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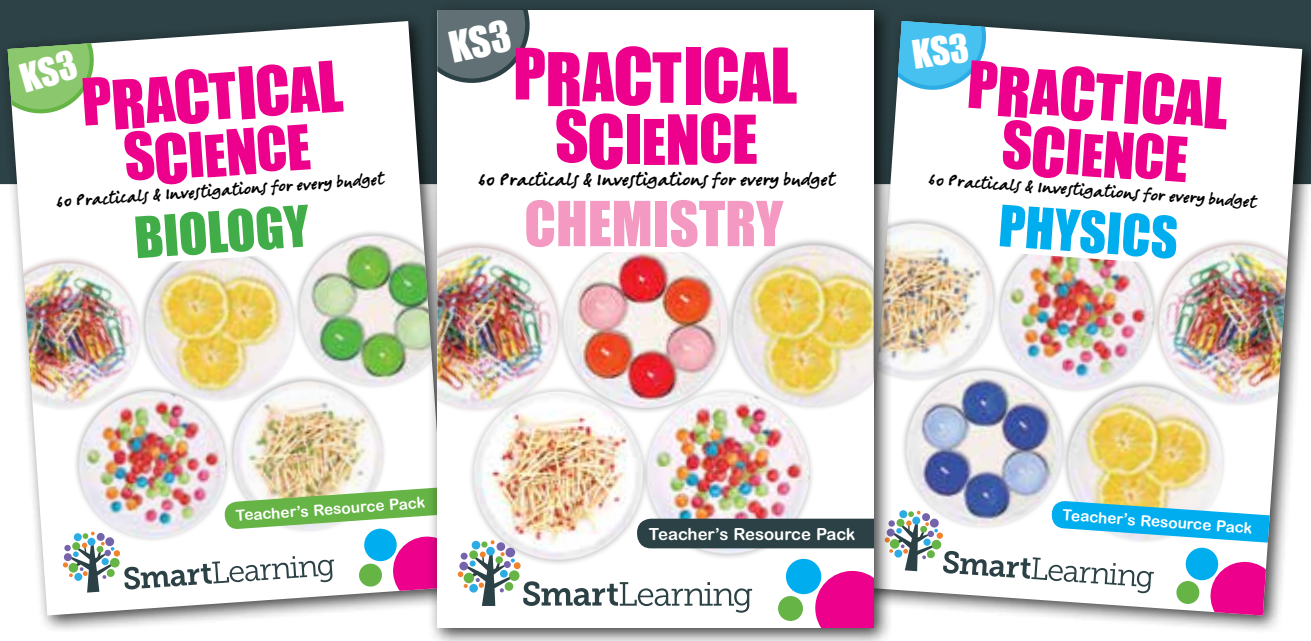
8 FREE PRACTICALS & INVESTIGATIONS INSIDE...



FREE lessons inside...

- ★ Biology – Mutations and Evolution
- ★ Chemistry – Reactive or Not?
- ★ Physics – The Static Circuit

Fits with any scheme!

TRY THEM OUT, THEN GIVE US A SHOUT!

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SmartLearning

Mutations and Evolution

What's the question?

How might a genetic mutation lead to a whole population changing? Let's find out!

Equipment

Mutation game:
- die
- calculator
- envelope
- paper

Changing populations:
- pasta
- marker pen

Key words

- mutation
- evolution
- sickle cell trait
- malaria
- gene
- population
- allele
- dominant
- recessive

Mutation game

This activity simulates how mutations, through altering our genes, can be a random event.

1. Each person in your group must throw the die and record the number they get.

Those who threw a number 2, 3, 4 or 6 have contracted influenza - a very dangerous viral infection.

2. Open your envelope to reveal a number.

A person who threw this number has a mutated gene that protects them from influenza.

Die Number	Consequence
1	Clear
2	Flu
3	Flu
4	Flu
5	Clear
6	Flu

What are the potential consequences for people in your group?

Using the information in the table above, work out the probability of contracting influenza. How likely would it be that the influenza would make a person very ill? (Don't forget the lucky number!) Probability is the chance that something will happen.

Changing populations

This activity helps to explain how the mutation that created sickle cell has protected a population from malaria, the world's biggest killer known.
Your group has a container of pasta which represents a community of people. Some of the pasta (people) have green dots drawn on them. This pasta (people) have a genetic mutation called sickle cell trait. Consequently they have added immunity to malaria.

1. Turn all the pasta opening-down
2. Carefully raise the container approximately 3cm from the ground and then drop it
3. Some of the pasta will turn opening-up. These have been infected with malaria. Those opening-down have not
4. Remove any pasta that does this, unless they have a green dot, as these represent people who have immunity to malaria
5. Record how many pieces of pasta (people) you had to remove
6. Turn the remaining pasta opening-down again and repeat
7. Once again, remove all upward facing pasta that did not have green dots
8. Record your results

What is changing about the population of pasta in the container?
How could this represent a change in a population due to a mutation?

Safety

Do not place any of the ingredients in your mouth.

So, what's the scientific explanation?

What's the science?

Mutations occur through natural changes in genes in an organism. If genetic changes result in beneficial adaptations, natural selection may result, i.e., survival of the fittest. Organisms that can't compete as well may perish and so this leads to the gene pool changing and this is an example of evolution at work.

Mutation game

Influenza is an extremely dangerous viral disease. Often when people say they have flu, they are referring to a bad cold. Influenza is a disease that can and does kill thousands of people each year.

Random changes in DNA can create mutations or differences in genetic coding. Some mutations are harmful and can damage organisms, whereas others can be beneficial. In the game, the mutation was beneficial as it increased a person's immunity to influenza. This change in the persons DNA would result in them having a greater chance to survive the disease. The severity of the symptoms of influenza (fever, vomiting, muscular pains, fatigue and severe headaches) would also be reduced.

Changing populations

Sickle cell is a mutation in a gene that instructs cells on how to make haemoglobin (needed to carry oxygen in the blood). Evolution can be measured in different ways. Sometimes we see quite dramatic changes occurring in populations and other times the changes can be less obvious. When we compare maps showing areas of high malaria incidence and high numbers of people with sickle cell trait, there is a good correlation.

Your results show that people who are infected with malaria, who do not have sickle cell trait to protect them, may die. Those with sickle cell trait recover and remain in that population. Off-spring of these people inherit the sickle cell trait allele (one possible form of a gene) and as a consequence the population changes towards a higher proportion of people who survive malaria. The population has a survival advantage over people without the mutated allele.

This change in a population is a good example of evolution that occurs through a random genetic mutation. It is an adaptation that is beneficial to survival in an environment where malaria is prolific.

What's the maths?

Probability: There are four possible numbers out of six that would result in a person being infected by influenza. This means there is a 4 in 6 chance of a person being infected. The proportion can be written in several ways. For example we can say 4/6. As a decimal this is 0.67 and as a percentage it is 67%.

There are 4 people who may become infected, yet one of these is protected by a mutation. This means that 3/4 (0.75) might become very ill.

Extension

Research sickle cell to find out the difference between sickle cell trait and sickle cell anaemia. What are the symptoms of sickle cell anaemia?

So, what's the scientific explanation?

Our genes occur in pairs (one from our mother and one from our father). They can carry different information (alleles) and this information could be either dominant or recessive. Sickle cell trait occurs when a person carries only one gene for sickle cell and a normal gene. As the normal gene is dominant, the person will make normal haemoglobin. If a person inherits two genes for sickle cell genes they will develop sickle cell anaemia. This allele combination instructs the body to make sickle-shape blood cells. These blood cells can't carry oxygen. The symptoms are: pain, fatigue, shortness of breath and vulnerability to infection.

Reactive or Not?

What's the question?

Why don't we use magnesium metal for a necklace or use iron for surgical implants? Let's find out!

Equipment

- test tubes
- measuring
- cylinder
- beaker
- tongs
- metal pieces
- 1M HCl

Key words

- reactivity
- series
- element
- compound
- reactive
- displace
- solution
- metal
- transfer

Who is the boss?

1. Pour 50ml of 0.5M copper sulphate solution ($CuSO_4(aq)$) into a 100ml beaker
2. Using tongs carefully hold a 2cm piece of magnesium ribbon
3. Carefully dip the magnesium ribbon into the $CuSO_4$ solution
4. Observe what happens to both the magnesium and $CuSO_4$ solution and write this down
5. Pour 50ml of 0.5M magnesium sulphate solution ($MgSO_4(aq)$) into a 100ml beaker
6. Using tongs hold a 2cm piece of copper wire
7. Carefully dip the copper wire into the $MgSO_4$ solution
8. Observe what happens and write this down

Use evidence from the experiment to decide which metal must be the most reactive. Can you write an equation for this reaction?

Identify that metal!

You have been given a list of metals in order of their reactivity (most reactive at the top) and a selection of metals labelled A, B, C and D. You are going to use your observational skills to determine the identity of each metal using its relative reactivity with acid.

1. Using a measuring cylinder transfer 5ml of 1M hydrochloric acid ($HCl(aq)$) into each of four test tubes
2. Select your first metal and drop this into the test tube. Carefully record your observations
3. Repeat this for the other 3 metal pieces
4. Place these unknown metal pieces in order of their reactivity
5. Compare your order of metals with the list you have been given
6. Identify each metal

What key observations enabled you to place these metals in reactivity order? When a gas was produced, what was it? How might you test this?

Safety

Safety goggles must be worn at all times. Magnesium must be kept away from heat sources. Copper sulphate must not be taken internally, Hydrochloric acid is an irritant. Wash your hands if you get any chemical on you and tell your teacher straight away.

So, what's the scientific explanation?

What's the science?

The reactivity series is a list of elements arranged in order of how reactive they are. Very reactive elements such as the alkali metals (e.g., potassium, sodium and lithium in group 1) react with water. Other quite reactive metals may not react easily with water, but do with acids (e.g., magnesium, iron and zinc), whereas some metals are very unreactive (e.g., gold and platinum). These metals make great jewellery.

Who is the boss?

This activity demonstrates how a more reactive metal displaces a less reactive metal when it is in a compound. In this case magnesium (the most reactive metal) substitutes for copper in the copper sulphate. This means that the copper in the copper sulphate solution is exchanged (displaced) for magnesium. This results in copper metal being formed. The magnesium metal ends up as magnesium sulphate.

$CuSO_4(aq) + Mg(s) \longrightarrow MgSO_4(aq) + Cu(s)$

Blue Silver Colourless Red/black

Observations that support this reaction include the formation of a reddish-black solid around the magnesium strip. This is copper metal forming. The blue copper sulphate solution may begin to fade as blue copper ions are removed from the solution and replaced by the colourless magnesium ions.

Identify that metal!

Scientists use careful observation to support their conclusions. In this activity you should have used evidence such as how quickly a metal changed, whether it fizzed or felt like it was getting hot to determine the order of reactivity.

Your observations might have looked like this

A Reacted slowly to produce a gas (this is zinc, Zn)	**B** Reacted vigorously and produced a gas (this is magnesium, Mg)
C Did not react at all (this is copper, Cu)	**D** Reacted extremely slowly to produce a gas (this is iron, Fe)

The gas produced is hydrogen, H_2. For example:

$Mg(s) + 2\,HCl(aq) \longrightarrow MgCl_2(aq) + H_2(g)$

Research idea: which of these metals would react with hot water? Why?

Extension

Most metals react with acids to produce heat. They are exothermic reactions.

Is there is a correlation between the reactivity of a metal with acid and the amount of heat produced?

Plan an investigation that will be able to answer the question above.

Some possible considerations:

a) Safety – make sure that whatever you do is safe for you and others. Check this with your teacher before you do any practical.

b) What will you measure and what will you use? How will you record your results?

c) Fair testing – is your investigation a fair test? What is your conclusion?

So, what's the scientific explanation?

This experiment shows that in general there is a correlation between reactivity and the temperature rise. The more reactive a metal, the more heat is produced, i.e., it is a more exothermic reaction and so the temperature rise is greater. However, in very vigorous reactions heat can be lost due to evolution of gases. As the gases escape from the solution they take heat with them. Measuring heat transfers is called **calorimetry.**

Students might want to consider: Repeating each experiment and averaging data. Other dimensions to this investigation might have been investigating how the mass of metal or concentration of acid affects the amount of heat produced in the reaction.

For very able students the energy released can be approximated using the formula $\Delta H = -m \times c \times \Delta T$ where m is the mass of water (i.e., 5g assuming the solution is all water), c is the heat capacity of water (4.2Jg-1°C-1) and ΔT is the change in temperature. For more detailed notes see the Teachers' Guide.

The Static Circuit

What's the question?

Have you ever wondered why your hair stands on end when you comb it or why some clothes crackle when you take them off? Let's find out!

Equipment

- plastic beaker
- balloon
- ruler
- cloth
- pepper
- oregano
- salt
- paper clip
- watch glass
- pencil
- metre ruler
- tissue paper

You will need a plastic beaker or ruler or rod and some cloth (laboratory tissue also works well).

Rub the plastic beaker, ruler or rod with the cloth for two to three minutes and do this for each of the experiments.

Key words

- static
- electricity
- charged
- electrons
- atoms
- negative
- positive
- repel
- attract

Bending water

1. Run a thin stream of water from the tap
2. Rub the balloon with the cloth
3. Bring the balloon close to the water, but don't touch it!

Watch what happens.

How accurate can you make your water jet bend?

What factors make water bend most?

Is there any way you could measure the angle of the bend?

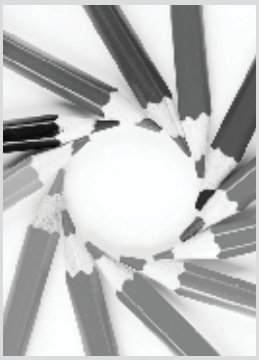
Dancing pepper

1. Sprinkle some pepper into a plastic food storage box and close the lid
2. Bring the beaker close to the lid of the box
3. Now touch the top of the lid with a paper clip

Watch what happens.

What might happen if you replaced the pepper with oregano or salt?

Spinning pencil



1. Lay the watch glass dome-up
2. Balance the pencil on the watch glass
3. Bring the beaker close to the pencil, but don't touch it!
4. Move the beaker to the other side of the pencil

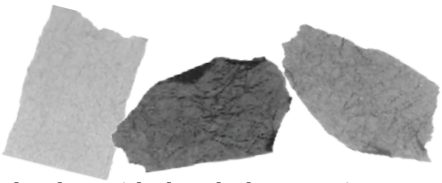
Watch what happens.

Now repeat the whole process using the meter ruler.

Which type of cloth provides the strongest attraction?

How is the number of 'rubs' related to the number of spins?

Jumping tissue



1. Tear up some tissue paper into small pieces
2. Bring the beaker close to the paper

Watch what happens.

Could you pick up more tissue paper if you rubbed the beaker with the cloth more times?

Which has the strongest attraction, a beaker, ruler or rod?

Which picks up the most pieces of paper?

Safety

There are no significant risks associated with these experiments.

So, what's the scientific explanation?

What's the science?

All materials are made from atoms. Atoms are neutral in charge because they contain equal numbers of positive protons (in their nucleus) and negative electrons, which move around the nucleus in electron shells.

When an object such as a plastic beaker is rubbed with cloth, some of the electrons from the cloth transfer to it. This gives the beaker an excess in negative charge (it now has more electrons than protons).

Bending water

Water is a remarkable molecule. It contains two hydrogen atoms and one oxygen atom. The oxygen atom has a greater pull on electrons in the bonds than the hydrogen atoms. This results in the oxygen atom becoming slightly negatively charged and the hydrogen atoms becoming slightly positive in charge.

Why do you think water bends towards the charged beaker?

Dancing pepper

The beaker is negatively charged. This induces a positive charge in the pepper particles and so they jump towards the beaker. When the paperclip is placed on the container any excess charge can move away from the container through the paperclip.

Why does the charge move through the paperclip so easily?

Spinning pencil

If the beaker is placed near the pencil, the electrons near the pencil's surface are repelled by the excess electrons on the beaker. This reveals the protons, which have a positive charge. The protons in the pencil and excess electrons on the beaker attract each other.

Why does the pencil move towards the beaker?

Jumping tissue

Read the explanations given for the Dancing pepper and Spinning pencil.

Can you write an explanation for the Jumping tissue?

What's the maths?

Graph: If you double the number of times the balloon is rubbed with the cloth, does this affect the number of spins of the pencil. Plot the number of rubs on the balloon against the distance the water jet moves away from its central line (vertical). Students could use some paper to record this distance, i.e., where the water jet hits it.

Extension

1. Take two balloons; blow them up to equal sizes.
2. Tie one to a stool with string.
3. Rub both balloons with cloth for one minute.
4. Move the loose balloon towards the tied balloon.

Can you explain what you see happen?

So, what's the scientific explanation?

The balloons are both charged negative and as we know, charges that are the same repel each other. We say, like charges repel.

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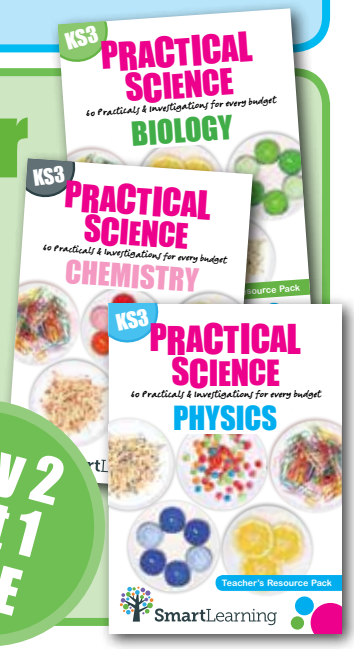

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