to self-administer. Call first aider. • 2. Call first aider in case of injury

ACCIDENT	• 3. Call first aider in case of injury

Last updated: 13/02/2017 - 00:57

Stethoscopes

Medicine: Using a stethoscope to listen to the heart and find out how it works.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Stethoscope.
Anti-bacterial wipes (or tissues and disinfectant).

Explanation

Using a stethoscope to listen to the heart and find out how it works
Use the 'heart rate and exercise' explanation too!

1. Do they know what it is?

2. Do they know what it's used for?
- Use it to listen to: Lungs, Heart, Bowel sounds, Bruits (noise due to turbulence in blood vessels for various reasons) in the following vessels:

1. Carotid
2. Femoral
3. Thyroid
4. Hepatic

3. What makes the sound?

Normal Lungs:
-Normally turbulent air going in and out of bronchi.
-Sounds different over bronchi/trachea and lung fields.
-Same noise, but in the lung fields it is heard through large amounts of other tissue and so is soften (I think it cuts out specific frequencies - high or low - but don't quote me on that).

Abnormal Lung (probably talk about Asthma as most kids now about it)

1) Bronchial breathing over lung fields.
Due to consolidation - solid debris in lungs with pneumonia- or fribrosis.
Means sound can't 'disperse' (I'm sure physicists would have better description).

2) Wheeze (can demonstrate this one).
Due to narrowing of the tubes.
Asthma wheeze, COPD gives polyphonic.
Tumour wheeze gives monophonic (because only blocks one tube).

b. Heart.
i. Have brief discussion about what heart does (see Heart Rate and Exercise or Heart Model explanations). Where is your heart? It is surprising how many children seem to think it's somewhere in their left shoulder!

ii. What makes noise in heart?
Valves - with older kids a discussion about why we have valves may be useful.

iii. Normal heart sounds.
- Lub-dub.

iv. Extra heart sounds:
Note, can have third and fourth heart sounds.
If you have both they make noise like train going over tracks - du-dub-du-dub.

v. Abnormal:
Due to turbulent flow through valves (make the noises).
Why do you get turbulent flow? - Valve doesn't fully open (stenosis) or Valve doesn't fully close (regurgitation)

Stethoscopes Risk Assessment

Last updated: 13/02/2017 - 00:57

DESCRIPTION	Using a stethoscope to listen to the heart

RISKS	• Transferring infection via ear pieces • Yanking of stethoscope causing injury • If using stethoscopes in Heart Rate and Exercise experiment, risk of injury from swinging stethoscope if child starts jumping/running whilst wearing it. • Wrapping stethoscope around their neck
ACTION TO BE TAKEN TO MINIMISE RISKS	• Wipe ear pieces with antiseptic wipes or tissues and disinfectant before use • Keep children under control, and if children are misbehaving, don't give them a stethoscope • Ensure stethoscopes are removed before doing exercise.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury

Last updated: 13/02/2017 - 00:36

Organ Vest

Medicine: A velcro apron with detachable 3D organs, to show what's inside your body.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Apron
Organs as listed below.

Explanation

This game can be tailored to the particular child, and depending on how old they are you can just either ask them to put the organs in the right place, or talk about each one in a little more detail.

I usually do the organs in the following order (getting more difficult as the game progresses) and talk about/ask the child what each one is for:

HEART

Ask them to look at the colour and guess what goes inside it.
Tell them that it acts as a pump, and is needed to push blood around the body.

Keen: could go into why blood is needed etc.)
Ultra keen, try and grab a spare stethoscope and find their their heart beat at the appropriate place.

LUNGS:

Talk about breathing; try and get them to link up lungs to the mouth with the trachea (NB trachea does not currently exist as a component of the vest, but you can talk about it anyway!). Interesting fact: If the inner surface of the lungs could be stretched out flat, they would occupy an area of around 80 to 100 square meters – about the size of half of a tennis court!

DIGESTIVE SYSTEM:
Try and get them to link it all up, and explain what it does in terms of breaking your food down into smaller bits so it can be used to re-build things inside your body. Also talk about what happens in the end, and try and get them to guess what it comes out as (usually good for getting a giggle, but be warned sometimes the kids come up with very rude words much to the embarrassment of everyone around...)

KIDNEYS/ BLADDER
Get them to link them up and talk about what happens when you drink too much water etc. Get them to try and guess what's in the bladder by its colour (also often gets another giggle).

LIVER:
Difficult one to explain. I usually go along the lines of its like a big factory in your body where things are broken down and important things like stuff in your blood is made.
Ultra Keen: talk about it also being needed to break things like poisons and alcohol, and try and mention what might happen to the liver for instance in alcohol poisoning.

INTERESTING FACTS / TIPS:

Small intestine is 7m long, but is coiled up to fit inside the body.
Furthermore, due to villi total surface area is 2000 square meters = half a football pitch.

By the time you turn 70, your heart will have beated two-and-a-half billion times (figuring on an average of 70 beats per minute.) = 175 million litres of blood = 50 olympic swimming pools!

Organ Vest Risk Assessment

Last updated: 13/02/2017 - 00:36

DESCRIPTION	Sticking 3D velcro organs onto an apron, to show what's inside the body
RISKS	• 1. Risk of grazing from the velcro • 2. Risk of small children tripping on apron whilst wearing
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Make sure organs are handled properly under supervision • 2. Do not allow children to run around while wearing vest.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury

Brain Model

Medicine: Anatomical model of the brain.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Brain Model

Explanation

Anatomical model of the brain split into several parts.
Shows the different parts of the brain

Take care with age of kids! If they've never heard of nerves... take it easy.
If they're the interested get them to ask you questions, its more fun for them...
DO NOT try and cover all of these or you'll only have the parents listening. If even them...

At the end get the kids to put it together again, amazingly they like it. When they get stuck ask them which bit does this? To see if they've remembered anything before telling them what bit they need to put in next.

This is the sort of things you could say/ might come up:

- Brain made up of nerves - what are nerves? E.g. say they're like telephone systems from the body to the brain and vice versa. (often they only mention pain etc so expand on that). Think about the spinal cord and what happens if it gets damaged. If you've used the tendon hammers remind them of that too.

- Cortex - really big, like newspaper scrunched up around an orange or something. Very big in humans. Bits to control movement, sensory, visual, etc. Get them to guess where senses are on the cortex by relation to the sensing organ, obviously they will get visual wrong because they won't know that nerves go from front to back of the cortex. Concept of controlling contralateral movement and sensory etc. Unfolded cortex is about 3 sheets of A4, think a lizard or something equally stupid is size of a postage stamp. Neocortex - another name to do with recent evolution.

Could mention prefrontal cortex and explain it using Phineas Gage -America 100 years ago, blowing up mines, accident with a metal pole shooting into his head embedded in his prefrontal. Perfectly normal after accident except before was nice and kind bloke, after was mean, nasty and became a criminal. Hence to do with personality.

Can talk about Wernicke's and Broca's areas - could talk about the English pilot who was gunned down sustaining damage to wernicke's area so that he couldn't understand the english doctors and nurses, leading him to believe he had been captured by the nazis.

Also could talk more about visual bits, different areas that are important for different things like seeing colour, motion, peoples faces etc. So what happens if these parts get damaged?

Corpus callosum - is it on the left, right or middle? what might it do then?

- Basal ganglia - they're to do with emotion and starting movements. Parkinson's. Could mention Muhammad Ali or Michael J Fox as examples. Ask them what problems they have. Explain by talking about how one bit increases movement and another dampens/decreases movement. In normal people it is balanced, in Parkinson's decreasing of movement is too strong hence shaking. Opposite is huntington's chorea. Also mention that if parkinson's patient was in burning house, he/she would be able to run out of it and if walking across a street and about to be run over would be able to jump out of the way because of brain finding an alternate pathway in an emergency, bypassing basal ganglia. Parents might ask about treatment, mention L-DOPA and also stem cells for dopamine receptors.

- Insula - pain perception (if they look interested in that sort of thing). Gating theory, i.e. can modulate pain signals released from nerves endings at the level of the brain through opiate nerves from insula that release morphine onto nerve endings. Example is when you play football and cut yourself but don't notice the pain till after the game is finished all due to attention being focused elsewhere on the game.

- Cerebellum - What does it look like (chewing gum, mint ice cream??)
Monitors all our movement and helps correct errors, balance (get them to think about how unstable we are because we stand on only 2 feet). Also movement memories - make it relevant to them e.g. what happens if you practice a sport or a musical instrument (you improve -right?), hand eye coordination when you play computer games or play tennis-don't have to look at your hands but you learn to control them.

Explain about cerebellar ataxia and overshooting and not being able to touch your nose with your finger when your eyes are closed. Get them to try - normal people can do it, but with a cerebellar injury, you can't touch end of your nose and will just poke yourself in the eye - gets a giggle. Cortex the area of tea towel, some cells surface area of a door (purkinje fibres)

- Hippocampus - makes new memories but not to do with storage - kids always ask where memories are stored - truthfully no one knows for sure but all over the place depending on what kind, eg. episodic, motor, semantic. Mention Dorrie from Finding Nemo, ask them to explain what is wrong with her and relate that to hippocampal damage. Also can mention HM and mirror drawing if you want/can remember.

- Pons, Medulla and Brain stem - things really essential for basic life that we don't have to think about like breathing, heart beating (a whole new can of worms I always find - could mention how the heart beats by itself but needs the brain to regulate speed), eye movements, chewing etc? So what happens if this bit gets damaged?

other FAQs!

- How does our brain work? (great...)

Having explained about how nerves help your brain to communicate with the rest of the body, explain that the brain itself is made up of lots of little ones all talking to each other. We get all this information in from our senses, then these little nerves have a good chat to each other, bit like what's happening when your computer makes a grrring noise (!), and then they make decisions about what we are going to do, and act on them by controlling our muscles to move us around/speak etc.

- How/why do we dream?

What is a dream? A dream includes any images, thoughts and emotions that are experienced during sleep. No one knows for certain why we dream. Some theories: 1) dreams help us process all the information we have enountered in the day 2) they are involved in how we form memories 3) that they represent your emotions 4) that they are pointless

- What are all the red bits?

On our model it shows the arteries etc. This can be a good talking point - why does our brain need blood? What happens if parts of it do not get blood any more (often they've heard of strokes etc. because of grandparents or something)?

Brain Model Risk Assessment

Last updated: 08/02/2017 - 22:29

DESCRIPTION	Various medical models.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes • Note the functional ear model is only filled with a few mls of water and is not a risk if it bursts
ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down to be as safe as reasonably possible
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Last updated: 10/02/2017 - 15:57

Eye Model

Medicine: Anatomical model of an eye with removable parts to show the structures inside.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Eye Model (of which there are two - use the big new shiny one on its own, the older grubbier one is useful in conjunction with eyeball dissection at CBS!)

Explanation

Kids often just enjoy taking the model apart and putting it back together. I often find it engages them more if you make it into a "jigsaw" game - but explain basic bits as they try and put it together.

- Ask them what eyes are for: they will say "seeing", but try and get them to think of it in terms of a light detector. Can use it to see: colour, brightness, outlines and movement. Get them to imagine how life would be without eyes. A way of getting info from outside into our brain.

- Ask if they recognise and can name any bits of the eye. Most of the time incorrectly say the clear plastic bit on the outside of the eye is the lens. It's the cornea, mention protection and also cataracts - they won't know the name but they will have seen old cats and dogs with cloudy eyes, or they may have grandparents with the condition.

- Pupil is actually hole (wow!) in middle of eye - lets in light. What happens to your pupil when you go into a dark room....some will answer correctly. Ask them why - because you want more light to reach retina. Can also relate this to doctor's shining lights in people's eyes to check pupil reflexes. Why get smaller in bright light? - to protect eye from damage.

- Iris, they dont normally know the name, but ask what its for and why it can be different colours.

- Lens - ask them what it looks like, some say glasses/contact lenses so this is a good start (although I've had sherbet flying saucers as one answer). Explain that lens bends picture so that it lands on back of eye. With long/short sighted people, the lens is too fat or thin so that picture lands infront or behind retina - that's why it's all blurry. When people get older, the lens gets less stretchy, and therefore they might need glasses when they maybe didn't before. Ask them how that is fixed and talk about needing another lens to correct it i.e. glasses.

- The light has to go through see-through stuff in the middle of your eyes (a bit like jelly). It see through because the light has to get to the back of our eye for us to see.

- Retina - could side track slightly into 'what are cells?' etc. Do all cells do the same thing? No - skin, heart etc do different things, and these cells are very special because they can tell us about the light in the world around us. If you fancy talk a bit about colour/ colour blindness. Get across the idea that in the most common sort of colour blind people its not that they can't see colour, just that they find it difficult to distinguish between colours (then could compare this to rarer sorts/cortical colourblindness).

-Compare the eye to a camera: "takes pictures of the surroundings" which are then sent to the brain by the optic nerve. Explain how it is your brain that works out exactly what you are seeing "e.g. duck or rabbit". Can get confused sometimes - optical illusion (there should be some sheets with optical illusions around which you can use to elaborate if you wish). Also that different parts do different things (like motion, colour, faces) - what would happen if these bits got damaged?
- Explain the brain also corrects for other problems - talk about and find blind-spot (there should be a test sheet). Sometimes hard to explain to younger kids.
- Most kids will talk about how the image is inverted and the brain flips it up the right way. But if they don't could put it in.

- Eye muscles and eye movements - get them to watch you keeping your head still but moving your eyes if theyre not convinced. Could talk about why you have two eyes e.g. to tell how far away things are. And differences between how a horse sees and how you see. You can also use this as an opportunity to talk about how nerves are 2 way - so theres the big one telling your brain about what your seeing, but your brain also needs to control how your eyes move with nerves too.

- Often they ask why we blink - so talk about tears and cleaning/protecting your eyes. Also can ask if theyve noticed getting a runny nose when they cry, thats because iof lots of extra tears going down your tear ducts into your nose.

- Mention blood vessels on surface of model, artery, vein and nerves.
- What is eye cavity made of..... surprising number of kids won't get this. And ask what the holes in the bone are for.....blood
- Ask them what the space behind the eyeball would normally be filled with in us. Say it's for protection and lead them on with hints to say fat. I normally do this by saying how some people have a lot of it around their tummies.

Eye Model Risk Assessment

Last updated: 10/02/2017 - 15:57

DESCRIPTION	Various medical models.
RISKS	• Small Parts, could be swallowed • If broken parts could be sharp • Some parts have fairly sharp points - risk to eyes

ACTION TO BE TAKEN TO MINIMISE RISKS	• Do not let children play with experiments unattended • Remove broken models • Sharp points filed down or taped over to be as safe as possible
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Advise parents to take child to A+E if an item is swallowed

Lung Model

Medicine: Working model of the lungs with diaphragm and rib cage.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Lung model
Standard CHaOS power pack plugged in to mains supply.

Explanation

A model of the lungs to show how the diaphragm and rib cage cause the lungs to inflate and deflate.

Explanation:

Begin with general concepts…

1. Ask what your lungs are for – answer is usually breathing
2. Get across the concept of 2 functions – getting the air into your lungs, then getting the oxygen from your lungs and into the blood – then say how the model show the first of those.

Then onto how the model works…

1. Get them to name the different parts of the model = ribcage and lungs
2. Get them to take a deep breath, and describe what's happening to their chest as they do it = getting bigger
3. Why is it getting bigger? This is where the confusion usually sets in, because a lot of kids think that the lungs fill up with air and push the chest out. So, need to say that the lungs are just bags, can't do anything on their own to get the air in
4. So, the chest is getting bigger because the ribs are moving up and outwards (moved by muscles)
5. Also, when you want to breathe in, you move the diaphragm, which is the big muscle underneath the ribcage – point it out on the model.
6. So what happens when we do these 2 things on the model – I usually pull the ribs up, and get them to pull the diaphragm down. What happens? Balloons (lungs) fill up with air, and all we've done is move the ribs and diaphragm.
7. Why do they fill up? When the ribs are moved up and out, and the diaphragm pulled down, do we have less or more space inside the chest = more space. When we have more space, something has to fill the space, but what? = Air, which comes into your mouth, down your throat, and into your lungs, makes them bigger, to fill up the extra space. (You can talk about pressure if they're old enough to understand, or if they've done the vacuums experiment!)
8. Then breathing out – ribs move down and inwards, and diaphragm moves back up – do it on the model – what happens? Balloons (lungs) get smaller, air is coming out of them. Why? Have made less space inside the chest, so no space for the air in the lungs, so air forced out of lungs.
9. So overall, breathing is all about changing how much space you have inside your chest.

General stuff:

– Point to parts on model and on yourself while talking.
– The annoying thing about this model is that it's very hard to keep the bags airtight. That's what the pump is there for, you shouldn't need it on all the time put probably in between explanations.

Additional stuff:

1. Gas exchange
- Why do we breathe? = to get air into our lungs. Why? What's in the air that we need? = oxygen
- Where does the oxygen need to go? = all over the body to all our cells. And why? = to make energy
- How does the oxygen get around the body? = travels in the blood (attached to red blood cells)
- So, the oxygen is in the air, and needs to get into the blood – how? = travels down tubes in the lungs to the edges of the lungs, into little sacks. (lung is big sack made up of lots of little sacks = alveoli). Next to the little sacks are blood vessels carrying blood. Oxygen travels from alveoli into the blood and gets carried away to the heart, which pumps the blood (and therefore the oxygen) around the body
- Also, in the alveoli, a gas comes out of the blood, a gas we don't need = CO2, which gets breathed out

2. If things go wrong
- PNEUMOTHORAX - When the lung is punctured (e.g. by broken ribs) so it can't take air in. Talk about how even if one lung is down, the other can still work.
- ASTHMA - Ask if they have it themselves or have friends who have it? The tubes get smaller, making it harder to breathe in and out. Show this by putting your hand over the top of the trachea and restricting the opening and asking them to breathe in. Could talk about how inhalers have medicine in that makes the muscle around the tubes relax, so they get bigger and more air can get in.
- HICCUPS - show that the diaphragm is right above your tummy. If you eat hot food too quickly sometimes it can irritate the diaphragm leading to involuntary contractions. Other times it can be spontaneous.

Lung Model Risk Assessment

Last updated: 13/02/2017 - 00:27

DESCRIPTION	Model of ribcage and lungs to show breathing
RISKS	• Splinters in edges of wooden frame • Electrical hazard from electric pump
ACTION TO BE TAKEN TO MINIMISE RISKS	• Discourage people from handling the wooden frame, look for any rough edges and apply sandpaper/tape as necessary • Pump is 12V so this is negligable Make sure power supply is PAT tested
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Switch off power to the pump • Call first aider in case of injury

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Skeleton and bones

Medicine: Meet Boris, the friendly CHaOS skeleton.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

- Full size articulated skeleton called Boris.
- Collection of individual bones
- Foetal skull to show differences to the adult skull
-Artificial hip replacement

Explanation

Working with the skeleton can be an art. I usually don't have a formal "speech" but have lots of little topics and let them mess around with the bones filling in as appropriate.

Some things to talk about:

- Fitting individual bones to where they are on skeleton. What is skeleton for?

1. Upright - Ask them to imagine what we would be like without a skeleton
2. Movement - muscles pulling on bones, joints
3. Protection - skull-brain, ribcage-heart and lungs, vertebral column-spinal cord

- Ask them to guess where certain bones go. Easy ones are skull, hand and foot. Harder ones are pelvis, spine, collar bone etc.

- Feeling bones on themselves - collarbone, kneecap, shoulder blade moving, jaw moving out

- Why we have 2 bones in forearm

- How many bones in fingers/hand/body. Often good to get them to guess how many bones there are in the hand and then explain why each finger has 3 bones etc

- Where are smallest and largest bones?

- If all else fails, get the little kids to make up the arm from the individual bones

SKULL:
-ask them obvious things like where the eyes are to get them orientated.
- Ask them why there are no ears or nose.
- Describe what the skull is for. I like to use the "helmet" protecting the squishy brain analogy.
- Explain how must have holes so all the nerves can reach the brain - like phone cables.
- show them some of the holes - optic chiasma, foramen magnum etc.
- talk about jaw and how it hinges.

FOETAL SKULL:

fetus = not fully formed - several bone plates coming
together. point to fontanelles.
- why? needs to be able to change shape - fit through birth canal
- small brain compared to adults thus need rapid growth in 1st year
- growth almost complete at about 6yrs (vs chimp = 3yr) - gives time for learning thus different capabilities of humans (intellect, sybolism, abstract thought, complex tool use, complex social behaviours etc)
- adults often ask about the 'squidgy bit' on their child's head when they were born - you could talk about the anterior fontanelle and how it can be used clinically to assess the level of hydration of the child.

JOINTS:

- explain how even without joints we couldn't move.
- different types of joints:
- Ball and Socket - get them to put one together (hip is best). Show how it allows movement in all directions. Get them to move their arms in all directions
- Hinge - get them to put one together (elbow is best). Ask them to move their elbows and knees. Point out how birds are weird as their knees bend the other way.

HIP REPLACEMENT
-This is one of my favourite bits to talk about!
-I usually start by getting them to guess what it is. Some will get it instantly, others will come up with odd suggestions ("A gun!"). You can tell the slower ones that it is used to replace a part of the body and get them to look at the skeleton and see if they can think where it might fit. Let them hold it and move it around at different angles etc. If all else fails I usually hold up a spare femur and the hip replacement next to each other in front of me until someone realises!
-Talk about why you might need to have a hip replaced - arthritis, fractured neck of femur results in death of the head of the femur due to the poor blood

supply so it must be replaced as it will not heal (many of them will know of people like grandparents who have had such replacements).
-They often ask about why the ball is so much smaller than the head of the femur, explain that we've only got half of it and there would be a replacement socket too (if you've talked about arthritis in the reasons for needing a replacement you could get them to think that you need to replace both damaged surfaces with new smooth ones).
-Then I often start pretending to be a materials scientist and briefly get them to think about what properties you'd want a replacement joint to have - e.g. ask them why it isn't made out of wood! Get them to work out that it needs to be strong, light, non-toxic and unreactive (not go rusty!). I assume ours is made out of titanium, newer and more expensive ones I believe are made from titanium (the head) and then some sort of ceramic which is much lighter. If they want more details about materials I tend to then have to send them off to ask a physicist/real materials scientist!

Skeleton and bones Risk Assessment

Last updated: 13/02/2017 - 00:29

DESCRIPTION	Full size skeleton, individual bones and foetal skull, artificial hip joint.
RISKS	• Poking injury from protruding parts. • Finger trap between bones (e.g. ribs, and joints). • Skeleton can be unstable. • Hip joint is heavy and could cause damage if used as a weapon. • People may not like psychological aspect of this experiment. Could feel faint/faint.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Make sure children do not go too near protruding parts; use tape to cover up the more dangerous parts of the skeleton. • Make sure children do not put fingers between bones, and ensure that skeleton is in a stable position when they do touch it. • Keep a careful eye on the skeleton, and stay near it to be in a position where you can stop it from falling on anyone. Do not leave the experiment unsupervised. Consider tying skeleton to a chair if demonstrator is not able to be close to the skeleton throughout. • Do not let children hold the hip joint if you do not trust the group to be sensible. • Be aware that a small percentage of people may feel uneasy or unwell when talking about skeleton and organs. Stop if someone looks unwell/ goes pale.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury.

X Rays

Medicine: A collection of x-rays and other forms of medical diagnostic imagery.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

X-ray light box.
Collection of X-rays and MRIs.
Kettle lead with 'right-angled' end that fits.

Explanation

- General - What is it? Do they know when are they taken (when someone might have a fracture) and where? Asking whether they know anyone who's had one or had a plaster cast can be a good way to get their attention/persuade them that you are not a child-eating ogre.

How do x-rays work? you can talk about the production of X rays to older kids - it involves very high voltages across metal releasing photons which travel along and get stopped by things which are dense and/or which have high molecular mass (this is why calcium shows up, and explains blood being somewhat radioopaque because of its iron content - you can see blood in the heart, and you can also visualise it on CT scans, which are just X rays taken at loads of different levels and cunningly put together).

Smaller kids will appreciate something a bit like light which can go through softer things eg. skin but not harder things eg bone, metal implants. Of course then explaining a barium enema can be tricky, but you could describe it as "special liquid which can be seen on X rays".

- Ask lots of questions, get them to work out what everything is for themselves (our skeleton can help with this). If they're young it will probably take them half an hour to work out what they're looking at.

- Legs - which way up? Broken bones - Why do the kids think we take different views?-, kneecap, hip joint, bone growth can be discussed if they look clever, with the views we have of immature bones, which are still cartilagenous at the epiphyseal growth plates.

- Chest - heart, lungs, diaphragm, collarbone, ribs

- Putting stuff into body to see on x-rays -intestines, arteriograms (not everything in your body is a vein…), why have arteries

- Skull-compare with skeleton, what you can see, eyes, nose, mouth, teeth, sinuses

- pathological X-rays are great, especially to talk about hip replacements and whatever fun pathologies there are!

Basically, you can go through the x-rays however you like and develop your own spiel, but as it's one of my favourites I thought I'd write down roughly what I do!

-Start with talking about why you might have an x-ray.
-Ask them how x-rays are made. I talk about a 'special kind of light' (if they're older, you can start talking about the electromagnetic spectrum, especially if they've had a look at our UV and IR experiments) that can go through soft bits of the body but not hard bits like bone.
I get them to tell me what they would see behind me if I stood with a big light in front of me and a wall behind (my shadow). So then what would you see if they shone x-rays at me instead (a shadow of just my bones - you can talk about x-ray film here too if you like).
-What are bones for? (support, locomotion, protection - see Skeleton explanation)
-Skull x-ray - why do we have big spaces in our skull? (decrease weight)
- why do some of the teeth look different? (fillings - can talk about x-rays not passing through metal)
-Chest x-ray - identify the bones (ribs, clavicles, spine)
- identify the organs (big spaces are air-filled lungs, the thing in the middle is the heart - they're always amazed by how low and central it is)
- but I said x-rays go through soft bits? What is the heart made of? How can we see it on the x-ray? Actually, x-rays can't go through metal. Do bones have metal in them? (calcium - they usually know this or will get it with prompts about why you should drink milk to keep your bones strong) What is the heart full of? (blood) Does blood have metal in it then? (iron - they may not know this. If you like you can then talk about iron and haemoglobin and red blood cells - there are lots of tangents to go off in on this experiment, depending on what they're interested in!)
-Hand and foot x-rays - did they know they have so many bones in their foot? Compare their hands to Boris if he's nearby.
-Arm angiogram - two things you can do with this: talk about the angiogram and contrast medium etc. If doing this, compare with the barium enema. Alternatively, this radiograph is clearly of a young child - large spaces between metacarpals/phalanges, few carpals visible. Can compare to adult hand x-ray and talk about calcification, can even relate to foetal skull, especially if the model is within reach. There is a radiograph of the pelvis which is also of a

child, the growth plates in the femur are clearly visible so you can compare them and talk about how space between the bones is needed for growth and you can judge the age/developmental level of a child from an x-ray.
-Pelvis - see above for growth plates. Yes, it is male (always gets some giggles if they spot the shadows!)
-Double contrast barium enema - I usually describe this as a late stage barium meal - cheating I know, but no-one's picked me up on it yet! Compare with the angiogram and talk about how we can use contrast media to see things otherwise not visible on x-rays.
-Endoscopic Retrograde Cholangio Pancreaticogram (ERCP) - at least I think that's what it is. To be honest I usually hide it. If you are capable of explaining it in a manner comprehensible to small children, please let me know and update this explanation!
-Humerus with screws - get them to work out what the screws are, talk about how some breaks are so bad/misaligned that pins and screws are needed to realign the bones.

MRI images
-First point - these images were donated by a committee member, so they are not anonymised as all the radiographs (which are teaching images) are. This is fine - you just might need to know as we have in the past had members of the public tell us off for using identifiable images, but it's ok as we do have full permission!
-I usually only go on to these with older/interested kids.
-Start by asking if the images look different to the radiographs. Ask if they've heard of MRI scans/seen people on TV going into those big scanning machines. Get them to work out what part of the body you're looking at, and that it's like you've sliced across the spine in two different directions. Point out that you can see soft tissues. Talk about why this might be more useful than an x-ray (you can see more than just the bone in fine detail!)
-My explanation of MRI is a bit rough: the machine contains an extremely strong magnet. This makes all the water molecules in your body line up in the same direction like lots of little magnets (they may have played with compasses in magnetic fields at school). The machine then fires radio waves at the body. This knocks all the little spinning water molecules slightly out of line, but a different amount out of line depending on the environment of the molecule (i.e. where it is). When the radio wave is turned off, the molecules all flick back to where they were in the magnetic field, releasing energy. This energy release is captured by sensors and turned into an image.

List of Radiographs (correct as of December 2015):
Blue Sticker (Animal)
1. Puppy Angiograms x 2 (lateral and dorso-ventral views)
2. Dog Angiogram
3. Cat Barium Contrast study- shows the presence of megaoesophagus
4. Arteries of the head (dog and sheep)
5. Lamb foetal skeleton (premature)
6. Bird skull
7. Dog pelvis- shows a left hip luxation
8. Dog intestines
9. Cat Barium Study of Gastrointestinal Tract

Green Sticker (Human):
1. Gastrointestinal Tract- gas/barium
2. Gastrointestinal Tract
3. Chest
4. Hands
5. Pinned Femur
6. Dislocated Shoulder
7. MRI Scan x 3?
8. Dislocated Elbow (Look at displacement of the radius)
9. Left foot
10. Unknown
11. Pelvic Fracture
12. Knee- displaced patella
13. Forearm
14. Skull 2 views- radiodense (bright white) tooth = filling
15: Dislocated Elbow
16: Angiogram Lung

X Rays Risk Assessment

Last updated: 13/02/2017 - 00:35

DESCRIPTION	Looking at x-rays
RISKS	• Electrical hazard from light box • Flicker from the fluorescent tube in the light box has the potential to induce seizures in individuals with photosensitive epilepsy - this is very unlikely but has happened once!
ACTION TO BE TAKEN TO MINIMISE RISKS	• See electrical parts RA (attached) • Discourage people from staring too closely at the light box for prolonged periods, if they complain of feeling unwell switch the box off and advise them not to look at it further.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Switch off the power to the light box • Call first aider in case of injury

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or

ACTION TO BE TAKEN TO MINIMISE RISKS	that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 10/02/2017 - 16:06

Hand Model

Medicine: Large working model of a hand and forearm, with all the tendons to show how a hand works.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Working hand model ("Emily").
Short lengths of string (optional)

Explanation

This experiment is a bit of a crowd-pleaser. There is a subtle technique of keeping kids' fingers out of the wooden joints, and after this has been achieved, all ages will be amused by playing with it.

Explanation

1. Guess what the model is of – nice and easy start!
2. Ask what do the pieces of wood represent = bones, and where in the body they are.
3. Talk about moving your fingers, and ask what in the body moves them = muscles (after several shouts of veins, ARGH!!), then where are the muscles that move your fingers = forearm not in the hand, and the fact the muscle belly mostly ends quite before the wrist. You can get them to wiggle their fingers and see if you can see the muscles moving in the forearm, but not above the elbow (this is often more visible on demonstrator/parent than child!)
4. Leads onto the fact that muscles are in forearm, but need to join onto fingers in order to move them – how? Gives off strings that run along fingers and attaches to the bones (show on model) – what are the strings called? = tendons (after more shouts of veins!!). So, to move, muscles contract (tighten up/become shorter), and pull the tendons, which pull the bones.
5. Then let them play around a bit – I usually get them to pick a blue string (but avoid thumb for now), and then a white string, and see the difference between them. Blue string goes all the way to the end bone, so can bend the end joint, whereas white string can't because it doesn't attach to the end bone.
6. Get them to bend all the fingers (tests if they've remembered which strings bend the fingers)
7. Then ask how to make the fingers straight again. Most will try to push the blue/white strings – tell them that doesn't work because muscles can only pull. Get them to look at fingers closely and spot any other strings. Eventually they'll realise to pull the yellow/purple string
8. Ask them why yellow/purple strings makes the fingers straight. If they struggle, get them to see the difference between blue/white and yellow+purple = different sides of the hand. Therefore muscles on front of arm (flexors) pull blue/white tendons on that side, which flex the joints, and vice versa with other side with the extensors.
9. So, all around the body, muscles work in pairs to do opposite actions. Point out biceps on you and say it bends the elbow, then ask where the muscle will be to make it straight = on the other side, triceps.
10. Then ask what's telling the muscles to contract and pull the tendons = brain. And how = send messages = nerves, and briefly explain concept of nerves sending messages
11. I usually end by saying that to play the piano for example, or type on a keyboard, your fingers have got to move in lots of different ways, so your brain has got to send all those messages in the right order to the right muscles, to pull on the right tendons. So, it's actually really complicated just to move your fingers.

Thumbs

The pink string pulls the thumb across the palm. You can use this to talk about how thumbs can move in an additional special way so you can pinch things - show them how you can oppose the pads of your thumb and fingers, but not of your fingers. They may have heard of opposable thumbs - some will tell you the word, others will recognise it. You can talk about different animals not having opposable thumbs and thus not being able to use tools etc.

If you've got the short (c. 6 inches) lengths of cord, you can challenge them to tie a simple knot in one. When they triumphantly present you with the resultant knot, get them to do it again without using their thumbs (police this vigilantly, people cheat without even noticing!). Usually this is much much harder. If somehow they do it easily, tell them to undo it without their thumbs. This is more challenging!

General stuff

– Useful to refer to your own or their hand while describing stuff, for example show the extensor tendons on the back of your hand (they're a lot easier to see in adults than on themselves). Get them to feel the muscles working on themselves or on you. Do this by getting them to place their whole hand over their arm (both sides!) and then wiggling their fingers! Then they have to believe you!
- This can be a good experiment to do with really quite small kids, but keep it nice and simple with them (i.e. I wouldn't bother talking about tendons, just say 'stringy like things that pull on our bones to make them move'!)

Additional stuff:

1. Carpal tunnel syndrome:
- Carpal ligament bridges wrist bones, making a small tunnel for nerves and tendons to go through.
- Median nerve goes through – sensation to most of hand (not little finger), and muscle control of some thumb muscles.
- Compression of tunnel walls (due to repeated wrist movements) or swelling (due to injury/arthritis), causes pressure on median nerve
- Symptoms – aches, pins+needles, pain, numbness, loss of fine finger movements e.g. writing.
- Treatment - stretching exercises, anti-inflammatory drugs, surgery (cut carpal ligament = relieve pressure)

2. Difference between ligaments and tendons
- Explain that a joint is where 2 bones come together and they can move. But the bones need something to hold them in place, this is what ligaments do, connect bones to other bones. Tendons connect muscles to bones so they can move the joints.

Hand Model Risk Assessment

Last updated: 10/02/2017 - 16:06

DESCRIPTION	Wooden Hand model
RISKS	Finger trap Wooden corners - injury risk Heavy model which moves easily when strings are pulled
ACTION TO BE TAKEN TO MINIMISE RISKS	Do not allow the kids to touch the hand itself when someone is pulling the tendons Hand is sanded and shaped to try to reduce this. Do not let the people pulling the tendons get too violent. Hold on to the model to prevent it from sliding along the desk, or place it on the floor if possible. Ensure kids are behaving sensibly
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in event of injury

Last updated: 08/02/2017 - 21:42

Articulated Knee Model

Medicine: A spare plastic skeleton leg, now with added ligaments.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Plastic skeleton leg with rubber ligaments.

Explanation

-See the Skeletons explanation for things to discuss about bones - e.g. why they are needed (support, movement, protection).

Ideas for What to Do:
-As always, first get the kids to tell you what it's a model of (the leg) and work out what the joints are etc.
-Talk about bones and skeletons (see above).
-Perhaps start with looking at the ankle (or even another spare bit of skeleton) and ask the kids what's different about this model compared to their real leg (there are lots of bits missing - you are not held together with screws!)
-Ask them if they know what holds the bones together in the body (ligaments - could compare these to tendons holding muscle and bone together if they've had a look at the giant hand model). Ask them if they have heard about ligaments before (they may have heard of injuries to cruciate ligaments etc, common injury to occur to footballers)
-The model shows the patellar ligament, anterior and posterior cruciates and medial and lateral collateral ligaments. It also has the quadriceps tendon, which is not attached at the proximal end because it's a tendon not a ligament and attaches to the quadriceps muscle. You could perhaps flex the knee and get the kid to 'be' the quadriceps, pulling on the tendon to straighten the leg. You could talk about the location of the patella (kneecap) and how it is a vital component in how the knee works mechanically.
-Cruciate ligaments - could talk about how 'cruciate' means 'crossed', let them look at how the ligaments cross within the joint. They may well have heard of these being injured in skiing or something. My first year anatomy notes tell me the following: Anterior cruciate - limits anterior draw of tibia on femur, tight in extension, tested by pulling the tibia forwards. You could perhaps show how, if it was ruptured, the tibia would move excessively far forwards. Posterior cruciate - limits anterior slide of femur on tibia, tested by pushing tibia backwards, used on hills and stairs (so if you've ruptured it, you cannot walk down stairs as the femur will slide too far forwards on the tibia).
-You could also talk about what else is missing from the model - evidently there are lots more tendons and muscle attachments, and also the medial and lateral menisci helping to shape the articulating surfaces (again they may have heard of these in the context of sporting injuries).

Articulated Knee Model Risk Assessment

Last updated: 08/02/2017 - 21:42

DESCRIPTION	Leg from full-size plastic skeleton, with added rubber ligaments in the knee joint.
RISKS	• Poking injury from protruding parts. • Finger trap between bones (e.g. joints). • Leg is surprisingly heavy and could cause injury.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Make sure children do not go too near protruding parts; use tape to cover up the more dangerous parts of the skeleton. • Make sure children do not put fingers between bones, and ensure that leg is in a stable position when they do touch it. • Do not leave the leg where it may fall on someone.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury.

Ear switching hat

Medicine: This magical hat will confuse your senses!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

One piece hat, please pack with care!

Explanation

The hat switches sounds from the left hand side to the right ear and vice versa. This leads to a couple of cool effects and is great as a way of attracting people who would otherwise pass by without stopping.

What to do (1):

Put the hat on a child or other volunteer - if they are very small you might have to get them to hold the ear defenders on.
Fairly quickly get them to shut their eyes, then go to one side or another and ask them to 'point where it sounds like I am standing' (these words partially get around the effect of the cunning kid who catches on very quickly and consciously changes where they are pointing).

You have two main ways of telling which direction a sound is coming from, volume and time delay. Which one you use depends on the frequency of the sound. Below 80Hz there isn't really an effective method; between 80Hz and 800Hz humans use the phase difference between their ears to determine location; between 800Hz and 1600Hz we're again a little lost but above 1600Hz we start using volume to locate the source of the sound. What about telling the difference between in front, behind or above us? That's the shape of our ears and heads that make sounds slightly different if they come from a different one of those positions. It's not perfect though, and a new noise in front of us sometimes sounds like it's behind.

What to do (2):

Put the hat on a volunteer (as before). Instead of getting them to close their eyes, get them to look (with their eyes only) to one side (right for the sake of description, although this works the same reversed). Stand more two people one either side of the volunteer. The person on the volunteer's right (who they are looking at with their eyes whilst keeping their head pointing forwards) mouths a simple sentence (for example: "My name is ...". They do this when counted in by the person on the left, who speaks the same words. For maximum effect, choose people with different voices/accents/genders and hopefully the person on the right will sound like they are speaking with the person on the left's voice. Maybe practice with some other demonstrators beforehand.

More information:

The brain integrates a range stimuli from the environment to help ascertain one's relationship to these. Particularly important is the processing of auditory cues - hence the vast majority of animals employ a 'two detector', i.e. two ear, system to pick these up. By comparing the input from one ear with that on the other side, special centres in the brainstem figure out the 3D origin of a sound wave - at its most simple level by comparing the intensity (volume) of the input to each side and the delay from one side to the other, but also by the more complex changes in pitch (frequency) that occur due to a 'acoustic shadowing' effect (different frequencies are affected differently by passing through your head) that the head getting in the way of a sound wave has!

The importance of this is huge - as predators this may help us to hone in our prey, rustling in the undergrowth, or in the converse situation, helping us figure out how to avoid being someone's next meal! This is evident in how most predators typically have relatively small external ear parts compared with many more 'docile' creatures with very large external ears (pinnae) that in many cases (such as rabbits and hares) can even be directed (kids might then ask about elephants - their ears are large for a very different reason, for cooling, much as the 'sail' of some dinosaurs is speculated to be) to help them localise sounds better (and I can't begin to imagine how complex the neural network integrating ear position with auditory input must be.)

In theory, if someone wears the hat for long enough, processes of synaptic plasticity will take place in the brain re-mapping inputs so someone can adapt to respond to sound cues in the correct direction. But even in the short term people can get used to the switched inputs and respond appropriately, much like an experiment that involved volunteers wearing prism glasses that inverted their environment - they were asked to throw a basketball into a net, which initially was impossible for most, but over time, presumably through cerebellar motor learning they adapted to their new state and were able to function perfectly normally despite seeing everything upside down! (intriguingly, when the prism glasses were removed, although it still took them time to adapt back to 'normal' again, it took less time than it did to learn when they tried the glasses for the first time).

So in people who have reduced hearing on one side, it's often still possible for them to discriminate whether sounds are coming from one side or the other due to these plastic changes, although it may not be as accurate.

Hearing is even all the more clever when you take into account how the hair cells of the cochlea can 'tune in' to certain frequencies and desensitise to others. Insect hearing is rather different to the above but (I think!) a basic intensity compatator is still employed, together with other clever mechanisms to distinguish externally-produced sounds from internal ones via a mechanism of 'corollary discharge'.

Ear switching hat Risk Assessment

Last updated: 10/02/2017 - 10:09

Do not shout loudly into each ear - risk of hearing damage.
Be aware of mild disorientation just after using the hat - risk of falling. Tell child to sit down if they feel disorientated/dizzy.

Tubing may get caught on subject.
Potential risk of transfer of hair infestation e.g. headlice between subjects, visibly inspect hat between use.
Call first aider in event of injury.

Prism Goggles

Medicine: Demonstrate how the brain adapts to changes in environmental input using prism goggles.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Prism goggles (currently on loan from Steve Edgely, Dept of PDN
Small objects to aim at box (e.g. beanbags)
Box (e.g. small blue experiment box, bigger one if working with younger children!)

Explanation

Interim explanation copied from http://www.umich.edu/~nkids/Neurokids_Program/Lessons_files/NeuroKids-Pr...

INTRO/BACKGROUND: The following is an example of what the leader might say during the introduction, including some specific questions to keep the kids engaged. It does not need to be repeated verbatim, and probably will contain more information that is necessary to explain.
Can anyone describe what learning is? Scientists like to say that “Learning is the way we acquire information about the world”, but this can mean a lot of things, information can mean things like phone numbers, friends names, times-tables, but it can also be things like friends faces, how to make a free throw, or how to draw a picture. When scientists over the last century have thought about learning, they realized something very important, and that is that some kinds of learning are require conscious activity and others happen unconsciously, and they refer to these kids of learning as explicit and implicit learning.
Consciousness can be tricky to talk about, maybe you think you know exactly what we mean by conscious and unconscious activity, but lets look at it a different way. If we asked you to describe how you learned that 6*8 is 48, you could probably describe how math works, that if you took a bunch of M & M’s and made a square with 6 rows of 8 M&M’s each that you could count each one and make 48. Some things that we learn are easy to talk about, but others are more difficult, take free throws for example, somebody probably showed you how to hold the ball, but how exactly do you know how to make the shot?
Scientists look at it this way, times tables and correct free throws are both kinds of information that can be learned. The type of information that you can easily think about and describe is termed explicit {think explained-explicit}, and the kinds that you kind of just do are termed implicit {less easy to remember, think implied}. Now in everyday life not everything fits nicely into one category or the other, but for today we’re going to stick with that definition.

When you learn something new individual cells in your brain change. One thing that scientists are currently studying is where in your brain specific cells are changing.
Were going to show you a little game that will change a few cells in a part of your brain called the cerebellum. One thing that your cerebellum helps you do is compare what you see with what your body is doing. You have lots of sensors in your muscles that keep track of where your body is. If you move your arm, you know where it’s moving even if you cannot see it, or aren’t paying attention. A copy of this, along with a lot of other information goes to your cerebellum.
Your cerebellum helps you by comparing what you want to do with what you actually did. So if you’re playing a beanbag toss game, and you throw a beanbag at a target then you either hit the target or miss the target. Part of your cerebellum is working like a little computer, and each time you throw a bag, it keeps track of how close you were to the target. It takes the information about how much you missed the target by and uses it to change the way your arm moves the next time you throw.
When you play the beanbag toss game, were going to move where the target appears to be, so you will end up throwing it further away from the target than you would expect, but if you take enough throws your cerebellum will do the work for you and change the way your arm moves without you even having to think about it. And your throws will get closer and closer.

ACTIVITY: Volunteers will lead groups of 4-6 students. Students will be trying to throw a beanbag into a target. Each student will first get an opportunity to practice a few throws and then they will be given a pair of Prism Goggles. Prism Goggles distort the field of vision to about 20 degrees in one direction and make it very difficult to hit the target and beanbags will probably be thrown all over the place. Other students that aren’t participating can help collect stray beanbags. While wearing the goggles, each student should get 20-30 attempts to hit the target. Students should be encouraged at this time to “let their brains adapt to the situation” rather than manually adjusting where they aim (many students will attempt to adjust their aim). After they begin to consistently hit the target, ask the student to remove the goggles and throw again. Many of the students will accidentally miss in the opposite direction. Some students may not show these effects of compensation. Allow each student to have his turn to wear the glasses and try the experiment.

DISCUSSION: Once we put on prism goggles, there are two ways to adjust and hit the target. One strategy is explicit, we tell ourselves that our aim is off and try to throw the beanbag where we think the target is, rather than where it appears. This type of strategy quickly adjusts our performance, but requires us to guess where the beanbag should be thrown. For students that use this strategy, when the goggles are removed, and they are asked to throw again, they will not experience an opposite shift in their aim. When using the implicit learning strategy we throw the beanbag where the target appears to be. This strategy requires several attempts, each time we throw a beanbag, our brain makes a tiny adjustment, in a brain circuit that we do not have conscious control over. The adjustments last for a while which is why after removing the prism goggles, our aim has been adjusted in the opposite direction, and takes a few more trials to re-learn.

Some questions to ask {feel free to add your own}:
Is one kind of learning better than the other? {each have their own benefits, think about the attention demands of explicit learning}
What is an example of an activity that is more effectively learned implicitly/explicitly? {maybe something like soccer/friends names}
Why would we want to learn things without having to pay attention to them?
Are there any subjects in school that are best learned implicitly? {foreign language}

Prism Goggles Risk Assessment

Last updated: 02/02/2017 - 21:55

RISKS:
1. Child becomes disorientated wearing goggles or on removing them and is more likely to fall over.
2. Small objects being thrown towards target escape and present a trip hazard
3. Small objects to be thrown towards target hit other people.

MITIGATION:
1. Ask child to stand still on one spot if they are wearing the goggles. If they feel dizzy, remove the goggles and tell them to sit down on the floor. Do not allow them to run around wearing the goggles. Remember that they may be equally disorientated on removing the goggles - do not allow them to run off immediately and again make them sit down if they are dizzy.
2. Keep an eye on the whereabouts of the objects, do not get too many out at once. Where possible, use objects such as beanbags which will not bounce and roll all over the floor.
3. Do not allow children to collect objects while the subject is still throwing them. Position the experiment so that other people are not in the firing line. Use soft, light objects where possible.

ACTION IN THE EVENT OF AN ACCIDENT:
1, 2 and 3. Call first aider if necessary.

Blood Groups

Medicine: Why are blood groups important?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Red and blue food colouring
Plastic droppers
20ml Universal containers
4 well plates
Water
Laminated cells and antibodies – A antigens are red and triangular, B green and semi-circular, RhesusD orange and squarish. The antibodies have corresponding shapes.

Explanation

In a nutshell:
Talk about different blood groups and why it is important to match blood for transfusion. Demonstrate how different blood groups are compatible using the food colouring, and use the laminated cells and antibodies as props for explanation.
How to set up the experiment:
Make up some A, B, AB and O 'blood' in the universal containers as follows:
A: 2 drops red food colouring in 20ml water
B: 4 drops blue food colouring in 20ml water
AB: 2 drops red and 4 drops blue colouring in 20ml water
O: water

Take four 4-well plates and lay them out in a square. Put about 1ml of A blood in each of the 4 wells in the first column, 1ml of B in the second, 1ml of AB in the third and 1ml of O in the fourth column. These represent the recipient blood.
You can then get the children to add about 4 drops of each blood type from the 20ml tubes to each of the types in the plates (so add 4 drops of A to each of the wells in the top row, 4 drops B to each in the second row etc). These represent the donor blood. It is worth testing this at first to check that your colouring concentrations give the results that you want! The idea is that if the colour of the 'blood' in the well changes, the blood groups are incompatible. If it doesn't change, they are compatible. For example, adding B (blue) blood to AB (purple) will not cause a colour change, but adding B to O (clear) will. The laminated cells and antibodies can be laid out in areas corresponding to each blood group. The contents of one area can then be transferred into another area (a transfusion) and any matches between the antibodies/antigens observed.

Background information:
(From www.blood.co.uk)
The most important blood groups in transfusion are the ABO blood group system and the RhD blood group system.
Blood groups are determined by a protein (antigen) on the surface of the red cell. So, the ABO system has A and B antigens and the RhD system has the D antigen.
In all, there are 30 major blood group systems. This means a person may be A RhD positive, and at the same time Kell (Kell system) positive, M and N (MNS system) positive and Lea and Leb (Lewis system) positive.

The ABO blood group system
If you have blood group A then you have got the A antigen on your red cells.
Blood group B means you have the B antigen, while group O has neither, and group AB has both A and B antigens.
The ABO system has associated anti-A and anti-B antibodies, antibodies being the body's natural defence against foreign antigens. These antibodies are found in the plasma.
Blood group A has the A antigen. This group recognises the B antigen as foreign and can make anti-B antibodies.
Similarly, blood group B has the B antigen and therefore recognises the A antigen as foreign and can make anti-A antibodies.
Group AB has both the A antigen and the B antigen so this group makes no antibodies.
Group O has neither A nor B antigen so this group can be given safely to any other group. This is why Group O donors are known as "universal donors". Group O can make both anti-A and anti-B antibodies if exposed to these antigens.
Giving someone blood from the wrong ABO group could be life-threatening.
For instance, the anti-A antibodies in group B attack group A cells and vice versa. This is why group A blood must never be given to a group B person.

remember the rules below apply to transfusions of packed red blood cells - so no donor antibodies are transferred to the recipient as these are in the plasma
Blood group AB individuals have both A and B antigens on the surface of their RBCs, and their blood plasma does not contain any antibodies against either A or B antigen. Therefore, an individual with type AB blood can receive blood from any group (with AB being preferable), but cannot donate blood to either A or B group. They are known as universal recipients.
Blood group A individuals have the A antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the B antigen. Therefore, a group A individual can receive blood only from individuals of groups A or O (with A being preferable), and can donate blood to individuals with type A or AB.
Blood group B individuals have the B antigen on the surface of their RBCs, and blood serum containing IgM antibodies against the A antigen. Therefore, a group B individual can receive blood only from individuals of groups B or O (with B being preferable), and can donate blood to individuals with type B or AB.
Blood group O (or blood group zero in some countries) individuals do not have either A or B antigens on the surface of their RBCs, but their blood serum contains IgM anti-A and anti-B antibodies against the A and B blood group antigens. Therefore, a group O individual can receive blood only from a group O individual, but can donate blood to individuals of any ABO blood group (i.e., A, B, O or AB). If a patient in a hospital situation were to need a blood

transfusion in an emergency, and if the time taken to process the recipient's blood would cause a detrimental delay, O Negative blood can be issued. They are known as universal donors.

What about plasma?
Recipients can receive plasma of the same blood group, but otherwise the donor-recipient compatibility for blood plasma is the converse of that of RBCs - plasma extracted from type AB blood can be transfused to individuals of any blood group; individuals of blood group O can receive plasma from any blood group; and type O plasma can be used only by type O recipients.

The RhD system
Another important blood group system in transfusion is the RhD system.
85% of people have the D antigen on their red blood cells and are RhD positive.
The remaining 15% lack the D antigen and are RhD negative.
Your blood group is defined by your ABO group together with your RhD group. For instance, someone who is group A and RhD negative is known as A negative.
The chart below explains the national distribution of blood groups. Click on a blood type for more information.
ABO Blood Group Rh(D) Type Percentage of Population with this Group
O +
Pos 37%
O -
Neg 7%
Total Blood Type O 44%
A +
Pos 35%
A -
Neg 7%
Total Blood Type A 42%
B +
Pos 8%
B -
Neg 2%
Total Blood Type B 10%
AB +
Pos 3%
AB -
Neg 1%
Total Blood Type AB 4%
Total Pos 83%
Total Neg 17%

Why is the Rhesus system important for pregnant ladies?
Unlike A and B antibodies, RhesusD antibodies are not found in people who are RhesusD negative. Therefore they won't react to RhesusD positive blood unless they have already been sensitised. If a RhD- mother has a RhD+ foetus (only possible if the father is RhD+), feto-maternal transfusion may occur during pregnancy/childbirth, causing the mother to produce anti-RhD antibodies. If the mother subsequently has a second Rh+ pregnancy, the anti-RhD antibodies can cross the placenta and cause agglutination and degradation of the red blood cells in the foetus. This causes 'haemolytic disease of the newborn', features of which include enlarged liver, spleen or heart in the foetus and anaemia, jaundice, enlarged organs and difficulty breathing in the newborn. To prevent this, RhD- mothers can be given IgG anti-D antibodies by intramuscular injection. These antibodies then cause destruction of foetal RhD+ blood cells before the maternal immune system can react to them. These are administered at 28 weeks of pregnancy, sometimes 34 weeks and within 72 hours of birth. This is passive immunity and wears off after 4-6 weeks so treatment is required with each pregnancy.

Why do people have antibodies against the A and B antigens if they don't have those antigens themselves?
It's thought that blood groups are very similar to some bacterial/food sugars which act as antigens so you get cross reactivity. Because ABO antigens are expressed quite widely in tissues (all endothelium and all epithelial cells, and other cell types express the H antigen which is a precursor and can still react with antibody) your natural tolerance mechanisms kick in to protect the sugar you do have, but obviously not to the ones you don't.

How can blood group be used to determine paternity?
BE CAREFUL discussing this! Do not ask the parents for their blood groups!
From www.transfusion.com.au
ABO inheritance patterns
The ABO blood group system is determined by the ABO gene, which is found on chromosome 9. The four ABO blood groups, A, B, AB and O, arise from inheriting one or more of the alternative forms of this gene (or alleles) namely A, B or O.
Genetic Combinations of ABO Blood Groups
Blood group Possible genes
A AA or AO
B BB or BO
AB AB
O OO
The A and B alleles are codominant so both A and B antigens will be expressed on the red cells whenever either allele is present. O alleles do not produce either A or B antigens, thus, are sometimes called 'silent' alleles.

ABO Inheritance Patterns
Parental blood groups Child's blood group
O and O O
O and A O or A
O and B O or B
O and AB A or B
A and A A or O
A and B O or A or B or AB
A and AB A or B or AB
B and B O or B
B and AB B or A or AB
AB and AB A or B or AB
Note: These are various possible blood groups that children may inherit according to the combination of parental blood groups.

Blood Groups Risk Assessment

Last updated: 10/02/2017 - 15:42

DESCRIPTION Using simple food colouring solutions to explain blood group compatibility
RISKS
1.Slip hazard
2. Feeling faint at sight of fake blood/ discussion of blood.
3. Cuts from sharp edges of broken well plates.

ACTION TO BE TAKEN TO MINIMISE RISKS
1. All spills should be cleared up immediately, get children to be careful using pipettes.
2. Remind people that the blood isn't real and ask them to tell you if they feel faint. Chair nearby for light-headed-feeling people
3. Clear up and dispose of broken well plates immediately, using dustpan and brush.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury.
2.Call first aider in case of injury.
3.Call first aider in case of injury.

Last updated: 13/02/2017 - 01:07

Urinalysis

Medicine:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Urine dipsticks
Paper towel
Bin bag
Large bottles
20ml universal containers
Laminated speech bubbles
Yellow food colouring
Sugar
Powdered milk
Meat blood (lamb or poultry)
Water
Nitrile gloves

Explanation

In a nutshell:
Use urinalysis dipsticks to test the content of artificial urine. Talk about some of the medical conditions that could cause these results (diabetes, urinary tract infection, kidney stones)

How to set up the experiment:
Make up bottles of each urine type:
Normal – water. You can add some yellow food colouring if desired
Diabetes – add some sugar (plus yellow food colouring if desired – only a small drop is required for a full 500ml bottle)
Infection – add a small amount of powdered milk (plus yellow food colouring if desired)
Kidney stones – add a few drops of blood from some fresh meat (e.g. lamb mince)
Pour a sample of each urine type into 20ml containers.
Kids can dip a urinalysis stick into one (or several) samples, place the stick on some paper towel and read off the result against the side of the bottle. You can play a diagnostic matching game, matching the urine samples to the patient's symptoms and the doctor's explanation.

Background information:
Urinalysis is a quick, simple and cheap test often used in GP surgeries – many children may have had to provide a wee sample at some point. The results of a dipstick may be all that is required to confirm a diagnosis, or further tests may be carried out (e.g. fasting blood glucose for diabetes, microscopy for infection or imaging for renal stones).
These urine dipsticks test a variety of parameters in addition to the protein, glucose and blood examined here, e.g. bilirubin, a breakdown product of haemoglobin, the presence of which might suggest hepatitis, and urine specific gravity (likely to be abnormal here as we're just testing water), which can give a measure of dehydration.

Urinary Tract Infections (UTIs) (from Wikipedia)
A urinary tract infection (UTI) is an infection that affects part of the urinary tract. When it affects the lower urinary tract it is known as a simple cystitis (a bladder infection) and when it affects the upper urinary tract it is known as pyelonephritis (a kidney infection). Symptoms from a lower urinary tract include painful urination and either frequent urination or urge to urinate (or both), while those of pyelonephritis include fever and flank pain in addition to the symptoms of a lower UTI. In the elderly and the very young, symptoms may be vague or non specific. The main causal agent of both types is Escherichia coli, however other bacteria, viruses or fungi may rarely be the cause.
Urinary tract infections occur more commonly in women than men, with half of women having at least one infection at some point in their lives. Recurrences are common. Risk factors include female anatomy, sexual intercourse and family history. Pyelonephritis, if it occurs, usually follows a bladder infection but may also result from a blood borne infection. Diagnosis in young healthy women can be based on symptoms alone. In those with vague symptoms, diagnosis can be difficult because bacteria may be present without there being an infection. In complicated cases or if treatment has failed, a urine culture may be useful. In those with frequent infections, low dose antibiotics may be taken as a preventative measure.
In uncomplicated cases, urinary tract infections are easily treated with a short course of antibiotics, although resistance to many of the antibiotics used to treat this condition is increasing. In complicated cases, longer course or intravenous antibiotics may be needed, and if symptoms have not improved in two or three days, further diagnostic testing is needed. In women, urinary tract infections are the most common form of bacterial infection with 10% developing urinary tract infections yearly.

Kidney Stones
A kidney stone, also known as a renal calculus is a solid concretion or crystal aggregation formed in the kidneys from dietary minerals in the urine. Urinary stones are typically classified by their location in the kidney (nephrolithiasis), ureter (ureterolithiasis), or bladder (cystolithiasis), or by their chemical composition (calcium-containing, struvite, uric acid, or other compounds). About 80% of those with kidney stones are men. Men most commonly experience their first episode between 20-30 years of age, while for women the age at first presentation is somewhat later.

Kidney stones typically leave the body by passage in the urine stream, and many stones are formed and passed without causing symptoms. If stones grow to sufficient size (usually at least 3 millimeters (0.12 in)) they can cause obstruction of the ureter. Ureteral obstruction causes postrenal azotemia and hydronephrosis (distension and dilation of the renal pelvis and calyces), as well as spasm of the ureter. This leads to pain, most commonly felt in the flank (the area between the ribs and hip), lower abdomen, and groin (a condition called renal colic). Renal colic can be associated with nausea, vomiting, fever, blood in the urine, pus in the urine, and painful urination. Renal colic typically comes in waves lasting 20 to 60 minutes, beginning in the flank or

lower back and often radiating to the groin or genitals. The diagnosis of kidney stones is made on the basis of information obtained from the history, physical examination, urinalysis, and radiographic studies. Ultrasound examination and blood tests may also aid in the diagnosis.
When a stone causes no symptoms, watchful waiting is a valid option. For symptomatic stones, pain control is usually the first measure, using medications such as nonsteroidal anti-inflammatory drugs (such as ibuprofen). More severe cases may require surgical intervention. For example, some stones can be shattered into smaller fragments using extracorporeal shock wave lithotripsy. Some cases require more invasive forms of surgery. Examples of these are cystoscopic procedures such as laser lithotripsy or percutaneous techniques such as percutaneous nephrolithotomy. Sometimes, a tube (ureteral stent) may be placed in the ureter to bypass the obstruction and alleviate the symptoms, as well as to prevent ureteral stricture after ureteroscopic stone removal.

Diabetes Mellitus
Diabetes mellitus, or simply diabetes, is a group of metabolic diseases in which a person has high blood sugar, either because the pancreas does not produce enough insulin, or because cells do not respond to the insulin that is produced.[2] This high blood sugar produces the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger). The cause of the polyuria is simply osmotic diuresis – the glucose content of the blood is so high that it cannot all be reabsorbed by the renal tubules and thus glucose is excreted in the urine. This increases osmotic pressure in the tubule, causing retention of water and thus high volumes of urine.
There are three main types of diabetes mellitus (DM).
Type 1 DM results from the body's failure to produce insulin, and currently requires the person to inject insulin or wear an insulin pump. This form was previously referred to as "insulin-dependent diabetes mellitus" (IDDM) or "juvenile diabetes".
Type 2 DM results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. This form was previously referred to as non insulin-dependent diabetes mellitus (NIDDM) or "adult-onset diabetes".
The third main form, gestational diabetes occurs when pregnant women without a previous diagnosis of diabetes develop a high blood glucose level. It may precede development of type 2 DM.

Urinalysis Risk Assessment

Last updated: 13/02/2017 - 01:07

DESCRIPTION Using urinalysis dipsticks to test artificial urine
RISKS
1.Slip hazard
2. Allergen hazard from powdered milk
3. Allergen hazard from nitrile gloves
4. Risk of bacterial contamination from uncooked meat blood.
5. Minute risk of prion disease transmission from animal blood.
6. Feeling faint/fainting.
ACTION TO BE TAKEN TO MINIMISE RISKS
1. All spills should be cleared up immediately.
2. and 4. Do not allow children to dip fingers in artificial urine, encourage use of gloves, encourage children to wash their hands afterwards. Alert parents to presence of milk if you are concerned that a child has dipped their fingers in the solution.
3. Nitrile gloves are a low allergen hazard. Do not use latex gloves. Do not let children put on gloves if they claim to be allergic, remove the gloves if they complain of allergic symptoms e.g. itch.
5. Ensure meat is not beef.
6. Be aware that a small percentage of people may feel uneasy or unwell. Stop if someone looks unwell/ goes pale. Have a chair nearby light-headed-feeling people, and ask anyone who feels faint to sit down.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury.
2. Call first aider in case of allergic reaction
3. Call first aider in case of allergic reaction
4. Symptoms of bacterial infection will only become apparent several days after the event. If you are concerned that a child has consumed a large amount of uncooked meat, tell the parents to take the child to a medical professional if they show any symptoms of food poisoning.
5. Effects will be too delayed to be seen. There is no known treatment for prion diseases.
6. Call first aider in case of injury

Last updated: 08/02/2017 - 22:02

Blood Glucose

Medicine:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Blood glucose meter
Test strips (these are expensive, use with care!)
100mM stock glucose solution
Syringes
20ml universal tubes
Water
Plastic dropper pipettes

Explanation

In a nutshell:
Use the handheld glucose meter to test the glucose concentration of different solutions (in place of blood). Many children will know someone who has diabetes but may not have had the chance to look at the equipment they use. Use this opportunity to let them investigate, and talk about the different types of diabetes and how it affects lifestyle.
How to set up the experiment:
Make up bottles of a variety of glucose concentrations using the syringes to measure out 100mM stock solution for dilution. Aim for solutions with concentrations of approximately 2 (hypoglycaemic), 5 (normal fasting), 7(normal post-meal, diabetic fasting), 12 (diabetic post-meal) and 25 (approaching ketoacidosis). I normally only use two different solutions though to conserve the testing strips (a normal one and a diabetic one). You may then wish to hide the numbers on the bottles, depending on how you wish to demonstrate!
Talk about diabetes in general. Use the charts to explain how blood glucose varies throughout the day and how this differs in diabetes. You could then get the children to choose one glucose solution and test the concentration, then work out what situation this reading is likely to have arisen in. You could also talk about the pancreas, its role in regulating glucose levels, and the actions of insulin and glucagon (this may also lead on to a discussion about hormones).
USING THE METER - this is very simple. Press the large on button and insert a new single-use test strip. Apply a tiny drop of solution to the end of the strip – not on top of the flat part, but poking the thin end into the droplet so it can be drawn in to the capillary. It may be easiest to do this by placing a small droplet of the solution onto the child's (clean – this isn't going to work if they're covered in chocolate) finger/back of hand and then poking the test strip in to it as if it were a real drop of blood.

Background information:

Diabetes Mellitus (from Wikipedia)
Diabetes mellitus, or simply diabetes, is a group of metabolic diseases in which a person has high blood sugar, either because the pancreas does not produce enough insulin, or because cells do not respond to the insulin that is produced. This high blood sugar produces the classical symptoms of polyuria (frequent urination), polydipsia (increased thirst) and polyphagia (increased hunger). The cause of the polyuria is simply osmotic diuresis – the glucose content of the blood is so high that it cannot all be reabsorbed by the renal tubules and thus glucose is excreted in the urine. This increases osmotic pressure in the tubule, causing retention of water and thus high volumes of urine.
There are three main types of diabetes mellitus (DM).
Type 1 DM results from the body's failure to produce insulin, and currently requires the person to inject insulin or wear an insulin pump. This form was previously referred to as "insulin-dependent diabetes mellitus" (IDDM) or "juvenile diabetes".
Type 2 DM results from insulin resistance, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. This form was previously referred to as non insulin-dependent diabetes mellitus (NIDDM) or "adult-onset diabetes".
The third main form, gestational diabetes occurs when pregnant women without a previous diagnosis of diabetes develop a high blood glucose level. It may precede development of type 2 DM.

Type 1 diabetes
Type 1 diabetes mellitus is characterized by loss of the insulin-producing beta cells of the islets of Langerhans in the pancreas, leading to insulin deficiency. This type can be further classified as immune-mediated or idiopathic. The majority of type 1 diabetes is of the immune-mediated nature, in which beta cell loss is a T-cell-mediated autoimmune attack. There is no known preventive measure against type 1 diabetes, which causes approximately 10% of diabetes mellitus cases in North America and Europe. Most affected people are otherwise healthy and of a healthy weight when onset occurs. Sensitivity and responsiveness to insulin are usually normal, especially in the early stages. Type 1 diabetes can affect children or adults, but was traditionally termed "juvenile diabetes" because a majority of these diabetes cases were in children.

Type 2 diabetes
Type 2 diabetes mellitus is characterized by insulin resistance, which may be combined with relatively reduced insulin secretion. The defective responsiveness of body tissues to insulin is believed to involve the insulin receptor. However, the specific defects are not known. Diabetes mellitus cases due to a known defect are classified separately. Type 2 diabetes is the most common type. Type 2 diabetes is a risk factor associated with 'lifestyle' problems such as obesity.

Diabetic Emergencies
People (usually with type 1 diabetes) may also present with diabetic ketoacidosis, a state of metabolic dysregulation characterized by the smell of acetone, a rapid, deep breathing known as Kussmaul breathing, nausea, vomiting and abdominal pain, and altered states of consciousness.

Diagnosis
Fasting plasma glucose level ≥ 7.0 mmol/l (126 mg/dl)

Plasma glucose ≥ 11.1 mmol/l (200 mg/dL) two hours after a 75 g oral glucose load as in a glucose tolerance test
Symptoms of hyperglycemia and casual plasma glucose ≥ 11.1 mmol/l (200 mg/dl)

Pancreas
The pancreas is a glandular organ in the digestive system and endocrine system of vertebrates. It is an endocrine gland producing several important hormones, including insulin and glucagon which circulate in the blood. Insulin is a peptide hormone, produced by beta cells of the pancreas, and is central to regulating carbohydrate and fat metabolism in the body. It causes cells in the liver, skeletal muscles, and fat tissue to absorb glucose from the blood (thus lowering blood glucose levels). Glucagon is a peptide hormone secreted by the pancreas that raises blood glucose levels. Its effect is opposite that of insulin.

Treatment (from diabetes.org.uk). Insulin is used to treat type 1 diabetes, and only used in type 2 diabetes when other, non insulin based treatments, have failed.
There are six main types of insulin:
• Rapid-acting analogues can be injected just before, with or after food and have a peak action at between 0 and three hours. They tend to last between two and five hours and only last long enough for the meal at which they are taken. They are clear in appearance.
• Long-acting analogues tend to be injected once a day to provide background insulin lasting approximately 24 hours. They don't need to be taken with food because they don't have a peak action. They are clear in appearance.
• Short-acting insulins should be injected 15–30 minutes before a meal to cover the rise in blood glucose levels that occurs after eating. They have a peak action of two–six hours and can last for up to eight hours. They are clear in appearance.
• Medium- and long-acting insulins are taken once or twice a day to provide background insulin or in combination with short-acting insulins/rapid-acting analogues. Their peak activity is between four and 12 hours and can last up to 30 hours. They are cloudy in appearance.
• Mixed insulin – a combination of medium- and short-acting insulin.
• Mixed analogue – a combination of medium-acting insulin and rapid-acting analogue.
Historically, people would have taken two doses of short-acting insulin and had to tailor their diet around it, eating specific quantities of food at specific times. Now, most people take a long-acting insulin once per day and then rapid acting insulin every time they eat, calculating the dose against the amount of carbohydrate in their food. This means more injections, but much greater freedom in eating.

What about insulin pumps?
These are increasing in popularity. They are small electronic pumps which are clipped to the waistband and have a narrow tube with a small plastic cannula inserted into the subcutaneous tissue in the abdomen (this set is changed every few days). They allow a constant infusion of insulin with ‘boluses’ added at the press of a button on eating. They allow freedom in choice and timing of food, but some people find them restrictive because of the tubing and the device clipped to the belt.

Is this the same as an ‘artificial pancreas’?
Not quite – it’s sort of half of one! The aim of an ‘artificial pancreas’ is to monitor blood glucose levels and respond to this by alteration of insulin infusion – i.e. a closed unit where the user does not have to have any input themselves and without having to do finger-prick blood glucose tests. One of the major difficulties in this is devising a way of monitoring glucose levels in the body.

Can’t we test real blood?
No! Good opportunity to talk about blood-borne diseases, blood and sharps safety.

Blood Glucose Risk Assessment

Last updated: 08/02/2017 - 22:02

DESCRIPTION Using a hand-held glucose meter to test the concentration of water and glucose solutions.
RISKS
1.Slip hazard
2. Feeling faint at sight of fake blood
ACTION TO BE TAKEN TO MINIMISE RISKS
1. All spills should be cleared up immediately.
2. Remind people that the blood isn't real and ask them to tell you if they feel faint. Chair nearby for light-headed-feeling people
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury.
2. Call first aider and close activity.

Last updated: 09/02/2017 - 23:40

Kiwi DNA

Biology: Breaking open cells of a kiwi fruit and making the DNA inside visible to the human eye

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Consumables: Kiwi fruit, salt, washing up liquid, 96% ethanol or 99% isopropanol (*caution*)
Equipment: Slow cooker, plastic pint glasses, half rolling pin (for mashing), sieve, plastic champagne flutes, ice bucket, bowl (for liquid waste), cloths (it's generally messy), sharp knife (*caution*), chopping board, spoon/fork/cocktail stick/pipette, model of DNA, posters about DNA and proteins
NB. Ethanol/isopropanol need to be kept out of reach of children, as does the sharp knife. If possible, keep the knife and any spare alcohol in the box when demonstrating

Explanation

Kiwi DNA repack for the 2011 Summer Roadshow

• Slow cooker, run on high for 30 mins in setup, then turn down to "warm" heat before visitors arrive.
• Stores box (small blue) has spares of most of the kit in the kiwi DNA box.
• Please use only 1-2 cm3 of ethanol/isopropanol per experiment to conserve our supplies for the whole roadshow. There are some plastic pipettes to help you with this.
• Poking the DNA at the end. As well as the cocktail sticks described in the main explanation we've now got some clear plastic cocktail stirrers, which are easier to get into the cocktail glasses when you're getting the DNA out.
• RNA model: in a plastic Tupperware tub in the main box, and new for 2010. Don't feel you have to use this, but if you want to talk about DNA being used as a template to make proteins it's a nice prop, and has the same colour coding.
• Laminated sheets: provide some useful images, and there's a wheel to show how DNA code is used to encode amino acids. Please try to dry these if they get damp during the day.
• DNA model in box. Roughly 1.4bn times bigger than real life (if my maths + memory is correct).

Overview

Breaking open the cells of a kiwi fruit to extract the DNA. You can demonstrate it to one family or a whole crowd as a show, discussing cells, DNA and proteins!

Tips for demonstrating:

- It's difficult for the audience to participate in the practical activities, so it's more of an interactive show with lots of questions and answers.
- Do the preparation work before the audience arrives! I work the experiment as a continuous process and maybe use five kiwis in the day.
- Be aware that young children won't know a lot of science. For instance, don't assume they know about cells (most don't), they know about humans being animals and that plants and animals have a lot in common. They might not even have reached the stage where they relate the idea of parts of the body having different structures and functions.

Preparation

You need to have:

- Isopropanol or ethanol on ice (as it works best when cold). If no ice is available, isopropanol seems to work better at room temperature than ethanol.
- Water bath heated to "warm"
- Use masking tape or similar to divide the water bath into pint-glass sized sections so that the glasses don't fall over when you put them in the water bath
- A kiwi or two peeled and cut into 1 cm chunks
- A bottle of lysis buffer - contains washing up liquid, salt and water. As a general guide, in a bottle, put about 1/8 volume salt and dissolve in 3/4 bottle of warm water, then top up with washing up liquid and invert a few times to mix. You don't want it particularly thick, so err on the side of less washing up liquid - you can always add more.

Basic procedure and explanation

The steps of the experiment are below in bold, with an example way of talking through the experiment for younger children. It includes questions and answers (of course if you get the right answer modify your reply). Try and use simple words and up the language as you deal with older kids or adults. You can use this experiment as a basis for talking about scale, with respect to cells and molecules and also as a basis for discussing what DNA does, and how similar our DNA is to kiwis (>50%).

You may want to have some mashed DNA in lysis buffer incubating, and use that rather than the one the group with you has prepared as it takes a while for the cells to lyse. Preparing a couple before you begin demonstrating also means you can check the lysis buffer is ok.

Do you know what this is? It's a kiwi fruit. And what's a kiwi fruit made out of? (you'll probably get seeds, flesh, skin types suggestions)

What are all living things made out of? If I scratch my nail across this what do I have under my finger nail? Cells. *Just as a house is made out of bricks every living thing is made out of cells but they're very small.* There are different cells in the flesh to what there are in the seeds or in the skin and in you their are hundreds of types of cell. Different types of cells in your eyes, blood, brain and skin too.

First what I want you to do for me is mash up some kiwi fruit.

Add a lump of Kiwi to a plastic cup and get them to mash it with the rolling pin (gently!). You can explain that what they're doing is like demolishing a house, all you've got left is a pile of bricks.

Now what I'm going to add is some washing up liquid.

Add lysis buffer to the cup containing the kiwi to a depth of about 1cm and put the cup in the water bath. You can ask: what does washing up liquid do? (You'll probably get "it makes bubbles" at this stage!) What do you use it for? Cleaning plates. Well what does it take off the plates? The grease and fat. It does this by dissolving the fat: this is like what happens when sugar or salt disappears into water. A cell is basically a bag full of water and other important things like DNA, and the bag is made from fat so the washing up liquid dissolves and breaks up the material the bag is made from (the cell membrane). This releases everything that is inside.

What do you know about DNA? Discuss! DNA is like the plans for building us. Just like you need plans for building a hospital. But if you build a hospital it's useless unless you know how to build the doctors, nurses and beds inside them and the doctors and nurses know what to do. So it's not just the plans for building you it's also the instructions for how you should be run. Alternatively, DNA could be like an instruction manual for how to build a person (or kiwi), and there is some inside almost every cell in our body and every cell in the kiwi. What we're going to do is we're going to take the DNA from the kiwi fruit.

Take the kiwi mush/lysis buffer mix out of the water bath. So this liquid here is full of DNA.

Pour the liquid from the cup into a plastic flute through a sieve to remove the lumps. We need to separate the DNA from everything else in the mixture.

Get out the alcohol and pass it around the noses present, taking care to keep control of it. What does that smell like? (kids often recognise it as hand gel) It's not water, it's pure alcohol. I emphasize this as children commonly think anything that is liquid has water in it.

Using a pipette, put about two pipettes-full of isopropanol into the glass by pouring it down the sides of the glass so it doesn't mix too much with the rest of the mixture and forms a layer on the top.

Show the glass around. What you can see here are two layers, the green layer is the water with the DNA in and the clear layer is the alcohol layer.

Now do alcohol and water mix? Sure they do. Because if you look at a bottle of whiskey or beer there's only one layer there. So what's happening is the water is moving up into the alcohol layer and the alcohol is moving down into the water layer *wibble your fingers about* and the two are mixing.

The DNA is the stringy white stuff that collects between the two layers. Can you see anything appearing between the two layers? Some stringy white stuff forming? That's the DNA. It takes a while to see this sometimes, so you can either show them a previous group's glass or pick up some of the bottom layer with a pipette and slowly release it through the top layer. It's helpful to have a few really good examples lying around to show "one that we made earlier", to make sure that they see the DNA even if the experiment didn't work for them.

Possible discussion points:

Now what I'm going to do is try and pick up a single molecule of DNA. (showman mode, on the end of a spoon I fish a little bit out.)
What's the largest number you can think of? Because what i have here on the end of this spoon is billions molecules of DNA. Just as the Kiwi is made up of the bricks we call cells the cells are made up of molecules.

So how big do you think one of these molecules is? It's about a millionth of a millimetre across. But because DNA is an especially long molecule it's a metre long. Now what I want you to do is use your imagination and I'm going to pick up one molecule of DNA *pretend to pick up a very thin strand and pass it to a child to hold and stretch it out to about a metre*

Now this is a molecule of kiwi DNA and if we use your imagination again I can pick up a molecule of your DNA and that's about a metre long too. Now in your right hand we've got a molecule of kiwi DNA, this is the instructions on how to build and run a kiwi and in your left hand we have your DNA which is the instructions on how to build and run you. Now how similar do you think these two are.

How much is the same? (Sweepstake the entire audience) About 85cm is the same (alternatively 85% the same), that's this much. (Mark out 85 cm and you've got around percentages!)

That's because both you and the kiwi are made up of cells and the cells in the kiwi do the same sort of thing as the cells inside of you. They make more cells, they use sugar and oxygen to make energy and use protein and fat. So who do you think is the most similar person in the worl to you? It's your brother or sister, not your mum or your dad. Which is why you've got to look after you're little brother as they're the most similar person in the world to you. You're all but a tenth of milimeter the same as you're brother or sister and you're all but about millimetre the same as anyone else in this room. You're all but 2 cm different from a chimpanzee. Which is why I think we should look after everything in this world as we're really not very different from anything else.

Kiwi DNA Risk Assessment

Last updated: 09/02/2017 - 23:40

DESCRIPTION	Heat mixture of salt, water, washing up liquid and mashed up DNA (60°C) for 15 mins. Decant some of the liquid into a plastic champagne flute. Drizzle an equal volume of ice-cold ethanol/isopropanol on top. DNA visible at interface. Using model and posters to explain DNA.
RISKS	1. Ethanol/isopropanol - Irritant, flammable, and very toxic 2. Water bath - Hot water can scald 3. Glassware and plastic containers- If broken can cause cuts 4. Kiwi/detergent solution Harmful 5. Sharp knife 6. Wet surfaces - Slip hazard 7. Small risk of allergic reaction to kiwi fruit in a small minority of people. 8. Risk of heat element and stirrer overheating if not covered by water.

	9. Small pieces in model may present choking hazard.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Only have a small amount of ethanol/isopropanol out, away from naked flames AND THE PUBLIC. Avoid contact with skin and eyes. Do not ingest. Only allow parents and children to mash kiwi on its own - not once mixed with detergent or ethanol/isopropanol. Ensure eyewash is nearby and that you know the location of it. 2. Maintain the water bath at 60°C out of reach of children. Ensure has passed PAT test in last 2 years. Ensure cables are taped to the ground/table to reduce risk of person tripping on/pulling the cables. 3. Dispose safely of any broken glassware immediately. Keep spares out of reach. Check plastic container and ethanol/isopropanol are compatible. 4. Do not allow children to mash the kiwi once it has been mixed with detergent or ethanol/isopropanol. Keep all mixtures within demonstrator's reach. Avoid contact with eyes or the mouth. Try to work on a surface which is not at eye level. Demonstrator can show children how to mash the kiwi without splashing kiwi everywhere. Know the location of the nearest eyewash 5. Supervised use only. Keep sharp knives away from children. It's impractical to cut all the kiwi beforehand, but after cutting fresh kiwi, keep the knife in the pencil case provided and keep this in a drawer, out of sight. 6. Wipe up any spills. Keep experiments away from electrics. 7. Demonstrator to check that visitors are not allergic to kiwi fruit before commencing the experiment. 8. Demonstrator to ensure that element is always covered with water and stirrer is always rotating. 9. Keep model completely assembled and prevent children taking it apart. Keep the black stopper on top of the stand as this prevents the rest being disassembled.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Wash off skin. Use eyewash to wash out of eyes if trained and confident to do so, and call First Aider. If ingested call First Aider immediately. 2. Run cold water over affected area for at least 10 mins. Call First Aider 3. Call First Aider 4. Use eyewash to wash out of eyes if trained and confident to do so and call First Aider. If ingested call First Aider immediately. 5. Call First Aider. 6. Call First Aider. 7. Call first aider. Rinse skin with clean water. 8. Turn off electricity at mains. Call first aider if necessary. Allow to cool before using again. 9. If child ingests small part of model, call first aider immediately.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 09/02/2017 - 01:02

Microscopes & Cells

Biology: Examining a variety of objects under a microscope, including a variety of slides

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Microscopes, slides, model cells (pillow model and inflatable plant and animal cells), video camera for microscope and laptop

Explanation

Microscope kit for 2011 Summer Roadshow

Microscopes are now in 4 boxes.

2 x Slide microscopes:
Two small blue boxes- each set is labelled alpha or beta to help stop them getting muddled up. In each box there's the main body of the microscope (stored in two pieces, undo the screw, slot together, tighten screw), and 4 lenses in small pots. Unscrew the lenses from the lids of the pots, and screw them in to the lower part of the microscope. The upper lenses are stored in the same box as the microscope slides- you won't really need them if you're using the microscope cameras and the CHaOS laptops (use Crick) to show visitors the slides, but feel free to. Ask a Committee member to help you set up if you're not sure!

Dissecting microscope:
Small grey box. This is good for introducing microscopes in primary schools, though you'll need to find some props to use with it. Everyday objects like money and textiles are good to look at with this. You can always raid the CHaOS food boxes for stuff like lettuce, kiwis and tomatoes, or look outside for a selection of leaves. There's a couple of squishy toy microscopes in the box too (just for fun!)

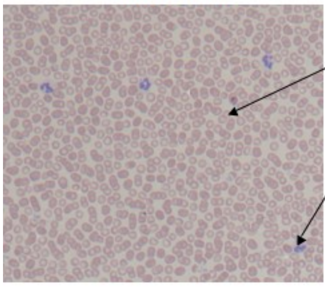
Microscope slides:
This box contains:
• 6 x boxes of slides for the slide microscopes (labelled man-made materials, human body, invertebrates, plants, parasites and microbes)
• A box of lenses for the slide microscopes (labelled alpha and beta)
• A box of accessories for the microscopes (dust covers and anything else you might want)
• A magnifying glass (to show that lenses can make an image bigger)
• A ruler (which can sometimes help to explain scale)
• Cameras for the microscopes (1 x silver, 1 x black and 2 x low res for backup), which work like webcams when attached to the CHaOS microscopes. (The software has shortcuts on the desktop of each of the CHaOS laptops)
• Laminated sheets with extra info for the 3 x slides in a pond life food chain that are in the invertebrate box (water organisms -> daphnia -> hydra)
• 3 x microscope books, which might give you some ideas for demos

Model cells:
Small grey box containing 2 inflatable cell models (inflate by mouth) and a cushion cell model.

How to explain what microcopes do/ what cells are

There are lots of different slides to choose from – feel free to talk about whatever you're interested in!
- Introduce cells using the cell models
- Cells are very small (typically 10 um for an animal cell... that's 1000 times smaller than 1 cm (you can use the ruler to show 1 cm)
- Cells are analogous to a building brick - houses are built of lots of bricks, like people are built of lots of cells (50-75 trillion!)
- Cells aren't just bricks - they are alive, and make things, use things, and process information
- Have a phospholipid membrane – barrier to extracellular environment
- Nucleus is the 'control centre' - contains instructions on how to make proteins, from which the rest of the cell is made. Instructions are written in a 4-letter code on very long molecules called DNA (see Kiwi DNA experiment). DNA to mRNA (transcription), transported out of nucleus, translation on ribosomes to proteins. Proteins go to the ER (endoplasmic reticulum) for further folding, then to Golgi apparatus (more modifications), then on export pathway to exit the cell.
- Cells need energy - this is supplied by mitochondria (they convert energy from sugars into ATP, the energy currency of the cell)
- Plant cells - cell walls and chloroplasts (we have a root tip squash slide where the cell walls are visible and the nuclei are nicely stained, but they don't have chloroplasts because it's a root. If they want to see more plant cells, there's a whole demo on plants...)
- Bacteria are also cells, but they are smaller and don't have a nucleus (associate bacteria with disease e.g. food poisoning caused by E. coli). Bacteria can be lots of different shapes (look at E. coli, Staphylococcus, Spirillum).
- See below for labelled diagrams of some of the slides!

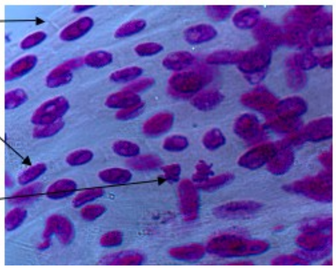
Blood smear



Red blood cell
- Red because of haemoglobin which makes them
-able to carry oxygen
- Flat and biconcave shape gives large surface area to allow oxygen to diffuse in and out
- No nucleus

White blood cell
- Defends the body against disease
- About 1% of blood of a healthy adult
- Some types have a multilobed nucleus (e.g. neutrophils) and ingest bacteria

Allium (onion) root tip squash

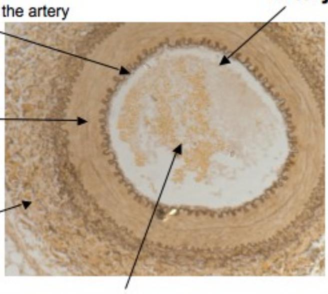


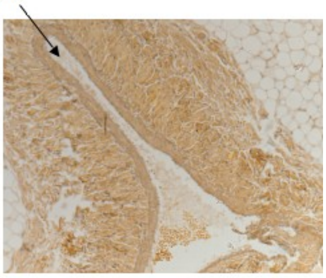
Cell wall
- Not found in animal cells
- Gives the cell a rigid shape

Nucleus
- Stained so DNA appears purple

Dividing cell
- Chromosomes condensed and visible

Artery & Vein





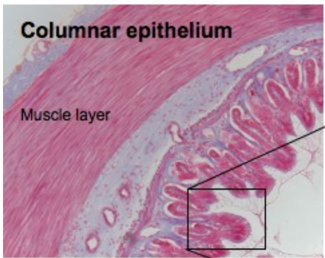
Tunica intima
- Endothelial cells line the artery

Tunica media - smooth muscle
- Thicker in arteries than veins

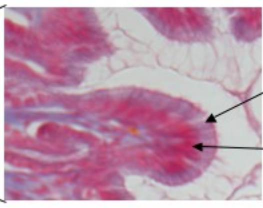
Tunica adventitia
- Mostly made of collagen

Artery lumen
- Oxygen-rich blood passes through here away from the heart

Vein lumen
- Deoxygenated blood at lower pressure passes through here

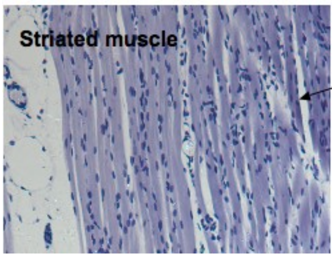


- Epithelium is a tissue comprised of cells that line the cavities and surfaces of structures throughout the body.
- Columnar epithelial cells are elongated and column-shaped with their nuclei located near the base of the cells
- Columnar epithelial cells line the stomach and intestine



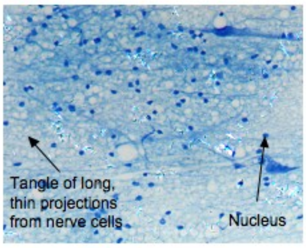
Columnar epithelial cells

Nuclei

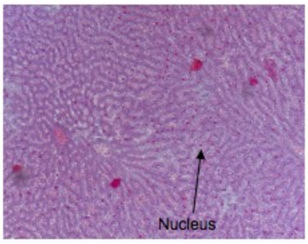


Individual fibres have several nuclei because they are made from cells that have fused together.

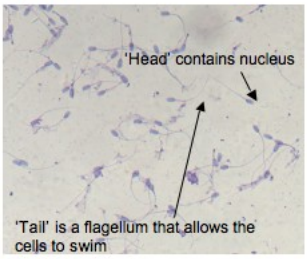
Nerve cells



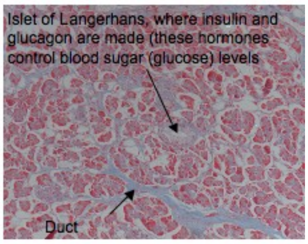
Liver



Sperm



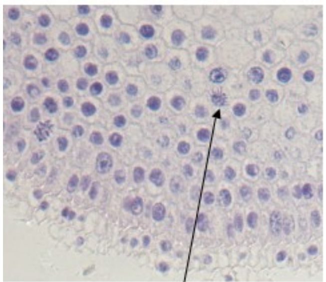
Pancreas



Dividing cells

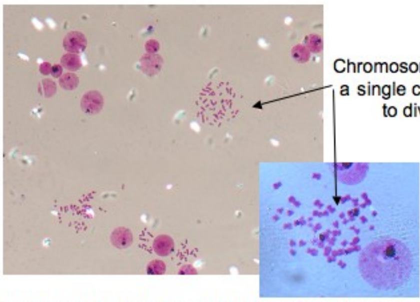
- When cells divide (by mitosis), their DNA has to be copied and then separated to the two daughter cells
- DNA in our cells is separated into 46 chromosomes (in onion, this is 16)
- To allow the DNA in cells to be easily separated, it condenses into chromosomes after it's been copied (this is analogous to having several tangled up pieces of wool and then coiling them up into balls to make it easy to pull them apart without breaking any and leaving it behind)
- It's important that this process is done accurately otherwise new cells lack some vital instructions!

Allium (onion) root tip



Condensed chromosomes
- Just before cell divides

Human chromosome spread



Chromosomes from a single cell about to divide

(The slide is made by fixing cells, making the nuclei swell, then dropping them onto the slide which bursts them. Where the chromosomes are condensed because the cell was about to divide, they spread out nicely. Lots of nuclei with decondensed DNA are also visible because most cells weren't about to divide.)

Bacteria

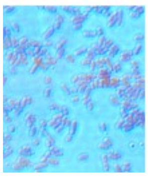
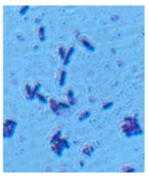
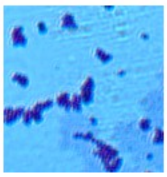
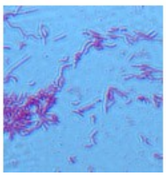
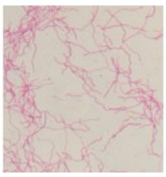
- Cells are smaller than eukaryotic cells
- Bacteria don't have a nucleus, but rather their smaller amount of DNA is usually in one large circular chromosome in a region called the nucleoid, with small (non-essential) circles of additional DNA called plasmids throughout the cell
- Different bacteria are different shapes…

E. Coli and *B. subtilis*
- rod-shaped

Staphylococcus
- spherical ('round')

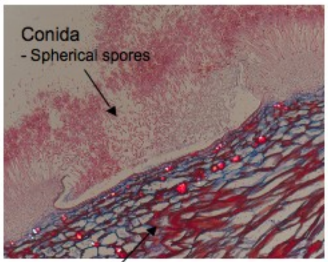
Vibrio
- curved rod shape

Spirillum
- spiral shaped

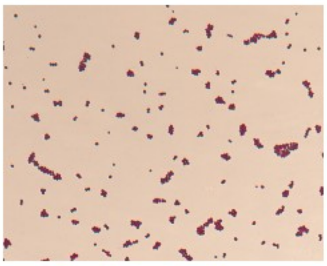
Fungi
- Also eukaryotic cells, like animal cells, so they have a nucleus
- Like plant cells, fungi have a cell wall, but theirs is made of chitin rather than cellulose in plants

Penicillium
- There are several species of penicillium fungi, which have uses ranging from production of brie, camembert and roquefort cheeses
- Some of these fungi also make the antibiotic penicillin



Mycelium
- Branched fibres forming the vegetative part of the fungus

Saccharomyces
- Unicellular fungi
- Used in brewing and bread-making
(Note that these look very similar to the staphylococcus bacteria, but are much larger).



Microbes: Parasites slides

Flukes (Trematodes): Adult flukes are leaf-shaped flatworms. Prominent oral and ventral suckers help maintain position. Flukes are hermaphroditic (both male and female) except for blood flukes, which are bisexual. The life-cycle includes a snail intermediate host.

Tapeworms (Cestodes): Adult tapeworms are elongated, segmented, hermaphroditic flatworms that inhabit the intestinal lumen. You can eat the cysts in undercooked animal tissues, and then they develop in your intestines. They eat your food from your intestine – instead of you getting the nutrients. They attach to the intestinal wall using suckers in the head. Problematic in the developing world where there is already malnutrition. People used to use tapeworms as a slimming aid… They can grow up to 15 metres long and live for 20 years! Larval forms live in extraintestinal tissues.

Roundworms (Nematodes): Adult and larval roundworms are bisexual, cylindrical worms. They inhabit intestinal and extraintestinal sites.

1) **Schistosomiasis** (caused by a fluke/ trematode)
• Schistosomiasis is a chronic, parasitic disease caused by blood flukes (schistosomes)
• At least 230 million people require treatment every year – praziquantel
• Infection from larval forms released from freshwater snails in contaminated water
• Penetrate the skin and live in circulation where females release eggs
• Cause damage because of the host immune response to the parasites

2) **Liver fluke** (*Fasciola hepatica*) (caused by a fluke)
• Freshwater snail intermediate host, where reproduction occurs, then they are released as cercariae and swim through water to be ingested by ruminants normally, or sometimes humans eating uncooked foods like watercress
• Adult lives in the liver where they feed on the lining of bile ducts – makes cheese-like holes in the liver
• Produce eggs – up to 25000 a day per female

3) **Dracunculiasis** (guinea-worm disease, caused by a nematode)
• Dracunculiasis (caused by Dracunculus medinensis, a long thread-like worm) is a parasitic disease on the verge of eradication
• Exclusively transmitted by drinking water contaminated with parasite-infected fleas such as rural isolated ponds
• Takes 10-14 months for worm to mature in the body

4) **Hookworm** (*Ancylostoma duodenale* and *Necator americanus*, kinds of nematodes)
• Soil-transmitted helminths (parasitic worms)
• Major burden of disease worldwide - estimated 576-740 million people infected with hookworm
• Hookworms live in the small intestine, eggs are passed in faeces of infected person – this is a problem in the developing world where people may defecate outside (near bushes, in a garden, or field) of if the faeces of an infected person are used as fertilizer, eggs are deposited on soil.
• Eggs then mature and hatch, releasing larvae (immature worms).
• The larvae mature into a form that can penetrate the skin of humans, and infection is mainly acquired by walking barefoot on contaminated
• Most people infected with hookworms have no symptoms. Some have gastrointestinal symptoms, especially persons who are infected for the first time. The most serious effects of hookworm infection are blood loss leading to anemia, in addition to protein loss.
• Infection is treatable – anthelminthic medications eg. albenadazole

PARASITE VECTORS:

(There are two cuddly toys for this, so you can show a second uninfected mosquito feeding off a human host)

1) **Mosquito**:
• Most mosquitoes are harmless but some can transmit disease
• Viral diseases, such as yellow fever, dengue fever and Chikungunya, transmitted mostly by Aedes aegypti
• Parasitic disease malaria, carried by mosquitoes of the genus Anopheles
• Lymphatic filariasis (the main cause of elephantiasis – worms block lymphatics impairing lymph drainage causing swelling of the limbs)
• We have cuddly toys of mosquitoes – in the parasites box

ECTOPARASITES:

(You can borrow cuddly toys (in parasites box) and some preserved samples (from "Horrible Housemates") to help you demonstrate.)

1)**Head louse** (*Pediculus humanus capitis*)
• Lice are wingless biting or sucking insects. Lice infestation of any part of the body is called pediculosis!
• Live on your head (an ectoparasite) - has a single strong claw on each leg that can grab onto 6 hairs so they can move rapidly (may be on several heads in one day). But their short stumpy legs mean they can't jump or walk well on flat surfaces.
• Your head provides a source of food - blood

• Eggs are called nits and the female attaches the eggs close to the scalp with a transparent quick-setting glue
• The time taken to hatch depends upon temperature
• Head lice have no lungs! They take in air by muscle contraction of the abdomen (via spiracles)
• Head lice have been recovered from prehistoric mummies!

2) **Bed bug** (*Cimex lectularius*)
• Ectoparasites that feed on human blood (haematophagous)
• Live in houses and especially beds – most active at night so they can feed on the host without being noticed
• Adults can survive more than a year without feeding
• They don't usually spread disease but they can cause allergic skin reactions
• Light brown flattened oval-shaped body, vestigial front wings, microscopic hairs on abdomen that give a banded appearance

HYDRA:

• Hydra live in freshwater (unlike other members of their phylum, Cnidaria, like coral)
• Attached via basal disc to a surface like rocks
• Hydra eat small water organisms like water fleas
• Have nematocysts – tiny stinging cells that inject toxin into their prey to paralyze them. The tentacles are sticky. The tentacles then move to bring the prey to their mouths, then prey is enzymatically digested. Sometimes they 'swallow' their tentacles so have to pull them back out.
• There's only one entrance and exit to the internal cavity – so indigestible parts come back out the same way!
• Hydra mostly reproduce by budding – young polyps mature attached to the parent and then detach. There is also some seasonal sexual reproduction with mature polyps developing gonads on the external body wall.

Microscopes & Cells Risk Assessment

Last updated: 09/02/2017 - 01:02

DESCRIPTION
Looking at a range of small objects down a microscope

RISKS
1. Electrical hazard, especially near possible water based samples.
2. Using thin glass slide could result in broken glass with risk of cuts.
3. The light fitting under the microscope becomes hot, and could cause burns.
4. Samples could present problems, for example looking at a dead wasp could result in someone being stung by its sting. Human (for example cheek cell) samples should not be used unless a seperate suitable risk assessment is in place. Water from ponds or puddles will contain unknown bacteria which could be pathogenic.
5. Inflating model cells could cause pulmonary distress eg. asthma attacks.
6. Model cells could present a trip hazard if dropped on the floor

CONTROL MEASURES
1. Keep water-based samples away from the microscope. Take care. See separate electrical parts risk assessment.
2. If slides are broken, carefully collect/sweep up broken pieces, wrap in paper and dispose of carefully.
3. Warn children to be careful, turn off lamp when not in use, if it's getting hot put a cardboard shield around (but not touching) the lamp to prevent accidental contact.
4. Consider possible risks of samples carefully. Discuss with the venue safety officer and note, date and sign any additional precautions. Warn children to wash their hands carefully after looking at water samples.
5. Avoid inflating the model cells if a sufferer of asthma.
6. Keep all props in contained area.

IN CASE OF EMERGENCY
1. In case of accident, call first aider.
2. Call first aider.
3. Call first aider. Run burnt area of skin under cold water for at least 10 minutes.
4. In case of accident, call first aider. In case of ingestion of pond water, advise responsible adult (parent/teacher) that in case of sickness they should see family GP and inform them of what happened.
5. Use inhaler. Call first aider.
6. In case of accident, call first aider.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase.

MINIMISE RISKS	Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 09/02/2017 - 23:54

Pipe-cleaner neurones

Biology: Making model neurones from coloured pipe cleaners!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Pipe cleaners - some full-length, others 1/3 length (cut using wire snips *caution - keep these hidden when demonstrating as they're very sharp!*)

Note: there should also hopefully be a model of a brain in the same box...

Explanation

This is a great way to explain the basic concepts of what nerves are and what they do. You'll be getting the kids to make a simple neuron from different coloured pipe cleaners. Each colour will represent a different part of the neuron e.g. cell body, axon, dendrites, myelin sheath!

---

1. Take one pipe cleaner and roll it into a ball. This is will be the cell body.

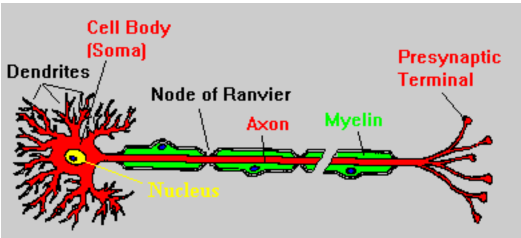
2.Take another pipe cleaner and attach it to the new "cell body" by pushing it through the ball so there are two halves sticking out. Take the two halves and twist them together into a single extension. This will be the axon.

3.Take other pipe cleaners and push them through the "cell body" on the side opposite the axon. These are dendrites. These can be shorter than your axon and you can twist more pipe cleaners to make more dendrites.

4.Wrap small individual pipe cleaners along the length of the axon. These will represent the myelin sheath.

5. Wrap another pipe cleaner on the end of the axon. This will be the synaptic terminal.

Background information about neurones:



Our nervous system (which includes the brain and spinal cord, together the central nervous system) is one of the ways we send messages around the body, working alongside hormones (chemicals that travel in our bloodstream). The nervous system uses electricity (but much lower voltages and currents than we use to run lightbulbs!!) to transmit these messages. A major component of the nervous system is the neurones. Neurones (also called neurons or nerve cells) are electrically excitable cells - with information travelling down the axon by shuffling of ions (charged particles). At synapses (connections with other neurons) chemical transmission is used, with molecules moving between the neurones across the synaptic cleft.

A number of specialized types of neurone exist: sensory neurones respond to touch, sound, light and numerous other stimuli. They send information from the periphery to the central nervous system. Motor neurones send signals the other way, from the central nervous system to muscles at the periphery and cause e.g. muscle contractions.

A typical neurone consists of 3 parts: the cell body (soma), dendrites and the axon. The nucleus ('control centre of the cell' as it's described in schools) is located in the cell body. Dendrites are lots of branches from the cell body that receive signals from other neurones. The axon is very thin and conducts electrical impulses away from the cell body, towards the axon termini where the neurone forms synapses with other neurones. The longest axons in the human body are of the sciatic nerve which runs from the base of the spine to the big toe of each foot! These single cells can be more than a metre long!

In vertebrates, the axon is insulated by a sheath of myelin, formed from Schwann cells. Loss of myelin from axons is found in people with multiple sclerosis. Along myelinated nerve fibers, gaps (approx a micrometre long) in the sheath known as nodes of Ranvier occur at evenly-spaced intervals (action potentials jump between these sites where ion channels are found in a manner known as saltatory conduction, but this is probably way above the heads of the majority of your audience for this experiment! - essentially myelination makes the messages travel faster). Even in vertebrates there are some unmeylinated axons because myelin uses up lots of space and you wouldn't be able to fit enough neurones into our bodies if they all had myelin sheaths - so neurones which need to conduct messages really quickly are myelinated.

Pipe-cleaner neurones Risk Assessment

Last updated: 09/02/2017 - 23:54

DESCRIPTION	Making model neurons out of pipe cleaners.
RISKS	• Kids getting pipe cleaners in their eyes or swallowing small bits of pipe cleaners. Wire core of pipe cleaner could potentially case cuts. • Wire snips are very sharp and could potentially cause cuts.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Ensure that children are carefully supervised; demonstrator to try to keep all neuron-making activity on the table. Demonstrator should calm down children if they are using the pipe cleaners in an unsafe way. • Keep wire snips hidden during demonstrating - they're only used to prepare pipe cleaners beforehand so don't need to be out.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call a first aider immediately; do not attempt to move anything lodged in the eye.

Last updated: 11/01/2017 - 16:55

Animal skulls

Biology: Looking at different animal skulls to compare them and see how they differ.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Various different skulls and a pile of laminated photos

Box 1
Mammals: sheep, dog, cat, fox, hare, mole
Birds: magpie, pigeon, oystercatcher, duck (one complete, one in parts), parrots

Box 2
Primates: human, chimp, gorilla, orangutan (all models)

For crash, bang, squelch, some can also be borrowed from the zoology museum.

Explanation

OVERVIEW

We have some skulls of different animals. Each has different adaptations relating to the animal's lifestyle and environment. Looking at a skull's characteristics, such as teeth, eye placement and size, scientists can determine whether the animal was an herbivore, carnivore, or omnivore, and if the animal was a predator or prey animal.

SETTING OUT THE EXPERIMENT
In a calm event it can be nice to set out all the skulls on a table, with all the photo cards spread out in front of them so that you can play a matching game. In a busier event or with an excited group of kids it's probably better to have them in the big blue boxes and pull out one skull at a time. That makes it easier to control which kids are holding the skull(s) and it makes it easier to control the questions, as you don't have to jump backwards and forwards between lots of different animals!

BASIC PROCEDURE AND EXPLANATION

Unlike some of the other biology experiments, the animal skulls experiment has no fixed story line. This makes it much more flexible, so you can talk about the skulls that you find cool or know more about. (No-one will know which ones you've left in the box!).

Our advice is to start talking about one skull in detail, then compare other skulls to the first one you picked. It's easier to pick one of the bigger/ less fragile skulls first, such as the human (made of plastic!) or the sheep skull. Make sure that you've established what a skull is on the first one- it's not as obvious as you might think that it's the boney stuff that is inside our head/ protects our brain. You might also want to briefly talk about what bones are for/ made of - an explanation of hard stuff that holds our bodies up is probably enough detail for the youngest kids!

* Start by asking the child if they recognise any of the skulls - they will probably recognise the human one at least
* On the human skull - can ask if they know the names of any parts of the skull (can help them out by providing a couple - remember to use simple terms e.g. teeth, eye sockets)
* Point out interesting points on the skull that you might know e.g. foramen magnum where the spine attaches to the skull and through which the spinal cord runs, or the holes on either side of the skull where the inner ear goes
* Once you've established the names of a few of the skull's main features, ask the child if they know what each of these features does or what they're for
* Point out that the jaw isn't fixed to the main part of the skull - apart from anything else we wouldn't be able to open our mouths to eat if it was stuck (fused) to the rest of the skull.
* Holes for nerves, such as at the back of the eye sockets. These allow the brain to connect to send and receive signals from the rest of the body.
* Can then move onto the other skulls - discuss the features of the skulls and how these relate to the demands that the animal has to cope with in its environment. Why might the adaptations help the animal to succeed in its environment/why might the animal have developed these skull features? You might want to discuss each skull in turn, or you may prefer to talk about a particular 'theme' i.e. teeth, brain size across a number of skulls at once
* Make sure you get child involved i.e. get them to (gently!) handle skulls so they can feel how delicate/sturdy they are, ask lots of questions. Remember to use simple language and explain difficult words in simpler terms (e.g. 'animals that come out at night' rather than 'nocturnal animals')

Interesting features/comparisons include:

TEETH

The type, shape and number of teeth an animal has can help determine its diet.

- Incisors are the front teeth. They are used primarily for cutting and grasping.
- Canines are the teeth next to the incisors. The canine teeth typically are large in a predator and are used for tearing and grasping.
- Premolars are the teeth behind the canines. These teeth have sharp edges for crushing food.
- Molars are the very back teeth. They are broad and flat and are used for grinding.

If a mammal has long, sharp canines, it is most likely a predator. Canines are used for grabbing, holding and killing prey. Some meat-eating mammals (carnivores) have sharp shearing cheek-teeth called carnassials. These teeth act like a scissor to cut through tough flesh and to break it into smaller pieces for swallowing and digestion. The fox is mainly carnivorous, although they also gather a wide variety of other foods like fruit and berries. The European Mole is also carnivorous, and feeds on invertebrates e.g. earthworms, insects. Ask the child if they can think of any other carnivores (cats and dogs are just two familiar carnivores).

Plant eating animals tend to have teeth specialized in chewing various parts of plants. Some plant eaters eat grasses (grazers e.g. sheep, using incisors to nip plants close to their bases), some eat twigs, leaves and berries (browsers e.g. goats/deer) while others eat only specific plant parts (i.e. roots, fruit, etc.). In order to properly digest vegetation, an animal must chew its food to help break down the plant. Most herbivores have cheek teeth called molars. These molars help grind leaves, stems, grasses, fruit and even seeds before the animal swallows them. Examples of herbivores in our skull collection include the hare (hares eat grasses during the summer and twigs/tree bark etc. during the winter, and also commonly re-ingest their faecal pellets...) and the sheep (these mainly feed on grasses, have a large and complex stomach which is able to digest highly fibrous foods that cannot be digested by many other animals). Sheep, cows, llamas and alpacas all don't have top inscisors! Instead they have a thick, hardened gum line (called the dental pad) which they use to pinch off blades of grass against.

Some animals (omnivores) eat both plants and animals, and have both types of teeth. The human and magpie are omnivores (although obviously the mapgpie doesn't have any teeth). Interestingly though, recent studies have shown that chickens (and possibly other bird species) still retain the genetic blueprints to produce teeth in the jaws, although these are dormant in living animals. These are a feature from primitive birds such as Archaeopteryx, which were descended from theropod dinosaurs.

We also have an Orangutan jaw - Orangutans find their food in the trees where they live. More than half their diet consists of fruit. They also eat nuts, bark, and other parts of plants and trees. Every once in a while they eat insects such as ants and termites, as well as bird eggs. Other examples of omnivores include pigs and bears.

BEAKS

You might want to talk about how birds such as the chicken use their beaks to feed, and talk about how other birds have adapted their beaks to help them eat their chosen food.

The beak of a bird is an extension of its skull and is designed for feeding. Some beaks have evolved to specialize for feeding on specific items.

Duck: wide flattened "bill" used for eating aquatic plants and mosses - specialised for "dredging" type jobs. Dabbling ducks, which feed on the surface of the water (or as deep as they can reach by upending without completely submerging) have a comb like structure along the edge of their beak called a pectin - this strains the water squirting from the side of the beak and traps any food. Also used to preen feathers.

Parrots: seeds are the most important part of their diet, which has led to the evolution of a large and powerful bill which is primarily an adaptation to opening and consuming seeds.

Oystercatcher: bill shape varies between species, according to diet - birds with blade like bill tips pry open or smash mollusc shells, and those with pointed bill tips tend to probe for annelid worms.

Pigeons: homing pigeons have iron containing structures in their beaks which may enable the birds to use the earth's magnetic field for navigation

Other birds (which we don't have, but that you could discuss) include - the hawk, which has a sharp hooked beak used in tearing flesh from its prey or carrion. A hummingbird uses its long narrow beak to lap nectar from flowers and a sparrow has a small powerful beak used for picking berries and cracking seeds.

NOSES

Possibly start by asking what is missing (nose, ears, eyes and other soft tissues) - they are not part of the skeleton, made of either cartilige or muscles and nerves. The kids can think about the differences in nose sizes, do they think that cats have a better sense of smell than dogs? etc (dogs are 10,000 times more sensitive to odors than humans). Apart from food, what else do animals need noses for? (smelling mould, predators, recognising family members, detecting when another animal is in heat). The sheep skull has large nasal cavities, with delicate rolls of (turbinate) bones, which support a large area of nasal epithelium (skin inside the nose (?)) for many, many scent receptors and to reduce heat/moisture loss.

EYE PLACEMENT AND SIZE (particularly relevant to mammals)

Large eye sockets suggest an animal is active at night (nocturnal). In this case, a larger eye has evolved to allow the animal to see better at night. Moles are nocturnal, hunting prey and remaining active at night.

Eyes that face forward on a skull suggest a predator ('an animal that hunts other animals for food'). Forward facing eyes allow for binocular or stereoscopic vision, which allows an animal to see and judge depth. Predators need this depth perception to track and pursue prey.
The fox is an example of a predator in our collection. The orangutan also has forward facing eyes that give it depth perception needed to swing and leap in their tree top habitat. Humans have forward facing eyes as well (you could talk here about us being descended from apes).

Animals with eyes that are located on the side of its head would suggest a prey animal. Side eye placement allows for greater peripheral or side vision. This enables the animal to see predators approaching from the side as well as from behind. This vision is very important for protecting an animal when it is grazing or feeding. The hare is an example of a prey animal in our collection. Other examples include deer and rabbits.

"Eyes in the front, the animal hunts. Eyes on the side, the animal hides."

CRANIUM

The size of an animal's cranium (relative to its body size) can give you an idea of how well developed its cerebral cortex (the part of the brain that contributes to 'intelligence') is. The size of an animal's cerebral cortex indicates how much 'processing power' its brain has in addition to the basic functions that all animals' brains need to perform (such as control of breathing, feeding and movement, which involve the hindbrain). A good way to compare the size of the brain cavity is to look at how big it is relative to the rest of the animal's skull. Generally, social animals such as monkeys, apes (including humans), dolphins, and elephants have large cerebral cortices. This is because keeping track of social relations within the group requires a great deal of 'processing power'.

Magpies are a member of the corvid family - group of birds including crows, jackdaws etc. - these birds are thought to be the most intellgent of all bird species, and have larger cerebral cortices than would be expected for their body size. This intelligence is demonstrated in several ways e.g. European magpies have shown self awareness (i.e. recognising themselves) in mirror tests, crows and rooks have tool making abilities (e.g. hooks to 'fish' for grubs) - things that people generally associate with higher mammals such as ourselves and other apes. These birds also have highly complex social lives, just like apes (need to have large brains with lots of computational power to keep track of what other animals are doing, understand their relationships with other animals in the group etc.).

Parrots also highly intelligent and have high brain size to body ratio - some have been shown to be able to associate words with their meanings and form simple sentences (e.g. Alex the African Grey), some species of parrots are highly skilled at using tools and solving puzzles.

Pigeons, by contrast, seem to be less "intelligent". If a pigeon is taught that doing something (e.g. pecking at light A) leads to reward, and doing something else (e.g. pecking at light B) doesn't, then they can learn these rules, but if you change the rules around (e.g. pecking at A doesn't lead to a reward, and pecking at B does) they find it difficult to "reverse" their behaviour (whereas corvids and humans manage easily!) Could demonstrate this with child using a coin and getting them to pick which hand they think it is in).

NB Unlike most other apes, orangutans are shy, solitary animals. They live alone in large territories. This is probably due to their eating habits; they need a large area in order to get enough food and too many orangutans in one area might lead to starvation. However, they are very intelligent. They have been known to use found objects as tools; for example, they use leaves as umbrellas to keep the rain from getting them wet. They also use leaves as cups to help them drink water.

*** OTHER THINGS TO TALK ABOUT ***

Can the child think of any other distinctively-shaped skulls that animals have, and why might they have developed to be like that? E.g. crocodile, hammerhead shark, elephant (tusks)...

If the child is old enough and seems keen, you might want to touch on the concept of natural selection (survival of the fittest) and how this drives development of the peculiar features that some animals have. For example nocturnal animals will have more success catching food and escaping predators if they have large eyes that let in as much light as possible in low light conditions. Animals with smaller eyes than average will find it more difficult to do this and are less likely to survive than animals with larger than average eyes. The animals with larger eyes will therefore be more likely to survive and have babies, who will in turn also have big eyes like their parents (you will need to briefly touch on genetics here too – has the child noticed that they share the same eye/hair/skin colour/nose shape etc with their parents?)

Animal skulls Risk Assessment

Last updated: 11/01/2017 - 16:55

DESCRIPTION	Comparing different real and plastic animal skulls
RISKS	• Some skulls may have sharp teeth or beaks. • If dropped, skulls may fall on feet or shatter, causing cuts and other injuries. • Possible infection risk from bone if skin is cut by touching the bone
ACTION TO BE TAKEN TO MINIMISE RISKS	• Remind children to handle skulls carefully; in particular, be careful not to pinch fingers/hands in the jaw. • Demonstrator only have a few skulls present at a time to minimise risk of children picking up or playing with skulls. Demonstrator to keep an eye on anybody holding skulls. If a skull smashes, clear it up immediately with dustpan and brush. Any skulls with sharp edges may need to be smoothed off or replaced. • We have boiled the skulls we found in bleach for a few hours to sterilise them. Please note, however, this does not necessarilly mean that the skulls are completely sterile now.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• In case of injury call first aider. • Warn parents of the possibility of infection if a child does cut him/herself on the skull; Advise parents to take child to a doctor if the cut looks infected.

Yeast & bread making

Biology: The idea is to look at how yeast grows and how it relates to bread making. It involves getting the kids to make bread dough.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Baker's yeast (a fair a amount - we got through 3 of the tins of it last year)
Flour 80g per child (lots!)
Sugar (a couple of bags)
water (warm - will have to keep getting this from tap)
beakers/cups for cultures
500 ml plastic drinks bottles
Balloons
Trays to do experiment over to contain the mess
Possibly somewhere for kids to wash hands as it gets a bit messy

Explanation

Key messages to get across about this experiment:
• Yeast is alive
• It gives off gas (carbon dioxide) when bread rises giving you bubbles in the bread

Suggested demonstration:
• Start with bread – ask if they have ever eaten bread (hopefully a 'yes' but this should get them engaged with you as it's a simple question that they don't have to struggle to think about).
• Ask if they know what goes into bread; you'll probably get told that it is made from flour. Some may tell you about water and yeast.
• Ask them whether they've ever seen bread dough rise. It rises because of bubbles of gas. This gas is made by yeast.
• Show them some yeast and add about half a teaspoonful to some water and sugar in a plastic cup.
• Yeast is alive (it's a fungus) and when you add water to the dried yeast it starts growing again. Yeast are little round creatures (if the kids are old enough to know what a cell is, they have one cell) and they grow, getting bigger, and then a new yeast buds off the side of the old one.
• Inside bread there isn't much oxygen so the yeast can't breathe oxygen to allow them to produce energy like we do. Instead they use 'fermentation' of the sugar that you gave them. This produces a gas called carbon dioxide (and ethanol/alcohol). This gives the bubbles that you get in bread.
• Add flour to the water and yeast mix and get the child to mix them together to form dough.
• Did they notice how the dough went stringy as they kneaded/mixed it? Why is that? Flour contains some proteins that make gluten when water is added, and as you mix the dough these all line up becoming more stretchy. This traps the bubbles of gas made by the yeast so the dough rises.
• Mark the level of the dough on the plastic cup. Tell them to come back and look at it later, but also show them some from earlier that have risen. If parents want to take dough then they can (but don't encourage it), but stress that it's not edible because it was made in a lab.
• Ask if they want to see something else? If yes, have a look at the balloon demonstration.
• Put some warm water, sugar and yeast in a 500 ml drinks bottle
• The yeast will use the oxygen in the bottle first, and then start fermenting the sugar to produce carbon dioxide
• This will increase the volume of gas in the bottle and inflate the balloon
• You may need these on a 'conveyor-belt' system where you set one up with a group but show them the previous group's one which is hopefully partially inflated.

Use trays as 'workstations' to contain the mess. Throw well-risen dough out after a few hours again to reduce mess.

Yeast & bread making Risk Assessment

Last updated: 10/02/2017 - 00:37

DESCRIPTION	Mixing dried yeast with sugar and water to inflate balloon over neck of bottle. Mixing dried yeast with sugar, water and flour to make bread dough.
RISKS	• Dough produced is not edible, as the kids' hands will not be clean and it is in a lab • Wet or floury surfaces – slip hazard • Risk of electrocution if water mixes with electricity from electrical experiments close by • Possible risk of allergy to flour or yeast • Risk of cuts from broken plastic, yeast tin lids etc. • Possible choking hazard if child tries to eat balloon or inhales flour
ACTION TO BE TAKEN TO MINIMISE RISKS	• Stop kids eating the dough, and tell parents of small kids it isn't clean. • Clear up any spills immediately. Use containment trays for the experiment. • Keep experiment away from any plug sockets or experiments involving electricity. • Demonstrator to ask about allergies to flour or yeast before commencing experiment. • Supervised use only. Demonstrator to dispense yeast and dispose of any broken plastic cups/spoons. • Keep only the balloons in use on display and make sure that children don't eat them, don't let children eat dry flour either and be careful not to knock it over and cause a flurry of flour dust.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• In case of injury call first aider. If dough ingested inform parents and advise them to take child to GP if they become ill. • If child is choking get parent to slap firmly on back and find first aider.

Last updated: 06/02/2017 - 19:44

Horrible Housemates

Biology: Jars of all sorts of horrible house pests; bugs, flies, worms and more!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Jars of preserved pests
A magnifying glass
Key with descriptions of each insect (below)

Explanation

*** OVERVIEW ***

Children will look at lots of jars of pests that we share our houses with, try to identify them, and learn a few things are each pest.

Other things to talk about:
1) What makes the animal a pest?
2) Where does the pest live in a house? How is the pest adapted to the environment in the house?
3) What is the life cycle of the pest?
4) What is the actual problem with having this pest in the house (perceived vs. actual)?
5) Taxonomy

Tips for demonstrating:
1) Always count the total number of insects you have on display before you start demonstrating…make sure that none of these disappear during the day (they roll away very easily)!
2) Ask them to look at their fingernail or a hair under the magnifying glass – this will give them a better concept of scale and show them how much more detail you can see under the magnifying glass!

*** BASIC PROCEDURE AND EXPLANATION ***

1) Ask the child to choose a sample on display that looks interesting to them. Then go through the following questions with them:
2) What do you think this is?
3) Where do you think it might live in your house? Why would it like to live there?
4) Do you want this living in your house? Why (not)?
5) Allow them to look at the sample under the magnifying glass.

See explanations for each insect/pest below

*** OTHER THINGS TO TALK ABOUT ***

Discuss the life cycle of each pest
o Egg
o Larvae (goal = eat and grow!)
o Pupae (undergoes metamorphosis)
o Adult
Discuss Taxonomy

*** SCIENCE BACKGROUND FOR DEMONSTRATORS ***

Good website discussing taxonomy: http://www.earthlife.net/insects/classtax.html

Key with descriptions for each insect

1) Grain Weevil:
Location = packet of cereal/bird seed/pasta in your food cupboard
Why does it live there? (Source of food)
Lays eggs inside the grain
Do you want these living in you house? Why not? (They eat your food!)
Interesting facts:
o Grain weevils can't fly…but are tireless walkers
o Live 7-8 months
o You can recognize them by their elongates snout
o When disturbed, they fake death by drawing up their legs close to their body, falling, and remaining silent
o About 4mm long

2) Seed Beetle:
Location = in garden
Why does it live there? (Source of food – lays eggs in certain types of seeds)
Do you want these living in your house? Why? (It depends on what kind of seeds the specific species of seed beetle destroys (i.e. can be used to control weeds by eating their seeds))

Interesting facts:
o More than 900 species
o Size <5mm long

3) Larder Beetle:
Location = cured meats in the kitchen
Why does it live there? (They eat meat and plant material)
Do you want these living in your house? Why not?
o No – they eat your food
o Larvae will bore into wood, cork, or insulation to find a place to pupate
Interesting Facts:
o Length is up to 13mm
o Larvae like the dark
o A female lays 200 eggs in a lifetime
o They spend winter outdoors and come inside in spring to lay eggs
o They are attracted to light and often are found near windows

4) Flour Beetle:
Location = bag of flour in your kitchen
Why does it live there?
o It eats the flour
Do you want these living in your house? Why not?
o No – it eats your food!
o Badly infested flour is characterized by a sharp odor and moldy flavor
Interesting Facts:
o Also known as a bran bug

5) Blowfly
Location = uncovered food in the kitchen
Why does it live there?
o It lays its eggs on uncovered meat and fish (i.e. decaying food in your garbage can)
Do you want these living in your house? Why not?
o Flies can transmit diseases (such as dysentery)
o Can destroy your food if they lay eggs on meat you are planning to eat
Interesting facts:
o Also known as blue bottles
o Were once used to eat dead tissue and promote healing

6) Aphid:
Location = pot plant
Why does it live there?
o Aphids feed on the plants
Do you want these living in your house? Why not?
o No – they eat/destroy your plants!
Interesting Facts:
o Over 4,000 species of aphid in the world
o The females of many aphid species do not have to mate in order to reproduce and they typically produce live young, rather than eggs
o Ladybugs eat aphids, and therefore are often used to protect your houseplants or garden!
o Signs of an aphid infestation include honeydew or sooty mould on leaves, yellow spots on upper leaf surface, cast skins on leaves, curling of leaves, and distortion of new growth

7) Fruit fly:
Location = around your fruit bowl
o Fruit flies feed on fruit
Do you want these living in your house? Why not?
o No – they eat fruit!
Interesting Facts:
o Over 1,500 species of Drosophila in the world
o Useful to biologists (a model species) because they are small and thus take up little lab space, they are easily cultured, they have a short generation time, they are extremely fertile and they have easily observable phenotypes.
o Life cycle of Drosophila is made up of four stages: egg, larva, pupa, and adult
o Eggs are laid in a food source such as a rotting fruit and develop into larvae after about a day.

8) Locust:
Location = your garden
Why does it live there?
o It eats your plants
Do you want these living in your house? Why not?
o No – they eat your plants!
Interesting Facts:
o Locusts outbreaks can destroy entire crops of food, which historically has led to famine
o There was a recent plague in West Africa, which led to food shortages because crops were destroyed

9) Wasp:
Location = Garden
o Nest is made up of chewed wood fibres mixed with saliva
o Wasps secrete a chemical to repel ants from the nest
o Adult wasps feed on nectar and sweet fruit, but bring insects and caterpillars to feed the larvae
(Really nice simple diagram showing life cycle of the wasp colony can be found at
http://www.waspcontrol.co.uk/wasp-lifecycle.php)

10) Caterpillar:
Location = garden
Why does it live there?
o It feeds on the plants
Do you want these living in your garden? Why not?
o No – it destroys plants

11) Mealworm:
Location = kitchen
Why does it live there?
o Source of food – eats grain
Do you want these living in your house? Why not?
o No! It eats your food.
Interesting facts:
o Not really worms, but larvae of the Darkling Beetle

12) Tick:
Location = on pet
Why does it live on pets?
o Pets provide a source of food (blood meals)
Do you want ticks living in you house? Why not?
o Transmit disease such as Lyme disease, ehrlichiosis, babesiosis, rocky mountain spotted fever, tularemia, and tick-borne relapsing fever
Interesting facts:
o 850 species of ticks worldwide

13) Flea
Location = on your pet or a rat
Why does it live there?
o Source of food! (blood meal)
Do you want these living in your house? Why not?
o Fleas can carry diseases
o Fleas are uncomfortable for your pet (very itchy!)
Interesting Facts:
o The Oriental Rat Flea is believed to have caused the black death
o Have two eyes, yet can only see in very bright light
o Mouth has two parts, one for squirting saliva into the bite and one for sucking up the blood
o Can jump long distances (i.e. from one pet to another)
o Live up to a year

14) Louse:
Location = your head/hair
Why does it live there?
o Your head provides a source of food (blood)
Do you want these living in your house? Why not?
o They itch!
Interesting Facts:
o Wingless biting or sucking insects
o Eggs are called nits
o Head lice have been recovered from prehistoric mummies!

15) Bed Bug:
Location = bedroom
Why does it live there?
o Feeds solely on the blood of animals (i.e. you!)
Do you want these living in your house? Why not?
o Although they don't usually cause disease, they can cause skin irritation
Interesting Facts:
o Can't fly – but can move very quickly
o Adults can survive for more than a year without feeding
o They are active mainly at night and don't come out if there isn't a potential meal

16) Cockroach:
Location = your bathroom (near a pipe)
Why does it live there?
o Cockroaches like dark, damp, warm places
Do you want these living in your house? Why not?
o Cockroaches can contaminate food with certain bacterial diseases that result in food poisoning, dysentery, and diarrhea
o Cockroaches can cause childhood asthma
Interesting Facts:
o Cockroaches don't like lights – they will run away from sources of light
o Cockroaches are nocturnal
o Cockroaches can survive without their heads for over a week - they breath through spiracles (holes in their exoskeleton) so don't suffocate without heads, but die of dehydration, they also don't bleed to death as they have open circulatory systems (unlike our high pressure systems)

17, 18, 19) See below

20) Slug
Location = Garden
Why does it live there?
o Some feed on the leaves of plants. Others feed on earthworms or other slugs
Do you want these living in your house? Why not?
o No - the eat your plants and leave slime trails everywhere
Interesting Facts:
o Slime is secreted to stop slugs from drying out (desiccating) and attracts water (hygroscopic)
o Slime trails can be used for slugs to find each other (e.g. for mating) or for carnivorous slugs to find slugs to eat
o Slime trails make it difficult and repulsive for predators to eat them
(o Humans control slugs by spraying nematodes (round worms) into the water, which then infect and kill the slugs. Slug pellets work differently causing the slugs to dehydrate - metaldehyde & methiocarb are the active ingredients in slug pellets. The first causes the slug to swell and the second causes damage to the mucus cells resulting in the over-production of mucus. (source the Naked Scientist)

Parasites
The kids will look at different parasites and learn how they cause disease in human/animal hosts.

Other things to talk about:

1) How are these parasites transmitted?
2) Where in the world are these diseases prevalent? Why?

Tips for demonstrating: Great for the "we've seen it all before" older kids.

17. ROUNDWORM:

R1) You can talk about how they live inside animals and sometimes humans - in their intestines.

R2) Ask the children if they know where their intestine is. If not, point to it on your body, and briefly explain what it is (food in through mouth, down into stomach, then into intestines, and out as poop).

R3) Then you could say that the life cycle for some human roundworms involves ingestion of eggs, hatching of eggs, the babies going out through your gut wall (because they're not big enough to live in the gut all on their own yet) and finding their way via the lymphatic system to the lungs.

R4) The baby roundworms aren't content to stay there, so they crawl up your lungs and "tickle," What would you do if something was tickling you inside your lungs? That's right, we cough the thing up. Then, once we've coughed, unless we spit out the phlegm, what do we do? We Swallow it.

R5) Roundworms go to intestine again, but by this time they're big, and they grow there.

R6) How do they grow? They eat. What do they eat? Your food in your intestines!

R7) How many do you think can live in your intestines? About 100 can live in one person.

R8) How do you think they make you feel? They can block your gut, cause pain, anaemia, and malnutrition.

R9) So - how do other people become infected? The roundworms produce lots of eggs, which you excrete in your feces (poop). If this gets on someone's hands/in their food (through poor sanitation/hygiene), they will get infected. Moral of the story: wash your hands after using the toilet!

18. FLATWORM (TAPEWORMS):

F1) Show the flatworm to the kids and explain that these flatworms infect cows and humans. How do they get infected?

F2) Show them the flatworm segments in the tube

F3) Explain that these segments are excreted in cow poop... because some of these segments are motile - they form a long sticky trail!

F4) Quite often, these segments are excreted onto grass, and another cow will become infected when it eats the grass.

19. LIVER FLUKES:

L1) These live in your liver, and make holes in it (like swiss cheese).

L2) How would this make you feel? Why do you need your liver? Explain how the liver detoxifies things that we eat, and without these toxins can build up in our body and harm us!

L3) The infection route is by eating of encysted juvenile form of the parasites. The parasites come out from the cyst when they reach intestine, then make their way to the liver and munch through for a living. Their eggs are released into environment with faeces.

L4) Animal infection with these parasite can cause troubles for sheep and cattle farming.

Horrible Housemates Risk Assessment

Last updated: 06/02/2017 - 19:44

DESCRIPTION	Looking at dead insects or other pests in small sealed tubes, talking about them and matching them to their home environment on a board
RISKS	• Smashing a specimen tube and magnifying glass can cause cuts, and the preservative to come out. Preservative is 1% Propylene phenoxetol, which should not be irritant to eyes or skin at that concentration, but which may be harmful if ingested. (If asked about the toxicity of propylene phenoxetol, mention that it is used as a preservative in personal care products and it is chemically inert.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Keep a careful eye on the tubes and magnifying glass, account for all specimen tubes every time a demonstration is completed. If necessary, reduce the number of tubes on display. Make sure all are tightly closed with sellotape on top of the seal to make it obvious that the tube should not be opened. Demonstrator must know the location of the nearest eyewash. • Make sure board is firmly attached to the desk, if not on the floor
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury. Wash skin with that has come into contact with preservative with water. If preservative gets into eyes call a first aider. Use eyewash to wash out of eyes if trained and confident to do so. • Unless large quantities ingested, recommend that parents take child to GP if child becomes ill, and state that 1% propylene phenoxytol was the substance ingested.

Last updated: 09/02/2017 - 23:42

Life cycles

Biology: Jars of specmens of frogs, bees and butterflies from different lifecycle stages

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Sets of preserved life cycles of frogs, bees, and butterflies.

Butterfly: Eggs (on a piece of cabbage), Larvae (caterpillars), Pupae, Adult butterfly
Bees: Larvae, Pupae, Male/drone, Worker, Female
Frog: Eggs, tadpoles, mature frog

A magnifying glass

Explanation

*** OVERVIEW/THINGS YOU MIGHT LIKE TO TALK ABOUT ***

- The life cycles of frogs, bees, cockroaches, and butterflies.
- Social structure of bee colonies and communication amongst bees
- Using stages of insect development to "date" a decomposing corpse
- Insect growth using the cockroaches

*** BASIC PROCEDURE AND EXPLANATION ***

1) Ask the child to choose a set of vials that they find interesting.

2) Once they have chosen a vial, ask them if they know what is inside the set of vials? (frog, butterfly, cockroaches or bees)

3) Next, say that this set of vials shows the life cycle of the butterfly/bee/frog. During this life cycle, the animal changes from an egg to an adult animal (which produces or fertilizes eggs which will go through the life cycle again).

4) You can then ask the child to try to put the vials in the proper order (egg -> adult) without looking at the numbers of the top of the vial. Once they have done this, you should go through exactly what is in each vial.

5) Start by describing the egg. This is one cell (a tiny ball of nutrient and information (DNA)) which divides lots and lots of times to produce larvae.

6) Next discuss the larvae. Emphasize how the larvae spends all its time eating and eating and eating! This is so it can grow really fast and store energy for metamorphosis!

7) Finally, explain the pupae stage - at this point the larvae undergoes metamorphosis and becomes an adult! What is metamorphosis? It refers to something changing from one form to another completely new form. Isn't it amazing that the larval form can change into the adult form in just about two weeks?!

8) After you've finished explaining the life cycle of the animal, you might ask the child if humans go through metamorphosis. Explain that while humans don't go through metamorphosis, we do change a lot in our mummy's tummy! We also go from an egg (one tiny cell smaller than the full stop at the end of this sentence) which divides lots of times to create a baby!

*** TIPS FOR DEMONSTRATING ***

1) Always count the total number of insects you have on display before you start demonstrating…make sure that none of these disappear during the day (they roll away very easily)!

2) Get out one set of vials at time to avoid overwhelming/distracting the children

*** OTHER THINGS TO TALK ABOUT ***

BEES
1) Social Structure of Bees (http://www.indianchild.com/honey_bee.htm)
- Each bee colony has a very organized social structure.
- Bees tell each other where food is through different dances.
- Males/drones:
- Develop from unfertilized eggs (parthenogenesis)
- Worker bees;
- Develops from fertilized eggs
- Female bee: Queen
- Develops from fertilized eggs
- Produces pheromones which controls the behavior of her workers
- Fed lots food!

2) Communication Among Bees (http://www.indianchild.com/honey_bee.htm)
- Bees communicate by pheromones (chemicals produced by the queen that the other bees "smell") and dances.

- This communication is very important to maintain the organization/social structure within the colony so that all of the bees can survive (the queen, workers, and drones cannot live alone - they depend on each member of the colony).

FROGS
1) Egg -> Frogspawn -> Tadpoles -> Frogs

2) Frogspawn is like jelly, provides a food source for the growing embryo (the black spot)

3) Tadpoles - sometimes eat each other (cannibalism)

) Tree frogs; where do they lay their eggs? - in the water collected at the bases of leaves. Are often brightly coloured and very poisonous (used to make poison arrows. The Golden Tree Frog is toxic enough to kill 20 people or two elephants, chickens and dogs have died from touching paper that has been touched by a frog!

BUTTERFLIES
1) Patterns/colouration - eye spots deflect attack from the butterfly's body , camouflage is another way of increasing the likelihood of survival allowing it to rest undetected

3) Forensic Entomology: (http://www.forensicentomology.com/appear.htm)
- Forensic Entomology examines the stages of develop of insects in a decaying corpse to determine when the body died!
- For example, many insects will lay eggs on a corpse. These eggs will hatch and become larvae, which feed on the decaying corpse. By examining the size/weight of the larvae, these scientists can determine how old the corpse is!

*** SCIENCE BACKGROUND FOR DEMONSTRATORS ***

More information on Forensic Entomology (http://www.forensicentomology.com/appear.htm)
"What information can a forensic entomologist provide at the death scene?"

Forensic entomologists are most commonly called upon to determine the postmortem interval or "time since death" in homicide investigations. The forensic entomologist can use a number of different techniques including species succession, larval weight, larval length, and a more technical method known as the accumulated degree hour technique which can be very precise if the necessary data is available. A qualified forensic entomologist can also make inferences as to possible postmortem movement of a corpse. Some flies prefer specific habitats such as a distinct preference for laying their eggs in an outdoor or indoor environment. Flies can also exhibit preferences for carcasses in shade or sunlit conditions of the outdoor environment. Therefore, a corpse that is recovered indoors with the eggs or larvae of flies that typically inhabit sunny outdoor locations would indicate that someone returned to the scene of the crime to move and attempt to conceal the body.

Similarly, freezing or wrapping of the body may be indicated by an altered species succession of insects on the body. Anything that may have prevented the insects from laying eggs in their normal time frame will alter both the sequence of species and their typical colonization time. This alteration of the normal insect succession and fauna should be noticeable to the forensic entomologists if they are familiar with what would normally be recovered from a body in a particular environmental habitat or geographical location. The complete absence of insects would suggest clues as to the sequence of postmortem events as the body was probably either frozen, sealed in a tightly closed container, or buried very deeply.

Entomological evidence can also help determine the circumstances of abuse and rape. Victims that are incapacitated (bound, drugged, or otherwise helpless) often have associated fecal and urine soaked clothes or bed dressings. Such material will attract certain species of flies that otherwise would not be recovered. Their presence can yield many clues to both antemortem and postmortem circumstances of the crime. Currently, it is now possible to use DNA technology not only to help determine insect species, but to recover and identify the blood meals taken by blood feeding insects. The DNA of human blood can be recovered from the digestive tract of an insect that has fed on an individual. The presence of their DNA within the insect can place suspects at a known location within a definable period of time and recovery of the victims' blood can also create a link between perpetrator and suspect.

The insects recovered from decomposing human remains can be a valuable tool for toxicological analysis. The voracious appetite of the insects on corpses can quickly strip the remains down to the bones. In a short period of time the fluids (blood and urine) and soft tissues needed for toxicological analysis disappear. However, it is possible to recover the insect larvae and run standard toxicological analyses on them as you would human tissue. Toxicological analysis can be successful on insect larvae because their tissues assimilate drugs and toxins that accumulated in human tissue prior to death."

Life cycles Risk Assessment

Last updated: 09/02/2017 - 23:42

DESCRIPTION	Looking at dead insects in small sealed tubes & talking about them
RISKS	• Smashing a specimen tube and magnifying glass can cause cuts, and the preservative to come out. Preservative is 1% Propylene phenoxetol, which should not be irritant to eyes or skin at that concentration, but which may be harmful if ingested. Propylene phenoxetol is a preservative used in personal care product and is safe.
ACTION TO BE TAKEN TO MINIMISE RISKS	• Keep a careful eye on the tubes and magnifying glass. If necessary, reduce the number of tubes on display. • Make sure all are tightly closed with sellotape on top of the seal to make it obvious that the tube should not be opened. • Demonstrator must know the location of the nearest eyewash.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury. • Wash skin with that has come into contact with preservative with water. • If preservative gets into eyes call a first aider. Use eyewash to wash out of eyes if trained and confident to do so. • Unless large quantities ingested, recommend that parents take child to GP if child becomes ill, and state that 1% propylene phenoxytol was the substance ingested.

Plant evolution & pollinator game

Biology: Plant evolution timeline and matching plants with their pollinators

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Evolution of plants: timeline on green mat, plant fossils, ginkgo leaves, set of cardboard tiles
Pollinator game: game tiles (x16) *Note, all pictures with copyrights or courtesy to someone other than CHaOS were sourced from Wikimedia Commons. The remaining 3 now belong to CHaOS.*

Explanation

Evolution of plants
A lot happened to allow cyanobacteria to evolve into the wide range of land plants we see today. This timeline shows some of the main points and key developments that give rise to modern plants

Expansion of the main points on the timeline (with tile number):

Cyanobacteria – are bacteria (prokaryotes) but they can photosynthesise (1, blue-green algae)
First eukaryotes – skip this point if the children haven't learnt about mitochondria and cholorplasts yet, if they have, explain that scientists think that eukaryotes evolved via symbiosis, with one bacteria engulfing another, but not digesting it. Chloroplasts were originally cyanobacteria engulfed by an organism that had mitochondria.
Multicellular organisms – again, may need to skip, otherwise discuss how bacteria have just one cell and that is the whole organism, whereas we have many cells, as do plants (13, anabaena) - this allows us to have specialised cells.
Primitive land plants – Explain that previously all organisms were in the water. Scientists think that the colonisation of land occurred only once, and that all land plants evolved from the Stoneworts (4, Charophyceae)
Liverworts – the first plants, still needed a lot of moisture, and live clinging to rocks in damp environments such as near waterfalls. Can be seen in Scotland still today (one is sketched on the timeline) (6)
Mosses – mosses have the first identifiable transport systems for water – xylem vessels. Can also explain the haploid/diploid thing here using standard wall moss – the green carpet part is the haploid and is the main part of the life cycle, the diploid emerges to spread spores and are on little stalks. (7)
Hornworts – developed the cuticle and stomata so are more independent of water than liverworts. All land plants except liverworts have these two features (9)
Next a true vascular system evolved that was capable of not only transporting water but also supporting the plant structurally, all other plants on land are 'vascular' (they have veins like us).
Club mosses – First plants to have leaves! Also developed roots which grew in the dark and needed photosynthate (sugars), so needed phloem too. (11)
Horsetails – Had a hollow stem surrounded by a ring of vascular tissue, were therefore light. Still survive today, but are much smaller than their ancestors (2)
Spore producing ferns – have proper complex leaves. Bracken, seen in most woodlands, is the most successful and widespread of all vascular plants. Reproduction is still water dependent. (3)
Then evolved all the seed plants!
Seed ferns – now extinct, but different to their surviving spore producing ancestors. See the fossils for examples, note the different leave shapes.
Cycads – the dinosaurs favourite food! We think some dinosaurs used to swallow pebbles to help them digest the tough leaves. (12)
Ginkgo – see the leaves, a living fossil in itself! (5)
Gymnosperms – mostly conifers (8). The have a novel method of growth, with an expanding ring of growing tissue round the outside of the stem. Both the largest organism and longest lived organism on Earth are conifers! Can they guess the largest? (Californian Redwood or Giant Sequoia, same tree)
200 MYA – insects evolved wings
Angiosperms (the flowering plants) – very exciting and the most diverse group of plants, still only evolved very recently (10)

Number order of photos:
1, 13, 4, 6, 7, 9, 11, 3, 2, 12, 5, 8, 10 (from most basal to most recetly evolved)

Plant fossil details:
All the fossils came from the Dover area and illustrate the horsetail point at 400 million years ago, NOTE, the ferns are seed ferns, which developed after seeds evolved, they are not the spore producing ferns we see today and evolved with the horsetails. The sketch of a horsetail on the timeline should help the children envisage what Annularia and Calamites looked like.
-Alethopteris: these are the leaves of seed fern (which are now extinct). The leaves are relatively long and thin and end in more of a point compared to neuropteris, see number 1.
-Neuropteris: also leaves of an extinct seed fern. These are the fat leaves with blunt, rounded ends, most of the leaves in the fossils are neuropteris.
-Annularia: also called Asterophyllites - don't think there is a difference. These are the leaf whorls of an extinct horsetail. (The leaves are spread concentrically about a point). There is only one of these in the fossils, next to number 3.
-Calamites: the stems of the horsetail. Can be recognised by the segmented stems. These are related to the modern horsetail. See number 2 for some well segmented ones, but also the largest one.

Ginkgo facts:
The leaves are from the Dept of Plant Sciences.
It is the species Ginkgo biloba (maidenhair tree) and has no living relatives! It even has its division (equivalent to an animal phylum). Phylum is the next classification step down from Kingdom, so to illustrate how different it is, you can explain that within the animals there are the 'chordata' (or vertebrates). Ginkgo is as different to a fellow plant as vertebrates are to invertebrates, e.g. tigers and insects!
Expansion of the main points on the timeline:

Major developments in the evolution of plants:

1) Multicellularity
Plants have different tissue types, like we do, so needed to be made up of more than one cell.

2) Cuticle
Once out of the water, plants needed to avoid drying out, so they evolved a waxy layer that prevented water loss (C)

3) Stomata
This waxy layer is a barrier to gas exchange – plants need carbon dioxide for photosynthesis so they evolved little openings in the cuticle to let carbon dioxide in and oxygen out (E)

4) Xylem
Plants needed to transport water from the base if they were going to be able to grow upwards, xylem allow for water transport (see coloured flowers demonstration). Xylem also provide support for upward growth as they are reinforced with lignin (G,I)

5) Phloem
Some parts of the plant are underground, and hence can't photosynthesise, so need sugar delivered to them, phloem tubes transport these sugars (D,I)

6) Roots
Plants have had some kind of anchoring since the movement of plants onto land, initially role fullfilled by fungi, but in order to grow up, plants first had to grow down. (F)

Xylem, phloem and roots all evolved at roughly the same time, with all three features supporting each other, there is also confusion due to the limited evidence provided by the fossil record (roots particularly fossilise poorly). Leaves evolved multiple times, early leaves (microphylls) had a single vein, whilst the leaves we recognise today (megaphylls) evolved on four independant occassions (in the ferns, horsetails, progymnosperms, and seed plants)

7) Dominant sporophyte
Previously the haploid phase (like our sperm) had been the main part of the life cycle, but these need a lot of water, there needed to be a switch to the more resilient diploid (like us) in order to develop further

8) Seeds
As the world dried out 250 million years ago, plants needed to protect their 'eggs' and evolved seeds (A)

9) Pollen tubes
These allow the pollen to grow down to the egg and fertilise it (and can be seen in another demonstration) (B)

10) Showy flowers
Once flowers had evolved, they could be adapted to as many different forms as there were pollinators (see the pollinators game) (H)

Pollinator game
Flowers are a plant's way of manipulating somebody else, usually an animal but sometimes the wind, into carrying its pollen around for it.
Start by asking them to think of pollinators, they'll probably say bees. Then introduce the other forms – and show them the tiles (1-8).

A few facts:
• There are between 250,000 and 400,000 species of Angiosperms (flowering plants)
• That's roughly a sixth of the total number of living species currently known
• Aside from the insects, the Angiosperms are the group with the most species

They are so diverse because, once you've mastered the ability to manipulate somebody, you can radiate into as many different sorts as there are different somebodies to manipulate.

Then ask them to match up the flower to the pollinator. Note – you may have to tell them some of their guesses are good particularly between beetle and moth as the key difference is not apparent just by looking. You may like to tell them at the start that C (the gardenia) opens at NIGHT to distinguish it from G.

More detail on the tiles:
1 = Birds (This one is a female hummingbird, species Thalurania colombica)
2 = Bees (Buff tailed bumblebee – Bombus terrestris)
3 = Beetles (pollinating beetles are small, these are Mordellidae beetles)
4 = Moths (Peppered moth – Biston betularia)
5 = Bats (Mostly fruit bats)
6 = Wind
7 = Fly (generic diptera is pictured)
8 = Butterfly (Red admiral)
A = Snapdragon (antirrhinum)
B = Grasses
C = Gardenia, note this flower has a distinctive scent at nighttime
D = Buddleia davidii (aka the butterfly plant, but that gives it away, normally call it Buddleia)
E = Red columbine
F = A Compositae flower, part of the daisy family (Asteraceae), Bellium bellidiodes
G = Magnolia
H = Jade vine, Cambridge Botanic gardens
ANSWERS:
A = 2, B = 6, C = 4, D = 8, E = 1, F = 7, G = 3, H = 5

Extra Idea for the Game (from summer tour 2013) - Make it vaguely competitive. Go through each of the different types of flowers and say what would be attracted to them. Don't go through the pollinators. Or do that vice versa. Then get them to match up the flowers to the pollinators as fast as possible. 15 second time penalty for every wrong answer. Keep track of the times for the day, as it gives this added excitement. From my vague recollection, the best time was around the 1 minute 15 second mark...

More details:

The concept of a broad association between flowers and the types of animals that pollinate them is called a pollination syndrome.

A pollination syndrome classically describes a suite of adaptations shown by a plant to a particular group of animals, usually a taxonomic order, and by those animals to a particular group of flowers, which may not be phylogenetically related to each other. The adaptations shown by the animals may be behavioural or morphological, while plants can only show morphological adaptations to animals.

Can they think of another method? There is also deceit pollination, where flowers pretend to be something, e.g. a bee in the case of some orchids. Or where flowers mimic those of another species but do not actually contain nectar so trick the pollinator into collecting pollen for free.

A = 2
Bee pollination (Melittophily)
Bees carry pollen on their bodies in a range of increasingly specialised structures from simply having hairy feet to having pollen baskets on the hind legs. Then they groom this pollen off and feed it to their larvae. Bees can see in ultra violet, blue and yellow, but not in red. They have the ability to perceive depth, and they usually have long tongues.
Bee flowers are usually quite big to bear the weight of the animal, and often have a landing platform. Bee flowers are usually brightly coloured. Yellow and blue are considered classic bee colours, but in fact many bee flowers are red despite the inability of bees to see red. The presence of UV absorbing pigments presumably modifies the red to a colour that is visible. Bees are sensitive to nectar guides, which enable them to handle the flowers more quickly by directing them straight to the nectar. Examples: snapdragon, nettles.

B = 6
Wind pollination
Wind pollinated plants do not have showy flowers, but instead have very large stamens and feathery stigmas to catch pollen from the air. This method is much less precise than using insect pollinators and requires the plants to make much larger quantities of pollen, although needs to investment in nectar (the reward to animal pollinators).

C = 4
Moth pollination (Phalaenophily)
The flowers are often white, which stands out well at night, and may close completely during the day. The moth usually hovers alongside the flower, which is bilaterally symmetrical with the rims bent backwards. Like butterfly flowers, moth flowers have nectar in long tubes. Another characteristic of moth flowers is the large quantity of nectar produced, as moths have higher energy requirements of the moth - hovering is a great deal more energy consuming than landing. Moth flowers usually attract pollinators by a strong scent, which can be quite overwhelming when the flowers open at night. Examples: gardenia, some honeysuckles.

D = 8
Butterfly pollination (Psychophily)
Butterflies usually alight on flowers, and psychophilous flowers have flat structures, held horizontal. Butterflies have long tongues, often 1 to 2 centimetres, and butterfly flowers have nectar in enclosed tubes, which can be quite deep. Butterflies have good colour vision, and can see red, so butterfly flowers are usually brightly coloured. Examples: Daisies, Buddleia.

E = 1
Bird pollination (Ornithophily)
The classic pollinating bird is the humming bird, which is American, but a variety of other groups also feed on nectar, including the African sunbirds, Australian lorikeets and American honey-creepers. Hummingbird pollinated flowers are either pendant or stand out so that there is free space for the animal to hover in. Sunbird pollinated flowers have a perch with the flower facing towards it. Bird flowers are usually either brush or tube shaped, and the nectar is secreted into spurs, which are usually shorter and wider than those on butterfly flowers. They also have to be quite tough, as a beak is both stronger and harder than a butterfly tongue. One of the key features of a bird flower is the quantity of nectar secreted. They produce very large quantities of a very concentrated nectar, so much so that it will actually drip from the flowers at certain times of the year. Ornithophilous flowers are almost always red, often with contrasting yellow markings. Unlike most insects, birds can see red, and in fact can't see ultraviolet. Examples: red columbine, poinsettia, eucalyptus, hibiscus, passion flower.

F = 7
Fly pollination (Myiophily)
The Diptera, the fly order, show the greatest variation in methods and habits of pollination of any group of insects. Many plants flowering in adverse conditions or at odd times of the year can be entirely dependent on flies for their pollination, as they are the only group of insects which are not strictly periodic. Because they do not feed their offspring they do not require much food, and so myiophilous flowers need supply only a small quantity of nectar. Flies are more visual animals than beetles, and have a positive preference for pale and yellow colours, and for nectar guides. Fly flowers do not often have much scent but they are usually palely coloured. Examples: Umbilliferae, Compositae.

G = 3
Beetle pollination (Cantherophily)
This is widely believed to have been the first pollination syndrome, the one used by the first Angiosperms, as the Coleoptera, the beetles, constitute one of the oldest groups of insects and were already numerous at the time that the higher plants came into existence. Beetle pollinated flowers provide extra pollen and nectar in a flat surface. Beetles do not have good colour vision, but rely heavily on scent. Beetle pollinated flowers are usually greenish or off white in colour, with a strong fruity smell. Examples: Magnolia, lilies, wild roses, poppies.

H = 5
Bat pollination (Chiropterophily)
A quarter of all bat species use flowers for food to some extent. The anthers of bat flowers open at night, and the flowers often only last one night. The flowers are usually white to cream or sometimes a greenish pink colour. Bats are colour blind, so strong colours are not relevant. The main attractant is scent. Bat flowers generate a very strong scent. Bat flowers produce the most nectar of any flower type - up to 15 millilitres at a time. A few bats have become totally dependent on flowers, and eat pollen as their only protein source. The flowers have to be very large and strong, with narrow tubes or bowls from which to lap nectar. Because the bats have to find the flowers at night they are not usually within the foliage, but either hang below it for easy access or actually develop on the trunk of the plant itself. Examples: cacti, Bignoniaceae.

Plant evolution & pollinator game Risk Assessment

Last updated: 09/02/2017 - 23:58

DESCRIPTION	2 metre long fabric timeline, plant fossils, ginkgo leaves, 22 selotaped card tiles and 16 polystyrene game tiles.
RISKS	• Trip hazard if timeline placed on floor • Scratching/poking from the card tiles • Dropping fossils could cause injury to feet • Dropping fossils may cause them to shatter, producing shale dust
ACTION TO BE TAKEN TO MINIMISE RISKS	• Place timeline in safe place if on the floor – i.e. not across a likely walkway, and ensure children do not walk/run across it • Don't allow anyone to throw the tiles, keep them flat on table/floor

	• Hold fossils over a table or close to the floor (when sitting on the floor) • Keep fossils in clear plastic bags for protection and to prevent dust if breakage occurs
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Contact first aider if injury • Clear up broken pieces and bag them in a plastic bag ASAP

Last updated: 09/02/2017 - 23:50

Model cells

Biology: Box of model cells

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

3 x model cells in small blue box

Explanation

Model cells can help to explain that the units of living things are cells. (You can explain this by saying that a living things is made out of cells like a house is made out of bricks).

The box contains 3 model cells:

• "Cushion" model cell, showing various organelles, including wool for DNA in the nucleus. (This cell was made by Isobel and Lara before 2010).
• Inflatable animal cell, showing various organelles (includes laminated sheet of notes)
• Inflatable plant cell, showing various organelles (includes laminated sheet of notes)

These cells are often used with microscopes and kiwi DNA, and can be split between a number of different biology experiments at an event.

Some biology to talk about (copied from the experiment Microscopes & Cells)
- Cells are very small (typically 10 um for an animal cell... that's 1000 times smaller than 1 cm (you can use the ruler to show 1 cm)
- Cells are analogous to a building brick - houses are built of lots of bricks, like people are built of lots of cells (50-75 trillion!)
- Cells aren't just bricks - they are alive, and make things, use things, and process information
- Have a phospholipid membrane – barrier to extracellular environment
- Nucleus is the 'control centre' - contains instructions on how to make proteins, from which the rest of the cell is made. Instructions are written in a 4-letter code on very long molecules called DNA (see Kiwi DNA experiment). DNA to mRNA (transcription), transported out of nucleus, translation on ribosomes to proteins. Proteins go to the ER (endoplasmic reticulum) for further folding, then to Golgi apparatus (more modifications), then on export pathway to exit the cell.
- Cells need energy - this is supplied by mitochondria (they convert energy from sugars into ATP, the energy currency of the cell)
- Plant cells - cell walls and chloroplasts (we have a root tip squash slide where the cell walls are visible and the nuclei are nicely stained, but they don't have chloroplasts because it's a root. If they want to see more plant cells, there's a whole demo on plants...)
- Bacteria are also cells, but they are smaller and don't have a nucleus (associate bacteria with disease e.g. food poisoning caused by E. coli). Bacteria can be lots of different shapes (look at E. coli, Staphylococcus, Spirillum).

Model cells Risk Assessment

Last updated: 09/02/2017 - 23:50

DESCRIPTION: Model cells

RISKS
1. Trip hazard if dropped on the floor
2. Risk of injury to demonstrator blowing up inflatable model cells

ACTION TO BE TAKEN TO MINIMISE RISKS
1. Keep all props in contained area
2. Demonstrators with respiratory conditions should avoid inflating cells

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury

Last updated: 08/02/2017 - 23:38

Exploring genes

Biology: Props to explain DNA and molecular biology, including a plastic DNA gel!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

• DNA model (in clear plastic box). The model uncoils, and can be split into two strands. There's a round black stand for this is the box too.
• 2 x plates of plastic bacteria. The GFP plate can be used to explain how you can insert useful genes into an organism (and it glows in the dark!). The pBlue plate can be used to explain how you can select a colony with the right gene it if you're doing cloning
• Box of lab plastic ware (falcon tubes and eppendorfs), which can be used to show how molecular biologists use small volumes in the lab
• Pipette (20 ul Gilson, on loan so please take care of it!)
• Pipette tips (1-20 ul)
• 2 x model gels, plus "tank" (use with crocodile clips and laminated sketch of battery to describe running the gel)
• Coloured dye for gel (use only 1-2 ul when you load each lane)

Explanation

"Exploring genes" is a box full of props that molecular biologists can use to talk about how you can actually work with DNA in a lab. All this kit was been bought just before the 2011 Summer Roadshow, so we haven't figured out all the best stories you can use it to tell quite yet. We're expecting it to be useful to for demonstrators who've got enough lab experience to be able to talk about the basics of DNA. The notes in kiwi DNA are probably useful to help get the right level for the public. Please add some notes if you've demonstrated this to help this to help us write up some more detailed notes for the next CHaOS event.

Suggested activity 1: Play with DNA model
- DNA is a chemical which encodes genetic information, these units/words of genetic information are genes. Genes are units made of DNA
- Genes are (mostly) instructions for making proteins
- 46 DNA molecules per human cell nucleus (23 chromosomes, two of each pair, one from each parent).
- Helix is about 20 x 10-10m wide, about 2m of DNA per human cell
- Shape is double helix, as two strands wrap around each other
- Structure of double helix discovered partly from work in Cambridge (Francis Crick & James Watson in 1953, with help from Maurice Wilkins and Rosalind Franklin in London)
- Straighten out, looks like a ladder
- Sides are ladder stay the same and protect the steps - information is in variable steps of the ladder
- Colours of steps: there are only 4. 4 letters in the DNA alphabet.
- Base pairing - only certain pairs allowed. This enables one strand to act as a template for another.
- Split first few base pairs, as DNA makes a template for itself, can make two identical molecules.
- As DNA can replicate exactly, enables one cell to divide into two daughter cells with identical genetic material.
- This is how all our body cells can have the same DNA!

Suggested activity 2: Loading model gels
- Show them the small tubes and pipettes- we've moved away from glass test tubes in molecular biology!
- Set up two tupperware tubs, one "gel tank", one for rinsing
- Fill "gel tank" above level of toy gel
- Load 1-2 ul of coloured dye, is a couple of wells
- "Run" gel, well not quite, but attach picture of battery to top (+ near wells) + bottom (-) of the tank
- Show second gel with bands to show how DNA fragments move according to size (small ones move fastest through gel)
- See notes in box on gel electrophoresis and DNA fingerprinting

Exploring genes Risk Assessment

Last updated: 08/02/2017 - 23:38

DESCRIPTION	Exploring genes props
RISKS	• Trip hazard if dropped on the floor • Staining clothes/skin with dye • Tips could cause injury to hands and eyes
ACTION TO BE TAKEN TO MINIMISE RISKS	• Keep all props in contained area • Demonstrator only to use dye with care • Demonstrator keep tips in box, and dispose of in 'Tip' box
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• Call first aider in case of injury • Wash affected area • Call first aider

Last updated: 10/02/2017 - 00:10

Tree

Biology:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Lumps of wood in a small grey box

Explanation

OLD VERSION

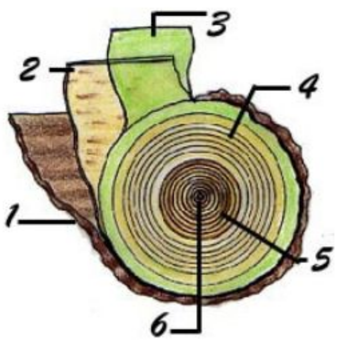
A small grey box filled with a various bits of tree. For keen plant scis mainly, but we think you could use it to explain transport of water/nutrients in the xylem and sugars in the phloem. You can also talk about aging a tree by counting the number of rings present, and how you can tell when the tree lived by comparing the relative size of each ring to trees of known age (thicker rings correspond to favourable growing conditions, while thinner rings correspond to a harsher climate).

NEW VERSION

Tree trunks – general facts and information – *don't worry, you won't get too much stick for knowing this…*

References - Many thanks to http://www.forestry.gov.uk/website/pdf.nsf/pdf/GrowingGreenActivityPack-Trunk.pdf/$FILE/GrowingGreenActivityPack-Trunk.pdf for a lot of information. Also usual thanks to Wikipedia (especially the bamboo article, and for half the pictures).

The structure of a tree trunk



1. The outer bark protects the tree from extreme temperatures, bad weather, insects and fungi.
2. The phloem (bast) is also called the inner bark. It conveys the food-bearing sap developed in the leaves down to the various parts of the tree.
3. The cambium is a thin layer of cells, which produce phloem on one side and xylem (sapwood) on the other.
4. Sapwood is the living wood in the tree through which the raw sap rises from the roots to the leaves.
5. The heartwood consists of old cells. This is the dead part of the tree that nevertheless provides structural strength.
6. The pith is the central core of the tree (missing in many species).

In areas where there are pronounced seasons, tree form new cells, arranged in concentric circles called annual rings or annual growth rings. These annual rings show the amount of wood produced during one growing season. Rings are made up of a light and a dark band. At first, the cambium produces numerous large cells with thin walls that form the springwood (earlywood). If you look at a cross section of a tree, this is the light-coloured band. The function of springwood is to help the transport of water to the buds. Then, towards the end of the summer, growth slows down. The cells manufactured at this time of year are small, with thick walls. They form the summerwood (latewood) which appears as a darker band on the tree cross section. This wood is primarily for support and strength.

The darker wood is not formed in winter, as some people believe, because the cambium is completely inactive in the winter.

The following year, a new two-part ring is added. The older rings are closest to the centre of the tree. The tree grows in diameter because it manufactures new cells around its circumference, not because the old cells get larger.

The old annual rings form the heartwood of inactive cells: this is the dead part of the tree. The live portion includes only the most recent rings. Depending on the tree's age and species, this portion is 1.5 to 7.5 cm wide. The dead wood is the largest part of the tree. Often, it takes on a darker colour.

Rings are narrower in years of low rainfall. The three main things we can tell from tree rings are
1. Age of the tree
2. Clues to the growth of the tree and factors affecting it e.g. reaction wood, fungal attack, where branches grew (knots), site conditions
3. Past weather patterns, particularly rainfall.

Bark facts – *I wouldn't want you to bark up the wrong tree*

• The bark is essential for protecting the tree against animals, fungi, disease, and from drying out.

1. Things growing on the bark

green furry moss

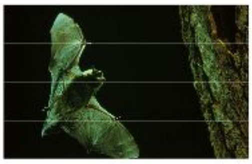
feathery lichens

fungi

Signs of things living in the trunk

round woodpecker hole

larger hollow for an owl



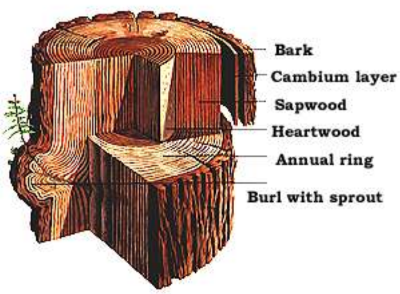
loose bark where bats can roost

• For most trees, when the bark is damaged, it allows a way for fungi and disease to get into the tree, affecting the health of the tree. Tree sap will ooze out of the cut and harden in an attempt to seal the damaged area. However, if the bark is stripped off all around the tree, most species of tree will die.
• Cork oak trees can survive the outer bark being stripped halfway around the trunk as it will regenerate.

Cork Oak trunk section

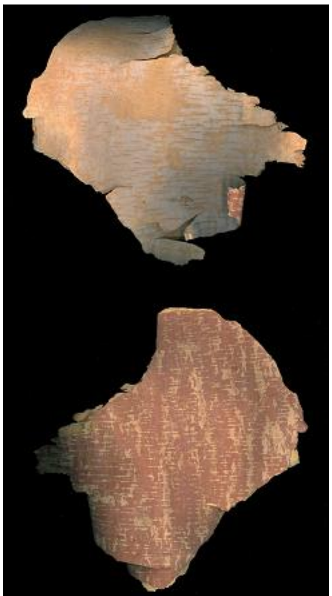
• The Wellingtonia, or giant redwood, has spongy, fibrous bark that can be up to 30cm thick. It's fireproof - protecting the tree from forests fires

The Redwood Tree



Costal Redwood bark

• The bark of many young trees is fairly smooth – it develops cracks as it grows older
• The horizontal dashes seen in birch bark are called lenticels. They are pores that allow gases from the air to reach the wood beneath. All plants take in gases through their stems /trunks as well as their leaves. You may notice that birch bark peels off naturally. When the lenticels become blocked with algae or pollution, fresh bark is grown beneath, allowing the old bark to peel away, cleaning the trunk.
A birch tree -



Birch Tree Bark (front and back)

Trunk facts – *stemming up with new ideas…*
• The centre of the trunk is called heartwood. It is very strong and enables the tree to grow tall, supporting the weight and spread of branches. This gives the tree an advantage as it gains good access to sunlight, shading out the ground plants below.
• Each year the girth of a tree increases, a new ring grows just under the bark, and this is necessary to support the extra height and spread of longer / new branches.
• The trunk also houses the transport network of the tree. There are two different types of tubes running up the length of the trunk – phloem that carry food-bearing sap, and xylem that carry the water and minerals from the roots up to the leaves.
• A mature oak tree can absorb 50 gallons of water in a day – that's the equivalent of 227 litres, or 689 cans of lemonade! On a hot day it can be more than this.
• The tallest tree in the world (an therefore the longest trunk) is called 'Hyperion' - a coastal redwood 115.5m high.

Hyperion-lookalike

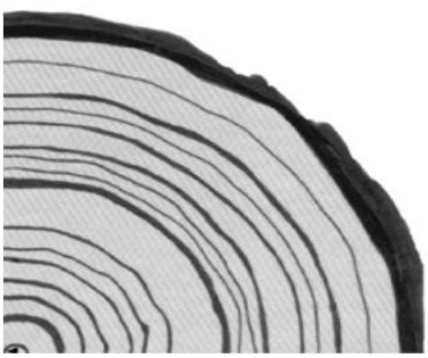
• The type of tree with the largest trunk (the greatest volume of wood) is called ‘General Sherman’ – a giant redwood or wellingtonia

General Sherman

Story of a tree’s life – *you are in for a treet*
Examining tree rings to tell the story of how a tree grows

Dendrochronology is the dating of past events (such as climatic changes) through the study of tree ring growth. A tree’s growth can be affected by rainfall, sunlight levels, wind, temperature, soil properties, snow accumulation and competition from other trees.

Using the wood, what can you find out about the tree’s life? Each year a tree grows a new ring just beneath the bark. Each ring is made up of two bands:
• A light band (the quick growth of spring)
• A darker band (the slower growth of late summer)



Not every annual ring is the same:
• In warmer, wetter years, trees grow well so the ring will be thicker

• In colder, drier years, trees do not grow so well so the ring will be thinner.
• If the rings are narrow on one side of a tree with wide rings on the other, the tree was either crowded on the side of the tree where the rings are narrow or exposed to the wind.
• The side with wider rings shows the tree had more space to grow or was sheltered from strong winds.

BAMBOO

Time to branch out a bit…

Brief(ish) version:

Stop pining for better jokes

1. Bamboo is actually a grass and not a tree, but it is very woody and very strong (some is apparently stronger than steel).
2. Each bamboo stick typically grows in one season only – it does not have branches, gets no wider the older it gets (as it appears at the diameter it will be), and reaches a maximum height in that one growing system.
3. There is a mass of interconnected roots, called the rhizome, under the soil, from which all the bamboo sticks appear from.
4. The middle hollow bit essentially acts as the xylem – that is the root up which all water flows from the rhizome.
5. Every so often, certain flowing bamboo flower – though this can be 65 to 130 years apart. They seem to flower all together at the same time, no matter what the climate is or where they are in the world – like an "alarm clock). The adults then die after flowering as they spent all their energy in making the fruit.
6. One hypothesis why is that if an area is flooded by huge numbers of seeds, then at least some will survive predators eating them, and so make a new generation. Furthermore, as there is such a long time between mass flowerings, it is longer than the lifespan of things that may eat the fruit, so they will die of starvation waiting for the next flowering.
7. Fire cycle hypothesis is a different version – the mass flowering and death creates a disturbance in the force, I mean in the habitat, allowing the seedlings a gap to grow in, as dead bamboo is very flammable and so there is an increase in the likelihood of wildfire. As bamboo is a very fast grower, they can outcompete and so grow up very rapidly indeed.

Long version (courtesy of Wikipedia):

Time to turn a new leaf

"**Bamboo** Listeni/bæmˈbuː/ (Bambuseae) is a tribe of flowering perennial evergreen plants in the grass family Poaceae, subfamily Bambusoideae, tribe Bambuseae. Giant bamboos are the largest members of the grass family. In bamboos, the internodal regions of the stem are hollow and the vascular bundles in the cross section are scattered throughout the stem instead of in a cylindrical arrangement. The dicotyledonous woody xylem is also absent. The absence of secondary growth wood causes the stems of monocots, even of palms and large bamboos, to be columnar rather than tapering.

Bamboos are some of the fastest-growing plants in the world, due to a unique rhizome-dependent system. Bamboos are of notable economic and cultural significance in South Asia, Southeast Asia and East Asia, being used for building materials, as a food source, and as a versatile raw product. High-quality bamboo is stronger than steel, a property that has made it a choice in building materials and weaponry.

##############
Aside – rhizome – *bet yew never knew this!*

In botany,[dendrology], a rhizome (from Ancient Greek: rhízōma "mass of roots", from rhizóō "cause to strike root") is a modified subterranean stem of a plant that is usually found underground, often sending out roots and shoots from its nodes. Rhizomes may also be referred to as creeping rootstalks or rootstocks. Rhizomes develop from axillary buds and are diageotropic or grow perpendicular to the force of gravity. The rhizome also retains the ability to allow new shoots to grow upwards.

If a rhizome is separated into pieces, each piece may be able to give rise to a new plant. The plant uses the rhizome to store starches, proteins, and other nutrients. These nutrients become useful for the plant when new shoots must be formed or when the plant dies back for the winter. This is a process known as vegetative reproduction and is used by farmers and gardeners to propagate certain plants. This also allows for lateral spread of grasses like bamboo and bunch grasses. Examples of plants that are propagated this way include hops, asparagus, ginger, irises, Lily of the Valley, Cannas, and sympodial orchids. Some rhizomes are used directly in cooking, including ginger, turmeric, galangal, and fingerroot.

Stored rhizomes are subject to bacterial and fungal infections making them unsuitable for replanting and greatly diminishing stocks. However rhizomes can also be produced artificially from tissue cultures. The ability to easily grow rhizomes from tissue cultures leads to better stocks for replanting and greater yields. The plant hormones ethylene and jasmonic acid have been found to help induce and regulate the growth of rhizomes, specifically in Rheum rabarbarum otherwise known as rhubarb. Ethylene that was applied externally was found to affect internal ethylene levels, allowing for easy manipulations of ethylene concentrations. Knowledge on how to use these hormones to induce rhizome growth could help farmers and biologists producing plants grown from rhizomes with better ways on how to cultivate and grow better plants.

#########
More detail about the bamboo - *time to blossom into new avenues*

Bamboo is one of the fastest-growing plants on Earth, with reported growth rates of 250 cm (98 in) in 24 hours.[2] However, the growth rate is dependent on local soil and climatic conditions, as well as species, and a more typical growth rate for many commonly cultivated bamboos in temperate climates is in the range of 3–10 centimetres (1.2–3.9 in) per day during the growing period. Primarily growing in regions of warmer climates during the late Cretaceous period, vast fields existed in what is now Asia. Some of the largest timber bamboo can grow over 30 m (98 ft) tall, and be as large as 15–20 cm (5.9–7.9 in) in diameter. However, the size range for mature bamboo is species dependent, with the smallest bamboos reaching only several inches high at maturity. A typical height range that would cover many of the common bamboos grown in the United States is 4.6–12 metres (15–39 ft), depending on species. Anji County of China, known as the "Town Of Bamboo", provides the optimal climate and soil conditions to grow, harvest, and process some of the most valued bamboo poles available worldwide.

Unlike all trees, individual bamboo stems, or culms, emerge from the ground at their full diameter and grow to their full height in a single growing season of three to four months. During these several months, each new shoot grows vertically into a culm with no branching out until the majority of the mature height is reached. Then, the branches extend from the nodes and leafing out occurs. In the next year, the pulpy wall of each culm slowly hardens. During the third year, the culm hardens further. The shoot is now considered a fully mature culm. Over the next 2–5 years (depending on species), fungus begins to form on the outside of the culm, which eventually penetrates and overcomes the culm. Around 5–8 years later (species and climate dependent), the fungal growths cause the culm to collapse and decay. This brief life means culms are ready for harvest and suitable for use in construction within about three to seven years. Individual bamboo culms do not get any taller or larger in diameter in subsequent years than they do in their first year, and they do not replace any growth lost from pruning or natural breakage. Bamboos have a wide range of hardiness depending on species and locale. Small or young specimens of an individual species will produce small culms initially. As the clump and its rhizome system mature, taller and larger culms will be produced each year until the plant approaches its particular species limits of height and diameter.

Many tropical bamboo species will die at or near freezing temperatures, while some of the hardier or so-called temperate bamboos can survive temperatures as low as −29 °C (−20 °F). Some of the hardiest bamboo species can be grown in places as cold as USDA Plant Hardiness Zones 5–6, although they typically will defoliate and may even lose all above-ground growth, yet the rhizomes will survive and send up shoots again the next spring. In milder climates, such as USDA Zone 8 and above, some hardy bamboo may remain fully leafed out year around.

Mass flowering – *I oak you are ready for acorn-y joke about trees!*

Flowering bamboo

Most bamboo species flower infrequently. In fact, many bamboos only flower at intervals as long as 65 or 120 years. These taxa exhibit mass flowering (or gregarious flowering), with all plants in a particular species flowering worldwide over a several-year period. The longest mass flowering interval known is 130 years, and it is for the species Phyllostachys bambusoides (Sieb. & Zucc.). In this species, all plants of the same stock flower at the same time, regardless of differences in geographic locations or climatic conditions, and then the bamboo dies. The lack of environmental impact on the time of flowering indicates the presence of some sort of “alarm clock” in each cell of the plant which signals the diversion of all energy to flower production and the cessation of vegetative growth. This mechanism, as well as the evolutionary cause behind it, is still largely a mystery.

One hypothesis to explain the evolution of this semelparous mass flowering is the predator satiation hypothesis which argues that by fruiting at the same time, a population increases the survival rate of their seeds by flooding the area with fruit, so, even if predators eat their fill, seeds will still be left over. By having a flowering cycle longer than the lifespan of the rodent predators, bamboos can regulate animal populations by causing starvation during the period between flowering events. Thus the death of the adult clone is due to resource exhaustion, as it would be more effective for parent plants to devote all resources to creating a large seed crop than to hold back energy for their own regeneration.

Another, the fire cycle hypothesis, argues that periodic flowering followed by death of the adult plants has evolved as a mechanism to create disturbance in the habitat, thus providing the seedlings with a gap in which to grow. This argues that the dead culms create a large fuel load, and also a large target for lightning strikes, increasing the likelihood of wildfire. Because bamboos can be aggressive as early successional plants, the seedlings would be able to outstrip other plants and take over the space left by their parents.

However, both have been disputed for different reasons. The predator satiation hypothesis does not explain why the flowering cycle is 10 times longer than the lifespan of the local rodents, something not predicted. The bamboo fire cycle hypothesis is considered by a few scientists to be unreasonable; they argue that fires only result from humans and there is no natural fire in India. This notion is considered wrong based on distribution of lightning strike data during the dry season throughout India. However, another argument against this is the lack of precedent for any living organism to harness something as unpredictable as lightning strikes to increase its chance of survival as part of natural evolutionary progress.

The mass fruiting also has direct economic and ecological consequences, however. The huge increase in available fruit in the forests often causes a boom in rodent populations, leading to increases in disease and famine in nearby human populations. For example, devastating consequences occur when the Melocanna bambusoides population flowers and fruits once every 30–35 years around the Bay of Bengal. The death of the bamboo plants following their fruiting means the local people lose their building material, and the large increase in bamboo fruit leads to a rapid increase in rodent populations. As the number of rodents increases, they consume all available food, including grain fields and stored food, sometimes leading to famine. These rats can also carry dangerous diseases, such as typhus, typhoid, and bubonic plague, which can reach epidemic proportions as the rodents increase in number. The relationship between rat populations and bamboo flowering was examined in a 2009 Nova documentary Rat Attack.

In any case, flowering produces masses of seeds, typically suspended from the ends of the branches. These seeds will give rise to a new generation of plants that may be identical in appearance to those that preceded the flowering, or they may produce new cultivars with different characteristics, such as the presence or absence of striping or other changes in coloration of the culms.

Tree Risk Assessment

Last updated: 10/02/2017 - 00:10

Risk Assessment:
DESCRIPTION:
Pieces of tree used to discuss tree growth and function.

RISKS:
Dropping the pieces of wood could cause injury to feet.

Any sharp edges of wood could cause splinters

ACTION TO BE TAKEN TO MINIMISE RISKS:
Place wood away from edges of tables.

Do not use any pieces of wood with sharp bits, and smooth them down when possible so can be used in demonstration again. Get first aider or parent to remove splinter and clean the skin. Tell parent to take child to GP if the wound appears infected later.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT:
Contact first aider if injury occurs.

Last updated: 09/02/2017 - 00:58

Microbes: viruses

Biology: Cuddly viruses and a few models too

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

A small grey box labelled "microbes (viruses)".

• 11 x cuddly viruses
• 1 x plastic model HIV virus (in box) and string ('DNA')
• laminated fact sheets
• microbiology text book

Explanation

Overview

Cuddly viruses and virus models to demonstrate. This experiment can be combined with the bacteria and parasites boxes too – all were new for the 2011 Summer Roadshow so are very open to suggestions for improvement!

Tips for demonstrating:
- Lay out the cuddly viruses on the table and let children pick them up and ask you what they are
- Ask questions to see what the children know about viruses and start from there!
- If it's busy it might be easier to keep most of the viruses in the box and bring them out one at a time to help control questions
- You can use the plastic virus model to give a more realistic representation to your group (better for older children)
- There is some more information about each cuddly virus on the attached labels in the box

Viruses box

Viruses can be as simple as DNA or RNA in a protein coat. Viruses use the host cell's machinery to make lots of new virus particles (virions). Often viruses are released from cells by making them burst (lysis). Others gradually bud off from the cell, taking some membrane with them and the cell survives (eg. HIV), giving a continuous release of virus particles. Viruses can't survive for very long outside of cells so new virions quickly find a new cell to infect. Viruses are also very 'clever' as they have lots of strategies to subvert the host cell function eg. by stimulating the host cell to divide so there is enough replicative machinery in the host cell to make lots of virus.

HIV (Human Immunodeficiency Virus): Retrovirus (RNA genome copies itself into DNA, using viral reverse transcriptase. The DNA integrates into the host chromosome and new viral genomes are produced by host transcription/translation machinery)
Can be spread via some bodily fluids and blood. Lives in white blood cells (CD4+ helper T cells) and eventually kills them, which means the immune system cannot function properly. People where HIV has killed too many white blood cells have AIDS (acquired immune deficiency syndrome), and this means that they can become very ill or even die from diseases that would not harm a healthy person (opportunistic infections – a big killer is tuberculosis caused by *Mycobacterium tuberculosis* – cuddly bug in the bacteria box).

Common Cold (Rhinovirus): positive sense RNA
Spreads easily from infected people when they sneeze or contaminate surfaces. The virus is very happy at the temperature and conditions in the human nose which is where they initially infect. There are lots of different types of rhinovirus whose protein coats all look different to the immune system, which is why we don't get become immune to the common cold.

Measles (Morbillivirus): negative sense RNA virus
Usually spread by breathing in virus from droplets in the atmosphere. Causes a fever, rash and red eyes. Most people will have been vaccinated against this with the MMR jab, which mostly eradicated measles from the UK. However since the scare about the MMR jab (spuriously linked to autism), the disease has been cropping up in affluent areas of London! (Vaccine scares can destroy herd immunity, the protection the population has when enough people are vaccinated and the virus cannot find enough hosts to spread to.)

Kissing Disease (Epstein-Barr Virus): DNA virus
Most of you will have this virus right now. It is usually spread via saliva, causing a mild fever in the majority of the population in early childhood. (Lots of people have asked me why this is and the answer is we don't really know – scientists think it might be something to do with how the immune response develops over childhood.) However some people who don't get the virus in early life might get it when they come into contact with other people's saliva in their teenage years - they then get Glandular Fever. An interesting thing about the virus is that you never really get rid of it; some of its DNA forms little circles in the nucleus of the white blood cells it infects, and it can remain dormant (latent infection) for a long time (occasionally getting out into saliva but not making you ill). The virus that causes chicken pox can do this in nerve cells.

Influenza: Negative sense RNA virus
Spread by breathing in virus particles (Respiratory tract). Causes symptoms including fever, headache, cough, muscle aches and less commonly vomiting and diarrhoea. It can be vaccinated against, however it is able to sometimes change the way it appears to the immune system in the body (by mutating its genome which is a random process). This means flu vaccines keep having to be updated to protect people against the new variations of the virus. This, and the fact that influenza virus also infects birds, is the reason why it would not be possible to eradicate influenza. Could compare this to viruses like smallpox and polio which have or have nearly been eradicated because they have more stable genomes and no animal reservoir.

Rabies: Negative sense RNA virus

Enters via skin and exits via saliva - spread through being bitten by an infected animal (usually dog). Results in death by killing brain cells in the cerebellum. The virus travels to the brain from the bite site up the nerves and it progresses slowly, so it is possible to stop the progression of the disease by vaccinating after being bitten.

Ebola: Negative sense RNA virus
Spreads by direct contact. This virus has a high fatality rate of up to 90% (but closer to 40% in the most recent outbreak). It causes symptoms including fever, muscle aches, skin rash, vomiting + diarrhoea, weakness, bleeding from nose, mouth etc. The virus can infect many cell types and it spreads within the body through the circulatory system. It causes such severe disease because it causes clotting within the blood vessels, bleeding inside the body (haemorrhage) leading to a drop in blood pressure and multi-organ failure. It is also so severe because it originated in a different animal to humans - the fruit bat - and transmitted to humans relatively recently. This is in contrast to viruses such as the common cold which have been in human populations for a long period of our evolution meaning we have adapted to survive it.

Winter Vomiting Disease (Norovirus): Positive sense RNA virus
Very common in the UK and very contagious. Causes vomiting and diarrhoea. Spread can be prevented by washing hands regularly.

Polio: Positive sense RNA virus
See "Polio, vaccination and disease eradication" experiment

Chicken Pox: Double stranded DNA virus
Otherwise known as Varicella-Zoster virus, a member of the herpesvirus family. Highly contagious; Spread through direct contact, coughing and sneezing, and causes red spots on the skin all over the body. Causes mild symptoms if caught when young, but causes Shingles in adults which is more serious. After initial infection, the virus goes dormant (latent) in the nervous system, and later in life it might reactivate to cause shingles.

T4 (T4-Bacteriophage):
Bacteriophage are viruses but they do not infect humans – they infect bacteria. One day this might be useful to us for treating bacterial infections (‘phage therapy’) where you can infect specific bacterial cells with genes that kill them/stop them reproducing.

Microbes: viruses Risk Assessment

Last updated: 09/02/2017 - 00:58

DESCRIPTION: Microbe toys and accessories

RISKS
1.Trip hazard if dropped on the floor

ACTION TO BE TAKEN TO MINIMISE RISKS
1.Keep all props in contained area

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury

Last updated: 09/02/2017 - 00:50

Microbes: parasites

Biology: Get up close an personal to some parasites (well, preserved slides), and find out more about them...

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

• 6 x cuddly parasites (4x protozoa, 2x insects)
• 2 x cuddly mosquitos (parasite "vectors")
• laminated fact sheets
• laminated parasite matching game
• microbiology text book

There are also some slides and a microscope in the experiment "Microscopes & Cells" which can be used with this experiment (Risk Assessment is in "Microscopes & Cells" - you would need to sign for this RA separately). The slides are: head louse, bed bug, malaria parasite, liver fluke, hookworm and guinea worm.

Explanation

Overview

In a nutshell...

- Cuddly parasite toys and laminated sheets showing parasites and their effects.
- It might be easier to get a couple of toys out at a time and get people to ask questions about them - it might help to control the flow of questions!
- If you're reading this in advance, more information can be found on the CDC website (homepage http://www.cdc.gov/)

Talking about parasites:

What is a parasite?

- Being a parasite is essentially free-loading off the host that it feeds on.
- Some parasites live on the surface of their hosts, these are ectoparasites (e.g. some mites/lice).
- Some types parasites live inside their "prey", these are endoparasites. Some of these live in gaps between the host tissues (eg trypansomes) while others live inside the host cells (eg malaria parasites)
- Most parasites live in more than one species at some point in their lifecycle (see individual descriptions).
- The parasites that you're most likely to hear about are single-celled Protozoa (including the parasites that cause malaria and trypanosomiasis), and parasitic worms (such as tapeworms).
- There is constant conflict between parasite and host: the host's immune system is trying to kill the parasite, and the parasite is trying to hide from the immune system. Co-evolution of the parasite with the host has led to them becoming well adapted to each other – a good parasite is one that manipulates the host so it can reproduce maximally but doesn't kill the host because it needs somewhere to live!
- Parasitic diseases are a massive problem for global health. Malaria kills nearly 1 million people per year, most African children under 5 years old. Parasitic worms might reduce your quality of life so much that you can't care for your family, leading to a wider impact (eg elephantiasis). In many regions where parasitic diseases are a problem there is very basic healthcare, making treatment more difficult to access.

Some examples of parasites

PROTOZOA: Single-celled eukaryotes

1) Malaria (*Plasmodium falciparum*):
4 parasites cause malaria: *Plasmodium falciparum* (the most common and most deadly), *Plasmodium vivax*, *Plasmodium malariae*, *Plasmodium ovale*. These are carried by *Anopheles* mosquitoes, the vector, which are active and hence bite people at night. When they bite an infected person they take up the parasite into their digestive system (parasite stage = sporozoite), and then secrete it into the next person they bite in saliva (used to inject anticoagulants to keep the person bleeding so the mosquito can get its blood meal). The parasite then travels in the bloodstream to the liver where cells are infected (parasite stage = merozoite). Parasites are released and enter red blood cells in the circulation, where they multiply and burst the red blood cell, causing the symptoms of malaria. Inside some red blood cells the parasites become gametocytes which are taken up by another mosquito if it bites the person.
Symptoms at first include fever, chills, headache and vomiting. In some cases this can rapidly progress to severe anaemia, respiratory distress or cerebral malaria - and can be fatal. However if you live in a malarial area (and get infected often) you may develop partial resistance to malaria and be infected without symptoms (asymptomatic infection). When you travel to a malarial area (Asia, South America, Africa - but the range is spreading) you use chemoprophylaxis (drugs to stop an infection becoming established), in combination with avoiding being bitten (mosquito nets, DEET mosquito repellent) - and there are also drugs available to treat malarial infections.

2) African Sleeping Sickness (*Trypanosoma brucei*):
Parasites are injected into you by the bite of a tsetse fly in Africa (tsetse fly = the vector), or they can cross the placenta to infect a fetus. Trypanosomes don't live inside cells like malaria but they live in the blood stream – this means they have to do clever things to hide from the immune system, such as constantly changing their protein coat so that the immune system can't recognise them as a parasite. 2 different trypanosome subspecies cause sleeping sickness: *T. brucei rhodesiense* gives a rapidly-progressing disease (death in weeks to months) whereas causes a slowly-progressing disease (you might

not have any symptoms for years!). Sleeping sickness occurs when the trypanosomes enter the brain and start to destroy the areas that control sleep and wakefulness, leading to blurred sleep/wake transitions and falling asleep at inappropriate times, progressing to coma and death! Trypanosomiasis (disease caused by trypanosomes) is treatable - but it's much easier at the early stage (drugs: pentamidine/suramine) than once the parasites enter the brain (drugs: melarsoprol - which comes from arsenic and has nasty side effects that can be fatal themselves!).
African trypanosomes also infect cattle, making agriculture in areas with tsetse flies really unproductive - cattle become really thin and so can't work (pulling ploughs etc) and aren't useful as food for people either!

3) Chagas disease/ American trypanosomiasis (*Trypanosoma cruzi*)
Chagas disease, also known as American trypanosomiasis, is caused by the protozoan parasite *Trypanosoma cruzi (T. cruzi)*. 10 million people in the world are infected, mainly in South America. The vector transmitting the trypanosomes to humans is the triatomine bug ('kissing bugs'). These live on the walls of houses and are nocturnal, biting people on their exposed faces when they are asleep at night. Unlike the African trypanosomes, South American trypanosomes aren't injected with the bug's saliva but the bug defecates next to the bite and it's the faeces that contain the parasites. They get into the person's bloodstream when they rub their face and smear the faeces into the bite!
The first sign of infection is often a large swelling of the eyelid on the side of the face that was bitten. Parasites can then enter the heart (30% cases) causing problems with the heartbeat, and maybe sudden death. Digestive problems can also occur (10% cases) when there is enlargement of the oesophagus as food can't enter the stomach - the food that gets trapped can start rotting which is pretty disgusting! Chagas disease is highly treatable though, with nearly 100% of people cured if treated early (benznidazole or nifurtimox).

4) Toxoplasmosis (*Toxoplasma gondii*)
Toxoplasma gondii is a species of parasitic protozoa.The definitive host (where the sexual stage of the life cycle occurs) is the cat - gametes are formed in the digestive tract and exit in the faeces. Then they enter another host (intermediate host) when they eat or drink contaminated food or water. So far every warm-blooded animal tested can act as a host - including humans. Here the parasite can enter any nucleated cell and replicates to form a tissue cyst. This can be passed on to another intermediate host or a cat by carnivory.
Usually toxoplasmosis has very mild symptoms (there might be some fever) and in France up to 90% of adults are infected (due to the French love of rare meat)! However serious disease can be caused in immunocompromised people (AIDS sufferers or post-transplant patients on immunosuppressive drugs) and pregnant women (increasing the risk of spontaneous abortion and birth defects). This is why pregnant women are advised not to touch cat litter!
T.gondii infection of the brain can lead to changes in behaviour by changing the amounts of chemicals in the brain (dopamine). Rats and mice lose their fear response to the scent of cats (tested using cat urine) and are more curious. Studies in humans have linked toxoplasmosis to schizophrenia (including hallucinations and reckless behaviour), slower reaction times and greater chance of causing traffic accidents.

PARASITIC WORMS:

(There's some slides for these in "Microscopes & Cells" which can be borrowed - same for some preserved specimens in "Horrible Housemates".)

Flukes (Trematodes): Adult flukes are leaf-shaped flatworms. Prominent suckers at the mouth and on the stomach help maintain position. Flukes are hermaphroditic (both male and female) except for blood flukes, which are bisexual. The life-cycle includes a snail intermediate host.

Tapeworms (Cestodes): Adult tapeworms are elongated, segmented, hermaphroditic flatworms that inhabit the intestinal lumen. You can eat the cysts in undercooked animal tissues, and then they develop in your intestines. They eat your food from your intestine – instead of you getting the nutrients. They attach to the intestinal wall using suckers in the head. Problematic in the developing world where there is already malnutrition. People used to use tapeworms as a slimming aid… They can grow up to 15 metres long and live for 20 years! Larval forms live in extraintestinal tissues.

Roundworms (Nematodes): Adult and larval roundworms are bisexual, cylindrical worms. They inhabit intestinal and extraintestinal sites.

1) **Schistosomiasis** (caused by a fluke/ trematode)
• Schistosomiasis is a chronic, parasitic disease caused by blood flukes (schistosomes)
• At least 230 million people require treatment every year – praziquantel
• Infection from larval forms released from freshwater snails in contaminated water
• Penetrate the skin and live in circulation where females release eggs
• Cause damage because of the host immune response to the parasites

2) **Liver fluke** (*Fasciola hepatica*) (caused by a fluke)
• Freshwater snail intermediate host, where reproduction occurs, then they are released as cercariae and swim through water to be ingested by ruminants normally, or sometimes humans eating uncooked foods like watercress
• Adult lives in the liver where they feed on the lining of bile ducts – makes cheese-like holes in the liver
• Produce eggs – up to 25000 a day per female

3) **Dracunculiasis** (guinea-worm disease, caused by a nematode)
• Dracunculiasis (caused by Dracunculus medinensis, a long thread-like worm) is a parasitic disease on the verge of eradication
• Exclusively transmitted by drinking water contaminated with parasite-infected fleas such as rural isolated ponds
• Takes 10-14 months for worm to mature in the body

4) **Hookworm** (*Ancylostoma duodenale* and *Necator americanus*, kinds of nematodes)
• Soil-transmitted helminths (parasitic worms)
• Major burden of disease worldwide - estimated 576-740 million people infected with hookworm
• Hookworms live in the small intestine, eggs are passed in faeces of infected person – this is a problem in the developing world where people may defecate outside (near bushes, in a garden, or field) of if the faeces of an infected person are used as fertilizer, eggs are deposited on soil.
• Eggs then mature and hatch, releasing larvae (immature worms).
• The larvae mature into a form that can penetrate the skin of humans, and infection is mainly acquired by walking barefoot on contaminated
• Most people infected with hookworms have no symptoms. Some have gastrointestinal symptoms, especially persons who are infected for the first time. The most serious effects of hookworm infection are blood loss leading to anemia, in addition to protein loss.
• Infection is treatable – anthelminthic medications eg. albenadazole

PARASITE VECTORS:

(There are two cuddly toys for this, so you can show a second uninfected mosquito feeding off a human host)

Mosquito (*Culex pipiens*):
• Most mosquitoes are harmless but some can transmit disease
• Viral diseases, such as yellow fever, dengue fever and Chikungunya, transmitted mostly by Aedes aegypti
• Parasitic disease malaria, carried by mosquitoes of the genus Anopheles
• Lymphatic filariasis (the main cause of elephantiasis – worms block lymphatics impairing lymph drainage causing swelling of the limbs)

• We have cuddly toys of mosquitoes – in the parasites box

ECTOPARASITES:

(There's some cuddly toys and slides for these, and hopefully some preserved samples borrowed from the "Horrible Housemates" experiment)
1) Head louse (*Pediculus humanus capitis*)
• Lice are wingless biting or sucking insects. Lice infestation of any part of the body is called pediculosis!
• Live on your head (an ectoparasite) - has a single strong claw on each leg that can grab onto 6 hairs so they can move rapidly (may be on several heads in one day). But their short stumpy legs mean they can't jump or walk well on flat surfaces.
• Your head provides a source of food - blood
• Eggs are called nits and the female attaches the eggs close to the scalp with a transparent quick-setting glue
• The time taken to hatch depends upon temperature
• Head lice have no lungs! They take in air by muscle contraction of the abdomen (via spiracles)
• Head lice have been recovered from prehistoric mummies!

2) Bed bug (*Cimex lectularius*)
• Ectoparasites that feed on human blood (haematophagous)
• Live in houses and especially beds – most active at night so they can feed on the host without being noticed
• Adults can survive more than a year without feeding
• They don't usually spread disease but they can cause allergic skin reactions
• Light brown flattened oval-shaped body, vestigial front wings, microscopic hairs on abdomen that give a banded appearance

Microbes: parasites Risk Assessment

Last updated: 09/02/2017 - 00:50

DESCRIPTION: Microbe toys and accessories

RISKS
Trip hazard if dropped on the floor

ACTION TO BE TAKEN TO MINIMISE RISKS
Keep all props in contained area

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury

Microbes: bacteria

Biology: Cuddly bugs, props from a lab, and a hand-washing experiment

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

A small grey box labelled "microbes (bacteria)".

In the box:

• 8 x cuddly bacteria
• 1 x cuddly penicillin bug (to talk about antibiotics)
• 1 x cuddly yeast (to say that not all microbes are bacteria)
• 1 x plate of plastic bacteria (E.coli)
• 2 x bacteria viewers (look a bit like small microscopes)
• 3 x slides sets for bacteria viewers
• 1 x flask for growing bacteria
• Packets of tools for growing bacteria
• Laminated fact sheets for cuddly bacteria
• Laminated instructions sheets for hand washing activity
• UV hand wash cream (this is £15 per bottle, so use only minimum amount per group)
• UV light for hand wash activity

If you want to do the hand wash activity you'll need a soap, warm water and bowl and some paper towels to dry hands on.

Explanation

Overview

There are several things to do: lots of cuddly bacteria to talk about (everyone loves these), UV hand-washing experiment (good for younger kids) and bacteria viewers and lab props (better for older kids).

The three microbes experiments were new for the 2011 Summer Roadshow, so are still being developed. Let us know if there's anything else you'd like to include!

Element one: cuddly bugs

The kit:
• 9 x cuddly bacteria
• 1 x cuddly penicillin bug (to talk about antibiotics)
• 1 x cuddly yeast (to say that not all microbes are bacteria)

Tips for demonstrating:
- Lay them out on the table (possibly with the slide viewers described below)
- Let children pick them up and ask you what they are
- Ask questions to see what the kids know about bacteria - "germs" is a common answer!
- You might find it easier to keep most of them in the box and bring them out one at a time if your experiment is busy, which can make it easier to control the questions

Talking about bacteria:
- Most bacteria are harmless: there are actually 10 times as many bacterial cells in your body than your own cells.
- Some of them produce toxins or invade your cells, which can make you ill.
- Bacteria are made up of just one cell, unlike us and other animals/ plants, which are made up of millions of millions of cells
- They're a few micrometres in length, which means if you could line them up, you'd get a million in a metre...

The following explanations are also found on laminated sheets in the box, and there is some additional information on labels attached to the cuddly bacteria:

1) *E. coli (Escherichia coli)*: Gram negative, rod shaped
SLIDE in microscope box
Found in the intestines of most mammals- it's there inside you only hours after you're born! There are lots of bacteria in our digestive system that are harmless to us – in fact they stop harmful bacteria from living and growing there instead. Sometimes E.coli can make us ill; some unusual strains produce toxins which can give us food poisoning. Biologists like *E. coli*: It's very easy to grow in the lab and can make lots of proteins and DNA very quickly.

2) *Salmonella (Salmonella enterica)*: Gram negative, rod shaped
SLIDE in microscope box

Can infect humans and animals, so sometimes infects people of food isn't cooked properly (particularly chicken or eggs). Causes gastroenteritis (diarrhoea and vomiting…) The bacterium itself can actually live inside certain types of white blood cell, which is a very effective way of hiding from the cells of the immune system that circulate in the blood.

2) *Typhoid Fever (Salmonella typhimurium)*: Gram negative, rod shaped
Very closely related to the Salmonella bacteria that cause food poisoning. Typhoid fever is a lot worse than food poisoning however: its symptoms include a high fever, abdominal pain, a skin rash and headaches. Some people can be infected without having symptoms, but can still pass it to other people making them carriers of the disease. 'Typhoid Mary' (Mary Mallon) was the first recognised asymptomatic carrier and spread typhoid around New York in the early 1900s in her work as a cook, over 50 have fatalities have been linked to her. It is spread by drinking water or eating food contaminated with the bacterium. Typhoid fever is most common in India and its spread can be prevented by good hygiene.

3) Diarrhoea (*Campylobacter jejuni*): Gram negative, spiral shaped
Most common cause of food poisoning in the UK, linked to handling raw chicken. It produces a toxin that kills certain human cells, which helps the bacteria to survive, without being attacked by the immune system.

4) TB (*Mycobacterium tuberculosis*): 'Acid fast' will not gram stain
Infects the lungs when the bacterium is breathed in. Here it gets contained by the immune system in a tough shell. Only about 1 in 10 people who have the bacterium get ill: this usually happens when the immune system is weak and cannot contain the bacterium. The disease can cause damage to the lungs and in really bad cases it can spread to other parts of the body.

5) Cholera (*Vibrio cholerae*): Gram negative, comma shaped
Usually spread when water is contaminated by the bacterium. Produces a toxin that stops you absorbing water through your intestines. This causes really bad diarrhoea, which can be fatal as you lose too much water and salt from your body.

6) Listeria (*Listeria monocytogenes*): Gram positive, rod shaped
Causes fever and muscle pains. If the bacterium can get to the brain this can cause meningitis. Pregnant women are the most commonly infected – the mother usually gets a mild fever but the baby might be badly affected or born early. The source of the infection is often food – pasteurising dairy foods helps kill the bacteria and reduce the numbers of infections.

7) Stomach Ache (*Shigella*): Gram negative, rod shaped
Very closely related to E. coli. When the bacterium is ingested it can get inside the cells of your intestine. It produces some toxins that can also make you ill.

8) Yogurt (*Lactobacillus bulgaricus*): Gram positive, rod shaped
One of a number of species of bacteria that can be used to make yoghurt.
What Wikipedia has to say about the use of *L. bulgaricus* in the manufacture of yoghurt:
"Lactobacillus delbrueckii subsp. bulgaricus is commonly used alongside Streptococcus thermophilus as a starter for making yoghurt. The two species work in synergy, with L. bulgaricus producing amino acids from milk proteins, which are then used by S. thermophilus. Both species produce lactic acid, which gives yoghurt its tart flavour and acts as a preservative. The resulting decrease in pH also partially coagulates the milk proteins, such as casein, resulting in yoghurt's thickness. While fermenting milk, L. bulgaricus produces acetaldehyde, one of the main yoghurt aroma components. Some strains of bulgaricus also produce bacteriocins which kill undesired bacteria. It is often helpful to sufferers of lactose intolerance, whose digestive systems lack the enzymes to break down lactose to simpler sugars."

YEAST/FUNGUS
(Yes, we know that they're not bacteria, but we'd found that people ask about antibiotics, so we think that they're a nice bonus to have in the box)

Penicillin (*Penicillium chrysogenum*)
This is a fungus that makes penicillin, an antibiotic that kills some types of bacteria. It does this to kill off the bacteria that are competing for the food it needs for growth, but we have used penicillin from this fungus to treat bacterial infections in humans.

Yeast for bread and beer
Also a kind of fungus. It's one cell, just like the bacteria, though the cell is much bigger. In bread the yeast can use the sugars in the dough for its growth; it breaks them down in a reaction that produces the gas carbon dioxide, which make the bread rise. In beer the yeast converts the sugars to alcohols.

Element two: growing bacteria in a lab

The kit:
• 1 x plate of plastic bacteria (*E. coli*)
• 1 x flask for growing bacteria
• Packets of tools for growing bacteria

NB. The kit we have has not been used in a lab and the 'bacteria' on the plate are not real!

Under sterile (no other bacteria) conditions:
1) You can grow some types of bacteria in the lab. *E. coli* is happy to grow on agar plates, as long as it has all the nutrients it might need. The L-shaped spreader is used when you put the cells on the new plate, to make sure that the bacteria aren't too close together.
2) If you want more cells than this, get some bugs you're interested in with the green tool.
3) The plastic flask can be used to grow bacteria in a growth medium/ broth. (Extra detail: For *E. coli* you'd usually use Luria-Bertani medium (LB) at 37 degrees C to provide the necessary nutrients. This contains 10g Tryptone (enzymatically digested milk protein casein - supplies amino acids), 5g of Yeast Extract (supplies lots of nutrients), 1g glucose, 10g NaCl pH ~7.2, deionized, distilled water to 1 litre.)

Element three: bacteria viewers

The kit:
• 2 x bacteria viewers (look a bit like small microscopes)
• 3 x slides sets for bacteria viewers

These are essentially a more durable version of a set of slides and a microscope. In the set of slides (which come with a booklet for information) you can see various different shapes of bacteria - just like in the cuddly bugs:
1) Round (1= "coccus", 2+ = "cocci")
2) Rod (1= "baccilus", 2+ = "baccili")

3) Spiral

These shapes are determined by the cell wall (the tough outer layer) and the cytoskeleton (internal "scaffolding"). They matter because they affect how the cells can absorb nutrients from its environment, how they can attach to surfaces and how they're able to move.

Element four: handwashing activity

Why should we bother washing our hands? This activity uses glow in the dark stuff to show how easy it is to miss the bits of your hands where bacteria are...

The kit:
• Laminated instructions sheets for hand washing activity
• UV hand wash cream (this is £15 per bottle, so use only minimum amount per group)
• UV light for hand wash activity
Also needs a bowl and paper towels that are not supplied in the box

There is a set of laminated instructor notes in the box, taken from the Wellcome Trust. A full version can be viewed online here: http://www.yourgenome.org/downloads/pdf/teachers/handshake/handshake_tno...

Essentially:
• No hand washing: Form a 'line' around your group of children. Squirt UV cream on the first child's hand and get them to rub their hands together, then shake the hand of the next person in the group, then they shake the next person's hand... Shine the UV torch onto each of the kids' hands to show up the 'bacteria'. All should now wash their hands thoroughly.
• Compare the results with hand washing: Repeat the procedure but get each person to wash their hands in the bowl after the UV cream has been rubbed in but before they shake the hand of the next person.
• If the group activity isn't suitable, you could always compare before and after hand washing on the same child.
• This should show that washing hands helps to remove microbes – and washing with soap does this better than with just water as the soap breaks down some of the natural oils on your hands that help the bacteria to stick. Look at where the bacteria were found – it's easier for bacteria to stay between our fingers and under our nails – and that's why it's important to wash your hands properly!

Microbes: bacteria Risk Assessment

Last updated: 09/02/2017 - 00:30

DESCRIPTION: Microbe toys and accessories

RISKS
Trip hazard if dropped on the floor

ACTION TO BE TAKEN TO MINIMISE RISKS
Keep all props in contained area

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury

DESCRIPTION Bacteria hand wash activity
RISKS
1. UV cream in eyes
2. Slip hazard
3. Possible allergic reaction to cream? (Widely used in teaching, so severe reaction is likely to be rare)

ACTION TO BE TAKEN TO MINIMISE RISKS
1. When giving UV cream to children, tell them not to put their fingers near their eyes and ensure they rinse it off.
2. All spills should be cleared up immediately.
3. Suggest that volunteer from group isn't one who is known to have sensitive skin.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT
1.Call first aider in case of injury. If washing up liquid gets into an eye, demonstrator must call a first aider and may perform an eye wash if trained and confident to do so.
2. Call first aider in case of injury.
2. Call first aider in case of allergic reaction, then seek further medical advice where appropriate.

Last updated: 12/02/2017 - 10:08

Citrus Canker SCIR Model

Biology: Show kids how disease dynamics, with a model of Citrus Canker spreading through a population of orange trees

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

2 CHaOS laptops
WiFi access - ask a committee member and or one of the teachers present
http://www.webidemics.com/ - This computer model was developed by Nik Cunniff's group http://www.plantsci.cam.ac.uk/research/nikcunniffe) in Plant Sciences. It models the spread of Citrus Canker under a variety of weather conditions, disease parameters and control efforts, allowing you to set initial conditions then watch the model run to a determined end point.

Explanation

Useful info and set up

What is it?
"Here I have a model of disease spreading between trees. We can see how quickly it spreads in different conditions and if our efforts to control it actually help."

Set up
[Read through the descriptions of the parameters and get a feel for how changes to each parameter effects the spread of the disease, you can also hover over any of the text within the model for a short description. Don't forget to accept the changes before running a new simulation, or else nothing will change!]

Set up a fairly basic run of the model

Epidemiology
• Model type = non cryptic infection, no death
• Expected primary infections = 0
• Expected exposed period = 100 days
• Expected cryptic period = 100 days
• Landscape type = random
• Dispersal kernel =100m
• Kernel type = exponential
• Stopping condition = epidemic eradicated (this can take a long time but you actually see the infection end (you can speed up running time)
Weather
• low weather severity
Control
• Disable Control
(second time around)
• Cull radius = 100m
• First survey = 0 days
• Fraction unsurveyed = 0
• Detection probability = 80%
• Survey interval = 90 days
• Expected notice period = 60 days
• Notice variability = 0

Start by talking about the spread of diseases:

"How do diseases spread?" - will probably get animal/human centred answers: sneezing, coughing, dirty hands, bad food, bad water, insects, bodily fluids

"What about how diseases spread between plants?" - insects (vectors) are more important, moving the bacteria/viruses/parasites between plants, humans move infected plant material between fields (on farm equipment etc)

[on computer] Here we can see a disease spreading between a bunch of orange/citrus trees: Green = healthy, orange = exposed, yellow = infected without symptoms, red = infectious, black = culled. "Can you see any pattern to how the disease is spreading?" - the disease doesn't spread randomly, but trees closer to a diseased tree are more likely become infected. With our model we can change how quickly the disease spreads [run the model with basic parameters (without cryptic infection), run it again with more initially infected trees, run again changing parameters to speed up spread of disease] Get the children to change the disease parameters (can split the group into two and use both laptops), trying to spread the disease the fastest. Ask them why they think the model is useful? - can see when the disease spreads fastest/which aspects of it make it most contagious, can see how it spreads through a landscape (which trees are most vulnerable to infection as the disease spreads)

[on computer] We can also try out different ways of stopping the disease spreading. "How would you stop a disease spreading?" Vaccination (doesn't work as plants don't have active immune systems like animals) Quarantine (you can't move trees away from each other, and it would be a lot of effort to seal the trees off from each other) Stopping insects (herbicides, this is one of our main ways of slowing the spread of diseases) Culling (stopping the disease spreading away from trees which are known to be infected). Culling is the only effective way of controlling the spread of Citrus Canker, but there are different ways of doing it [run with control parameters, then run again with new parameters, chat through the differences] Get the children to change the control parameters, trying to save as many trees as possible, you can make it a competition between the two groups. Ask them why they think the model is useful? - can test how effective different control options are, then can use the results to find the optimal control mechanism, can run the same control plan many times to see how it is most likely to turn out.

Team Disease vs Team Control
You can split the children into two teams; Team Disease; who are trying to kill as many of the threes as possible, and Team Control; who are trying to contain the spread of the disease (they tend to enjoy this challenge!)

[on computer] We can't always tell when trees are infected. This is called a cryptic infection and makes it more difficult to control the spread of the disease as the infected trees can infect other trees, without being infected. [run model with cryptic infection - should take longer to bring the infection under control]

Explaining the point of computer models:

[probably for older children] Computers are really useful for biologists. They make it easier to do calculations, work out statistics and can help us predict how a disease will spread.

"Why do we want to know how a disease will spread?" Work out who/what might get infect next, how we can slow the spread of a disease.

"Why is it good to have a computer to do this for us?" Makes it easier (not having to do the sums ourselves), don't have to infect animals or plants in real life, can put in specifics about our outbreak of disease (where it started, how many people/animals/plants [organisms, depending on age of child]) to make it more accurate.

Models simplify reality. To make it easier to understand the disease we can split all of our trees into different 'disease states/compartments', the most simple has just three compartments - Susceptible, Infected and Removed. More complicated models include Exposed and Cryptic Infections (like this model). Mathematical equations describe the movement of plants between the different compartments, the more compartments, the more complicated the equations get, but the more accurate the model gets.

Multiple Runs - [only for older, keen, kids who want to know more about modelling]. Each time the model is run (run new simulation) the results are different, partially because the initial conditions are different (two different trees are initially infected) even if the same trees were infected each time, the results would still be different as there are many variables not quantified in the model (e.g. precise landing spot of individual raindrops, wind speed and direction etc) we end up with a different result each time - chaos!(theory).
To get a better grasp on the system you can run the simulation multiple times and watch the results of 100, 200 or 500 simulations run on a series of graphs which show the number/percentage of trees in each category (healthy, infectious and dead) change over time. You can see the typical pattern of infection e.g. that (given the initial conditions that you have set) most times about 250 trees will have to be culled, but that about 5% of the time only 600 trees will be left alive and the disease will run for over 8 years.

Demonstrator background info:

This is a computer model for a disease called Citrus Canker. It is caused by a bacteria (Xanthomonas axonopodis) and infects orange and lemon trees causing them to drop their leaves and fruit early. The fruit is safe to eat, but too ugly to be sold. It can be easier to model plant diseases because unlike animals plants aren't going to move around and spread the disease further themselves. The only way that the disease can be controlled is by cutting down infected trees.

Parameters

[Read through these descriptions and work out how they changes to each parameter effects the spread of the disease, you can also hover over any of the text within the model for a short description. Don't forget to accept the changes before running a new simulation, or else nothing will change!]

Talk through the model parameters in as much detail as you like. Less is more, probably chat through them in stages - run the model without controls to look at the epidemiology parameters, then keeping those parameters the same, introduce controls.

Epidemiology
(change how the disease spreads)

Initial infection – how many trees are infected right at the start (in real life this will depend on when the farmers spots that some of his trees are diseased)

Secondary infection rate – how quickly the disease will spread from an infected to an uninfected tree

Typical kernel range – a dispersal kernel is the area around an infected tree which the disease is likely to spread into, shows us which other trees are in danger, the type (either exponential or cauchy (apparently a better model for describing long distance dispersal)) probably doesn't make much difference.

Initial infections - number of trees infected at the beginning of the trial

Model type - different disease scenarios e.g. can it spread before it has been detected (cryptic infection) or not (probably easier to start off without cryptic infection or death)

Expected primary infections - the number of new infections which come from outside the trial (i.e. not from trees that you can see on screen, but the 'external environment') best to keep this at zero to avoid confusion

Expected exposed period - length of time that it takes for a tree to become infected (or how long it needs to be exposed for before becoming infected), once infected the tree can be discovered (as infected but not causing other infections) or start infecting other trees (if there is a cryptic infection period)

Expected detectable period - length of time a tree will be detectable for before becoming infectious

Landscape type - can simulate two neighboring plots of orange trees in a grove or citrus trees across a large landscape

Stopping condition - the simulation can either stop after a set period of time or once the disease has been bought under control (it's more satisfying to let it run until either you or the disease have 'won')

Weather
Citrus canker is spread by in water droplets so it spreads more quickly between plants in high severity (wetter and windier) weather. It 'll be easier to start by keeping the weather the same throughout the trial (go for low severity throughout, you'll have a greater chance of 'beating' the disease)

Probability that a low/high weather severity index - these two parameters alter the changeability of the weather, if the cursor is to the right for both then the weather will remain constant throughout the experiment, if to the left then the weather will oscillate between high and low

Weather change interval - how often the weather status could change severity

Weather low severity factor - controls the difference in rate of infection spread between low and high severity weather conditions

Controls
The main method for controlling Citrus Canker is culling visibly infected trees and a number of the surrounding trees.

Cull radius - all of the trees within this area are culled at the same time as the infected tree. The larger that this area is, the more likely you are to locally eradicate the disease, but you might end up killing all of your trees!

Detection probability - likelihood of spotting the symptoms of diseased trees

First survey - the time point at which the trees are first checked for disease

Survey interval - how often the trees are checked for disease

Fraction unsurveyed - proportion of trees which can't be accessed to checked for disease (since they are on private property or are physically inaccessible), these trees will still be culled if within the cull radius of another tree

Expected notice period - average time between finding a diseased tree and culling it

Notice variability - standard deviation of time between finding and culling a given tree (makes the model more realistic - as you can't guarantee to remove all trees exactly 20 days after finding them)

Cull together - remove all trees simultaneously

Disable control - no intervention, watch spread of unopposed disease

Citrus Canker SCIR Model Risk Assessment

Last updated: 12/02/2017 - 10:08

DESCRIPTION
Looking at computer model of disease spread

RISKS
1) Electrical hazard
2) Trip hazard (trailing laptop cable)

CONTROL MEASURES
1) Keep away from water. See separate electrical parts risk assessment.
2) Set up close to power source, avoid cables crossing walkways and tape down cables.

IN CASE OF EMERGENCY
1) Turn off power at wall, call first aider.
2) Call first aider.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 12/02/2017 - 22:28

Polio, vaccination and disease eradication

Biology: Use our cuddly poliovirus to learn how we can prevent and eradicate diseases!

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Cuddly poliovirus

Explanation

This is a first draft of an explanation, so it's liable to evolve over time. Ideas for visual aids to explain immunity, vaccination etc. would also be gratefully received.
There are a few key concepts you can talk about with polio, depending on how keen the children are and their level of understanding:
• The virology of poliovirus; how it replicates etc.
• How poliovirus causes disease
• Vaccination
• Disease eradication

The Virology
This is quite hard to explain without getting bogged down in detail. For most children, I'd restrict it to explaining that polio is a virus, so it needs to hijack our cells to make more of itself.
Polio is a virus which can cause a disease called poliomyelitis. Viruses are incredibly small particles (virions) containing the genetic instructions needed to make more virions. To infect a cell, the virus sticks to the cell surface then injects its RNA into the cell (if we're being precise, the whole virion is internalised by receptor-mediated endocytosis before the genome enters the cytoplasm, but we can probably skip this).
The host cell is then 'tricked' into producing thousands of new virions; the RNA has the instructions to make the viral proteins and also acts as a template to produce more genomes. Eventually, the cell bursts, releasing up to 10,000 new virions into its environment, ready to infect more cells.

How polio causes disease
Polio spreads by the faeco-oral route; ie poo contaminating drinking water. That's why it's often seen in areas with poor sanitation. It's also the reason that young children are more likely to get infected, since they tend to have lower standards of hygiene!
The vast majority of people infected get a fairly harmless infection in the gut or get vague 'flu-like' symptoms.
Polio becomes a problem if it infects cells called motor neurones in our spinal cord. We need these cells to control our muscles, so if lots of them are killed then the muscles become paralysed. The resulting disease is paralytic poliomyelitis, which is what most people think of when you mention polio.
Interestingly, infecting the cells in the central nervous system does not help the virus transmit to other hosts.
What effects can paralysis have? It depends on where is affected. Obviously, if the legs are affected the patient won't be able to walk. Even worse is bulbar poliomyelitis, where the muscles we use to breath can become paralysed.
There isn't a cure for polio. All we can do is support the patient to keep them alive. If their breathing muscles become paralysed then they need mechanical ventilation, meaning that a machine is used to do the work for them. Famously, in the 1950s this took the form of negative pressure ventilation, aka the iron lung

Vaccination
Polio affected thousands of people in the Western world in the 1950s. But ask the children how many people they've met who've had polio. The answer should (hopefully!) be none. Why? Because there's a vaccine to prevent it!
Normally our bodies fight infections using our immune systems. Our immune system 'learns' how to fight an infection when it's exposed to the pathogen, so it fights it more effectively the second time around. That's why we normally only get chickenpox once, even though it's a really infectious disease.
Vaccines are a way to teach our immune system to fight a disease.
Different vaccines work in different ways; some use a dead pathogen or part of a pathogen, while others use a live one that's been deliberately weakened so that it's no longer able to cause disease, but still similar enough to the dangerous one that our immune system learns to fight that one too.
In the case of polio, there are actually vaccines that work both ways; the live vaccine is more 'realistic' so it produces more effective immunity, but there's a risk that the 'safe' strain can mutate back into a 'dangerous' one. In the UK we use the dead vaccine, since you're highly unlikely to be exposed to polio anyway, but in areas where polio is still common we use the live one, since the benefit outweighs the risk.

Disease eradication
The polio vaccine is important because it might be possible one day to use it to eradicate polio completely. In fact, we're tantalisingly close to doing so!
Have they heard of any other diseases that have been completely eradicated? There's only one human disease: smallpox. For the vets, there's also rinderpest, which I'm informed infected cows…
Polio has certain special features which are needed for a disease to be eradicated:
• It doesn't change so much over time that the vaccine stops working. Contrast with flu, where we need a new vaccine very year, and even that isn't guaranteed to work!
• It doesn't infect animals. Animal viruses which also infect humans are basically impossible to eradicate, since it just needs one person to be infected by an animal and we're back to square one. Sadly, this applies in the case of Ebola.
We've come incredibly close to eradicating polio in recent years, and it's now largely confined to Nigeria, tribal regions of Pakistan and Afghanistan. However, these areas are all highly politically unstable and health workers have been targeted by violence, so it remains to be seen whether the final push will be successful.

Polio, vaccination and disease eradication Risk Assessment

Last updated: 12/02/2017 - 22:28

DESCRIPTION	Cuddly poliovirus
RISKS	1.Trip hazard if dropped on the floor 2.Children might try to put cuddly poliovirus into mouths
ACTION TO BE TAKEN TO MINIMISE RISKS	1.Keep all props in contained area 2. Supervise all props, and always put them away out of site before leaving the area.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1.Call first aider in case of injury 2. Remove and wash the cuddly poliovirus

Last updated: 02/02/2017 - 21:38

Cathedral

Engineering: How can we use arches to hold up a cathedral?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Base - three sections connected with hinges x1
Foundation blocks with metal connecting pins x4
Large arch connected with elastic cord x1
Small arches (buttresses) connected with elastic cord x2
Thin walls x2
Thick walls x2
Weights x2

Explanation

*** OVERVIEW ***

Investigating how the ideas used to make arch bridges can be used to build cathedrals and other buildings. Looking at the foundations needed for arches and flying buttresses.

Possible Activities:
Building a single large arch without walls but with foundations.
Building a single large arch with thick walls.
Building a single large arch with thin walls and weights.
Building a single large arch with thin walls and flying butresses.

Other things to talk about:
Resolving forces in different directions.
Examples in real cathedrals (see photos).
Foundation depths and strengths.

Tips for demonstrating:

Best demonstrated if the children have already looked at the arch bridge experiment, as then you can link the two experiments nicely.

Be careful with the weights as they do pose a finger-trap and bruising hazard - best to get them to hold the wooden arches, well away from where the weights will drop, whilst you position the weights in the correct places. It is *very difficult* to get the weights to balance, so I often just get the kids to press vertically down on top of the block with their index finger. This achieves the same effect, but you should make clear that this is the same as putting a big weight on top.

*** BASIC PROCEDURE AND EXPLANATION ***

1. Starting off

Explain that it's a cathedral. We're trying to build one. What are cathedrals built from? Stone. How to get a stone roof, window or door to stay up? Show them a photo - why doesn't the roof fall in? Ask if they've ever been in a cathedral and what shapes did they see. Arches!

Explain that the model is a cross section of a cathedral. This is actually quite difficult - young children are not used to models and cut-away views so you'll have to wave your hands and show them what would go where.

2. Large arch falling in

Now you can do the actual experiment. Start with the large arch and place it straight on the base (without supports). Ask the children to hold the two ends of the large arch and ask them what happens when you let go of the ends. Let go of the ends and it falls down.

Why does this happen? Normally children say something along the lines of "nothing is holding it up" but you can go a bit further than this. Try to get across the idea that you need something to push the ends of the arch inwards, as follows.

Repeat it but rather than getting them to hold the ends of the arch, ask them to keep the arch up by pushing only with one finger. Most children then try different directions until they realise they have to push the ends of the arch inwards. It can be difficult to get this working with two children but let them persevere and give them clues if necessary.

When they've done it, ask which way they're pushing. If they're old enough you could talk about forces but be very careful! Bear in mind they might not have heard the word "force" before and even if they have they might not know what it means - it can prove a bit of a distraction and just bore them.

3. Large arch with foundations

Once you've done that, put the foundation bricks in (match up the numbers (1 & 2) to ensure a good fit) and ask what will happen when you let go now. Don't mention "foundation" yet.

The arch stays up. Why? Why didn't it fall down? Previously we had to use our fingers to push inwards to stop the arch falling down, and that's what the bricks do.

What are the bricks called? Foundations. Talk about house construction, danger of building houses on uneven or muddy/sandy ground.

4. Arch with walls and buttresses

What is the problem with this cathedral so far? No walls, ceiling very low!

Try putting the arch on top of the thin walls. What will happen when you let go? It falls down. Why? Get them to explain, using the finger method like before, that we need something to push the arch inwards. If we don't have anything pushing in then the arch falls down.

Now put the smaller arches (flying buttresses) in between the outer foundations (numbered 3 & 4) and the thin walls. Let go and it stays up! Why? Again, because the buttresses push inwards.

Explain that they're called flying buttresses. Have they seen any? Show photos - where are the flying buttresses in the photos. What are they holding up?

5. Thick walls and weights

This next bit is quite subtle and you might not want to try it with young children.

Instead of flying buttresses we could use thick walls and put weights on top. Try it. Why does it work? Extra weight adds extra force in direction required. This is very subtle - children need to understand forces and have some idea about how forces in different directions add up. Don't try it unless you think they'll get it!

This is quite tricky to do, so make sure you practice it before trying with the children. First place the thick walls at the locations marked on the base, then rest the arch (matching up the A and sides) on the marked part of the top of the thick walls. The arch won't stay up at this stage so keep holding it up. Next place the thin walls (upside down and oriented so that the top surface is flat) on top of the thick ones and add the weights to the top of the thin walls. The weights need to be as close to the centre as is possible without them falling off, the structure should now stand up on its own.

*** OTHER THINGS TO TALK ABOUT ***

Applications with bridges.
How old buildings were made
Cement as a glue for bricks.
How modern buildings are made.
Look at the buildings around you.
How does your roof at home stay up? Look in the attic - timber beams...

*** SCIENCE BACKGROUND FOR DEMONSTRATORS ***

Using the science behind arch bridges to make buildings.
Resolving forces - how adding weights/using thicker walls, stops the roof from caving in.

Cathedral Risk Assessment

Last updated: 02/02/2017 - 21:38

DESCRIPTION	Various small wooden arches are built to explain flying butreses and pinnacles
RISKS	• 1. Slight finger trap between the elasticated wooden blocks • 2. Dropping one of the brass weights on a finger • 3. Getting splinters from blocks or the base • 4. Wooden blocks may be trip hazards
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. The bungee holding the blocks together isn't too tight, but be aware of the problem and ask children to move fingers if they are in danger of being trapped. • 2. Try not to leave or let kids lean on the floor by the bridge. Brass weights may easily be replaced by getting kids to press down with a single finger. • 3. Ensure all blocks and the base are well sanded. If not, sand them or don't use them. • 4. Keep blocks in same area and out of public walking areas.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in case of injury.

Breaking Paper

Engineering: Stretch pieces of paper to demonstrate just how strong paper is under tension.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Paper stretching board with newton (force) meter.
Roll of fax paper.
Shielded scalpel and cutting mat.
3 paper stamps (Circle, square and heart shaped).

Explanation

Things to do
Basic idea: Attach a piece of paper between the clamps (needs clamping very tightly), tighten the nut at the end until the paper breaks, notice the reading on the newton meter just before it does. Then try variations on the paper, such as:

* Different widths (full/half)
* Different lengths (should have minimal effect on results)
* Square holes
* Diamond holes
* Rounded holes
* Full width with small cut; with practise you can actually see the crack propagating away from the cut if you tune the force really carefully.

With the holes you can also ask where the paper will break, you should find that it happens next to a corner or a sharp bend where the paper was cut badly (if scalpel was used). Children of a sensible age can use the shielded scalpel/help do up the clamps, though often they're surprisingly bad at doing them up tightly enough!

What can go wrong?
Aside from the risks in the RA, there are a few ways in which this experiment can not work too well unless you're careful to avoid them:

* Clamps not tight enough, meaning that paper slides rather than breaks - if this happens check that the washers are on the outside of the blocks. The paper can also slide out if the piece you are using is not long enough and only a small part of it is clamped. If the length of the paper is long enough to completely go through both clamps and still have a bit of over hang you will likely avoid this problem
* Paper not straight, so it twists and buckles rather than stretches
* Freak results: In particular when you're dealing with holes, the results aren't always as consistent as they might be, eg a square hole can be stronger than a badly cut circular one!
* Scales decide to reset/turn off mid-experiment. There's not much you can do but release the tension and start again if this happens.

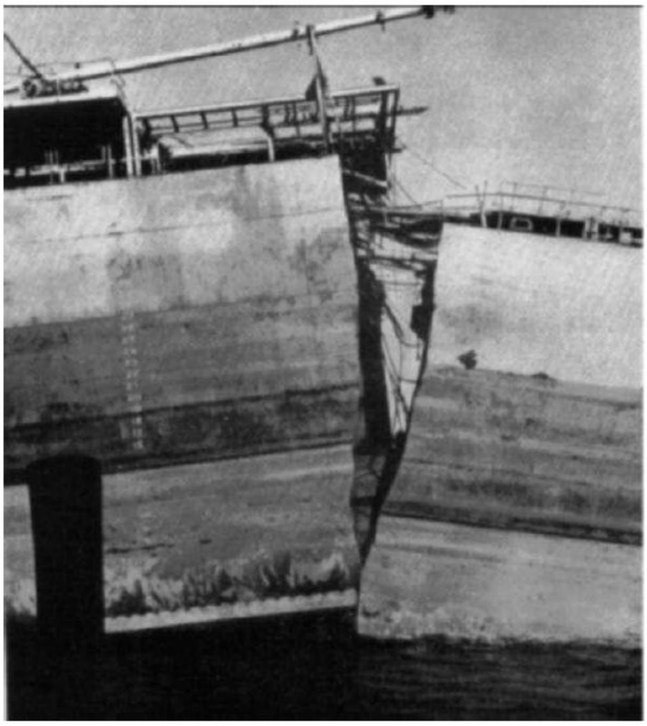
Things to talk about:

* What are the scales measuring? The reading is in kilograms, but really it's measuring the pulling force, you may need to persuade the visitors that a sideways pulling force feels just the same as weight on the bottom + gravity (can talk about stretching a child/tying a large weight to their feet if you like...!) With older/brighter children you can talk about converting to Newtons.
* Why do the clamps have foam attached to them? If you get them to move their hands along the surface of both sides of the clamp you can easily tell that there is much more friction with the foam. If there wasn't any foam the experiment wouldn't work as the paper would just slide out.
* Paper is really weak under compression, and tears easily when sheared, but it is strong under tension. It's made up of lots of long fibres, thing of it as lots of tiny bits of string, which are strong when you pull them but collapse when pushed (can compare this to the suspension bridge if they've already seen that).
* The breaking point of a full width piece of paper is about the same as the weight of a typical child in your audience, at 50kg=500N (usually ok to ask children how much they weigh, don't try this with adults...!) So you could almost dangle them off a cliff supported on a piece of paper!
* When the paper is half the width, there are half as many 'bits of string', so it only takes half the force to break it. It's often useful to get a marker pen and draw on the paper to show how the force can be split across the paper (about 100N in each of 5 sections or something like that...remember to explain what you mean by a Newton if you use this terminology).
* Corners are weak. You can think of all of the force for one of the sections being concentrated at a very small point, which causes it to break there. Can make shapes stronger by rounding the edges...circle perhaps ought to be strongest for given area.
* When can this be useful? Perforations in toilet paper or 'tear off' strips concentrate the force in the paper links so it is easier to tear it.

How is this linked to the real world?

* When you go in an aeroplane what shape are the windows? What might happen if they were completely square? The de Havilland Comet I was the first commercial airliner, built in 1949. It passed all safety testing, and went into commercial use, but there were two catastrophic accidents that were eventually traced back to the square windows.

* In WW2, almost 3000 Liberty ships were built in sections, and fitted together later, as a cheap way of transporting massive amounts of cargo from the US to UK. The problem was that they had square joints, which tended to fracture in heavy seas, with disastrous effects...12 ships broke in half unexpectedly for reasons along these lines (trivia: Constance Tipper of Newnham College was first person to understand why this happened). Use of brittle materials was also partly to blame.



* There are probably other examples along these lines that engineers/materials scientists might know, let us know if you think of any more good ones!

PLEASE REMOVE BATTERIES FROM FORCE METER WHEN PACKING AWAY - the batteries have a tendency to drain between events

Breaking Paper Risk Assessment

Last updated: 01/02/2017 - 23:06

DESCRIPTION	Stretching paper until it breaks.
RISKS	1. Risk of being hit by paper clamp when paper breaks. 2. Bolts in paper clamp may be sharp. 3. Finger trap risk from wing nuts during tightening. 4. Experiment contains scissors to be used by children. 5. Shielded scalpel is still sharp beneath the shield, and can cause cuts if the shield is pushed aside.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Demonstator to ensure that children are away from the clamp the first time the paper is broken. After this children will normally be wary enough, but demonstrator to remain vigilant. (Energy released on breaking is comparatively small, since force is applied by tightening a screw and fax paper does not stretch much before breaking) 2. Top of bolts which will be moving covered in tape to minimise potential damage. Demonstrator to replace tape if required. 3. Unlikely to occur, but be aware of the possibility if kids are doing the tightening. Warn children to be careful if required. 4. Don't give scissors to very young children. Supervise children when they're using scissors. 5. Don't give the shielded scalpel to young children, show children how to use it before letting them handle it. If in doubt, keep it to use yourself.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call a first aider in the event of injury.

Mechanical advantage

Engineering: Using pulleys and levers to explore mechanical advantage

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Tripod
Various pulleys
Water weights

Explanation

Here is a hopefully not too ropey write-up of what is an awesome experiment (I hope you won't string me up with all these puns)! You start with the contraption up and the bag containing 4 filled 2 litre water bottles out loose

The bag

First, get the kids try and lift the bag, and then like a Christmas turkey get them to guess the weight. Wild guesses will ensue. Tell them there are 4x2l bottles in the bag. Ask them how heavy 1l of water is. (Wild guesses). Tell them that 1kg = 1l of water. Then get them to tell you how heavy the bag is (4x2=8 is surprisingly difficult). 8kg of weight is how heavy the bag is (or 80N downwards), so how much force do you need to apply to lift it slowly? Just over 8kg worth of weight (or 80N). I think we have bagged that idea, let's move on. Maybe say that as far as you pull down, the bag lifts up, as it maybe is useful to say that at this point so they are thinking of it…

First Pulley

Put it on to the pulley that looks like the first picture in figure 1 (I know the diagram isn't great, but I am not artistic and was using paint). Ask them how much weight is pulling down (8kg/80N), then ask how much force you need to lift it up (just over 8kg/80N), then ask how much one rope must pull up to lift it (just over **8kg/80N**). Get all people to lift weight (try and get everyone to do it, so they appreciate the change in other pulley system). *Make sure you are holding on to the leg opposite pulley one, or else it will shift across the floor*.

Second Pulley

Move the bag on to pulley two. Before you get them to lift it ask how many ropes are there *(ensure the one you pull it with is pulled out to the side so they don't mistakenly count it – there should be two of them).* Then ask them how much weight is pulling down (8kg/80N), then ask how much force you need to lift it up (just over 8kg/80N), then ask how much one rope must pull up to lift it (just over **4kg/40N**). Get all people to lift weight (try and get everyone to do it, so they appreciate it is easier to lift). Some may spot that you have to pull it twice the length to get it to lift the same amount of distance (don't worry if they don't yet).

Third Pulley

Move the bag on to pulley three. Before you get them to lift it ask how many ropes are there *(ensure the one you pull it with is pulled out to the side so they don't mistakenly count it).* They will say 3 or 4 usually, so then say no and ask them to actually count. It is 5 taking the weight. Then ask them how much weight is pulling down (8kg/80N), then ask how much force you need to lift it up (just over 8kg/80N), then ask how much one rope must pull up to lift it (this is a bit trickier - just over **1.6kg/16N**). With the first person, ask them to hold the rope, and walk backwards, and keep on going, keep on going, keep on going. They realise now how much more rope you have to pull. Thus you can now discuss how to lift it the same distance, you must do the same work, so in total put in the same amount of force. Thus as the force is less, you have to go further (5x the distance). Get all people to lift weight (try and get everyone to do it, so they appreciate it is much easier to lift).

Closing Comments

Whilst everyone else is having a go at the Third Pulley, ask them if you had a very heavy weight, which system is better (some will say first here as you have less far to pull – this is incorrect as very heavy things you couldn't pull). The answer is three – easiest to do work. Therefore you use two and three to help you lift heavy weights. So what is the point of 1 then? Get lots of answers about how it is easier to carry, and you then point out to them that it doesn't change the weight they are carrying. What it does is that it changes the direction in which you are pulling, so you are pulling downwards. You can also ask them which system did they use the most energy while lifting. The answer is that it doesn't matter which one you use, you will expend the same amount of energy. This is because the height you lifted the weight through was the same for all three systems; it doesn't matter whether you pulled with a large force and moved the rope a small distance (first pulley), or whether you pulled with a small force but moved the rope a large distance (third pulley).

Appendix

You want more? You must be pulleying my leg. For advanced people, you can talk about why a pulley system with an odd number of pulleys may be beneficial (as in fig. 3) as it allows the user to pull down, using their weight to their advantage. With an even number (fig. 2) you'd have to pull up, which is harder. You may also want to explain uses of pulleys getting cargo out of ships etc... how would you use them to move a heavy weight horizontally, whilst keeping it off the floor (or out of the sea!)... you could talk about components here and forces pulling against each other etc.

Figure 1:

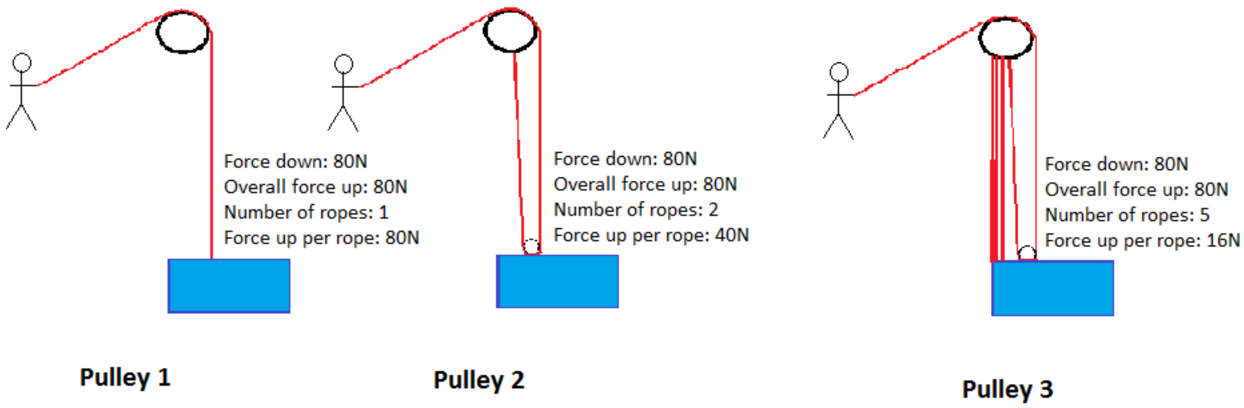


Figure 2:

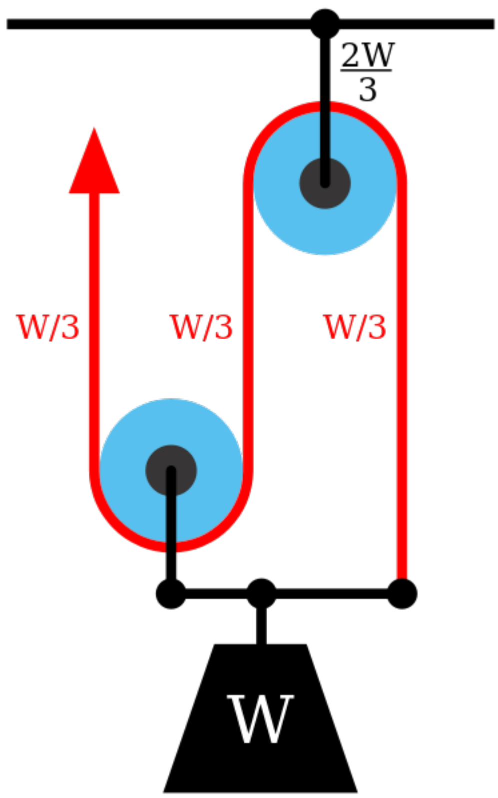
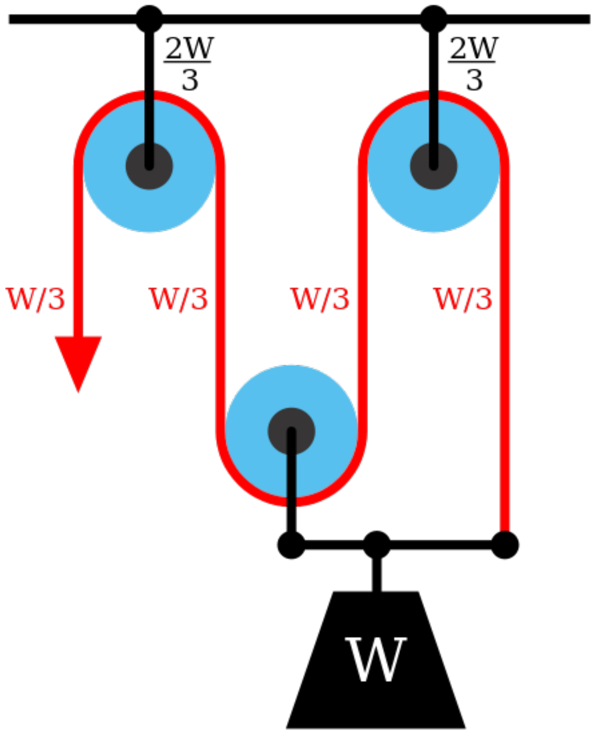


Figure 3:



Mechanical advantage Risk Assessment

Last updated: 02/02/2017 - 21:49

DESCRIPTION	Children use pulleys and levers to explore mechanical advantage
RISKS	1) Injury due to weight dropping suddenly and hitting audience member or demonstrator 2) Rope burns if rope is allowed to slide through hands 3) Entanglement/finger trap in pulley blocks/ropes. 4) Water spillage from weights 5) Impact injury due to frame collapsing 6) Rope lying across floor may be trip hazard.
ACTION TO BE TAKEN TO MINIMISE RISKS	1) Water weights are used - intrinsically soft with no sharp edges. Demonstrator to inspect the ropes prior to use for signs of wear and replace as necessary. The ropes have soft stoppers on them (tennis balls) so that the weight can't hit the ground 2) Ropes are relatively short, making it difficult for sufficient heating to cause burn to occur. Demonstrator to discourage audience members from running rope through hands. 3) Demonstrator to maintain control of experiment. If the experiment must be left unattended in a public area the pulley blocks should be detached and stored safely, and the frame folded down. Verbal warning initially will draw attention to risk and so be preventative. 4) Water weights should be double wrapped with translucent/transparent plastic. Cloth should be available to mop up spills. Site experiment away from mains electricals where possible. If any electrical equipment may be affected make sure it is turned off. 5) Frame is designed to be stable and far stronger than it needs to be, and cannot collapse if correctly put up. It would, however, be possible for it to be pulled over by kids pulling hard on the ropes after raising the weight to its maximum height and pulling sideways, demonstrator should familiarise themselves with the stability of the frame so that they know what directions and forces might present a risk. Experiment should always be closely supervised when in use. 6) Ensure rope does not lay across anywhere the public may walk.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in event of injury

Last updated: 02/02/2017 - 21:35

Cantilever Bridges

Engineering: Building a series of cantilever bridges

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

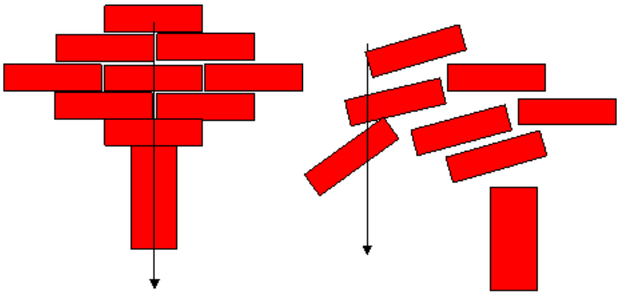
Thank you!

Kit List

Base boards
Small blue box of blocks
Laminated photos

Explanation

Basically you want to get across that you have to balance everything, and if the centre of balance goes over the edge of any support it will fall over.



Setting up the experiment:

Kids: works best on the floor, as the blocks don't fall too far when stacks topple! Get everyone to sit on the floor around the board/ pile of bricks
Grown ups: we've run this at an adults-only science evening, on a table, which worked fine. But adults are much less confident about stacking blocks than kids are!

The challenge:

The challenge is to build three bridges across the river. There are two rules...
1) You're only allowed to use the wooden blocks
2) The wooden blocks can only stand on the support blocks, not on the land (it's marshland, too soggy!) or in the river (cheating!)

The first bridge (smallest gap)

Start with this one, as everyone can do it! The first gap is easy, as you can just put a block across it.

Extension: Why does the block not fall into the river? One answer is that the block is being pulled down (by gravity), but is being pushed up the same amount by the supports at each end. This balance (of forces) is why it stays still.

The second bridge (bigger gap)

Do this one next, once they've succeeded at the first bridge. This gap is the width of three bricks. If you hold a brick partially across the gap/on the end of the support and let it go, it falls- why? (The brick/the forces acting on the brick aren't balanced.) How can you balance the blocks? (Think of a see-saw.) How can you get more of the block to go across the gap? (Balance it on the other side).

Try to do this yourself before you demonstrate the experiment. The most obvious design uses 8 blocks (2 towers of 1;2;1), the fewest we've see it done in is 5, but this doesn't look much like any bridge we've ever seen! It's not as stable - why?

Look for mirror lines/ symmetry: this is a simple way of making sure the towers are balanced. For the most common 8 block design the two towers are symmetrical, and each tower is symmetrical in the line above the support/ along the middle layer of bricks. (This is also true of the most common version of the third bridge).

It can be a bit of a surprise to find out how much of this is not obvious to some children. Many will start trying to build something like an arch, or want to put supports in the river. The first thing is to get them to see that combining bits of structure that tip over in opposite directions can produce something that balances.

The real trick is knowing how long to let them try to build the bridge without telling them how to do it. It's much better if they figure it out for themselves, but you want them to be able to build the bridges even if they can't spot the balancing trick! You want to give them a clue *just before* they get bored of trying - the real pro demonstrators can do this without being obvious that it's a clue, but that takes practice!

Once you've got to the end of this second bridge don't forget to tell them "well done" for completing a tricky challenge!

Here's an alternative version of our explanation for engineers/those used to thinking about moments:
The second bridge requires you to start cantilevering. Get the kids to show you where they want to put the next block - and why it won't work - suggest that they need to counterbalance it with weight - another block. Making the smallest bridge from 2 balancing blocks can help to get them started on the others. Then get them to see that things further from the fulcrum have more tipping power (moment). You can demo this with the bricks, using one as a fulcrum another as a beam and more as weights. Or get them to hold the heavy mass from the spinny chair (another CHaOS experiment that may be nearby...) close to them, then at arms length. Comparison with see-saws might be useful, as most children should have played on one of these).

The third bridge (biggest gap)

This builds on the ideas in the second bridge - take how long that took as an indication for how quickly to go through this. If they really struggled on the second bridge you don't have to make them do this one themselves. Get them to help you do this one, as you can't hold all the blocks yourself (which is usually true - two pairs of hands makes it much easier!)

You can use the same idea as the bridge above to go across a bigger gap, but this time the towers need to be wider (which ends up making them taller if you pick the simplest design). The most obvious solution is 2 towers of 9 blocks (1;2;3;2;1), but we've seen it done in as few as 7 blocks. What's the smallest number you can build it in? (We're mainly aiming that challenge at you demonstrators, but you might also want to give it to kids that have figured out the first challenge quickly!)

Extension: If you add more blocks to the top, to look something like the Corbeled arch below, the bridge appears to be more stable. Why is that?

For engineers: The third gap is more difficult, with the number of blocks you have, you can't just pile up a counterweight near the fulcrum, you have to get some of it further out to counterbalance the bridge.

These bridges exist in reality!

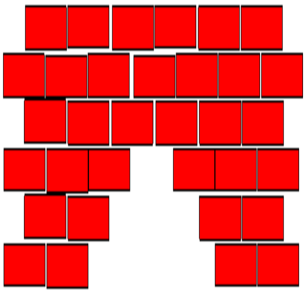
Note: some of the pictures in the box are arch bridges that go with the arch bridge experiment (which doesn't have its own box). Try not to confuse the two - the forces aren't the same in each.

You can compare the bridge to the Forth Bridge: a real example of a cantilever bridge. There are photos in the box. This bridge is in Scotland, and is famous for being so long that by the time you've finished painting one end that you need to go and start painting the other end!

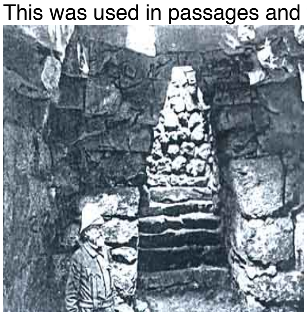
Look for the picture of the bridge in construction - here you can see the cores of the towers before sections were added to each side. That's analogous to our supports before we add sideways with extra blocks.

Two questions that seem to come up quite often with the bridge photos:
Why isn't it solid like the blocks? The Forth Bridge is made out of metal, this behaves differently to wood, and if you can fix the pieces of metal together you can get away with less metal than something completely solid. Apart from anything else, that saves money on metal?
Is our bridge weaker than real ones? Yes, because the blocks aren't joined. But it's very solid considering!

A primitive form of arch was called the Corbeled arch, this is basically two of the balanced cantilevers next to each other with the wall acting as the counterweight.



This was used in passages and tombs, before the true arch was developed.



Cantilever Bridges Risk Assessment

Last updated: 02/02/2017 - 21:35

DESCRIPTION	Children use a set of wooden bricks to build a cantilever bridge across a painted board.
RISKS	1. A very tall tower may mean bricks have enough energy to bruise when the tower falls down... 2. There is a trip hazard from the board placed on the floor. 3. Children may pinch their fingers in between the boards on the floor. 4. There might be splinter coming out of the wooden blocks.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Demonstrator to monitor building, anticipate collapse, and get children to stand back. 2. Don't put the experiment in an area which is likely to be used as a thoroughfare. 3. Demonstrator to ask children to not place their fingers where they can be pinched between the boards. 4. Demonstrator to make sure only wooden blocks with no splinters coming out are used.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	Call first aider in event of injury

Last updated: 01/02/2017 - 23:02

Arch Bridge

Engineering: Building an arch bridge, and then walking over it.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Bridge Base (flat board and two triangular pieces, they attach together with wing nuts)
5 Blocks (all the same)
2 wooden supports (scaffolding to assist the building process)

Explanation

*** OVERVIEW ****

This is an arch bridge built of 5 identical blocks, which the children can then walk over.

Possible activities:
1. Build bridge.
2. Walk over it.

Other things to talk about:
Forces on blocks.

Tips for demonstrating:
The blocks are quite heavy for small children, so you may need to lift them for them/get parents to help. Don't let them jump on the bridge/too many on at once - jumping off sideways may cause the bridge to fall to the side, too many children on at once may push each other off.

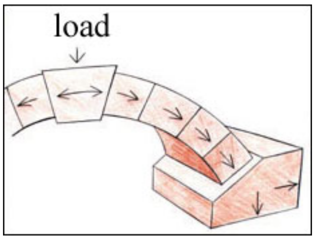
*** BASIC PROCEDURE AND EXPLANATION ***

To build the arch bridge, get the children to place the wooden supports between the ends of the bridge, then get them to add the blocks, starting at the ends. If they have trouble working out which way round to put the blocks try showing them the trapezium shaped side of the block. Ask them whether the longer or shorter side needs to go on top to make the arch shape.

Check that the blocks are all lined up straight and that the tops of the blocks all meet. Ask them what will happen when you take the wood away - will the bridge stay up? Why?

Take the wood away - the bridge stays up! Talk about how the shape of the brick means that they are being squashed in from the sides ('in compression') and they can't fall down. Ask if they think the bridge is strong enough for them to walk over (subtly check that the bridge is sturdy first) - take care that they don't fall when they do this.

When the child is standing on the middle of the bridge, ask them what is stopping them from going straight down. Depending on the child's age, could talk about the force of their weight, and explain how it is pushed out sideways and that it is because the ends of the bridge cannot move away from one another that they don't fall down.



Explain that this is how real arch bridges work - the mortar 'gluing' the bricks together isn't very important, all the strength is due to the bricks being squashed together horizontally. Bricks are strong in compression, but no good in tension.

It can be useful to ask the children how the other blocks would have to move to allow one of the blocks to fall, to get them to see the arch as a lot of wedges jammed in between the piers. Very wide stone arches have a tendency to force apart their piers and collapse.

Arch Bridge Risk Assessment

Last updated: 01/02/2017 - 23:02

EXPERIMENT	Build a bridge out of the blocks then walk across it.
RISKS	• 1. Dropping Blocks on feet • 2. Falling off bridge • 3. Blocks getting smooth over time and slipping against each other

	• 4. Bridge falling over sideways • 5. Being hit by carried bridge scaffolding
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1. Blocks are designed to be fairly light and covered with rubber. Demonstrators may need to help younger children carry the blocks. • 2. Make sure that the bridge is erected somewhere the floor is flat, with no sharp corners to fall on. Don't let kids jump up and down on the bridge (both because the blocks can slip and the child can fall off). Children should only go on the bridge one at a time. Don't let children crawl under the bridge. • 3. Blocks should be checked for smoothness at the beginning of the event. Demonstrator should remain vigilant for blocks slipping during the event. • 4. Demonstrators should test the bridge by walking over it before any children do. Children should not be allowed to jump off the bridge sideways, as this may cause the bridge to fall. • 5. Small or overexcited children should be supervised when moving bridge scaffolding.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Call first aider in event of injury • 2. Call first aider in event of injury • 3. Demonstrator must stop experiment if they suspect that the blocks are getting smooth. Call first aider in event of an emergency • 4. Call first aider in event of injury • 5. Call first aider in event of injury

Last updated: 10/02/2017 - 09:40

Trebuchets

Engineering: Using a medieval inspired siege-weapon to launch bean bag bunnies

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

2 x collapsible trebuchet
4 x bean bag rabbits (mostly missing, have been replaced by rice in balloons)
(all in a big red box)
bolts (with wingnuts) to assemble trebuchet in plastic tub
release pins (also in plastic tub)
Note for future: An artificial soft surface (e.g. piece of roll mat) would lower the wear rate of the weights, esp. on tarmac or dry mud. If they start leaking nuts during a session, repair with gaffer tape!

Explanation

New for 2010.

The Challenge:

Split the group into two teams. This could be two groups of children at schools or a child and their parents at events.
Each team gets a trebuchet.
Compete to try and launch the bean bag the furthest or to get the bean bag into a box if space is limited.

Optional challenge to beat the day's record.

Explanation:

The trebuchets can be modified in two main ways, the pivot position and and the angle of release.

The optimal pivot position seems to be the third or fourth hole from the weight (don't tell them this). With the weight close to the pivot, it cannot accelerate the arm fast enough. This can be explained via the analogy of opening a door via pushing it near the hinge, which is much harder than doing it normally. However, with the mass too far from the hinge, the acceleration of the arm is greater, but speed of the bean bag end is small as it is now too close to the pivot. This time, the structure of the trebuchet also needs to be taken into account, as the weight hits the ground before completing the full swing. As it is not good at either end, the best position needs to optimise the balance between these two ideas.

The angle of release can be altered by the position of the spaghetti spoon launcher. The best launching angle should be 45 degrees, or a bit less accounting for air resistance. However, it will not necessarily fire at the same angle when the pivot position changes so this may also have to be adjusted.

Some of the bean bags have a string attached, which act as a sling to launch the projectiles further. At the moment that the bean bag leaves the trebuchet, it is swinging relative to the arm, so its relative speed adds up with the normal launch speed. Show them this after they have tried it normally.

Things to talk about:

* Levers: the more the distance to the pivot the less the force, but the greater the distance moved. It might be worth starting off with a brief explanation of how levers work using an arm.
* Why it's best to have the projectile far from pivot.
* Angle of release: 45 deg should always be best for range, neglecting wind. How can we control the angle? - the rabbit is ejected from the trebuchet when centrifugal force overtakes any force the holder exerts on it. (Centrifugal force gets bigger as the arm accelerates through the swing.)
* Using a sling to get extra velocity.

(more suggestions welcome)

Trebuchets Risk Assessment

Last updated: 10/02/2017 - 09:40

Risks
- Injury from projectile-carrying arm flying up and hitting audience member or demonstrator in the face. This is a bigger problem when the weight is far from the pivot, as the arm flies up with large force. Also has the potential to be especially nasty if pointy bits of spaghetti spoon hit someone in the eye.
- Injury due to weight dropping suddenly and hitting audience member or demonstrator
- Projectile - could hit audience member or demonstrator
- Trapping fingers between arm and support when the trebuchet is fired.
- Spare projectiles may act as a trip hazard on floor

Action taken to minimise risk.

- Instruct kids and demonstrators to fire the trebuchet by standing to one side, releasing the arm by pulling away the release pin.
- Weight - has been made from nuts - no sharp edges and will deform on impact.
- Projectile - light bean bag, trebuchet designed to have limited range and velocity, and will not hurt on impact, even at high speeds.
- The supports are solid to reduce possibility of fingers being in way of arm.
- Ensure all spare projectiles are near to the experiment, and don't end up in walkways.

Action to be taken in the event of an accident.
Call a first aider in the event of injury.

Last updated: 11/02/2017 - 18:47

Engines

Engineering: What are the different types of engine, and how do they work?

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Internal combustion engine model, Jet engine model, Stirling engine model, soft pencils, kettle, mug.

WARNING: STIRLING ENGINE MUST NEVER BE LUBRICATED WITH OIL. It will gum it up. Lubricate bearings with graphite from soft pencil only.

Explanation

Engines Experiment - Explanation
Last Update - Gareth Funk, April 2015

************** INTRODUCTION **************
I like to start with the Stirling Engine whirring away whilst I give the following introduction. To do this, the Stirling Engine should be placed on a mug of freshly boiled water and given a push to get it going. It will only go one way for reasons which should become clear.

Before looking in detail at any of the models, it is worth asking the question “what is an engine?”, or alternatively, “what do you know that has an engine?” and as a follow-up “why does it need an engine?”.
Many of the children will not be able to give a good answer to the first, but can answer well enough the second two. The key thing about all engines is that they turn energy from one form into mechanical (or kinetic) energy and an engine is simply any device that does that.
Examples of engines are:
- Electric motors
- Jet Engines
- Steam Engines
- Internal Combustion Engine
- Stirling Engine

Excluding the Electric motor, all the above are heat engines: they use heat energy as their input. Obviously this energy usually comes from burning something, but thermodynamically the input to the engines is heat. It is worth noting that the jet engine is also, strictly speaking, an type of internal combustion engine. Similarly it is worth noting that the steam engine and the stirling engine are examples of external combustion engines.

The Stirling Engine is the best one to demonstrate because it best exemplifies the idea of a thermodynamic cycle and gives a real-life demonstration of an engine in action. The Internal Combustion Engine and the Jet Engine models are just models and a lot of children can’t see past the fact that a battery and an electric motor are what is making them turn. However, if there is time left after the Stirling Engine demonstration, feel free to move on to the others if you have time.

************** STIRLING ENGINE **************
The Stirling Engine we have is one of three commonly seen implementations of the Stirling Cycle. Out of interest, ours is a Gamma Configuration Stirling Engine. Most Stirling Engines used in practice are of different configurations but the thermodynamic processes they undergo are the same.

The following explanation requires that the children are familiar with the concepts of pressure and volume. A good, quick way to explain pressure is to get them to consider running around in a room with their eyes closed. They’d bump into walls every so often. They’d bump into walls more often if there were more of them in the room, or if the room got smaller.

Before we proceed, the following things need to be pointed out concerning the names we will use for the various different parts of the engine. Point out the two different pistons. Note that the black piston simply moves the gas to the hot space (when it lifts up) and to the cold space (when it comes back down). It is as such termed the “displacer piston” however during the demonstration I tend to stick to “black piston” but it is nonetheless worthwhile to show them that is simply moves the gas around and does NOT compress it. The glass piston at the top changes the overall volume of the chamber: when it lifts up, the volume increases (expansion) and when it descends, the volume decreases (compression). The hot space of the engine is the metal surface in contact with the hot steam (please stress that this is not a steam engine!) and the cold space is the upper metal surface in contact with the surrounding air. Also tell them what the flywheel is and point it out (it’s the large gold-coloured wheel which spins). The flywheel is there mainly to store the mechanical energy we extract but also to tip the pistons from one phase to the next.

Stop the Stirling Engine by keeping your finger on the flywheel so that we can slow the process down and step through the stages in turn. Let the engine get to the point where the black piston is about to come up and then proceed with the following explanation.

The idealised Stirling cycle consists of four thermodynamic processes acting on the working fluid (in our case, the air trapped inside the chamber):

Constant-Volume (known as isovolumetric or isochoric) heat-addition:
The glass piston is staying roughly still at the bottom of its stroke during this process which means that the volume of the chamber is remaining constant. The big black piston is moving up which moves the gas into contact with the hot space and so it heats up. During this process, the pressure will also increase.

Isothermal Expansion:
The small glass piston rises up thus expanding the hot fluid meanwhile the gas continues to be in contact with the hot space as the black piston is staying roughly still.
It is NOT important to stress the constant temperature; the expansion of the gas and the intake of thermal energy are the key points.

Constant-Volume (known as isovolumetric or isochoric) heat-removal:
The glass piston stays still (now at the top of its stroke), hence constant volume, and the black piston moves down moving the gas from the hot space and into contact with the cold space and so heat is lost.

Isothermal Compression:
The glass piston now moves down and compresses the gas. The black piston stays still so the gas continues to lose heat at the cold space.

The cycle repeats:
Now we are back where we started but in getting back to where we started we made the wheel spin! Now the cycle will continue over and over again until we run out of heat.
This is the really important point to stress: by doing those four thermodynamic processes we extracted some mechanical energy!

Note here that these processes have to happen in this order hence why the wheel only spins one way.

To finish off, take the stirling engine off the heat, let it stop, and then ask "what would happen if we were to spin the flywheel in the opposite direction to the way it normally spins?". Think about the system we had before: Heat was added at the bottom, the wheel turned round. The answer to the question is that the opposite would happen if we were to spin the wheel in the opposite direction the bottom surface would heat up. This will not be practical the demonstrate as it's difficult to spin the wheel sufficiently fast but it is nonetheless true. Some children will instinctively get this without much prompting but in my experience most struggle with the concept.

************** INTERNAL COMBUSTION ENGINE **************

Our particular model is of a four cylinder, four-stroke engine. The piston completes four separate strokes which together comprise a single thermodynamic cycle. A stroke refers to the full travel of the piston along the cylinder, in either direction. The strokes are as follows:
INTAKE: this stroke of the piston begins at top dead centre. The piston descends from the top of the cylinder to the bottom of the cylinder, increasing the volume of the cylinder. A mixture of fuel and air is forced by atmospheric (or greater) pressure into the cylinder through the intake port.
COMPRESSION: with both intake and exhaust valves closed, the piston returns to the top of the cylinder compressing the air or fuel-air mixture into the cylinder head.
POWER: this is the start of the second revolution of the cycle. While the piston is close to Top Dead Centre, the compressed air–fuel mixture in a gasoline engine is ignited, by a spark plug in gasoline engines, or which ignites due to the heat generated by compression in a diesel engine. The resulting pressure from the combustion of the compressed fuel-air mixture forces the piston back down toward bottom dead centre.
EXHAUST: during the exhaust stroke, the piston once again returns to top dead centre while the exhaust valve is open. This action expels the spent fuel-air mixture through the exhaust valve(s).

Focus on one cylinder when explaining these but make sure you are pointing out the correct stroke! Check the valves to check you're telling them the right stroke at the right time: If the valves are open then the stroke is intake or exhaust, depending on which way the piston is moving. If you get this wrong the spark won't be at the right time and the valves will be open when you're saying the fluid is being compressed etc.

Note that the cylinders are not all moving together and even those that are do not fire at the same time. This is in order to deliver the power more smoothly with four smaller bursts per two revolutions than one large burst per two revolutions. Most cars have 4 cylinder engines like our model.

Side Note: The model can be switched off and on such that it gets out of sync with the spark. If it does this, turn it off and on again, stopping at a different point in the cycle, until it gets back in sync.

************** JET ENGINE **************
As of this update, the Jet Engine model has not been built yet. This section will need updating once the model is finished and I have decided what can be demonstrated with it.

The following is from wikipedia:

A turbofan engine is a gas turbine engine that is very similar to a turbojet. Like a turbojet, it uses the gas generator core (compressor, combustor, turbine) to convert internal energy in fuel to kinetic energy in the exhaust. Turbofans differ from turbojets in that they have an additional component, a fan. Like the compressor, the fan is powered by the turbine section of the engine. Unlike the turbojet, some of the flow accelerated by the fan bypasses the gas generator core of the engine and is exhausted through a nozzle. The bypassed flow is at lower velocities, but a higher mass, making thrust produced by the fan more efficient than thrust produced by the core. Turbofans are generally more efficient than turbojets at subsonic speeds, but they have a larger frontal area which generates more drag.[11]
There are two general types of turbofan engines, low bypass and high bypass. Low bypass turbofans have a bypass ratio of around 2:1 or less, meaning that for each kilogram of air that passes through the core of the engine, two kilograms or less of air bypass the core. Low bypass turbofans often used a mixed exhaust nozzle meaning that the bypassed flow and the core flow exit from the same nozzle.[12] High bypass turbofans have larger bypass ratios, sometimes on the order of 5:1 or 6:1. These turbofans can produce much more thrust than low bypass turbofans or turbojets because of the large mass of air that the fan can accelerate, and are often more fuel efficient than low bypass turbofans or turbojets.

Engines Risk Assessment

Last updated: 11/02/2017 - 18:47

4-stroke and Jet engine models:
======================

These are commercially available childrens' toys, so risks are minimal

Risks
------
1) Choking hazard from small parts

Action to mitigate risks
----
1) Keep away from very small children. If engines break, close experiment and put parts in box.

Action to take in event of hazard still occurring
----
1) Call first aider.

Stirling Engine:
===========

Risks
------
1) Hot water may cause burns
2) Water may be spilled
3) Risk of burns from boiling water in kettle/on hotplate
4) Some sharp edges if engine dismantled (flywheel runs on point bearings)
5) Finger trap risk in fly wheel

Action to mitigate risks
----
1) Warn of hot water (and steam) before experiment starts, keep hot water away from easy reach of children's hands.
2) Use stable mug for water. Do not over-fill. Mark mug as "HOT".
3) Heat water in kettle or temperature-limited hot plate. Keep heating apparatus well away from rest of experiment/children
4) Do not allow children to play with Stirling engine. If flywheel becomes detached, demonstrator to reassemble
5) Flywheel is very light and has little angular momentum, even at high speed.

Action to take in event of hazard still occurring
----
1) Rinse burnt area under cold water for at least 10 minutes; call first aider
2) Close experiment; Mop up spilt water if cool enough to do so
3) Rinse burnt area under cold water for at least 10 minutes; call first aider
4) Call first aider
5) Call first aider

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 06/02/2017 - 01:39

Robots on tour!

Engineering: Challenges that can be done with robots in a relativley short time period.

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Lego Mindstorms Robot kit (Spare pieces are in the box, along with NXT bricks, batteries and cables. The motors and frame are in a separate bag wrapped in bubble wrap)
18 x AA Batteries (Currently there are 16 rechargeable and 2 non rechargeable)
2 x Recharge stations
1 x Green fabric with blue fabric "pond" sewn on

Explanation

Set up:

For the computer:
Turn on the CHaOS laptop (currently 2,3 and 4 have the software installed but it is free to download from the lego website)
To login the password is CHaOS (capitalised correctly)
Start the lego mindstorms program
Go to file -> new project. If you want to be able to find programs you have created more easily I recommend you go file -> save as.
It is also possible to double click on the program name to rename it. At public events I like to ask children their names and name it that so which program is theirs can be easily seen.

For the robot:
If you aren't sure of the level of charge immediately start charging its batteries
If you are confident the batteries are suitably charged, put the batteries into the NXT Brick.
If the robot is damaged, fix it (I need to take pictures so everybody knows what it looked like).
The Nxt Brick should be put onto the robots base.
Connect the colour sensor to port 3, and the motors to ports B and C. The motor wires **should** cross due to way the steering works

The programming
Ideally you should experiment with the robot before you start demonstrating. All programs consist of series of blocks that contain instructions which the robot will follow in order.
There are four blocks that I use more than the others:
Green Tab, 3 along. This is "Move Steering" with this you can control which direction the robot turns and how tightly, which direction it will travel and how fast and how long it will do so for. Alternatives to this would be the "Move Tank" and "Large motor" Blocks which I feel are less intuitive
Green Tab, 7 along. This is "Brick Status Light". It can be set to three different colours and be on continuously or flash. It is useful for identifying sensor inputs easily. An alternative to this would be the "Sound" block which I find is too quiet too be heard in a room full of children. The "Display" block can also be used too.
Orange Tab, 3 along. This is the "Loop" Block. Loops are an important concept in programming and quite simple. It works especially well in combination with the next block.
Orange Tab, 4 along. This is the "Switch" block and is the most interesting block I frequently use as it allows the robot to make decisions based on inputs. I use the colour sensor but if you wanted to make modifications there is potential for other sensors to be used. If you want to follow the edge of a colour I would recommend using compare colour. If you wanted to stay with in a coloured area separated by two different colours you would use measure colour. Compare is more reliable as it can tell whether or not something is a certain colour quite well, but with measure it can be hard to determine what the robot will decide it is e.g. purple when you are asking it to choose between red and blue. The two 'paths' of the switch should have the robot turning different directions or travelling in different directions in order for something interesting to be observed.

Demonstrating:
I start off by asking them their names so that we have an easily identifiable program (In schools the groups will likely be too large for this. I then ask them, what do robots do? You will get a range of different responses, sometimes close to the answer of "they follow instructions". I then introduce the program to them and tell them that the blocks are just instructions for the robot.

Depending on the age of the children you can ask them what they want it to do e.g. "Do you want it to turn left or right?" and program it yourself or tell them "this slider controls how it will turn" and let them do it. After they have made their block they need to download the program to the robot.

Connect the cable to the computers USB port and the pc port on the output side of the robot. Press the download arrow in the bottom right of the screen. It may be grayed out if you have just connected the robot. After you have pressed download the robot will make a noise. This means it has downloaded. You will now need to look for your program on the robot. Go to the file tab, pick the correct project, then scroll down to the correct name. Get the child to verify that that is their name on the program that is about to be run. Place the robot in a suitable space and let them press the middle grey button.

You can then move on to making the program more complex, normally by making lights flash and a second movement block. If you think they are mature enough move on to using the sensor. Delete the previous program and put the loop and switch in place. Let them chose what they want in each option but give hints so that it ends up doing something interesting.

If they really want to do more let them, but I normally end by discussing in which jobs are robots most useful. The boring ones (painting cars), and the dangerous ones (missions to mars).

To get ready for the next child create a new program and keep the old ones as some may do interesting things which take time to program. However keeping too many programs can resulting in downloading taking more time.

Advice for demonstrating in Schools:
- It is more important that you don't keep the children for too long, this experiment can easily take 20 minutes if you try to get them to do the line following even with significant prompting.
- Try to ensure that all students make an input to the program, this becomes more difficult with larger groups
- For primary school students it is probably fine to ignore the sensor completely and just let them play around making a basic program with flashing lights, sounds and movement.
- For older secondary age (Y9+) students you should try to get them to do line following.
- For children in Y7&Y8 ask them whether they want a challenge (line following) or just to play around.

Big Kids/PLUS/whatever we are calling it now
The line following works well for this age as most have not done significant amounts of programming so it will still be a challenge. For students who complete that quickly you can push them further. Instruct them to start far from the blue and travel in a straight line until they hit the pond then follow it around, stopping when they get to a red piece of card.

You should not yourself be restricted by these instructions if you have other ideas of how to run this. There is a huge potential of things that could be done.

The below sections are not part of a demonstration but are retained as they could be used in future designs

Maze

A simple maze can be created with the wooden blocks or cardboard. The challenge is to program the robot so that it can navigate its way through the maze without any outside influence once it has started. This can be be done in several ways that progressively advance in difficulty:
1. Dead reckoning: the robot is programmed to move forward a certain angle, turn, move forward another certain amount and so on. This requires no sensor use and the robot is likely to generate errors in its positioning as it moves further. The robot could potentially fitted with a missile to try and hit targets once it has been through the maze.
2. Sensors with knowledge of the maze: The robot is equipped with touch/light sensors on its front and detects when it hits an obstacle. With knowledge of the maze, it will be possible for children to have set the correct direction for the robot to turn. The robot should be able to progress through the maze with smaller errors.
3. Sensors and a generic maze: The robot will be programmed to turn whenever it hits an obstacle and if that turn leads to another obstacle it will turn the other way. Through use of counters it could even find its own way back through the maze with little crashing. Sensors on the sides could be used to correct its course if it has a glancing impact with the wall.
4. Maze with coloured tiles. Using the ability of the robots to detect colours we can tell them to perform certain actions when they see a certain colour.

Robot Writer

The A3 sheet will be placed under the wooden blocks used for the maze so that it does not slide. The robot will be equipped with a pen holder arm that will be raised or lowered as necessary. This arm could be stationary relative to the robot or could move, allowing more effective writing to be used. The movements are likely to be by dead reckoning.
Children could be instructed to program the robot to make letters of the alphabet and write words. A simple task could be for them to write the word CHAOS. They would create a sub-program for the letter "H" and then add it to to subprograms created by the demonstrator that write the other letters. Potential inputs could be morse code claps to be picked up by a microphone and subsequently written down by the robot. This bit is likely to be too advanced for the time we have but could be used in less time sensitive places such as public events.

Robots on tour! Risk Assessment

Last updated: 06/02/2017 - 01:39

Laptops

DESCRIPTION	Laptops with NXT programming software installed
RISKS	1. Trip hazard of wires 2. Electrical hazard
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Ensure wires are either taped securely to surfaces, or are placed behind tables, so no one walking past will catch themselves on the wires. 2. All laptop chargers will be PAT checked for safety and will be kept out of reach of children
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Turn off power at the mains, do not touch any other components, such as the laptop or its battery. Call First Aider

Lego Mindstorms NXT Kit

DESCRIPTION	Kit consists of control brick, with enclosed batteries, associated cables to connect the brick to peripherals, and lego pieces to construct robots with. Motors and sensors are also provided
RISKS	1. Swallowing hazard for small lego components 2. Short circuits in motors 3. Objects wrapping around motors i.e. hair 4. Robots falling off tables and hitting small children/sitting children
ACTION TO BE	1. All visitors will be monitored regularly by demonstrators to ensure they do not swallow any lego. The robots are largely pre-built, minimising visitors' use of individual parts, and any modifications will be supervised by a demonstrator. Particularly young children must be supervised closely. 2. Motors are sealed in a robust manner, so any short circuits will result in a simple failure, with no risk to users. In the very unlikely event of an exposed short, voltages and currents used are very low (powered by 4 AA batteries), so present no significant risk to users

TAKEN TO MINIMISE RISKS	3. Motors are sealed, so hair is unlikely to be caught, though it may be caught by gearing systems. All visitors will be made aware of the risk and asked to ensure any dangling objects on their person are kept out of the way. They will also be made aware of the emergency stop, which will shut off all motors instantaneously 4. If at any time the robots are going to be left unattended, they must be put into a box to prevent children from using them while unsupervised 5. Robots should be used on the floor unless they are immobile or all children present are standing and have their heads above the edge of the table
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. Immediately stop robot if anything is caught in motors. If short circuit occurs, power down the robot and do not use the kit further. Call a first aider if required, though risk here is minimal. If any parts are swallowed, immediately call first aider.

Electrical Parts Risk Assessment

DESCRIPTION	This experiment uses mains electrical equipment. Please be aware of the following potential hazards arising from this.
RISKS	• 1. Faulty/loose wiring - risk of fire or electrocution. This risk applies only to mains voltage equipment that plugs into the 240V mains supply; any part of an experiment that comes into direct contact with the public will use a power supply with a safe low voltage output. • 2. Water getting in contact with the equipment - risk of electrocution • 3. Trip hazard on cables - risk of injury or pulling things over
ACTION TO BE TAKEN TO MINIMISE RISKS	• 1a. DEMONSTRATOR must visually inspect all electrical equipment before using it. Please look for loose cables, bare wires or anything else suspicious. If you spot faults then please do not use that equipment, and report it to a comittee member. • 1b. DEMONSTRATOR to ensure that there is a PA test sticker dated within the last two years on any mains voltage equipment, or that the equipment was purchased within the last two years (should be marked with the date of purchase if there is not a PA test sticker). If the equipment was PA tested or purchased more than a year ago, DEMONSTRATOR to check that there is a sticker to show that the equipment has been formally visually inspected within the last year. • 1c. DEMONSTRATOR to ensure that electrical equipment is not placed next to or under flammable materials (eg. under a jumper). • 1d. COMMITTEE to ensure that all mains voltage equipment is PA tested every two years, or if possible, annually. Newly purchased (unaltered) equipment need not be tested immediately, but should be tested, at the latest, within two years of purchase, and then every two years thereafter. If newly purchased equipment is not marked with a PA test sticker, it should be marked with the date of purchase. Electrical equipment that has been modified in any way should be PA tested before first use. COMMITTEE to ensure that, if equipment has not been PA tested within the past year, it is formally visually inspected by a committee member approved by the committee to carry out such checks, and marked with the date of inspection. • 2a. DEMONSTRATOR must think about the danger of water coming into contact with the equipment. Ensure electrical equipment is not near water, or on the ground in a place where water might pour in event of a nearby experiment breaking. • 2b. If outdoors, DEMONSTRATOR to keep cables off ground and away from damp, especially if using the venue the next day as well (dew settles). • 2c. DEMONSTRATOR please make sure that you know the location of the electric wall socket where the equipment is plugged in, and the location of the cut-off switch for the room, if there is one. • 3. DEMONSTRATOR to ensure cables are safely taped down
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	• 1. Turn off electricity at mains. Call first aider in case of injury. • 2. Call first aider in case of emergency. • 3. Call first aider in case of emergency.

Last updated: 20/03/2017 - 18:48

Kruskal's count

Maths: Players follow playing cards around a circle and watch as they magically come together

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

* One pack of giant cards
* Two normal packs of cards (red and blue backs)
* Various coloured duplo pieces

Explanation

By placing cards on the floor in a circle and assigning a number of steps around the circle to each card, it can quickly be seen that people starting on cards all around the circle will converge. The question is why does this happen, and what will make them converge quicker?

You can then predict the future by laying out a whole deck of cards and predicting (with about 90% accuracy) what the last card they'll pick is.

Setup
You can either set up with standard or oversized cards. For the large ones spread the cards in a large circle, not every card needs to be used if space is limited, with plenty of space around the cards. For standard cards you can set up on a table, either in a circle or as multiple rows of around 8 cards, you may want to set up with cards in between or curving to make more of a snake shape as well so people know what to do when they reach the end of a row.
If you need to skip cards for space you'll probably find leaving out picture cards saves the complication of explaining how to move on them.
With the small cards duplo pieces can be used as placeholders. With the large cards, everyone can be their own placeholder, standing on the cards.
(Warning, the whole point of this experiment is that everyone ends up on one card, so don't play with so many people that it becomes a scrum)

Explanation and Demonstrating

1st part. The circle
Much of the point of this experiment is that you can, with the children's instruction, vary the rules of the game somewhat to examine the effects. However a basic idea of the rules is et out here:

Lay about half the deck on the floor in a circle (can use the whole deck, or even more than one, but the game will take longer and space is an issue), it doesn't really matter which cards go down, although lower cards will lead to a shorter game.

For cards 2-10 players will move that number, aces will move 1 and jack, queen, king 5 places each. If you're not using all the cards you may want to have some of the high numbers move less spaces but try and see what works.

Once everyone's moved, they check their current card, and move again as appropriate.

Repeat, indefinitely. Although at some point everyone will end up on the same card, or at least going round the same sequence of cards ad-infinitum.

You can challenge people to try and work out who needs to move to catch everyone up to each other, or challenge them to see who the first person to land on a particular card is (if you pick one not on the circuit it becomes much more clear that they're confined to a small subset of cards)

Now, why does this happen?

It's not too hard to see that everyone on any particular card will then stick together for the rest of the game, as they are all on the same card being acted on by the same rules.

However, there are more than one 'routes' to most card (not true for all, and abundantly true for some), meaning that it's not just people coming from one particular card that might end up on the next card. Thus the group slowly accrues people as others happen to find their way into it.

This explanation is simple enough, and most children should grasp it. But what we really want to ask them is what happens when they change the rules. Particularly, what can we change to make the game quicker or longer.

What happens when we increase the number of cards? The game gets longer as there are the same number of people spread out over more possible spaces.

What about if we reduce the number of steps, try -1 or even more? On writing this I'm not even sure, have a go yourselves!

Why do we set a low value for all face cards, what happens when we increase it? In the long run this should make the difference between the mean amount of time, and that found in experiment, bigger. I.e. increases the standard deviation, but this is hard for anyone to grasp. What you will instead see is that people flit about the board much faster, and even if it doesn't prove that the system has higher uncertainty, it'll certainly feel like it.

What about if you multiply all the step values by 2? Actually groups should form at the same rate as before, but you should eventually see two, roughly equal sized groups, unable to meet, as of course, if they are an odd number of cards away from each other there's no mechanism by which they'll come together.
Once you've done this sometimes it's fun to try with multiplying by 3. People may feel that three groups should form however as 3 doesn't divide 52 you just end up moving further and still bunching up. It might increase the chance of independent cycles though. If they're really keen try 13 afterwards.

2nd part. The ladder

After you've shuffled and layed out the deck, pick one of the first 9 cards and play the game, as before, reading the cards left to right, going down line by line like a book. (If there's space you can even lay them out in a very long line) When you go past the far end, take a note of the last card of the deck you were on (e.g. if you land on a five, with only three cards left, that's your card).

There's now roughly a 85% chance that any card picked on the first row will lead to this particular card. The reason for this is much like the first part, that there are many routes to one card, but only one route off of it. I suggest getting the first volunteer to do it on their own, when you can astound them by guessing where they'll end up, and then letting the rest all go together, and they may begin to notice that they've all grouped together long before the end.

P(success)~1-(1-x^-2)^N
x = average card value N=number cards

Again you can experiment with changing the rules and see how well your guesses work. Adding more cards or reducing the step length will increase your likelihood of being right, simply put, the more steps people take, the more likely they are to coincide.

--Real World Applications--

What we're really demonstrating here is a many to one mapping, where there are lots of paths onto one card, but only one path of it. I wouldn't really recommend going into too much detail about this with children, but we can talk about some other interesting examples of many to one mappings.

Buses bunching up are a fun example, there the reason for the bunching (that the first has to pick up lots of passengers, taking a long time allowing the next bus to catch up and as the gap shortens, the number of passengers the next bus has to pick up reduces markedly) is different, but the effect is much the same, showing that once these things come together, the only way to split them apart is ending the game (or in this case the bus line) or artificially holding one back.

This experiment also links to ideas of when things coincide, for example with only even valued cards, it's clear that separate groups that will never meet must form. A really cool example of this in nature is with cicada lifetimes. Predators have a boom, bust style life cycle, where food is plentiful, they over populate, over predate, food becomes scarce, populations dwindle and thanks to low predation the populations of prey increases and the cycle repeats. The cicadas who only emerge after a number of years, don't want to emerge during any of the predator booms, as this would decimate their populations, so in order to avoid this, they have developed prime number life cycles, such that the number of years between periods when they emerge during high predator populations is maximised. As this will happen every lowest common multiple of both the lifecyles, prime numbers maximise this time. You can try and visualise this experimentally by getting people to move around different multiples of the value, those who have common factors should land on the same card more frequently than those whose multiples are coprime. It's important to note that they haven't "chosen" their life cycle, only that the ones with the favourable length cycles have survived best and reproduced to form the largest remaining populations a la natural selection.

There are a few more abstract examples, like water in rivers, that joins together from many different tributaries into one body of water that flows to the sea. You could even talk about the way new technology is invented and sold, different companies often follow the same path (touchscreen on a phone? preposterous!) but lag behind or jump ahead of each other in much the same way that people on the cards lag behind or stay ahead of others.

There are also plenty of examples in computing of many to one mappings, and if you think of any other good ones let us know and we'll add them in to this description!

You could also relate this to other Markov Chains, if random walks is out that's a good example of a slightly different Chain where what you do is not deterministic at each step. You could even do a random walk on this by flipping a coin to decide if you go clockwise or counter-clockwise at each step. Who knows what will happen. You could also talk about this process as being a 'smoothing out' of the randomness of where people start. You can predict very well what card someone might be on after 1000 steps just by picking one in the cycle people get trapped in, no matter where they choose to start. This can then be related to Brownian motion (a continuous time Markov Chain) imagine dropping some food colouring in a fish tank, at the start it's particularly random just a series of droplets, after an hour everything has smoothed out and your fish tank has pale coloured water. If you're feeling brave relate this to Entropy rates and Entropy.
An example lots of people like is Monopoly, it's an irreducible markov chain and has an interesting stationary distribution. Essentially as there are lots of ways to go to jail that skewes the distribution to around 9% jail time, then rolling a double to get out skewes further for Trafalgar square at 3%. You can then use this to estimate how many houses you should optimally buy, however it's all probabilistic, you can get people to think how long it takes to realise these expectations, for Monopoly it's quite a while but for Kruskal it's pretty quick. This introduces mixing times.

Kruskal's count Risk Assessment

Last updated: 20/03/2017 - 18:48

DESCRIPTION	Following the numbers on a card around a circle
RISKS	1. Children swallowing duplo pieces 2. Many children trying to occupy the same card 3. Cards are slippy if stood on
ACTION TO BE TAKEN TO MINIMISE RISKS	1. The duplo pieces should be sufficiently large to discourage swallowing, but keep an eye out for children putting them in their mouths anyway 2. Keep the number of children playing the game on the giant cards under a sensible limit, I would suggest 8 at a time, and discourage them from running or any form of pushing and shoving 3. Discourage people from actually stepping on the cards.
ACTION TO BE TAKEN IN CASE OF ACCIDENT	1. Call first aider if child swallows, if choking encourage child to cough. 2. Call first aider in case of injury 3. Call first aider in case of injury

Last updated: 20/03/2017 - 19:29

Random Walks

Maths:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

* Duplo blocks
* Dry wipe pen
* Duplo baseplates (2 stuck together for the race)
* Fair coin (10p)
* Biased coin (2p)

(n.b. if there isn't a biased coin, because it's got lost for any reason, you can always just use a bit of sleight of hand and lie, saying it's heads two thirds of the time...)

Explanation

A variety of experiments can be done with random walks, showing not only the idea of a biased probability, but also that even when an outcome is weighted one way, random chance can lead it to come out the opposite.

Setup
There are a few fun games to play here. Most involve building up individual children's results into a nice smooth distribution, by building duplo bricks with their names on them into a nice smooth wall.

Explanation and Demonstrating

The simplest thing to start with is with a brick on the middle of a baseplate and an unbiased coin. If you set the rule that when the brick gets to an edge it falls off and the game is over, that a head moves you in one direction, and a tails in the other. They should see that there's a good bit of back and forth, but eventually you should end up dropping off one side or the other.

Then try doing the same with the biased coin (roughly 66% of the time it gives heads) making sure the coin is allowed to land on the table (preferably on a piece of paper to damp bounces and speed up the whole process), show that if repeated a few times the brick has a tendency to fall off the same side.

Alternatively, as the first method can sometimes take too long, use about six bricks build a tower: placing the next brick on top of the previous one and one set of teeth to the side depending on the toss being heads or tails. Then repeat this a couple of times with both coins and you should see that with the biased coin the tower of bricks tends to lean to one side.

Now set up a few bricks, all starting different distances along the board, and watch which one is the last one left, it should be the one initially roughly two thirds of the way along, not as many people might assume when first introduced to a biased coin, as far from the side it's biased towards as possible.

--ORIGINAL PLAN--

Finally, you can build a really lovely distribution by starting the block at one end of two mats put together and using the biased coin. With every flip you move the block one space forwards (one block length, not one set of teeth) and one space in whichever direction the coin dictates. When the blocks reach either side, that's where they stop. Keep everyone else's blocks on the board as well, and a nice distribution should build up. It should look, very roughly speaking, like a pear cut in half, with a bulge at the near end and then at tail trailing off. Write their name on the block with the dry wipe pen, you'd be surprised how keen they are to come back later and see how the distribution's evolved around their block.

You should see roughly the same distribution on both sides, just with significantly less blocks on the side that is biased against. You can discuss with them things like why there are no blocks at all in the first few spaces, why there is a peak (it roughly corresponds to the balance between a point which there are a lot of various paths to, and where the probability the brick hasn't already fallen off the board, balance out).

--ALTERNATIVE PLAN-- (experiment still developing so let us know what works best!)

Some demonstrators, rather than building up a distribution over the day, which can take a long time and still won't look exactly smooth even after all the pieces have been used, prefer to just trace the path of one random walk, placing a new brick for each step. This gives a clearer memory of the rambling nature of the walk, and there should be sufficient bricks for two or three paths simultaneously.

This also helps defend against the odd child who comes along and tries to tear the whole thing down...

It may be the better options for events with younger children, where the concept of a distribution is a bit much, and also it just looks really cool!

--Real World Applications--

If you fancy it, theirs a great analogy between this experiment and genetic drift. Genes that develop in populations of animals normally have some selective bias for either adoption throughout the population or deletion. But genetic drift is the process of random genetic evolution, and has a strong analogy in a biased coin toss. From this it's possible to see that even a positive evolution (one that natural selection favours some percentage of the time) may be deleted by chance, or a deleterious one spread throughout the entire population.

The key idea here is that when there is one or more boundary, i.e. the edge of the board, we see markedly different behaviour to that we'd expect for an infinite number of tests, where deleterious mutations would never remain in the population and we'd always expect to the brick to end up on the side that it's biased towards eventually.

There are many other examples of random walks in nature, like photons in the solar atmosphere which take thousands of years to complete a 'drunkards walk' from the centre to surface of the sun and only eight minutes to make it all the way out to earth. More complex examples include the game of life, a simulation of how populations grow, receded and migrate over time. You could even mention the fact that for some random walks, even in infinite time you would not expect it to pass through all points.

--Transience/Recurrence--
By flipping two coins you can do a random walk in 2d, ask people if you think you'd be able to get back to the start, will it take longer to fall off an edge. Then repeat in 3d where this isn't true.

Random Walks Risk Assessment

Last updated: 20/03/2017 - 19:29

DESCRIPTION	See how biased coins and random chance can lead to surprising conclusions.
RISKS	1. Swallowing duplo blocks and coins 2. Tossed coins flying off and hitting someone
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Duplo blocks should be sufficiently large that they are safe from swallowing for all ages, but keep an eye out just in case. Don't let small children handle coins. 2. Check you can flip a coin without losing control of it, otherwise just spin it on the table. It's perfectly fine to let the children toss the coin themselves, but make sure they're capable of doing it safely with a trial flip first.
ACTION TO BE TAKEN IN CASE OF ACCIDENT	1. Call first aider if child swallows, if choking encourage child to cough. 2. Call first aider in case of injury

Last updated: 20/03/2017 - 17:40

Horse Racing

Maths:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

* Duplo blocks (horses) and cardboard racetrack
* 2 giant write on/ wipe off dice
* 3 giant normal dice
* Lego blocks and baseplate
* Drywipe pen for writing on dice and lego
* Laminated sheet of paper for use as whiteboard

Explanation

Explanation and Demonstrating

The Horse Race

This can be done either with duplo horses on the boards, or if space permitting with the children playing the part of the horses.

(If children are playing the part of the horses make sure they're all taking steps of the same length roughly, chances are they'll all take the biggest steps they can but particularly tall children might have to have their ambitions tempered a little)

Each horse has a number associated with it, in the most basic formulation, with two normal dice, the numbers range from 2 to 12, although with less children it's better to assign them numbers nearer the middle rather than the edges.

Each step, roll both dices, get everyone to shout out what they both add up to and whoever's number is shouted out moves forward one step. Done like this, horse number 7 should win pretty comfortably everytime (although the shorter a track you use, the more likely 6 or 8 or even others might win).

What's the reason for this, simply put a seven is the most likely number to be rolled. The easiest way of explaining this is showing them how many different ways there are to add up two dice to seven (1+6, 2+5...5+2, 6+1). There are 6 ways to add up to seven, 5 to add up to six or eight and so on until only 1 for two or twelve. There are 36 total possibilities (and each is equally likely), so the chance of getting a seven is 1/6. Depending on ages you may find they've seen some of this before in schools so you may move through it quite fast.

People might ask how 6+1 and 1+6 are different. The formulation used above ensures all 36 possibilities are equally likely, which makes all the calculations much easier. One way to look at it is throwing the dice one at a time and showing that the two different possible orders shows that there are twice as many ways to get, for example, 1 and 2, than there are to get 1 and 1. This point is quite subtle and I wouldn't advise going into it unless prompted or if you have a really great explanation!

Now, using the wipe clean dice, try changing up the rules to see what effect it has on who wins. I advise having explained all the different probabilities to them already. Maybe even make a chart of how many different ways there are to add up to each outcome.

There are lots of things you can try here, but here are a few ideas, you may find some work better with different ages:

1. Change Dice Numbers

Subtract one from each side of one dice (or better yet, change the six to a zero!) - Now six and seven should be neck and neck. You can either show them this beforehand, or get them to guess which horse they're going to be and see whose understood it (nothing wrong with letting more than one person be represented by the same number now, but keep them in separate lanes).

Change all sides except three and four of both dice to one - Firstly get them to pick horses, explain why now there are only 6 options (2, 4, 5, 6, 7, and 8), as 7 is still a possibility many will likely go for it, but of course now number two should fly ahead, as there are hugely more ways of making 2, and all others should stay roughly level (two ways to make all other numbers)

Change how many steps some numbers get to take - Why not let all numbers less than 4 and more than 10 take two steps each time they're picked, now the race should be much more even. Ask them to work out how many steps the people with numbers 2, 3 and 4 would need to take each go to be neck and neck with seven (the answers are six, three and two respectively). This introduces the concept of an expectation value, the product of probability and result (here counted in steps forward), and that events with the same expectation value should have roughly the same total result after a lot of tests.

2. The two dice

This is a very nice demonstration of why the previous experiment works. Simply ask people to throw two dice, and put a lego brick in the column relating to their result. Quite quickly a pretty uniform distribution should build up, looking like a pyramid (this isn't actually the underlying distribution, just the fact that we've got very few different possibilities flattens the sides of what should look like a bell curve). That said, at times it will look quite irregular and it's a good chance to talk about error, lots of people will think the dice must be weighted to cause irregularities but actually it's simply that there is a natural variation to any test and that only for a large number of tests is this smoothed out (error in mean scales as 1/sqrt(N) and roughly speaking so does all the variations, where N is the number of tests).

Now try it with three dice, this should give a smoother curve, but will take much longer to build up as there are now 15 possible values. You should see something akin to a bell curve with long tails, a rise in the middle with a flat top, and symmetric across the line between 11 and 12.

You can put name labels on both curves but you may want to periodically deconstruct the two dice curve, so you can keep talking about the variation from the expected shape. Definitely put labels on the three dice curve, and encourage people to try multiple times and to come back and see how it's developing.

See here for how it evolves for one, two three or four:
http://www.syque.com/quality_tools/toolbook/Variation/measuring_variatio...

You could link this to central limit theorem and talk about how heights are distributed roughly normally, as are most other things.

3. How long until you roll a six

Very simple premise but a slightly more complex explanation this one: throw a dice as many times as necessary until you get a 6. What distribution would you expect to see?

What we actually see is that the highest possibility occurs on the first throw (1/6th of total bricks should be here) and then reduces in a smooth curve that in theory goes on to asymptote to 0 at infinity.

Now get them to do the same but now waiting for either a five OR a six. And then again with either four, five or six. (Make sure they do all three tests so that there are about the same number of bricks in each distribution)

You should see that the second has a higher peak then drops quicker and even more so for the third experiment.

These are all geometric distributions (http://en.wikipedia.org/wiki/Geometric_distribution) relating to some probability p (p=1/6 for the first, 1/3 for the second and 1/2 for the third)

If the person you're explaining to seems comfortable with fractions, you can try the full explanation:

Firstly (and this works with all ages), try and get them to work out the probability of throwing the particular value, and show them that this fraction is almost exactly the fraction of bricks in the first column.

Secondly, ask them what the probability is of NOT throwing the required value, explaining that probabilities must add up to one (or do it in percentages adding up to 100%). Obviously this is the fraction NOT in the first column.

Thirdly, (and this is where you may want to stop for younger kids) show them that for every throw that you don't throw a six, the probability compounds by 5/6ths, and on the final throw that you do there is an added fator of 1/6th. Or more fully, the probability of throwing the first six on the nth throw is (5/6)^n-1 * (1/6).

The main thing to get across here is that all probabilities must add up to one, and some idea that the more likely situation should have the tallest peak at n=1 and then drops off much faster.

Write the initials on each brick that someone places on the distribution and watch how it builds up over the event.

Horse Racing Risk Assessment

Last updated: 20/03/2017 - 17:40

DESCRIPTION	Looking at probabilities and distributions for throwing dice
RISKS	1. Children swallowing duplo or lego pieces 2. Dice could be a trip hazard if dropped on floor
ACTION TO BE TAKEN TO MINIMISE RISKS	1. The duplo pieces should be sufficiently large to discourage swallowing. Do not use lego with very small children and keep a close eye on the box of lego. 2. Keep an eye on where any dice go, and try to confine them to a desk or fixed area. Do not let multiple unattended children use dice at the same time.
ACTION TO BE TAKEN IN CASE OF ACCIDENT	1. Call first aider if child swallows, if choking encourage child to cough. 2. Call first aider in case of injury

Last updated: 06/02/2017 - 17:26

Tangrams

Maths:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

* 2 Tangrams (should fit into a square, if not pieces may be missing), 7 pieces each
*Some laminated print-outs of paradoxes

Explanation

What this experiment is really all about is area, and showing that it's always the same and a useful tool that helps us work our way out of variuos paradoxes.

I start by arranging the two sets in a “paradox pair” to grab attention and ask them what is going on. They tend to suggest that one piece is missing or that the pieces are different. Ask them to rearrange them to make them into a different shape, or to make the two sets identical - just let them have a play around with the pieces. You could try challenging them to recreate various shapes, or seeing if they can reform it into a perfect square. Much of this experiment is less about you explaining things and instead them exploring them physically, getting a sense of shape and area.

The real fun though is showing them some of the "paradoxes" that can be made with tangrams. A couple of these are shown in the images, but feel free to make up your own. Most of the paradoxes stem from the fact that some of the side lengths almost match up, but not quite, as well as some liberal use of empty space between pieces. The two squares paradox shows this the most strongly, where all the small triangles are rotated by 45 degrees, and therefore their side length changes (as the length of the longest side is root two the other sides) and thus there's very little chance of it all fitting together perfectly. Thus some gaps are left whilst other pieces are squished together, which can lead to the whole thing looking very different.

However we might rearrange the pieces though, the area will always remain the same, showing that we haven't actually lost any area, just given the illusion it's gone by rearranging it (and introducing some extra space between pieces). This is perhaps best shown in the fat monk paradox where he seems to literally lose a foot (however it takes a lot of table space to set it up, maybe use the floor?).

Another very effective one is two “squares” where one is missing a corner. With this one, you can start by asking them about what happened to the corner: is a piece missing? Are the pieces different. Try to get them to rearrange one of the shapes into the other (e.g. both perfect squares). They'll see that they're identical and at this point they're usually really interested. You can ask them what happened to the area, or where the corner went, or what shape the irregular polygon is (some realise that even with the corner it wouldn't be a square). Then, to make it clear, put the two shapes on top of one another. This works best if the square is yellow and the hexagon is orange, so you can see the orange has a longer side and the yellow fills some of the missing corner.

You can explain briefly how to add up the area of the tiles. Both using formulas for area of common shapes (n.b. the trapezium is really just a rectangle with a triangle cut off one end and moved to the other) and by counting the number of triangles that add up to each shapes total area. The second may be easier with younger kids.

You could think about discussing tessellation with them, how repeating patterns of shapes that fit together can be extended to infinity.

As an aside, there is also a kind of an illusion at play here, where the missing corner in the square appears bigger than the corner that is actually “missing” from the square.

Real world applications:

I'm a bit stumped here... Of course there's lot's of discussion to be had about geometry and areas, and even some stuff about tiling (could expand with some Penrose tiles or even some Islamic art) but as for where you see this in real life I'll leave you to think of your own examples. And then tell us because clearly we need some help...

Tangrams Risk Assessment

Last updated: 06/02/2017 - 17:26

DESCRIPTION	Rearranging shaped tiles
RISKS	1. Children hurting themselves on corners of shape
ACTION TO BE TAKEN TO MINIMIZE RISK	1. The shapes will have smoothed corners
ACTION TO BE TAKEN IN CASE OF ACCIDENT	1. Call first aider

Last updated: 08/02/2017 - 16:23

Hexaflexagons

Maths:

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

Pre-printed Hexaflexagon templates (preferably prefolded as well) as well as a guide on how to fold them
Scissors
Glue
Pens to colour them and stickers.

Explanation

Hexaflexagons are a good experiment for young kids up to adults.

For the young kids you can treat it more as a logic puzzle; they need to figure out how to take a hexaflexagon and turn it inside out by only folding it (emphasise that you're only allowed to fold- you can do it by just 'pulling' the inside face through, but this is cheating and really damages the paper hexaflexagons). This (or other guides on the internet) show you how to do it correctly:
http://www.puzzles.com/hexaflexagon/img/how_to_flex_a_trihexaflexagon.pdf
Once they've mastered that (get them to do it a few times), then ask them if they can do the opposite flex. See, there are 2 types of flexes, the one in the guide (the down flex) and the similar up flex. You do this by getting the other three corners and lifting them up to meet at the top, then opening out the bottom. Try to make sure they don't flip over the hexaflexagon as they do this. One way to encourage them to find the up flex themselves and not flip it over is to start the entire group off with their hexaflexagons with the same colours on the top and bottom as each other. Say green on top, pink on the bottom. Then ask them to, in one move, get pink on top and yellow on the bottom. Once they have up and down, if you still have there attention then you can get them to figure out equations: up up up= back to the start. flip up flip= down (this is a good one). If they're too young for that (or get confused with how many flips they've done- this happens a lot), move them onto the patterns.

A really fun one to get them to solve is, draw a sad face on a hexaflexagon (this has to be done in a particular way but there should be an example in the box). Ask them to figure out how to make it smile. This will illustrate to them that when you do one flex, the face that's still showing from before is now actually inverted. Give them each a blank hexaflexagon and get them to decorate it with this in mind- lines from the centre out and circles in the middle etc look really cool when flexed. There should also be one with pictures on it like a snake and a planet etc. Show them these for them to get some ideas for designing their own.

For more capable people, you can start talking to them about equations and even solving equations. For example, if any equation like (up flip up up) x (down down flip)=flip you can solve this. But to work up to this, get them used to the idea that ax=b means x=a^-1 b not x=ba^-1. Explain it as, order matters. Putting an action on the left means you do it last, where as putting it on the right means do it first.

Hexaflexagons Risk Assessment

Last updated: 08/02/2017 - 16:23

DESCRIPTION	To play with hexaflexagon and understand their properties, and to make some with cool patterns.
RISKS	1. Risk the children will grab scissors. 2. Risk that children will take and possibly eat glue.
ACTION TO BE TAKEN TO MINIMISE RISKS	1. Make sure you cut out hexaflexagons before the kids arrive. If you need to have scissors on the table, have the safety scissors. 2. Put the glue behind you (in the box) after you use it each time.
ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT	1. If there is any cuts, call a first aider 2. Glue isn't toxic, however, do alert parents immediately and call a first aider if necessary.

Last updated: 07/02/2017 - 09:50

Rocks and Fossils

Geology: A box of rocks and fossils

Read before you demonstrate

These sheets contain important information about how to protect yourself, members of the public and other demonstrators.

Please take time to read this information and sign the attached sheet before you demonstrate the experiment. Feel free to ask any questions.

Thank you!

Kit List

In this box there should be:
• DK fossil book
• DK rocks and minerals book
• viewer (a magnifying glass on a stand)
• dark red box of rocks, with a leaflet inside
• white box of rocks and minerals, with straw packing
• white box of fossils
• laminated visual aids

Explanation

Note:
If you're confident with demonstrating and know your geology give this kit a go though, and please write down the bits that work and don't work. (A sheet of paper that stays in the box would be great!)

Most of this kit was bought by a biologist (Lia) who claims to know nothing about geology, so if there's more kit that would be useful please let us know!

Intro:
This demonstration consists of a large number of different rocks and fossils, which may seem a little bewildering at first. Don't worry, I've studied Geology for three years and I still don't know much about some of the specimens we have. If you've done 1A Geology/Earth Sciences or something similar, you should know enough to demonstrate a decent number of the rocks and fossils. If you need help on specific specimens, there is a list of contents with each set, I've prepared this guide to hopefully give additional explanation, and there are books on fossils and minerals in the box too.

I like letting the children hold the rocks and fossils, and look at them under the magnifying glass, as I feel it makes things a lot more interactive. This is fine; just make sure they're careful with them, as the fossils in particular are quite fragile. It might be best not to let the smallest children handle them, for the sake of the fossils and the children's windpipes.

There are a few ways to go about this demonstration, which you can vary depending on the venue you're demonstrating in, and what suits you best. You could keep the boxes closed and only bring out specimens one or a few at a time which you want to talk about, or you could leave out all or lots of them, and let the children lead the demonstration a little more. I find the second option more interesting, and it tends to draw children in more easily in a public event, but I might keep most of the specimens in their boxes at a school, especially if the children want to just grab everything in sight! However you choose to do demonstrate, you don't have to talk about anything you're not confident about. You can either leave specimens in their boxes, or admit you don't know much about them if children ask.

One thing I find interesting about this experiment is the variety of opinions about geology. Some children will think rocks are really boring, while others will love fossils or crystals, and want to talk to you all day! It can be really rewarding convincing people that rocks and fossils are interesting, or talking to a child who is fascinated by everything you say, but if sometimes you'll talk to kids who really don't want to know. I usually try showing them the bits I think they'll find most interesting, but in the end I might just send them to another experiment if they're clearly not getting anything from this demonstration.

You can use the specimens as links to talk about almost anything you (or the children) want. A lot of them come from the Atlas Mountains in Morocco, so I might use this to talk about continental drift and mountain-building, as they were formed by the collision of Africa with Europe. I often end up talking about the rock cycle and how fossils are formed and preserved (or not). I also like talking about the structure of the Earth, and why it's hotter underground. The visual aids are there to help you with this sort of thing, especially if like me you end up rambling about something completely unrelated with a group of intelligent and interested children! If there's anything else you feel would be useful to include, by all means mention it to a committee member, write it in the tour diary, or even print it yourself - this experiment is still relatively young, so any input would be appreciated.

I should perhaps include a warning that you may occasionally have to deal with people, who do not believe in evolution, think crystals have healing powers, or something similar! Unfortunately it's unlikely you'll manage to persuade them against these beliefs, but you could have a go!

The rest of this guide provides brief details about each specimen, and some ideas about what to talk about with each one, but remember, this guide is in no way complete, and there are probably interesting things I have left out or simply don't know about plenty of the specimens. We've included the box of plant fossils in this experiment box, which is written up as part of the plant experiment (biology). There are some notes to go with this, but you'll probably only want to use these if you've studied plants at some point. It's fine to just leave them in the box and use the rest of the kit.

All specimens should be labelled.

The Fossils Box:
At some point it is a good idea to ask children if they know what fossils are and how they form. If they aren't too sure, explain how hard parts of animals – teeth, bones, shells – can be buried under layers of sediments, and eventually become fossilised. However, plants, footprints, tree sap and excrement can all be fossilised too. The fossil we see may be as it originally was, it may have recrystallised, or it may be an imprint. The details of fossilisation processes are actually very complicated, but fortunately a general idea of what happens is sufficient. The book in the box explains this for a general audience, so it's probably worth a look through.

Wikipedia says that:
"Fossils (from Latin fossus, literally "having been dug up") are the preserved remains or traces of animals (also known as zoolites), plants, and other

organisms from the remote past. The totality of fossils, both discovered and undiscovered, and their placement in fossiliferous (fossil-containing) rock formations and sedimentary layers (strata) is known as the fossil record. The study of fossils across geological time, how they were formed, and the evolutionary relationships between taxa (phylogeny) are some of the most important functions of the science of paleontology. Such a preserved specimen is called a "fossil" if it is older than some minimum age, most often the arbitrary date of 10,000 years ago.

Hence, fossils range in age from the youngest at the start of the Holocene Epoch to the oldest from the Archean Eon several billion years old. The observations that certain fossils were associated with certain rock strata led early geologists to recognize a geological timescale in the 19th century. The development of radiometric dating techniques in the early 20th century allowed geologists to determine the numerical or "absolute" age of the various strata and thereby the included fossils.

Like extant organisms, fossils vary in size from microscopic, such as single bacterial cells only one micrometer in diameter, to gigantic, such as dinosaurs and trees many meters long and weighing many tons. A fossil normally preserves only a portion of the deceased organism, usually that portion that was partially mineralized during life, such as the bones and teeth of vertebrates, or the chitinous or calcareous exoskeletons of invertebrates. Preservation of soft tissues is rare in the fossil record. Fossils may also consist of the marks left behind by the organism while it was alive, such as the footprint or feces (coprolites) of a reptile. These types of fossil are called trace fossils (or ichnofossils), as opposed to body fossils. Finally, past life leaves some markers that cannot be seen but can be detected in the form of biochemical signals; these are known as chemofossils or biomarkers."

An awkward question I have been asked a few times is how do we know that a given fossil is 50 million years old? This is a hard one to answer, since most of the fossils are old enough to be dated using Uranium decay series. If children are old enough to understand Carbon-dating, you can make an analogy with this, otherwise you may have to make do with talking about relative dating using layers of sedimentary rocks.
The timeline should be useful for talking about ages of various fossils, since large numbers of years become a bit meaningless, but saying that something lived twice as long ago as the first dinosaurs impresses most children.

Bivalve
These molluscs have lived in a huge variety of situations. They can be marine or freshwater, live in deep or shallow water, above or buried in the seabed, or even swim like scallops or attach themselves to rocks along the coast like mussels (both kinds of bivalve) do. Their shell consists of two usually symmetrical halves called valves, but some bivalves, such as Gryphaea (or Devil’s toenails) have one valve much bigger than the other. They have been around since the Cambrian.

Amber
Amber is fossilised tree resin (not sap apparently, although I’m not entirely sure what the difference is). Animal and plant material is often preserved in amber, particularly insects which have become stuck in the resin. As far as I know, this is the only way in which insects can be preserved, as their exoskeletons are simply too weak to be fossilised normally. Children may have seen Jurassic Park, in which the DNA of a dinosaur is extracted from blood that a mosquito has drunk before becoming trapped in resin and fossilised. This idea has some basis in fact, since the preservation of fossils in amber is so good that fragments of DNA may be recovered. Unfortunately, unless we’ve found a new piece of amber, there are no insects in this one.

Gastropod
Gastropods are another group of animals which have lived in various different situations. They can be freshwater, marine, or even live on land (e.g. the snail), and have been around since the Cambrian. They can be recognised by their coiled shell. I often just use the words “sea snail” here, since I’m not sure the word “gastropod” will add much, but it’s up to you.

Shark Teeth
The box contains a variety of shark’s teeth. These are some of the most easily recognisable fossils we have. There is an opportunity here to talk about why sharks have such sharp, and often serrated, teeth, as well as why they are such common fossils (sharks have many sets of teeth and frequently lose and replace them). Sharks have skeletons made from cartilage, which makes them unlikely to be preserved, and have been around for more than 420 million years. One of the teeth is from a shark related to the Megalodon, which some children may have heard of. It lived roughly 28 to 1.5 million years ago, could grow up to around 20 metres in length, and had huge impressive jaws!

Brachiopod
These shelled organisms used to be far more common, occupying many of the marine environments which bivalves do today. Their shells are made from two halves, or valves, which tend to be different, and can be distinguished by a mirror plane down the centre of each valve. They have been around since the Cambrian, and were most common during the Paleozoic.

Ammonite
These marine molluscs had spiral shells and were alive during the Mesozoic- the same time as the dinosaurs. These should not be confused with Nautilus, an animal with a spiral shell more closely related to the straight Nautiloids. They can be told apart by the position of the siphuncle – a tube used to move water between the shell’s chambers and control buoyancy – which runs along the outer edge of ammonites’ (and all ammonoids’) chambers, but through the centre of Nautiloids’. Ammonites vary in size from a couple centimetres to a couple metres, and are commonly found on the Dorset and Yorkshire coastlines.

Goniatite
These are another type of ammonoid (the subclass to which ammonites belong) which rarely exceeded 15cm in diameter. They can be told from ammonites by their simpler suture line (the line where the divisions between chambers make contact with the edge of the shell) and lived earlier than ammonites – during the late Paleozoic.

Trilobite
These are an extinct class of arthropods which lived during the Paleozoic, though they declined towards the end of it. Trilobites were some of the first animals to evolve hard parts (which is why they are also some of the earliest fossils that are regularly well-preserved) and eyes. Their hard shell meant that they could roll into a ball to protect themselves (as I think this specimen is doing). Their eyes were made from calcite crystals which had to be orientated correctly to avoid a double-image (you can demonstrate the double-image with the calcite crystal in the minerals box). Some had their eyes on stalks, while others were blind. Most moved over the sea-bed, but some swam, and they could be predators, suspension feeders or scavengers. The name trilobite refers to their three “lobes” – one that resembles a spine down the middle of the trilobite, and one on each side of it. I usually liken trilobites to woodlice to help children to imagine them.

Triceratops Bone
Whole fossilised bones, and especially whole skeletons, from land-dwelling animals are pretty rare, as they will only be buried and fossilised in an area where deposition is taking place, such as the sea or a delta; much of the land is being eroded. If the animal does not die in a place where its bones are quickly buried, the bones may be separated from each other, bashed around, or even fragmented before finally being buried. This is probably what happened to this piece of triceratops bone. The small holes are most likely where the marrow used to be.
Triceratops was an herbivorous dinosaur with three horns on its head (two above its eyes and one on its nose), a large bony frill, and a beak-like mouth. It walked on four legs and grew up to 9 metres long and 3 metres high. It belongs to a suborder of dinosaurs called ceratopsians, which had similar features, but different numbers of horns. There is discussion as to whether the horns were primarily for defence against large predators such as Tyrannosaurus Rex, or for fighting amongst each other for mates. Triceratops lived at the very end of the Cretaceous, which provides an opportunity to talk about the mass extinction at the end of this period which wiped out the dinosaurs (one of several that have been identified throughout the Earth’s history). A lot of children will know the most popular theory- that the Earth’s collision with a huge meteorite caused the extinction. Far fewer may know about the less popular hypothesis, that an enormous set of volcanic eruptions covering half of India in lava flows known as the Deccan Traps in less than a million years contributed to this extinction event, or may even have been the primary cause. Both of these events happened, but there is debate as to which was the main cause of the mass extinction.

Mammoth Bone
This fragment of woolly mammoth bone has much bigger holes in it than the Triceratops bone. This implies that it had a lot bone marrow, which led a scientist I was talking to to suggest that it might be from a femur (thigh bone). Most children will have seen Ice Age, so describing woolly mammoths as "Manny the big hairy elephant from Ice Age" seems to work quite well. These animals lived from roughly 150,000 years ago until 10,000 years ago, although a race of dwarfed mammoths continued to live on Wrangel Island (about 200km north of Siberia, just inside the Arctic Circle) until about 4000 years ago. There is debate as to what led to the extinction of mammoths and other large ice age mammals such as sabre-tooth tigers and giant beavers around 10,000 years ago. The main hypotheses are hunting from humans and climate change; although in reality it may have been a combination of the two.

Mosasaurus Tooth
From the canine-like shape of the tooth, we can tell that this is from a carnivorous animal. Mosasaurus was a huge sea-reptile that reached 15-20 metres in length (I like to compare this something real, like the length of the room I'm in). It was alive during the late Cretaceous, and was another victim of the mass extinction at the end of this period.

Echinoid/Sea Urchins
The sea urchin is a member of a class of animals called echinoids. Echinoids are related to star-fish and tend to have a similar five-fold symmetry, though this may be less obvious depending on the specimen. During life, sea urchins are colourful balls of spikes that live on the sea-bed, feed mainly on algae, and can be found shallowly enough in warm seas such as the Caribbean that people occasionally step on their spines (which can hurt a lot!). The spines are designed to protect sea urchins against predators. They fall out within several days of the animal dying, leaving fossil sea urchins with tiny holes where each of their spines were attached during life.

Coral
Coral have been around since the Cambrian, but the kind we know today (called Scleractinian coral) such as this fossil only evolved during the Triassic when the old Rugose and Tabulate corals became extinct. Corals (with the exception of some Rugose corals) are colonial organisms which form huge coral reefs. These can be hard to explain to children; I find it helps if they've seen Finding Nemo. I like to use coral to talk about continental drift, as I have found fossil coral in the Lake District- clearly not the warm shallow sea favoured by these organisms.

Turtle Shell
The oldest known turtles lived during the Triassic. The fossils we have are individual plates (or scutes), many of which together would have made a whole turtle shell. There is an opportunity here to talk about the usefulness of having a huge shell you can hide inside.

Straight Nautiloid
Nautiloids have been around in one form or another since the late Cambrian, and are today represented by the spiral-shaped Nautilus (mentioned in Ammonite). Straight Nautiloids are often cut and polished to be sold by crystal-sellers. The animals that lived inside these shells were squid-like, but from a different sub-class to squids.

Crinoid/Sea Lily
Sea lilies are crinoids which are attached to the sea bed by a stalk. Crinoids have lived since the Ordovician, and, despite their name and plant-like appearance, are actually animals. They use their arms to trap small particles of food.

The Minerals Box:
Or, more accurately, the minerals, gemstones and other stuff box.
The colours of many minerals such as quartz and calcite are determined by the presence of impurities, particularly transition metals. Whether they dissolve or precipitate in a particular setting depends on the solubility of the mineral in groundwater, which depends on a number of things, including temperature and pressure. The growth of crystals in this way can be likened to the growth of salt/sugar crystals in a bowl of salty/sugary water left out to evaporate, except that it is changes in temperature/pressure etc that mean that the water is over-saturated and a mineral will precipitate rather than the evaporation of water. This is how geodes (balls of crystals) of amethyst, quartz etc can form in water-filled cavities deep underground.
The most impressive crystals I have heard of are the 12m long crystals of gypsum (which is softer than fingernails) in the Cave of Crystals in Mexico, which is essentially a giant geode.

See book for more detailed notes than those I have included.

Wikipedia says that:
"A mineral is a naturally occurring solid chemical substance that is formed through biogeochemical processes and that has a characteristic chemical composition, a highly ordered atomic structure, and specific physical properties. By comparison, a rock is an aggregate of minerals and/or mineraloids and does not have a specific chemical composition. Minerals range in composition from pure elements and simple salts to very complex silicates with thousands of known forms. The study of minerals is called mineralogy."

• Pyrite
Pyrite is also known as Fool's Gold due to its similarity in physical appearance to gold. It is found in quartz veins, coal beds, sedimentary and metamorphic rocks, as well as a replacement mineral in some fossils. It is associated with other oxides and sulphides, and often forms during diagenesis- low pressure and temperature alteration to deposited sediments during early compaction which may result in recrystallisation and precipitation of minerals. Its chemical formula is FeS_2.

• Calcite
Calcite is a form of Calcium Carbonate, and is one of the two main minerals from which animal shells (as well as Trilobite eyes) are made. It is rare to see such well-formed calcite rhombohedra as the one in the box. Calcite is strongly birefringent, which means that it has different refractive indices for light oscillating in different directions. This means that light entering a calcite crystal splits up into two beams polarised in the directions of the highest and lowest refractive indices, causing a double-image if you look through it. Limestone is mostly made up of calcite, and this can recrystallise during metamorphism, or calcite can form stalactites and stalagmites in limestone caves. It often cements together other sediments if it has precipitated from the water trapped between individual grains of sediment, forms veins particularly in fractures in rocks, and can be found in some mantle-derived rocks. It is harder than fingernails but softer than steel (Mohs hardness of 3), and is colourless and transparent with no impurities. I find a lot of children assume that calcite and quartz are the same thing because they are both clear- this is an opportunity to talk about other ways of telling different minerals apart such as crystal shape, hardness and birefringence.

• Red Aragonite
Aragonite is the other main form of Calcium Carbonate from which animal shells are made. It is metastable and will revert back to calcite over 10s to 100s of millions of years and means that aragonite fossils are often replaced by calcite. It is often found in sedimentary rocks and cave deposits. The red colour is probably due to impurities such as iron.

• Connemara Marble
Marble (not a mineral but still lives in this box) is a rock formed by the metamorphism of limestone and other carbonate rocks. However, Connemara Marble, which comes from the region of Ireland of that name, is not technically a marble. It is a serpentinite breccia. Ultramafic rocks are close to the composition of the mantle, are brought up from the mantle in magma, and tend to contain a lot of a mineral called olivine. Heat and the presence of water can metamorphose olivine into another mineral, serpentine, transforming the rock into serpentinite. A rock made from broken up pieces of serpentinite is a serpentinite breccia, such as this Connemara marble (see Breccia). The main other minerals in this rock are carbonates. The green colour is common in ultramafic rocks, probably due to nickel and reduced iron.

• Quartz
Pure quartz is SiO_2. It is very hard (Mohs hardness of 7) - harder than steel – which is why most sand is made up predominantly of quartz, as softer minerals wear away more quickly when battered by waves on the coast or the winds of the desert. Quartz is the main ingredient of window glass, usually in the form of sand. It can be formed in a variety of ways, including as a metamorphic or igneous mineral, a cave deposit, or as quartz veins in fractures in rocks. It can crystallise in fluid-filled cracks and holes underground to form geodes – balls of quartz crystals. Pure quartz is clear and colourless, but often quartz has impurities which change its colour, and can make rose quartz (pink), smoky quartz (grey) and other varieties. Quartz is piezoelectric, which means that it distorts when a voltage is applied across it, and can generate its own voltage when the applied voltage is removed as it returns to its original shape. This sets up a circuit with a frequency determined by the resonant frequency of the quartz crystal, and is used to keep time accurately in watches.

• Amethyst
Amethyst is a variety of quartz which is purple in colour due to impurities including transition metals such as iron. Discussing the similarities in crystal shape may help to convince children that this is indeed the same mineral apart from these impurities.

• Tiger's Eye
It is thought that Tiger's Eye is a gemstone which used to be blue asbestos (also called crocidolite), a fibrous mineral. During metamorphism, the asbestos is dissolved, and quartz precipitates in its place. This replacement allows the quartz to maintain the fibrous nature of the asbestos, and some of the iron oxide in the asbestos is left behind, and becomes an impurity in the quartz, giving it its golden colour. This leads to Tiger's Eye's appearance of parallel layers with slightly different golden shades that reflect the light in different ways.

• Agate
Agate is yet another form of silica (since the crust is mostly made up of silica it shouldn't be too surprising that there are so many forms of it). This most commonly forms in water-filled cavities, where the silica precipitates on the walls of the cavity as layers of tiny crystals of quartz and moganite (a polymorph of quartz, so also SiO_2). The multi-coloured banding is due to the different impurities in each band.

• Crackle Quartz
The colours in this crackle quartz are man-made. They are added by heating up quartz in dye.

• Flint/Chert
Flint and chert are very similar rocks, and I'm not actually sure which this is, as the only difference is the type of carbonate rock they form in. Flint forms in chalk, whereas chert forms in other rocks such as limestone. They are made from microcrystalline silica, with impurities and occasional fossils. It is not yet well-understood why the silica in these sediments has localised in this way, but is probably to do with dissolution and reprecipitation of silica in the buried sediments before the water has been squeezed out by compaction. It is thought that the shape of flint/chert nodules may be related to burrows in the sediment, and the source of the silica may be the skeletons of zooplankton such as radiolaria and sponge spicules which are both made from silica. Flint and chert are also very interesting from an archaeological perspective due to two important properties. The first is their ability to be hammered (or "knapped") into hard sharp blades, which led to them being used as the main material for tools by Stone Age people. The second is that when iron (or a mineral containing iron such as pyrite) is struck against flint, it produces sparks which can be used to light a fire. In general flint was better for these purposes than chert as it tends to be harder and more pure.

• Red Jasper
Jasper is an impure form of silica (SiO_2), quite similar to chert (see Flint/Chert). Its colour varies according to the impurities, and the red colour in this jasper is probably due to ferric iron.

• Mookaite
Mookaite is an impure form of silica, and in fact a kind of chert (see Flint/Chert) formed from sediments which have a very high proportion of microfossils from zooplankton called radiolaria. Radiolaria make their tiny skeletons out of the silica dissolved in water.

• Magnetite
This mineral began its life with CHaOS with the label "Hematite". However, not only does the colour seem slightly wrong, but, more importantly, hematite cannot be made into as strong a permanent magnet as the pieces in the box. Therefore Dave worked out that this must be another iron oxide, Magnetite. Magnetite is an early mineral to crystallise from most magmas, and is stable to high temperatures, so can be found in small amounts in a lot of different kinds of rocks. When found naturally, magnetite may be weakly magnetised, but not to the same degree as those in the box – these have been artificially magnetised. However, in rocks with a lot magnetite, such as the basic igneous rocks of Skye, even the natural weak magnetism can be enough to offset compass needles and confuse hikers! Magnetite crystals have been found in the brains of some animals (including pigeons and us), and are thought to be useful for navigation.

• Lepidolite
Lepidolite is a lithium-rich mica, a major source of rubidium (which was first discovered in this mineral) and caesium. It can be found in pegmatites (granites with crystals larger than an inch, which is thought to be due to the presence of water), as well as other granites and high-temperature quartz veins. Like all micas (see Mica), it is a sheet silicate with one well-developed cleavage plane, and contains OH, so can only form from magmas in which at least a small amount of water has dissolved.

• Moonstone
Moonstone is a gemstone formed by the intergrowth of two kinds of feldspar – albite and orthoclase. These are minerals which crystallise during the cooling of magma. The two minerals may grow together in such thin flat layers that they are close enough to the wavelength of optical light to scatter it, producing a milky glow in the presence of light, said to resemble moonlight. This is called adularescence.

• Peacock Ore
Peacock ore, also called Bornite, has the chemical formula Cu_5FeS_4. It can be found in igneous rocks, contact metamorphic rocks (those heated up by a nearby igneous intrusion such as a magma chamber) and shales. It is an important copper ore and is iridescent.

The Rocks Box:
You might want to talk about rocks in general, and define what they are. (Ask something like "Can anyone describe what a rock is like?") Depending on the age of the kids, they might be able to name rocks such as limestone, chalk and marble.("Does anyone know the names of any types of rock?") You could ask where rocks are used (old buildings mostly). You could say that newer buildings aren't made of rocks as man-made materials like brick and concrete are cheaper.

Warning to geologists: you may have to resist the urge to murder people who some of the specimens as "just a normal rock". The box should contain a key to these rocks and rock-forming minerals, and I will use the same numbering system.

ROCK-FORMING MINERALS:
A selection of the most common minerals which make up the majority of rocks in the Earth's crust.

1. Quartz
See minerals section.
The specimen in the minerals box has a well-formed ("euhedral") crystal shape, whereas this one has not – perhaps it was rounded while being transported by a river or something similar?

2. Feldspar (Microcline)

Feldspars are the most common mineral in the Earth's crust – almost two thirds may be made from feldspars. They most commonly grow from magmas during crystallisation, but can crystallise in veins (e.g. as part of impure quartz veins) and some metamorphic rocks. They are also found in some sedimentary rocks, but as they are much softer than quartz, are worn down far more quickly in high energy environments. There are two main groups of feldspars: alkali and plagioclase feldspars. Alkali feldspars, such as microcline, tend to be pink in hand specimen, and are the pink blocky minerals found in some granites (but not the one in this box).

3. Mica (Muscovite) and
4. Mica (Biotite)
Micas are a group of sheet silicates, which means that their molecules are arranged in flat layers. This is why they have such a perfect cleavage (flat shiny surface, yes I know the word is hilarious) and grow in sheets. In fact, you can take tiny individual flakes off these micas, though I wouldn't recommend it if you want them to last! Micas all have OH in their chemical formulae, and thus are described as hydrous minerals – this means that they require the presence of water to grow. If the micas form from cooling magma, the magma must have some dissolved water. For example, granite (but not the one in this box) often has muscovite and/or biotite. If the micas grow as a result of metamorphism (putting rocks under heat and pressure), the OH will come from other hydrous minerals such as chlorite, or even from mud.
Muscovite is a white mica, and biotite is a dark brown mica. They form in similar circumstances.

5. Calcite
See minerals section
This crystal is probably opaque due to small amounts of impurities.

6. Hornblende
Hornblende is a type of mineral called an amphibole. These have two cleavages at 56¬o to each other, which you can see if you look at one shiny surface of a crystal, and then rotate it through 56o in the correct direction. Hornblende is found in many intrusive igneous rocks, and some metamorphic rocks such as amphibolite.

IGNEOUS ROCKS:
Rocks formed by the solidification of magma in a magma chamber (intrusive) or on the surface of the Earth (extrusive). Magma = underground, lava = above ground

7. Pumice
Pumice is solidified magmatic froth. Magma has dissolved volatiles such as water and CO2¬, and these are more soluble under high pressure than low pressure. For a volcano to erupt there must be a build-up of pressure which forces the magma up to the surface. When the volcano begins to erupt, this pressure is rapidly release, and so the volatiles are no longer as soluble in the magma. This means that bubbles of water and CO2 will form, and as they magma and bubble travel up to the surface from the magma chamber, the pressure drops even more, so that more volatiles exsolve. Because the gas is much more compressible than magma, the bubbles grow even more as the pressure decreases. This creates a froth of magma and gas analogous to opening a fizzy drinks bottle.
If the magma travels quickly to the surface so that pressure is quickly released, and there is a high volatile content, and the magma is sufficiently viscous (e.g. andesite), then there may be so much gas expanding so quickly that the magma fragments, creating an explosive eruption, as ash and pumice are thrown high into the air, creating an eruption column which may rise high up into the atmosphere or fall back to earth and form an ash flow (also called a pyroclastic flow). The pumice is solidified froth, which cools so quickly that it is technically a glass (it has no mineral structure, see Obsidian). Pumice often has so much gas inside it that it floats on water (this one does), an some people use it to rub the dead skin off their feet, as all the vesicles (bubbles) make its surface very rough.
Examples of explosive volcanoes which erupted pumice include Vesuvius, Mount St Helens and Krakatoa. They tend to be subduction zone volcanoes (formed when old ocean floor sinks underneath another plate) because these have water-rich silica-rich (and therefore viscous) magmas. The other extrusive (erupted) igneous rocks in this box are from non-explosive volcanoes.

8. Obsidian
(Most children will have heard of this from Minecraft. In the game you can make it from adding lava to water, which is close to the truth, but emphasise that the game isn't factually accurate.)
Obsidian is also known as volcanic glass. During crystallisation, it takes time for the molecules to arrange themselves into a given crystal structure. If a liquid is cooled quickly enough (such as when window glass is made it is cooled quickly in water), there will be no time for this to happen, and so the resulting solid, called a glass, will have the molecular structure of a liquid despite being solid. Obsidian is made when lava cools very quickly and becomes a glass. This is most likely to happen to thin rhyolitic (very silica-rich) lava flows, as other compositions of lava would have to be cooled more quickly than could naturally happen. Obsidian is metastable at the Earth's surface, and thus none has been found older than the Cretaceous, as, particularly in the presence of water, it changes into another rock type, perlite.
Obsidian is archaeologically interesting, because it is hard, and can easily be made sharp (I think the hand specimen already has some fairly lethal edges), and so was used by Stone Age man to make knives and other tools, though not as frequently as flint/chert due to its comparative rarity. It could also be polished to create rudimentary mirrors.

9. Basalt
Basalt is an extrusive igneous rock. This means that it formed from the cooling of lava which flowed from a volcano. It has cooled quite quickly to allow only small crystals to grow (you can make out some shiny surfaces under the magnifying glass, although the bigger crystals may have started to grow in the magma chamber – most of the crystals will be too small to see). The main difference between basalt, andesite and rhyolite is composition. Basalt is more iron and magnesium-rich and less silica-rich than rhyolite, and andesite is intermediate between the two. When magma cools in a magma chamber, iron-rich and silica-poor minerals crystallise first and fall to the bottom of the magma chamber. This means that the remaining magma becomes more silica-rich, iron-poor, magnesium-poor, and therefore lighter. The system becomes more complicated if new (SiO2-rich Fe-poor) magma is injected into the magma chamber, or if crustal material from the edges of the magma chamber (SiO2-poor Fe-rich) is assimilated into the magma. Thus in general magma moves slowly from basaltic to andesitic to rhyolitic composition until it completely solidifies, is erupted, or is mixed with new material. Magma of basaltic, andesitic or rhyolitic composition may erupt as lava.

10. Andesite
See Basalt for how extrusive igneous rocks are formed. Andesitic lava will only flow in a non-explosive eruption if it does not have a high volatile content (see Pumice).

11. Rhyolite
See Basalt for how extrusive igneous rocks are formed. Rhyolitic lava will only flow in a non-explosive eruption if it does not have a high volatile content (see Pumice). It forms a glass if cooled quickly (see Obsidian) and so only thick rhyolitic lava flows would cool to make rhyolite like that in the box. The larger crystals in this rock would have formed in the magma chamber, and didn't fall to the floor of the magma chamber due to the high viscosity of rhyolitic magma (and perhaps also because of a similarity in density between the crystals and the magma). The rest of the rock is composed of tiny crystals (called groundmass) which formed when the lava cooled subaerially.

12. Granite
This is an intrusive igneous rock – a rock formed when magma trapped underground in a magma chamber cooled and solidified. Other intrusive igneous rocks include gabbro, which has the same composition as basalt, and diorite, which has the same composition as andesite. Granite has the same composition as rhyolite. Its larger crystal size is due to its slow cooling rate. There are three types of crystals to see in this granite:
• Quartz – the shiny grey ones
• Plagioclase feldspar – the dull white ones
• Hornblende – the shiny black ones

Alkali feldspars (such as microcline) and micas can also form in granites, but not in this specimen. All the minerals mentioned are in this box. Granites can have much bigger crystal sizes than this, and those with crystals more than 2.5cm in size are called pegmatites. These are thought to have grown in the presence of water.

METAMORPHIC ROCKS:
When rocks experience high temperature and/or pressure they change, becoming metamorphic rocks. Four of the metamorphic rocks (mica schist, slate, gneiss, garnet schist) could have been made from the same protolith (original rock) – a (see Shale)
Very high pressure is usually associated with orogenic (mountain building due to continental collision) belts, whereas high temperature may be due to depth of burial, or the presence of a nearby magma chamber.

13. Mica Schist
Shale is made up of clay minerals and silt-sized particles (which are finer than sand) of other minerals such as quartz. The clay minerals become unstable at a lower pressure than the quartz, and so if shale put under sufficient heat and pressure, they will start to change into other minerals – usually micas. Micas tend to be aligned so that their cleavage is perpendicular to the direction of maximum compaction. All of the shiny minerals you can see in this rock are these micas.

14. Slate
A slate can also be made from the compaction of shale. This is a lower metamorphic grade than schist, the difference being that a slate has not experienced new crystal growth. The silt and clay minerals have aligned themselves in response to the pressure they have experienced, creating this characteristic slatey cleavage. It is this cleavage (a foliation along which the rock tends to break) which allows slate to be broken into the big flat slabs used for roof tiles.

15. Quartzite
Quartzite is metamorphosed sandstone. Since sand is often largely made up of quartz, it is simply formed by the recrystallisation of this quartz under high temperature and pressure.

16. Gneiss
Gneiss has undergone a higher grade of metamorphism than a slate or schist, but also made from shale. The high pressure and temperature conditions allow the rock to develop compositional banding perpendicular to the direction of maximum compaction. For this to occur, there must be both diffusion and recrystallisation happening. This allows the rock to have bands of white felsic (SiO_2-rich, Fe-poor) and dark mafic (SiO_2-poor, Fe-rich) material.

17. Garnet Schist
This is rather like the mica schist – it is also a metamorphosed shale in which recrystallisation has occurred, producing crystals visible to the naked eye. However, the large crystals in this specimen are of a mineral called garnet. This is a very dense mineral, and consequently is most likely to form under a lot of pressure (decently higher pressure than would be required to form the mica schist). This means that this garnet schist probably formed deeper in the Earth's crust than the mica schist, but otherwise is rather similar in its formation.

18. Marble
Marble is metamorphosed limestone. Since limestone is mostly made up of carbonate minerals (calcite, dolomite etc), so marble is predominantly composed of carbonates which have recrystallised under high temperature and pressure. Kitchen surfaces are often made of Marble, so you can tell them they're eating off dead sea creatures to add interest.

SEDIMENTARY ROCKS:
Bits of sand, mud, dead organisms (which may become fossils) and other matter fall to the bottom of lakes, seas and rivers. As more layers of this sediment accumulate, the buried sediment gets squashed together, a lot of the water is squeezed out, forcing the sediments together into a sedimentary rock. During this compaction (which at a much lower pressure than metamorphism), minerals such as quartz and calcite that may be dissolved in the water may recrystallise between the sediments to form a cement, holding them together more securely.
Not all sedimentary rocks are made beneath bodies of water – for example, some sandstones are formed in deserts. However, they must all be formed by the compaction of grains of sediment together during burial.
If you can see layers in any of these rocks, it is probably the bedding, which is formed by the deposition of each new layer of sediment.

19. Sandstone
Sandstone is a rock composed almost entirely of sand grains which have been compacted together. They can form in a range of environments, including deserts, rivers, deltas, lakes or seas. Due to the currents or waves required to transport sand, softer minerals are often broken down before deposition, leading to very quartz-rich sand in many cases, as quartz is a very hard mineral.

20. Shale
Shale is a rock composed of silt-sized grains and clay which have been compacted together. They are formed in low energy environments, as currents and waves would wash away such small grains of sediment, and carry in and deposit heavier grains such as sand. This includes very slow rivers and deep lakes or seas.

21. Arkose Sandstone
This is a rock formed by the burial and compaction of sand with the softer minerals still intact. By definition, there should be at least 25% feldspar, but other minerals such as micas and calcite may also be present. To prevent the breakdown of these minerals physically or chemically, the sand must be deposited rapidly (for example at the base of a mountain range where a river slows down and spreads out, called an alluvial fan), preferably in an arid environment. A likely source rock for the required feldspar-rich sediments is an igneous rock such as granite.

22. Conglomerate
This rock is made up of pebbles, so must have been deposited in a particularly high energy environment, such as a beach with strong waves or a fast-flowing river. The pebbles are from fragments of rock which have been eroded, and then bashed into a smooth shape by the river or the waves. There may also be finer material if a river has quickly changed from being fast-flowing to slow-flowing.

23. Breccia
Breccia is made up of angular fragments of rock which have been eroded and deposited by a landslide or a river, without enough time spent in the river to be smoothed into rounded pebbles.

24. Limestone
Limestone is a sedimentary rock made up mostly of carbonates. This may be organic – from the shells of animals and the skeletons of microfossils – or inorganic – from calcium carbonate which has precipitated from sea/lake water where the water is oversaturated in calcium carbonate (this happens because to solubility of calcium carbonate in water is dependent on a number of things including pH and temperature).

Plant fossils:
The explanation for this experiment is included in the sheets in the box, and as part of the plant experiment (biology).

References for Images:

• The Rock Cycle – By Kreislauf_der_gesteine.png:Chd at de.wikipedia derivative work: Awickert (Kreislauf_der_gesteine.png) [CC-BY-SA-3.0 (www.creativecommons.org/licenses/by-sa/3.0)], from Wikimedia Commons
• Map Plate Tectonics http://vulcan.wr.usgs.gov/Glossary/PlateTectonics/Maps/map_plate_tectoni...

Rocks and Fossils Risk Assessment

Last updated: 07/02/2017 - 09:50

DESCRIPTION:
Sets of small rock, mineral and fossil samples, and a magnifying viewer.

RISKS:
Possible choke hazard for small children with the smallest pieces
Dropping fossils could cause injury to feet.
Dropping fossils may cause them to shatter, producing shale dust
Fossils could be sharp and cause cut injury

ACTION TO BE TAKEN TO MINIMISE RISKS:
Ensure that items are not in the reach of small children.
Hold fossils over a table or close to the floor (i.e. when sitting on the floor).
Keep fossils in clear plastic bags for protection and to prevent dust if breakage occurs.
Make sure fossils have no sharp edges.

ACTION TO BE TAKEN IN THE EVENT OF AN ACCIDENT:
Contact first aider if injury occurs.