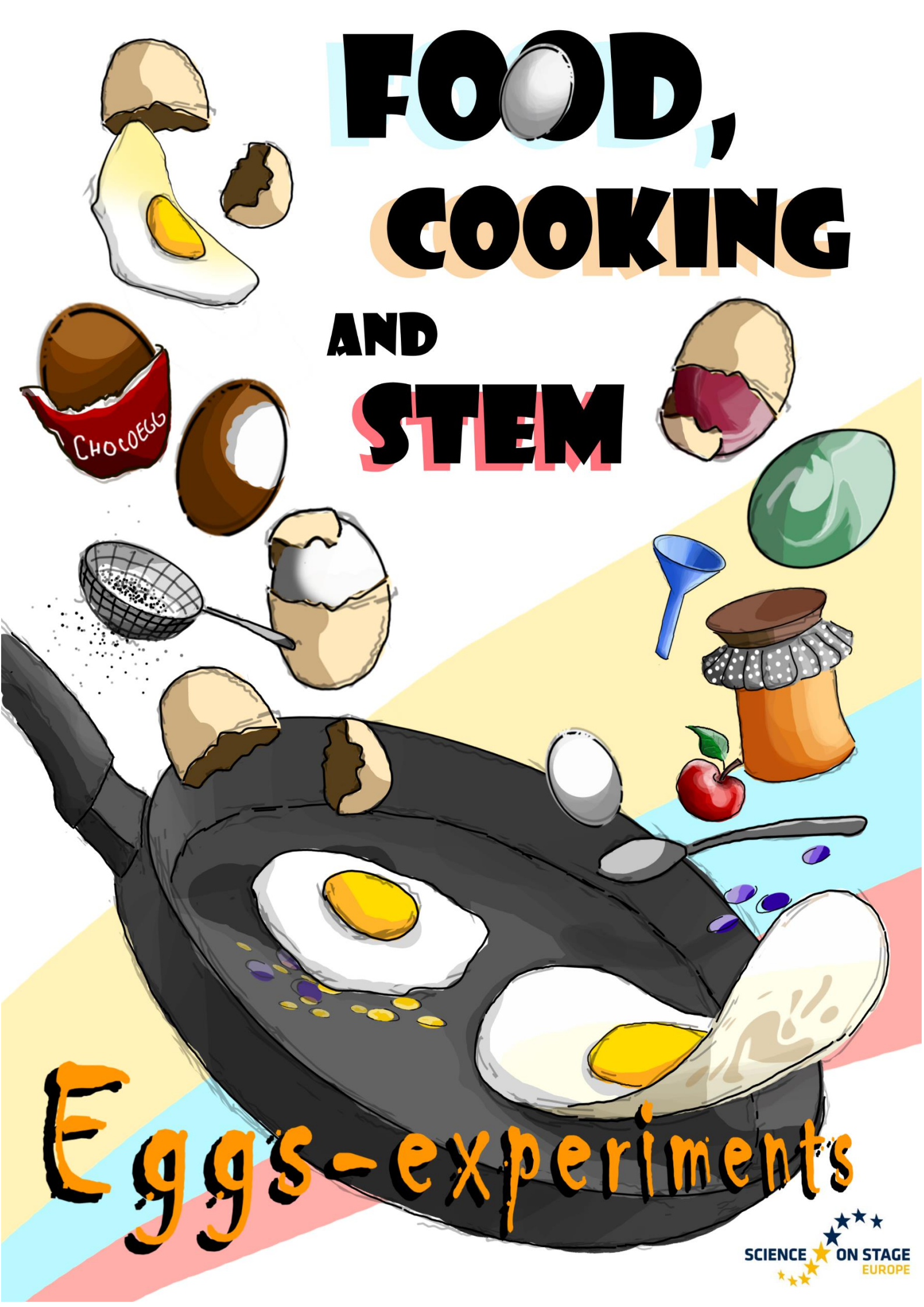
FOOD, COOKING AND STEM



Eggs-experiments

SCIENCE ON STAGE EUROPE

FOOD, COOKING AND STEM

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About us

Science on Stage Europe brings together science teachers from across Europe to exchange best practice and teaching ideas and concepts with passionate colleagues from over 30 countries. Science on Stage Europe believes that the best way to improve science teaching and to encourage more schoolchildren to consider a career in science or engineering is to motivate and inform their teachers. The non-profit organisation was founded in 2000 and reaches 100,000 teachers Europe-wide.

Credits

Cover illustration by Kristina Dovalova (Badin, Slovakia)

Health and Safety

All experiments should be performed with due diligence taking into consideration the children concerned and whether they need direct supervision, or whether the experiment is only suitable for demonstration, and conforming to the safety regulations of your own country.

FOOD, COOKING AND STEM

Content

Foreword

FOOD and COOKING and STEM is the product of a brainstorming session at the Science on Stage Festival in Prague in March 2022, when 15 or so teachers from over Europe decided that sharing our ideas using everyday items would be useful. Over the next year or so we are producing a series of experimental sheets giving introductions to different areas of the science curriculum, using everyday "food" items. We have divided our posts into several sections so that each one will contain some material suitable to all stages of school education and STEM subjects.

This third section covers some simple experiments which uses eggs, both chickens' egg and chocolate eggs for Easter! We hope they will inspire you to try some out with your classes.

The skills of observation, asking questions and prediction are at the forefront of the primary science curriculum and this makes the whole booklet accessible for all ages, but at different levels. Secondary students may find the challenge to explain the processes challenging. However everyone can have some fun with these science experiments, and maybe learn something about the food we use every day.

Thank you for downloading this … we hope you find some inspiration in the following pages…and maybe add some ideas of your own.

In our next booklet, due in the summer of 2023, we hope to bring together several recipes from around the world that demonstrate some basic science principles. So, if you have a particular recipe that might be useful, please get in touch.

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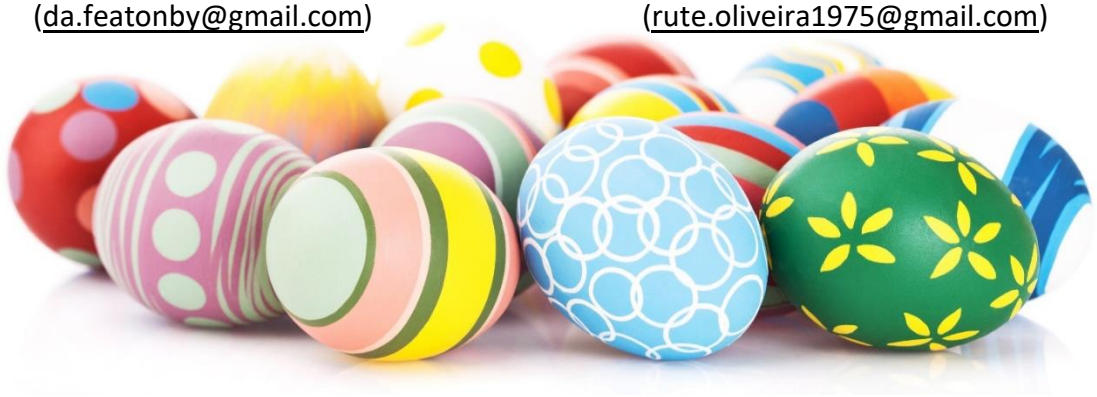


Standing on Eggs

Science: Demonstrating the strength of eggshells

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Structures

EQUIPMENT/MATERIAL NEEDED

- Fresh eggs
- Egg boxes

Description

Take two dozen eggs, in boxes and the students (without shoes) can gently step on the eggs without breaking them or put another way, the eggs can support a full body weight.

Figure 1: 24 eggs in an egg box, and just about to feel the full weight of a young girl.

A more qualitative demonstration can be performed using a blown egg (shell only) supported vertically with weights being placed one by one onto it. (As shown on the German "Physics in Advent" Website 2022, Day 15). Our own versions are shown below, using either sticky tape rolls (figure 2) or cut off egg boxes (figure 3). They give the extra support needed to keep the egg stable while more and more weight is added.

Figure 2: Showing egg able to hold 1kg bags of sugar using two tape rolls to give stability. Two bags of sugar are shown but more bags are possible.

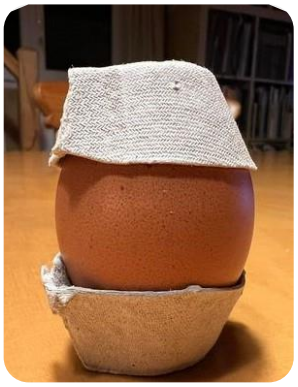


Figure 3: Showing egg able to hold a selection of books using cut outs from egg box to give stability, so the egg doesn't fall over, or books slip off.

Conclusion/Result

A combination of strong eggs and the force being spread over an area means that the eggshells don't break.

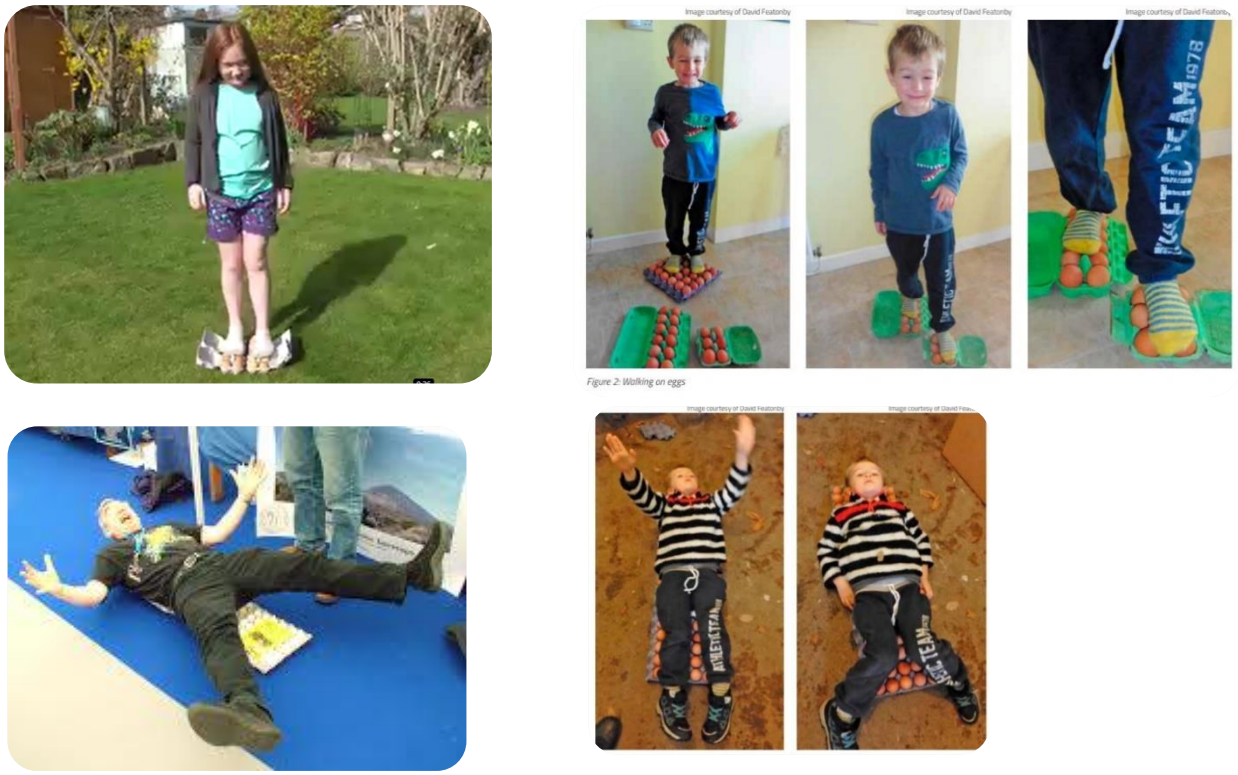


Figure 3: Demonstrations: Standing on eggs, without breaking them, and lying on eggs – the author at a recent Science on Stage Festival and grandchildren down on the farm.

Top Tips: Step very gently and bring your body off the eggs evenly.

Internet links: Physics in Advent https://www.physics-in-advent.org/

https://youtu.be/rU0g00in0R4

Further Experiments: An egg held firmly in one's hand is unlikely to be broken easily with a firm grip, as the pressure is being applied evenly. If however a ring is being worn the egg is likely to crack because of the concentration of the force in the region of the ring. It is probably a good idea to wrap the egg in cling film in case this goes wrong!!

Figure 4: Holding the fresh egg tightly …. and it doesn't break

Dropping Eggs – Large and Small

Science: Acceleration and gravity. Newton's Laws

Age Range
Primary /Secondary

Science Principle
When anything is dropped under the force gravity, it's acceleration and speed of fall depend on its mass, the force between it and the earth, and any air resistance, which in turn depends on its speed and shape.

Equipment/material needed
- A selection of eggs (chocolate)
- Slow motion camera

Description

The first experiment is to take two similar chocolate eggs, same shape, same density but different sizes, and drop them together from the same height. Which will reach the ground first? Does your answer depend on the height from which they are dropped?

Figure 1: Two chocolate eggs, large and small, ready for dropping.

In the second experiment we take two small identical eggs. Using a piece of wood about 30 cm long, we place the wood on the edge of a table as shown in figure 1 with one egg still on the table and the other on the wood which overhangs the table.

When the wood is given a sharp twist about its centre the egg on the table is knocked forwards so falls in a parabolic path, away from the table, whereas the egg on top of the wood simply slips off and falls vertically downwards. Which egg reaches the ground first?

Figure 2: Two eggs on table, one to be projected away from the table, and the other falls vertically when the wood is rotated.

Conclusion/Result

Experiment 1: The two eggs reach the ground at the same time when dropped a short distance, e.g. from body height. This is because, over such a short distance, and for reasonably heavy objects, the air resistance is negligible.

Over a much larger distance, e.g. 3rd story of a building, as the eggs speed up the air resistance, (which depends on the speed of the egg) increases and becomes significant, so that acceleration is reduced.

The air resistance force will depend on the area presented by the egg (proportional to r^2) and the speed of the egg. And the acceleration in turn also depends inversely on the mass, (which is proportional to r^3). So, the larger egg has greater resistance than a small egg but since the mass increases in proportion to r^3 the acceleration is greater. So, it will be the smaller egg which increases in speed at a slower rate, so from a height the large egg reaches the ground first.

This simple experiment can of course be repeated with almost any two contrasting objects. It provides an interesting discussion as to the significance of air resistance compared with the weights being dropped.

Experiment 2: One egg falls vertically under the force of gravity. The second egg also falls vertically under the influence of gravity, but also travels horizontally following the impact of the wood. The horizontal and vertical parts of the motion of this egg are independent of each other, so that each egg will reach the ground at the same time. This shows the independence of two motions at right angles, (vertical and horizonal motion) In the absence of significant air resistance the horizontal motion of the projected egg remains constant, so it travels on a parabolic path.

Top Tips: It is best to have a surface for the eggs to make a sound when they land, e.g. metal tray.

Internet links: Videos of the experiment are in David's "What Happens Next Experiments" Facebook series See Dropping Eggs April 9th and 10th.

Further ideas: The experiment 2 can be easily performed using two coins and a ruler. Another of my favourite experiments in this area is a version of the monkey and hunter experiment. Where should a hunter aim to hit a monkey on a distant tree if he knows that the monkey jumps off the tree as soon as it hears the gun go off? Should he aim below or at the monkey on the tree? (I used apparatus with a ball bearing projected through a gate, which automatically released a can held by an electromagnet in such a way that the ball bearing hits the can every time!!

Eggs and Inertia

Science: Inertia and impulse

FOOD, COOKING AND STEM

Age Range
Primary /Secondary

Science Principle
Inertia and Newton's 3rd Law

Equipment/material needed
- Toilet roll empty tubes
- Eggs
- Plate (plastic or metal) or placemat
- Beaker containing water wide enough to hold egg.

Description
This can be great fun, and what looks like a difficult task is easily achieved by the youngest of students. The items (figure 1) are arranged as in the photographs (figure 2) with the egg on top of the tube directly above the beaker. NB You can do this with several eggs at once for a more spectacular effect (see below)

Figure 1: Items necessary.

Figure 2: How to set up the experiment.

Conclusion/Result
When the plate is struck sharply (figures 2 to 3) the plate slides away (figures 2 to 3). There is enough friction to move the base of the tube with the plate, (figure 4) and like the plate it continues to move from the beaker (figure 4).

There are no horizontal forces on the egg which remains above the beaker of water and the egg falls directly down into it (figure 5).

Figure 3

Figure 4

Figure 5

Figures 2 to 5 show the sequence of events once the plate is firmly struck. The plate moves off and takes with it the plate, but with no horizontal force to move the egg to the right, the egg simply falls downwards and into the beaker.

The tension in the class can be increased by having more than one egg (figure 6) or a larger chocolate egg (figure 7). There are also several similar demonstrations of this experiment, not all using eggs of course (figure 8).

Figure 6

Figure 7

Figure 8

The real beauty of this experiment is that if the plate or placemat is struck confidently it works every time.

Internet links: What Happens Next Experiments 12th April 2022, also WHN 16th May 2020

Further ideas: The principle here is demonstrated in several additional experiments, e.g. pulling the tablecloth away from a table laden with china or pulling a monetary note from under a bottle.

Eggshells and Toothpaste

Science: Corrosive property of acids

Age Range
Primary

Science Principle
Chemical reaction

Equipment/material needed
- 4 plain and raw eggs
- Toothpaste
- Cola
- Black coffee
- 4 transparent glasses

Figure 1: Material and equipment needed.

Description

1. Once you check the eggs are in good condition (that means there is no breakage or leakage of egg), wash the eggs carefully and dry the wet eggs using paper or cloth napkins.
2. Coat two plain eggs with a good amount of toothpaste evenly. And the other two eggs remain as they are. That means we are not coating these eggs with any other material.

Figure 2 and 3: Coat two plain eggs with a good amount of toothpaste evenly, the other two eggs remain as they are.

3. Fill two glasses with cola and the other two glasses with black coffee. You can measure and pour the liquids into the glasses to keep the quantity equal.
4. Pick one plain egg and one toothpaste coated egg and drop them in the cola-filled glasses respectively. After that pick another set of eggs and drop into the two glasses filled with black coffee respectively.
5. Leave the experiment set-up for 3 hours approximately to see the results.

Conclusion/Result

Glass 1, filled with cola and plain, egg got stains. Glass 2, egg coated with toothpaste dropped in cola, does not have any stains. Glass 3, the plain egg dropped in black coffee, showed stains. Glass 4, the egg coated with toothpaste dropped in black coffee, does not show any stains.

Figure 4: On the left glass 3 and on the right glass 4

Figure 5: On the left glass 2 and on the right glass 1

The egg shell is made of calcium carbonate whereas black coffee and cola are acids. The acidic contents immediately start reacting with calcium carbonate and form stains. On the other hand, for the eggs coated with toothpaste, the fluoride in the toothpaste builds a protective layer between the eggshells and the acidic solutions, making the eggshell stronger and protecting it from reacting to acidic contents of cola and black coffee.

Eggshells can be compared to human teeth as the outer layers of both are made of same material, calcium. And the chemical composition of eggs, bones, and teeth are the same. So, we the eggshells are representing teeth. Cola and black coffee represent the acids caused due to bacteria in the form of plaque. Plaque is the result of constant consumption of artificial sweeteners.

So, when we brush our teeth properly using toothpaste, the fluoride content in it protects teeth from the damage of acids, stains, and plaque.

Top Tips: The eggs should be at room temperature in order to achieve an appropriate outcome. The acids in these liquids react with calcium carbonate in eggshells. Carbon dioxide is the gas released during this reaction. If you let the reaction continue for long hours, you can observe acids dissolving the eggshells gradually and completely.

Internet links: https://youtu.be/UNvmRdD-3hk

Contributor: Nuria Muñoz, Spain (algenuria@gmail.com).

BALANCING EGGS

Science: Instability to stability

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Unstable and stable equilibrium

EQUIPMENT/MATERIAL NEEDED

- Egg
- Salt

Description

The challenge is to work out how an egg can be balanced on its end as in the first photograph.

Figure 1: One balanced upright egg, one egg ready to be balanced.

It may be just possible, (try it!) but this will be (very) unstable equilibrium. There needs to be something extra to hold the egg vertically.

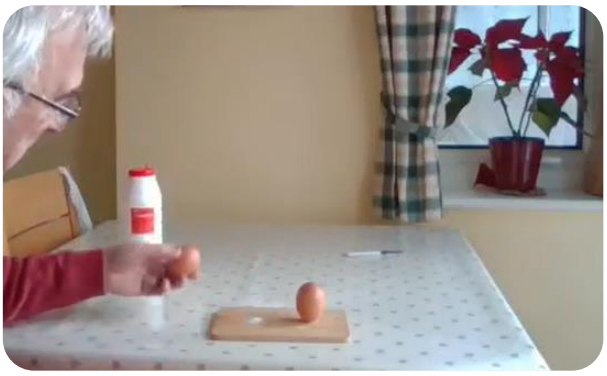


Figure 2 and 3: Preparing a small pile of salt on which to stand the egg.

BALANCING EGGS

Science: Instability to stability

Figure 4: The two eggs resting on the salt. Note that the salt is not visible on the right as all excess has been blown away.

Figure 5: Showing egg at an angle balanced on larger coarse salt.

The egg balances on the pile of salt and any excess can be blown away such that without careful examination the remaining salt cannot be seen. It only needs a few grains to support the egg.

Conclusion/Result

For guests or pupils, the balanced egg can be removed and then they are challenged to rebalance it. (Of course, they should not notice the few grains of salt that have previously kept the egg erect, or you could gently blow them away !!!).

Top Tips: General care is needed with raw eggs.

Further ideas: The idea can be extended by investigating how much salt is needed to balance the egg, and how the different amounts are able to balance the eggs at greater angles to the vertical. (figure 5). Does the size of the salt grains affect the answers?

Internet links: What Happens Next Experiments: Facebook video: Balancing Eggs 26th and 27th March 2021

Eggs in a Vertical Circle

Science: Motion in a circle and forces

Age Range
Primary /Secondary

Science Principle
Centripetal forces and motion in a circle.

Equipment/material needed

- Frisbee, string
- Egg in egg cup
- Chocolate egg

Description

First drill three holes on the edge of a plastic frisbee so that string can be attached to hold it as shown in figure 1.

(If you don't want to a sacrifice your frisbee to this experiment you can tie the three strands of string under the frisbee, as in a hanging plant potholder.)

Place the egg in its cup at the centre of the frisbee as shown, and you are ready. (You may wish to start with a single object, e.g. an orange or tomato)

Gently at first, in a pendulum motion, swing the frisbee back and forth until you are ready to swing in a full circle.

Figure 1: Egg and eggcup on the frisbee suspended on strings.

Figure 2,3, 4: Egg and eggcup on the frisbee being rotated. Nothing falls off due to the forces.

Eggs in a Vertical Circle

FOOD, COOKING AND STEM

Science: Motion in a circle and forces

Conclusion/Result

Providing you are moving fast enough the egg and cup will make full vertical circles, remaining on the frisbee.

The motion in the circle provides the forces necessary to hold the egg and egg cup in position on the frisbee. It is useful to consider all these forces, which are always in pairs. (Newton's 3rd Law).

Consider each part and identify:

1. The force of the earth on the egg, and the force of the egg cup on the egg;

2. The force of the egg on the eggcup, the force of the earth on the eggcup, the force of the frisbee on the egg cup;

3. The force of the eggcup on the frisbee, the force of the string on the frisbee.

At the top of the swing the weight of the egg plus the force on it of the eggcup add to give the centripetal force needed to move the egg in the circle.

Top Tips: The most difficult part is when you have finished, (to stop the motion). It is best to reverse the starting process moving from circle to swinging pendulum reducing in amplitude until it stops.

Health and safety: Have the rest of the class stand clear when the frisbee is being rotated.

Internet links: 24th March 2021, 25th March 2021 **What Happens Next Experiments Facebook group** "Egg, Eggcup and Frisbee".

28th May 2020, 29th March 2020 **What Happens Next Experiments Facebook group "**Apple in a bucket".

Further ideas: Just for fun at Easter, replace the eggcup with a large chocolate easter egg. This could be used as an introduction as it is just one item on the frisbee.

A further extension could be to FLOAT a hollow chocolate egg in a bucket of water and whirl it. What happens to the egg? Will it sink?

Beating Egg Whites

Science: Molecular forces

Age Range
Primary /Secondary

Science Principle
Molecular forces, protein chains.

Equipment/material needed

- Eggs
- Salt
- Sugar
- Electric mixer

Description

First, we must separate the egg whites from their yolks in clean bowls.

Figure 1: Separated egg white and yolk

Figure 2: Beating the egg white with an electric whisk.

Next, we take 4 samples:

1. Egg white only

2. Egg white plus sugar

3. Egg white plus salt

4. Egg white plus egg yolk (fat)

and beat them with the mixer.

An additional investigation can be made with eggs at room temperature and eggs from the fridge as well as fresh and older eggs.

Conclusion/Result

The “fluffiest” foam will be made from the egg white only, whereas the white with sugar will form into a much thicker foam.

The science is in beating the eggs:
Egg white is 90% water and 10% proteins. Beating egg whites breaks the chemical bonds that hold the protein chains in their initial spherical shape, twisted together, allowing them to unwind into their long strands. These protein strands can form a kind of skin around captured air bubbles. If there's any fat or fat-like molecules present, e.g. from the yolk or some oil the skin can't form easily, and the air leaks away. Even a trace of fat is ruinous. Sugar helps more proteins gather on the surface

of the air bubbles, making the bubbles more stable so we get a much thicker meringue, but it will take longer to form. Salt added to the mixture also inhibits the formation of bubbles, so the foam takes longer to form and is less stable once it has formed.
The eggs from the freezer do not fluff up as readily as eggs at room temperature. There is also a difference between fresh eggs with firmer whites and older eggs whose white is more runny.

So, you can see there can be a lot of investigation here, and challenges to make your tests and comparisons fair.

Top Tip: If experimenting in these ways always have a recipe in mind to use the beaten eggs, whether it be in making a (sweet) meringue or a (savoury) omelette.

Internet links: https://www.exploratorium.edu/cooking/eggs/eggscience.html

https://letstalkscience.ca/educational-resources/stem-in-context/meringue-science-behind-a-wonderfully-fluffy-dessert

Chocolate Bar vs Chocolate Egg

Science: Estimation of size

AGE RANGE
Primary/Secondary

SCIENCE PRINCIPLE
Can we estimate with accuracy the amount of chocolate in different shapes?

EQUIPMENT/MATERIAL NEEDED
- Large bar of chocolate (yummy!)
- Various chocolate eggs and bars (not necessary)

Description

Experiment 1

A bar of chocolate is cut into 5 pieces (figures 1 and 2), and these are to be rearranged back into the bar shape.

Figure 1: An uncut bar of chocolate

Figure 2: Chocolate bar showing cuts

Conclusion/Result

Experiment 1

When rearranged there appears to be one square of the chocolate over. How can that be?

Science: Estimation of size

Figure 3: Chocolate being rearranged, left hand piece slid up to the right

Figure 4: Rearranged Bar - Where does the extra piece come from?

Answer: The longer length of the bar is a few millimetres shorter because the pieces along the diagonal cut are all slightly smaller.

It is also possible to rearrange the pieces such that there is an extra gap the size of a piece! The rearrangements do depend to some extent on the shape of the individual pieces within the bar, whether they are perfectly square or rectangular, and precisely where you make the cuts. It can then be demonstrated as a "magic" movement of chocolate from one end to the other,

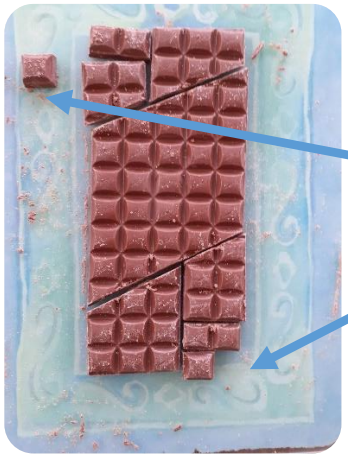


Figure 5

Spare chocolate square at the top?

Missing chocolate square at the bottom?

See: https://www.youtube.com/watch?v=NmEkL0yHQaI

Science: Estimation of size

An alternative way of cutting the bar is shown here https://www.dailymail.co.uk/femail/food/article-3573250/Unlimited-chocolate-bar-riddle-solved

Experiment/Research 2: Value for Money

Of course, chocolate varies significantly in quality. Supermarkets often sell a huge variety. In addition, packaging can also make a difference to the cost.

Here is a research project for the Easter holidays!!

1. To compare ingredients and cost of different bars (NB to make tests fair compare similar bars. e.g. plain chocolate)
2. To compare the amount of chocolate and price of comparable items whether in a bar for or novelty, e.g. egg (use a common manufacturer)

Figure 4

Which of these chocolate items offers the best chocolate value?		
Egg	121 g	special offer £1.25 normally £1.75
Aero Bar	90 g	£1.00
Chocolate Orange	157 g	special offer £1.50 normally £2.00
Bournville	180 g	£2.00

Half Eggshell Experiments

Science: Stability of irregular objects

Age Range
Primary /Secondary

Science Principles
1. The stability of an object depends on the arrangement of mass within the body.
2. Force and momentum change.

Equipment/material needed
- A selection of half eggshells
- Tall jar of water
- Pointed knife (Camping knife)

Description
PROBLEM 1: Sink a half eggshell so that it sinks with the open side downwards

Choose from a selection of half eggshells and immerse them in water and see with which orientation they rest on the bottom of the jar of water.

Figure 1: Dropping half eggshells into the jar of water

PROBLEM 2: Holding a half eggshell with its open end down, balanced on the pointed end of a vertically held sheath knife, bring the knife down sharply so that it's hand grip strikes the table, The challenge is to get the pointed end of the knife to penetrate the shell.

Conclusion/Result
Experiment 1 All half shells without an air sac will reach the bottom with their open upwards, (the heaviest part of the shell at the bottom) This will apply to all the pointed end half shells, but those half shells with air sacs, (i.e. those half shells with the more rounded ends) will sink with the rounded end, the air sac end upwards.

You can give a challenge to get the half eggshell to land with the eggs shell upwards. After having demonstrated with a successful shell, if the air sac is burst, your "victim" will not be able to land the shell that way upwards, instead it will land with the shell at the bottom.

Science: Stability of irregular objects

Experiment 2 The knife will penetrate the shell if the experimenter's grip is released just before the knife hits the table. In that way the knife (relatively large mass) is travelling upwards into the shell as it "bounces" upwards from the table. If the experimenter does not let go of the knife the two objects are both travelling downwards, and the force produced by the eggshell (small mass stopping) is not sufficient to penetrate the shell. Whereas when the knife is travelling upwards it has sufficient momentum to penetrate the shell.

Figure 2 and 3: Holding eggshell before bringing knife down……. resultant knife through the shell

Top Tips: It is best to use a knife with pointed tip, but care must obviously be taken.

Internet links: Videos of this is in the "What Happens Next? Experiments Facebook selection

(21/2 August 2022, and 5/6th April 2020)

Further ideas: You can try the same experiment using e.g. an apple which has been partly stabbed by the knife. How will the mass of the apple affect the answer compared with the eggshell? (Apple much heavier than the shell)

Spinning Chocolate Eggs

Science: Couples and vector addition

AGE RANGE
Primary/Secondary

SCIENCE PRINCIPLE
The tippee top principle

EQUIPMENT/MATERIAL NEEDED

- Small cream chocolate eggs
- M&M sweets
- Tippee top for extension

Description

The challenge is to spin a solid egg (figure 1) (a chocolate cream egg works best as mass is fairly evenly distributed) so that it erects itself (figure 2) so that it is spinning upright.

Figure 1: The author about to spin a cream egg. The newspaper gives the appropriate roughness.

Figure 2: The cream egg has erected, spinning at a faster rate.

The eggs must be spun horizontally (figure 1) on medium rough surface, and it will self-erect as it continues to spin (figure 2).

If the surface is too rough the egg does not spin fast enough, if it is too smooth the friction is too small so that the couple that erects the top is not sufficient.

Conclusion/Result

Given sufficient angular momentum and a good surface (not too smooth, not too rough!) the egg will erect. A discussion of the energy and angular momentum should ensue, and for more advanced students the vector product that gives rise to the erecting couple. Is angular momentum conserved? Is energy conserved? How does the speed of rotation change when the egg erects?

The same effect can be demonstrated with M & M sweets. (They are smaller and it is cheaper than providing a whole class with cream eggs!) The principle is that of the "tippee top", a small top which when spun rapidly inverts itself.

The theory of how it works is discussed in the article "**Can we understand the tippee top? ", see below.** Essentially there are several couples working on the spinning egg which combine to erect it, the key couple being the frictional drag between to base of the egg and the surface on which it rotates. The "spin" of the egg is described by a vector along its spinning axis, and involved is the couple due to the weight of the egg in relation to the point of contact with the surface. It is the large, rounded bottom of the egg with a centre of curvature above the centre of mass of the egg which leads to the erection.

Internet links: **Dare we teach tops?** Physics Education, Volume 45, Number 4**Citation** David Featonby 2010 *Phys. Educ.* **45** 409 https://iopscience.iop.org/article/10.1088/0031-9120/45/4/013/met

Can we understand the tippee top? David Featonby © 2014 IOP Publishing Ltd Physics Education, Volume 49, Number 1 https://iopscience.iop.org/article/10.1088/0031-912

For videos see the Facebook pages of "What Happens Next Experiments" Spinning Eggs 25th March 2021.

Raw and Hard-boiled Egg

Science: Rotational inertia

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Inertia and Newton's first law

EQUIPMENT/MATERIAL NEEDED

- Two fresh eggs. One is raw and one is hard boiled.

Description

Students are given two similar looking eggs but are told one is hard-boiled the other uncooked, how can you tell which egg is hard boiled?

The uncooked egg contains the runny white and yolk, but the hardboiled egg is solid inside.

It is possible with a little practice to feel the difference with the uncooked egg contents moving around inside when you move the egg, however a more certain way is to spin the eggs.

Figure 1: Two eggs, but different. One is fresh, one is cooked (hard-boiled).

Figure 2: Spinning the egg.

Figure 3: Stopping the egg.

Raw and Hard-boiled Egg

Science: Rotational inertia

Conclusion/Result

If you spin a hard-boiled egg (figure 2) and stop it by gently touching (figure 2), the egg remains at rest. However, if you do the same with an uncooked egg the spin is slower because of the drag of the contents inside. But more noticeably, when you stop it and immediately lift your hand, the egg continues to rotate. This is because although you stop the shell of the egg, the inside keeps on turning. (A body continues in its state of rest or of uniform motion unless acted upon by an external resultant force)

Internet links:

See What Happens Next Experiments 10th 11th April 2020

Science in School "Eggs Experiments for Easter 2016" https://www.scienceinschool.org/article/2016/eggsperiments-easter/

Tissandier's Experiments with Eggs

Science: Inertia plus moments

AGE RANGE

Primary /Secondary

SCIENCE PRINCIPLE

Inertia and moments combined

EQUIPMENT/MATERIAL NEEDED

- About 75 cm of fairly thin wood with cross section aprox 0.5 cm by 2 cm
- Raw eggs in egg holders
- Table tennis balls

Description

Tissandier's famous experiment using wine glasses and a rod is shown in figure 1.

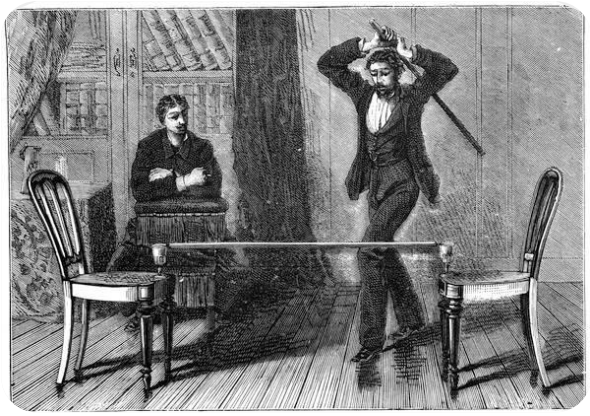


Figure 1: Tissandier's experiment taken from "Popular Scientific Recreations" by Gaston Desander (ca. 1890).

Figure 2: The modified set up with two fresh eggs as supports for the rod. Table tennis balls are balanced on the rod above the eggs in order to show the resultant motion.

Our experiment is to replace the glass with two eggs and add two table tennis balls (figure 2). Whilst Tissandier used a rod to smash the rod, it is possible using just a karate chop for the eggs. (A useful tip to be sure that the rod breaks in the centre however is to make a small saw notch at the centre underside of the rod). The aim is to snap the rod without breaking the eggs.

Conclusion/Result

The photographs show the author breaking the rod (figure 3). As the rod breaks at its centre the two halves rotate about their centres of mass. Thus, in rotating the ends of the original rod lift off the eggs so the eggshells aren't broken. This rising also projects the table tennis balls upwards (figure 4). As can be seen in figure 5 the eggs are unbroken.

Science: Inertia plus moments

Figure 3: Breaking the rod.

Figure 4: Half rods rotating sending the balls into the air.

Figure 5: Showing the unbroken fresh egg.

Further ideas: There are several similar experiments that can be performed using alternative fragile items below the rod which add to the excitement/fun. One of my favourites is to use tomatoes below a long French bread loaf (figure 6).

Figure 6: Grandchildren performing Tissandier using tomatoes below and above a long bread stick.

Internet links: An article giving fuller details of the original experiment of Tissandier

https://www.ase.org.uk/system/files/SSR_June_2020_056-057_Balta.pd

A selection of Tissandier videos https://www.youtube.com/watch?v=HnkeTlYEpOo

References Physics Education 2014 Tissandier Revisited : Question Phys. Ed 49 , p 120, Answer 49. p 259 (D. Featonby)

Facebook "What Happens Next Experiments 3rd and 4th June 2020, 25th June 2020 (Slow Motion) 11th June 2022.

FLOATING AND SINKING EGGS

Science: Stability and changes in eggs over time

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Stability, and chemistry within an egg

EQUIPMENT/MATERIAL NEEDED

- Eggs
- Large beaker
- Frying pan
- Patience

Description

This is a long-term experiment. During the few weeks after it has been laid, an egg undergoes many changes both physical and chemical.

The changes within the eggs change the orientation of the egg as it sinks in water or later eventually floats. The observations take several weeks. The eggs should not be left in water, as this affects what happens.

Observations:

1. Immediately after being laid (<24hrs) the eggs will sink in water, with the larger rounded end downwards.

2. Gradually the egg moves to the horizontal when sunk, and then the rounded end lifts up.

3. After a few more weeks the egg floats when put in water.

Figure 1: Eggs in water.

Apart from the “bad” egg which floats, fresh eggs float with different orientations.

Science: Stability and changes in eggs over time

Conclusion/Result

1. The egg is fairly uniformly filled with white and yolk, however the heaviest part is the wider rounded end.
2. During the first week or so the egg sac is formed at the wider end of the egg. So there is a sack of air which will rise up, effectively making the egg stand on its end.
3. Gradually there is an interchange of air and CO_2 through the shell, reducing its mass.

Reference: The Science and Lore of the kitchen Harold McGee ISBN-10 0-684-80001-2

Top Tips: It is important to keep the eggs out of the water in between tests.

Further ideas: Fresh eggs change quite significantly during the weeks after laying. Initially the two parts of the "white" (thick and thin) are quite distinct, and this can be seen when frying eggs. The white of a fresh egg is clearly in two parts compared with an older egg, which has a runnier white. What often is sold as a fresh egg can be over a week old!! Not so fresh. (See figures 2 and 3).

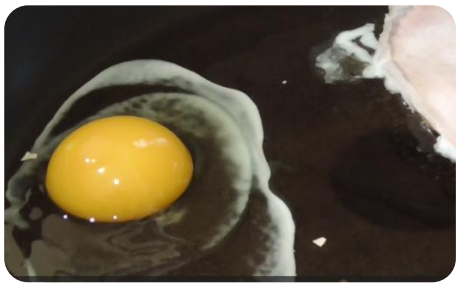


Figure 2: A very fresh egg (few days) showing the two thicknesses of albumen.

Figure 3: The older egg showing that the two layers of albumen have merged into a runnier fluid before cooking.

Internet Links: What Happens Next Experiments: Facebook video : Into the frying Pan 3rd April 2021

The Egg Boiler

Science: Latent heat

Age Range

Primary /Secondary

Science Principle

The energy to cook eggs is found in this kitchen appliance from the steam which circulates until the water in the reservoir is used up.

Apparatus:

- Egg boiler (as from Lakeland UK, but many other suppliers)
- Eggs
- Water

Figure:1 The egg boiler

Figure 2: Open boiler with one egg to cook

Description

Electric egg boilers (figure 1) are quite common in hotel restaurants where the customer has to cook his/her own egg for breakfast. They work by boiling a measured amount of water in an enclosed (but not totally airtight) container, containing the egg to be cooked. The amount of water used is carefully measured in order to ensure that the egg is cooked by the "right" amount of time. Eggs may be lightly cooked with soft runny interiors, medium or hard cooked. The principle is that the water will boil for a length of time depending on the amount of water used. Once all the water is boiled away, the hotplate temperature will exceed 100 °C, and this initiates a signal (beep) and switches off the hotplate.

Starting with one egg (figure 2) in the container a small, measured amount of water is required for say "medium" cooked eggs. The water boils and although some will condense on the egg, in time all the water will have vapourised, and the egg boiler switches off.

Surprisingly in order to cook 2 eggs (Figure 3) the measured amount of water is LESS than for one egg to cook the eggs to the same hardness/softness. More than 2 eggs require even less! (See figure 4) How come you need less water for more eggs? The answer is in, or on, the eggs themselves. There are two processes before all the water is vapourised. When the water in the base boils it boils and leaves the container or recondenses on the cold eggs. With three eggs there is a far greater surface area on which the water vapour can condense. This condensed vapour must now fall and be re-boiled before the temperature rises above 100 °C, a process which increases the time that the container is filled with steam. This extra time balances the time reduction by having to boil a smaller amount of water. Producing the perfect boiled egg (figure 5).

The Egg Boiler

Science: Latent heat

Figure 3: Egg boiler with 2 eggs

Figure 4: Water measure showing volume of water for 1, 2, 3, 4, 5 and 6 eggs, getting smaller each time.

Figure 5: Boiled egg: yolk perfect! The white has solidified, and the yolk is still liquid.

Top Tips: Take care with boiling water.

Egg boilers are available from many retailers. Boiling different numbers of eggs provides a useful basis for discussion in class.

Internet links: Physics Education End Results 2011 *Phys. Educ.* **46** 731 **What Happens Next?: The great boiled egg mystery** *David Featonby* *https://iopscience.iop.org/article/10.1088/0031-9120/46/6/M04/pdf*

Further ideas: Examine the processes that take place in an egg as it is cooked. For example, why does the white solidify before the yolk?

Throwing Eggs

Science: Force and impulse

AGE RANGE
Secondary

SCIENCE PRINCIPLE
Impulse and force

EQUIPMENT/MATERIAL NEEDED

- Eggs
- Bed sheet

Description

A fresh egg thrown against a solid brick wall most certainly will break.

Two students should then hold the sheet vertical. With one hand each holding the sheet up a little way from the wall and the lower hand holding the bottom so that the sheet makes a trough, which is hopefully going to catch the eggs without them reaching the ground. (See figure 1).

Figure 1: Photographs showing the egg being thrown at the sheet. Note position of egg in 3rd photo. The sheet means the egg is stopped over a distance much greater than if it simply hit the fence behind.

Conclusion/Result

No matter how hard the egg is thrown against the sheet it will not break, because the sheet increases the time taken for the egg to come to rest. The danger is of course that your thrower misses the sheet altogether.

A 100 g egg travelling at 20 m's, which is stopped within 0.1 seconds on the wall experiences a force of $F = ma = 0.1 \times 200 = 20$ N ($a = 20/0.1 = 200$ m/s^2)

Throwing Eggs

Science: Force and impulse

A 100g egg travelling at 20 m's, which is stopped within 1.0 seconds on the wall experiences a force of F = ma = 0.1 x 20 = 2 N (a = 20/1 = 20m/s^2)

Top Tips: Take care in your choice of thrower.

Further ideas: Students will enjoy devising means of catching thrown or dropped eggs, so the force exerted to reduce their momentum to zero is minimum.

The faster the egg moves the more skilful they need to be to catch it without breaking.

You may also wish to try catching an egg. We used to run egg throwing competitions on the school field. Some students caught the egg without breaking it. Others weren't successful. Those eggs that break are the eggs which are stopped too quickly.

Here the catcher is successful because he moves his hands in the direction of the egg's travel as the egg reaches him, increasing the time over which it has to stop. (Perhaps several years ago he might have just held his hands out and hoped, and the egg would have broken when it hit him).

Figure 2: Catching an egg. In order that it does not break, he moves his hands in the direction of the egg as it reaches him, so it has a longer distance over which to stop.

Try catching a hard ball, (hockey or cricket) without making any movement of your hands. You will feel the extra force to stop the ball instantly.

An interesting project we sometimes call the "egg race" is to be able to project an egg over an obstacle and catch it (mechanically) so that it doesn't break.

Internet Link: What Happens Next Experiments: Facebook video: Throwing Eggs 10th, 11th March 2023

Eggs Into a Bottle and Out Again

Science: Pressure changes with temperature and other things

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Increased or decreased pressure from an enclosed container can be applied evenly to a surface

EQUIPMENT/MATERIAL NEEDED

- Hard-boiled egg
- Wide mouthed milk bottle
- Hair drier

Description

How many ways are there to get a shelled hard-boiled egg into a bottle without breaking it?

The eggshell needs to be removed very carefully to not break the surface of the egg. (The older the egg the easier this is to do.)

The principle is to reduce the pressure inside so that the greater outside pressure forces the egg in.

1. Water method

   Warm the glass bottle first to prevent cracking. Pour in a few cms of boiling water so that the bottle fills with steam. Immediately place the shelled egg on top of the bottle sealing the entrance and wait.

   (Alternative: Using a wide-necked pyrex flask, you can begin by boiling a few cms of water in the flask)

2. Matchstick Method

   Drop a lighted match into the bottle so that it continues to burn for a while, but still sealing the bottle with the egg as above as soon as possible. Wait and watch.

   (Alternative: Burn strips of newspaper or cardboard and drop them, while still burning, into the bottle. I prefer a match as it messes the egg up less!)

In both cases the egg is forced into the bottle, (we hope) without breaking.

Figure 1

Once the whole egg [illegible]

a) **Blowing**: Place the bottle opening in your mouth and blow hard. The pressure inside the bottle is increased forcing the egg out.
b) **Hair dryer heating:** Turn the bottle and egg upside down so that the egg fits snuggle towards the mouth. Gently heat the bottle with the hair drier blowing on the outside. The increase in pressure due to rise in temperature is enough to force the egg out of the bottle.

Conclusion/Result

Provided that the egg is not broken before you start, the egg should almost magically squeeze its way into the bottle. In similar fashion the egg squeezes its way out of the bottle in the second experiment.

Figure 2: Blowing the egg out of the bottle!

Top Tips: It is useful to dampen the rim of the bottle opening before placing the egg there as this gives a better seal.

Health and safety: Take care with boiling water, and make sure bottle is warmed first to avoid breakage.

Internet links:

https://youtu.be/AqFQ47NT008

https://youtu.be/3_i9V1-Jbo0

https://youtu.be/kdGDPcssJvQ

Encore: The Strength of Eggshells

Science: Eggshell strength, impulse and inertia change

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Strength of eggs and inertia

EQUIPMENT/MATERIAL NEEDED

- Eggs
- Large log of wood
- Nail and hammer

Figure 1: All you need for this experiment.

Description

The 10 kg log of wood is to be placed on top of 2 dozen fresh eggs. Will the eggs support it? I think we know the answer is yes if it is placed gently on top! (figure 2)

But what happens when we try and hammer a nail into the log? (figure 3)

Figure 2: 10 kg log on eggs, no cracked eggs!

Figure 3: Hammer in the nail, cracked eggs?

Conclusion/Result

The eggs are strong enough to support the log, but they also do not break as the nail is being hammered in!! (Figure 3) The large mass of the log (10 kg) resists passing the force of the hammer onto the eggs. This is called the **inertia** of the log.

Top Tips: NB Take care when lifting the log not to drop it on the eggs, or on your feet.

Egg Pendulum and Bernoulli

Science: Bernoulli pressure changes

AGE RANGE
Primary /Secondary

SCIENCE PRINCIPLE
Bernoulli pressure changes

EQUIPMENT/MATERIAL NEEDED

- 2 Easter eggs
- 2 Cups (or 2 other supports)
- 1 Pencil

Description

1. Assemble the material as follows:
2. Hang two Easter eggs on a pencil or other support so that they can move freely.
3. Blow strongly between the two eggs.

Figure 1: How to set up the experiment.

Figure 2: Blow strongly between the two eggs.

4. Observe.

Conclusion

You will find that by blowing through Easter eggs they will come closer together. This phenomenon is due to Bernoulli's Effect, which states that the greater the speed of a fluid, in this case air, the lower its pressure. Therefore, the air pressure will be higher outside the eggs and lower between the eggs, which makes the eggs tend to occupy the central position.

Bernoulli's Principle states that the internal pressure of a liquid decreases as its velocity increases.

This phenomenon explains, for example, why we should not be too close to the train tracks when we are at the station.

Red Cabbage and Fried Eggs

(Repeated from previous booklet)

Science: Colour changes of red cabbage liquid

AGE RANGE

Primary /Secondary

SCIENCE PRINCIPLE

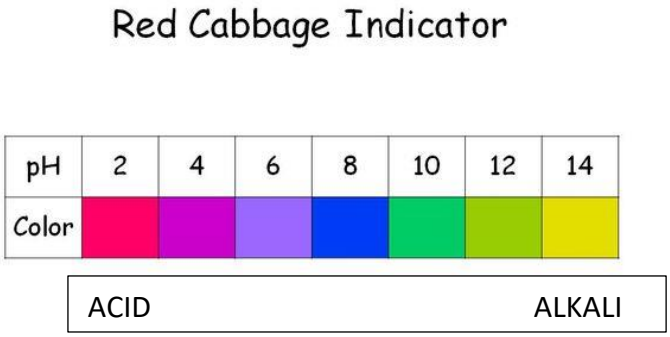
Red cabbage as an indicator and the changing pH of eggs

EQUIPMENT/MATERIAL NEEDED

- Eggs
- Red cabbage
- Pan

Description

Prepare solution of red cabbage by boiling some cut up leaves. This is the indicator solution. Red cabbage solution ranges from acid at pH 2 through neutral at pH 7 to alkali at pH 10/12.



For the experiment get ready to “fry” and egg in a pan. (Various aged eggs from newly laid onwards may be used). Break the egg into the pan and before the albumen begins to turn from clear to opaque white drip some of the solution onto it as it cooks.

Look carefully at any colour changes and link them with the above table.

Figure 1: Preparing the red cabbage liquid and cracking an egg into the frying pan. Note clear albumen.

Conclusion/Result

The “white “part of the egg turns green, indicating that the “white” is alkaline. The newest eggs only show a slight tendency towards green, but as the eggs get older, the “white” becomes more alkaline until a fairly clear green is visible.

Red Cabbage and Fried Eggs

(Repeated from previous booklet)

Science: Colour changes of red cabbage liquid

Figure 2: The picture shows two eggs, the one on the left has had lemon juice (acid) added whilst the other on is just as it came out of the shell (Both have cabbage liquid added).

NOTE: The older the egg the more alkaline the white becomes due to the changes that take place. The carbon dioxide in the egg is in the form of carbonic acid when it is dissolved in the yolk and white. In time the carbon dioxide is slowly lost through the pores in the shell. The yolk rises from a slightly acidic pH of 6.0 to a nearly neutral 6.6 while the albumen (white) goes from a somewhat alkaline 7.7 to a very alkaline 9.2.

The other change in the white as it becomes more alkaline is that it changes from thick slightly cloudy to clear, which is because the proteins in the albumen initially cluster together in masses large enough to deflect light rays, but in more alkali conditions those proteins repel each other, and the white gets more and more runny.

Top Tips: Obviously car must be taken when cooking over a flame.

Internet links: There are many “red cabbage “experiments to be found online.

Notes:

FOOD, COOKING AND STEM

Notes:

FOOD, COOKING AND STEM

SCIENCE ON STAGE
EUROPE

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