

A booklet and guide to  
**Enquiry Based  
Science Education**

Some of these experiments are modified from:

SUPERCOOL SCIENCE EXPERIMENTS

Published by: ARCTURUS

A booklet and guide to Enquiry Based Science Education  
**Funding and Publisher**



## Scientific contributors

Mohamed A Eltoum

Fathi Alrabaa

Endashaw Bekele

Eltayeb Mustafa

Muntaser Ibrahim

Mohamed A Elrayah

Rouaa Hamza

Fatima Hamadtu

# **A booklet and guide to Enquiry Based Science Education**

Dear parents and teachers,

This booklet includes some guidelines on enquiry based science learning known also as learning by doing. It is prepared by a number of life experienced educators and educationist. its aim is to evoke the maximum potential of the child capacity to understand the world, implant creativity and acquire the necessary skills for problem solving, encouraging the child to use whatever available material to produce a product or solve a problem (see below for pillars of EBSL).

In this booklet we have included examples of experiments and exercises, ranging from the simple to the complicated, examples intended to postulate the possibilities of IBSE and it is by no means the most comprehensive or exhaustive. You may add as much as possible from other available sources , local games etc.. the aim is to make the process of learning appealing and enjoyable, through games , experiments, visual materials etc.... it is the pleasure of finding out.

Humans are hardwired to imitate and create meaningful ordered stuff, having this in mind you should not discard any produce of the child, discuss and see his point of view on what he/she attempted. Children have different perspectives in problem solving.

Concepts come later in childhood; for instance numbers a mere abstraction in describing objects may not be known yet for a child when beginning these exercises. However a child will know how to count and do basic processes from very early on. At this digital age children deals with key

boards and informatics intermediates most spontaneously.

The booklet is two sections: an elementary preschool section in which the child goes through the simplest tasks a child can perform and a section for primary school where the child could associate tasks and exercises to concepts and writing systems and numbers. For example the task no ? where the child could find the flying speed of a locust or an insect of abundance within the child environment. In this experiment the child will be exposed to the body parts of a living object where she\he could describe and draw the parts of the insect, appreciate the symmetry in nature, in addition to understanding the meaning of a pests then understand how to count a speed of a flying object and take measures etc..

Don't worry much about the categorization of the Sciences (physics.. chemistry..biogy). As the boundaries are already blurred between the scientific domains, the child should instead learn the essence of science and research: to observe record analyze and generalize employing tools, (e.g. math, drawing etc..). The booklet hopes to stress the oneness of our cosmos and its laws at an early stage. The example of the concept of building blocks, in physics, chemistry and biology and energy as state of matter and life driving force.

Another example is in section A on using of matches to form geometrical shapes animate or inanimate like shapes etc....could also be used to introduce basic arithmetic (counting) e.g associate between number of sticks and the shape the child is able to form. Matches are available everywhere but if unused could be a potential sources of hazard to the child always use already burnt sticks or the children could be asked to

collect used matches as a recycling exercise.

The future relationship with the immediate and global environment is decided at this stage of the child life where She/he will learn how to behave respectfully towards nature and natural resources. Children at a later stage may become relatively more aware of the plight and threats within and against the earth environment, experiment like no, ....and no.....will help establish behavioral traits that will last a life time

As the materials for the experiment/produce could be anything from the surrounding, these could be normal daily waste, or broken machinery etc. should encourage waste management culture and recycling.

For that later age (B) we have included «Almudawana» a brilliant relic of a glorious educational past, It was introduced during early classes of primary school (and see no reason not to have it even earlier) the children asked to observe record their surrounding whether animate plant or weather condition, draw maps. We see no reason also why this experimented reincarnated in digitized form. Cameras are now available everywhere on mobile phones, children could go into an endless observation and recording spree in such pursuit.

Encourage the utilization of memory in both simple tasks and the ..... but not the memorization of scientific facts: «In a world where facts and data are readily available, memorization is not the most important skill anymore»

The booklet is bilingual. Apart from the guidelines the text was kept to a minimum, in the case of translation to local languages. The importance of the use of mother tongues in learning/ education is now well recognized.

## **The Basic Principles of Enquiry based Science Education**

According Joe Exline in Workshop: Inquiry Based Learning, there are four principles to help guide educators when using inquiry based learning in the classroom.

### **Principle 1:**

All learning activities should focus on using information-processing skills (from observations to synthesis) and applying the discipline «ground rules» as a means to learn content.

### **Principle 2:**

Inquiry learning puts the learner at the center of an active learning process, and the systemic elements (the teacher, instructional resources, technology, and so forth) are prepared or aligned to support the learner.

### **Principle 3:**

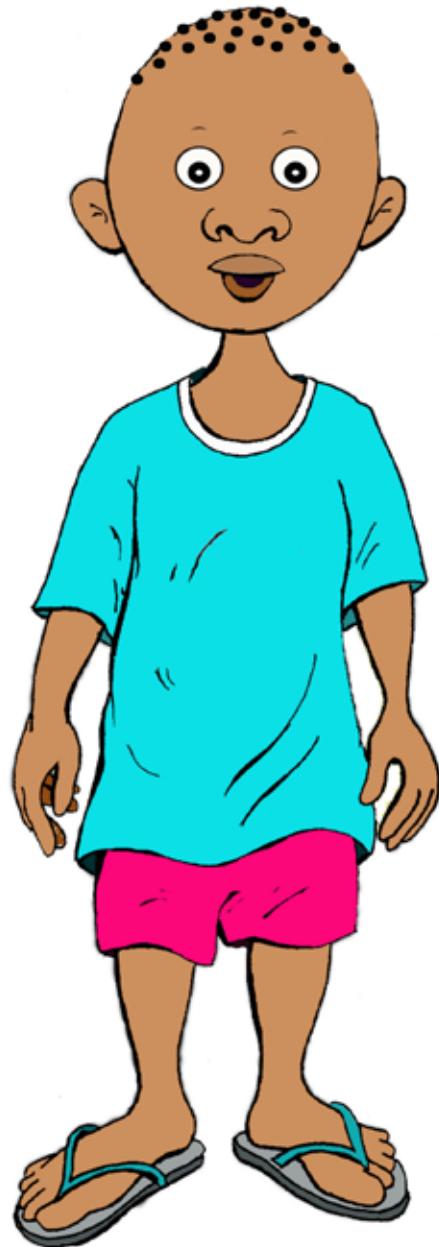
The role of the teacher becomes one of facilitating the learning process. The teacher also becomes a learner by finding out more about the learner and the process of inquiry learning.

### **Principle 4:**

What is assessed is what is valued. Therefore, more emphasis needs to be placed on assessing the development of information-processing skills, nurtured habits of mind, or «ground rules» of the discipline, and conceptual understandings -- rather than just the content of the field.

One of the main principles that teachers often struggle with is the idea that they are no longer knowledge machines for students to extract information from. On the contrary, in order for inquiry based learning to be successful

educators must take on the role of facilitators and join students in the questioning and investigation process.



**AMAN**



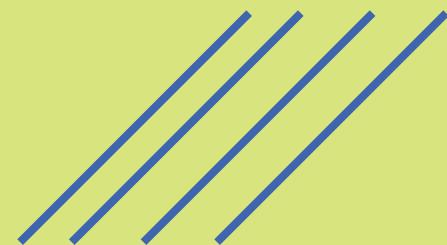
**AMANY**

# Lines

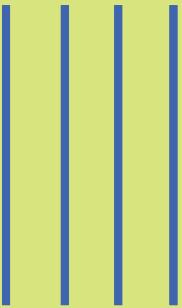
*Straight line*



*Horizontal Straight lines*



*Diagonal Straight lines*



*Vertical Straight lines*



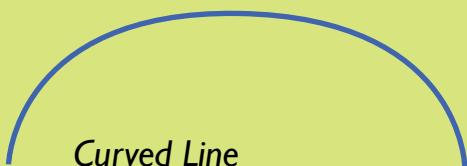
*Straight lines (Dot)*



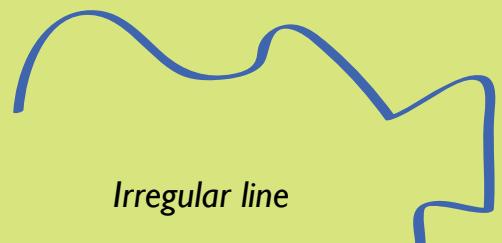
*Straight lines (Dash)*



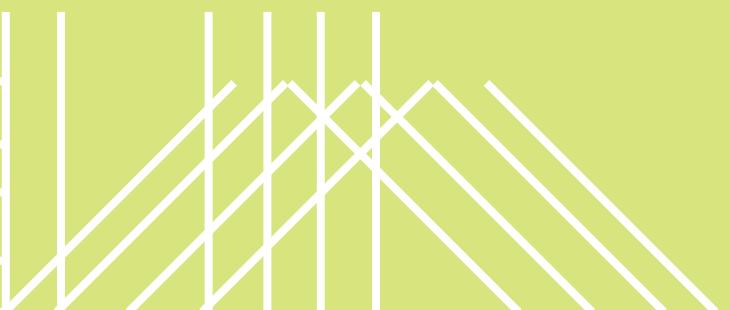
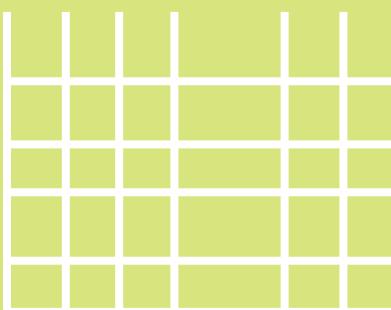
*Wave line*



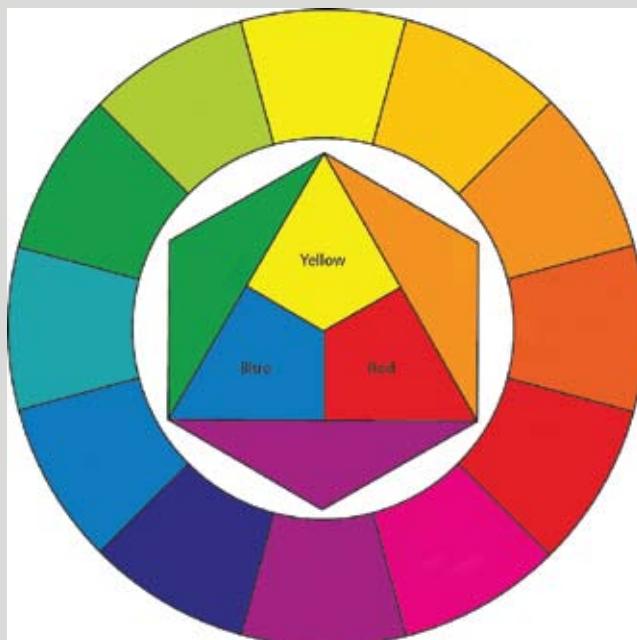
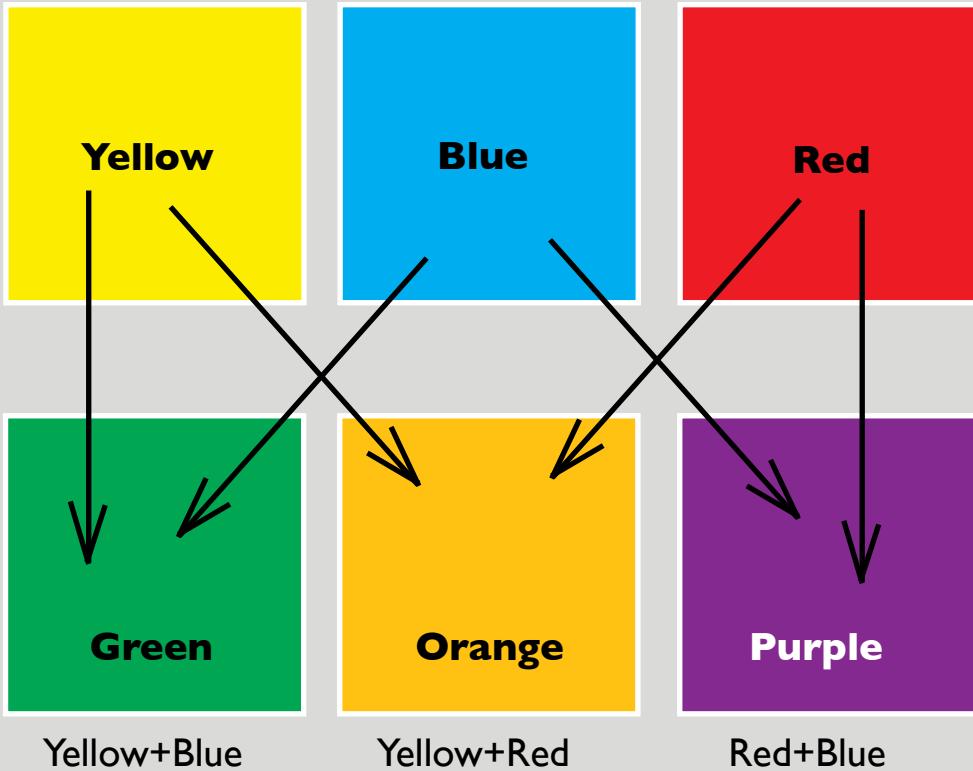
*Curved Line*



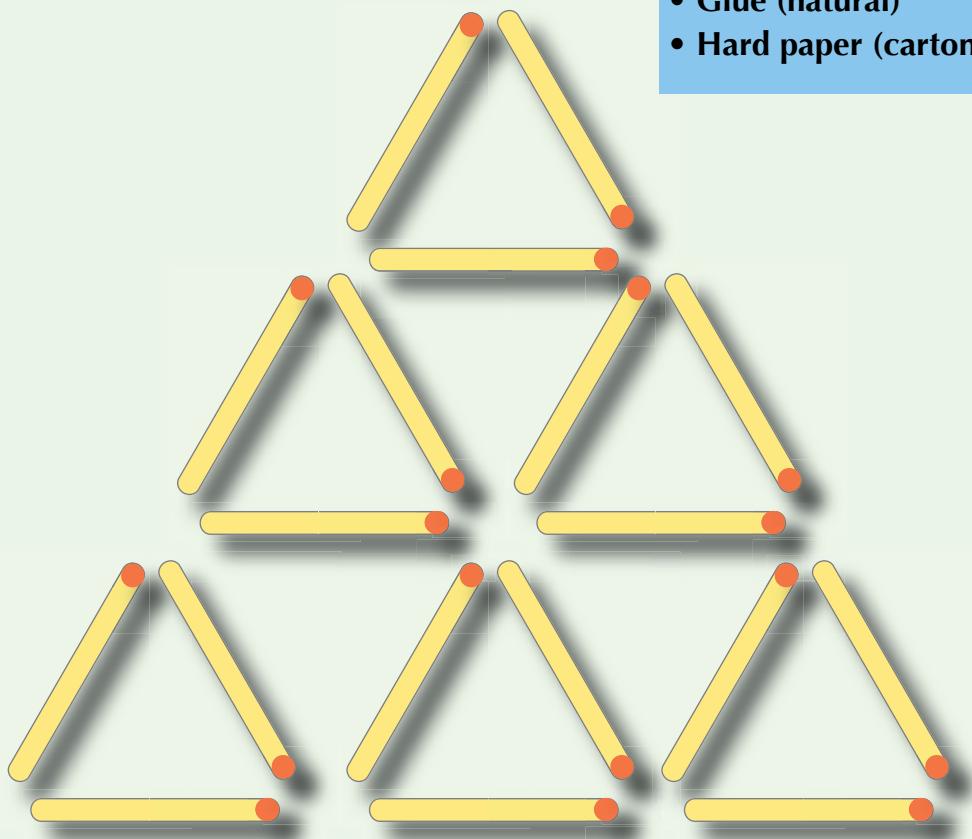
*Irregular line*



# Colours



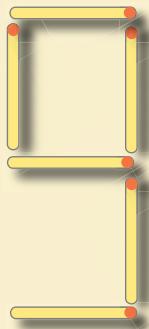
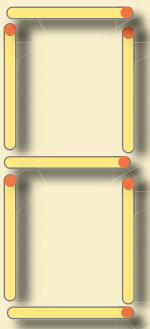
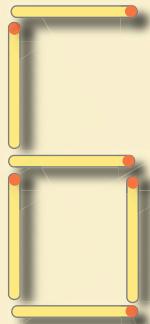
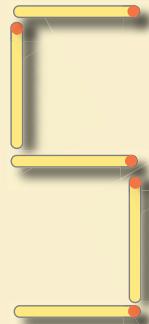
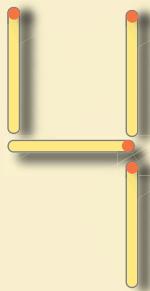
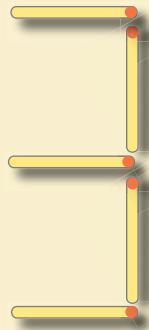
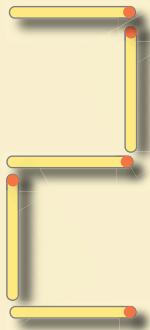
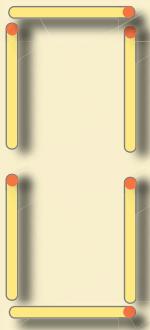
# Make 3D Shapes (I)



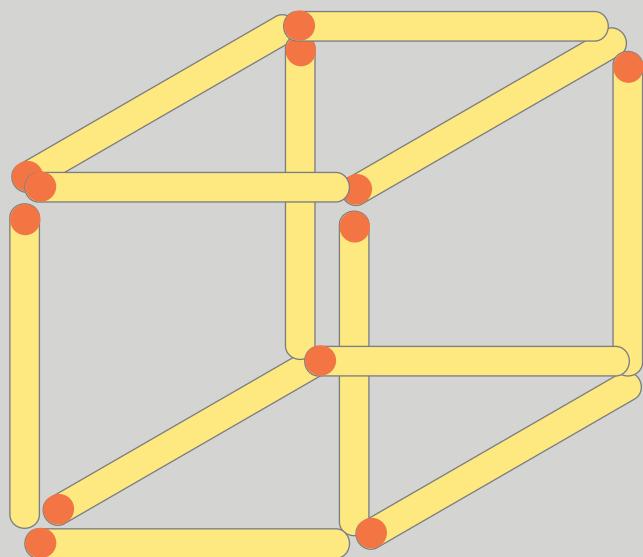
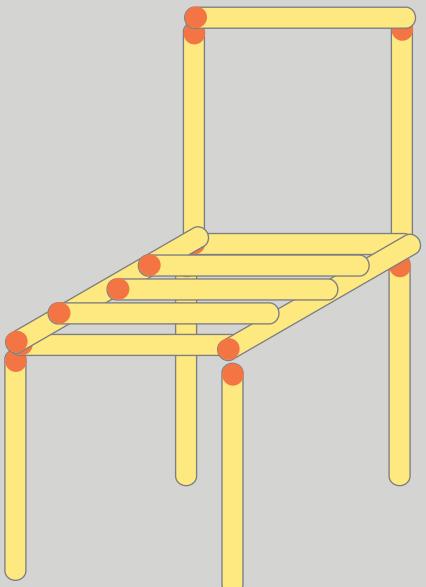
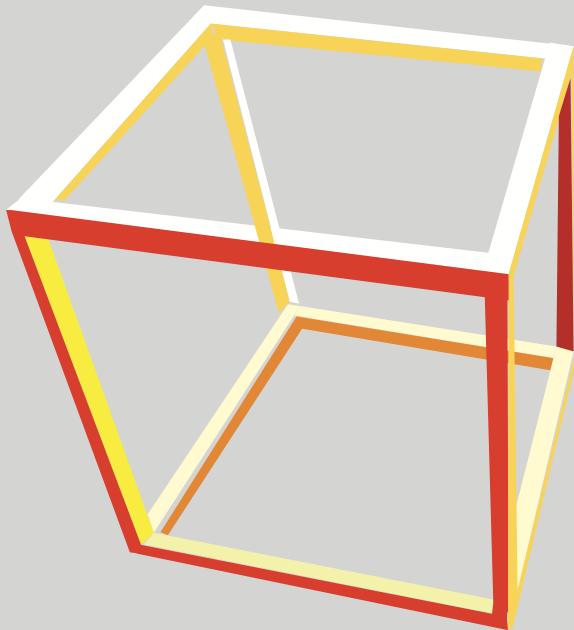
## You will need

- Match wood sticks
- Glue (natural)
- Hard paper (carton)

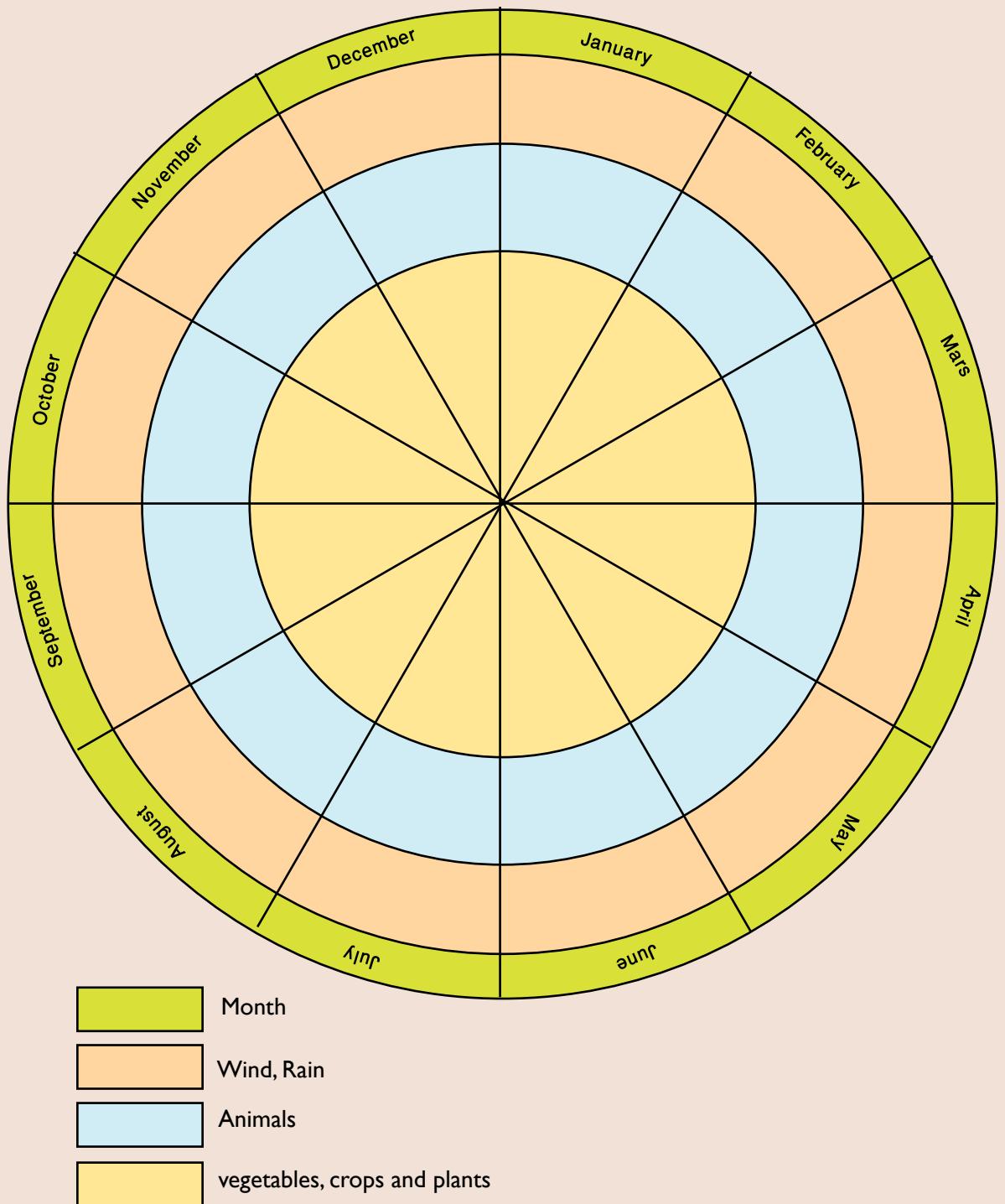
# Make 3D Shapes (2)



# Make 3D Shapes (3)

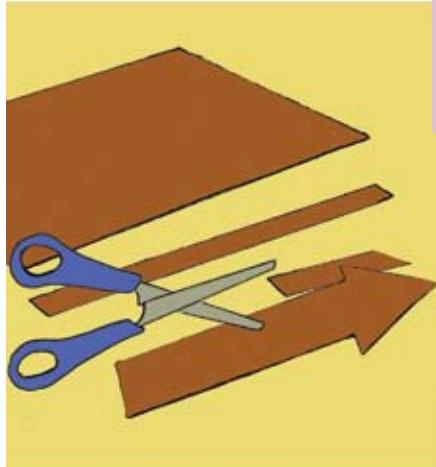


# Environmental Record



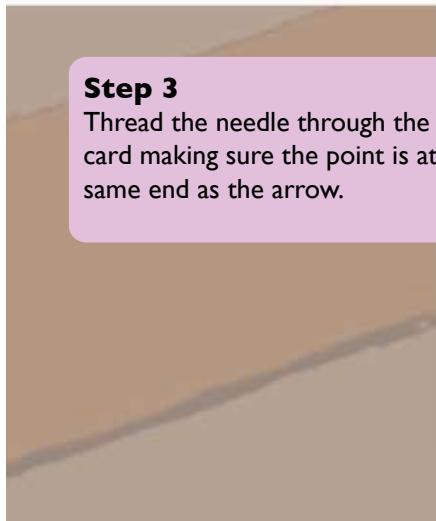
# HOMEMADE COMPASS

You will never be lost again once you know how to make your own compass



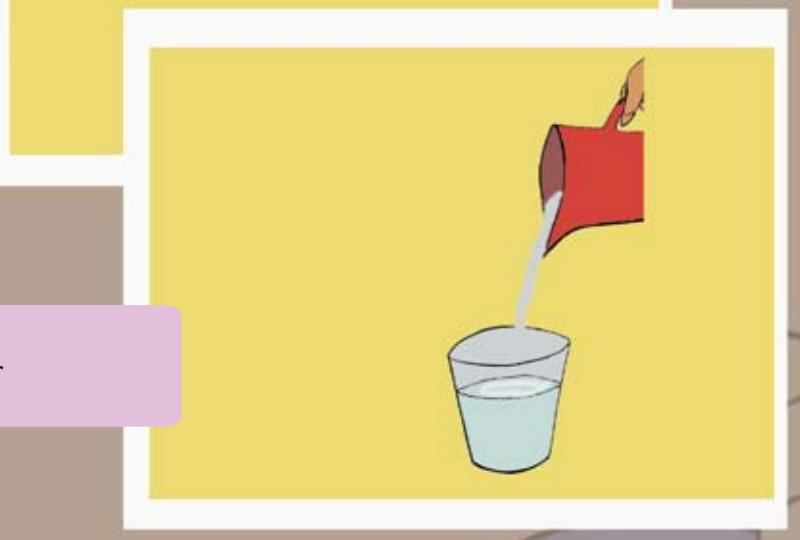
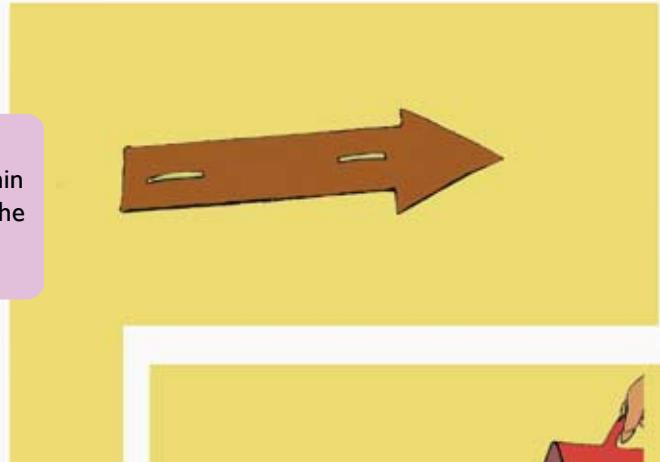
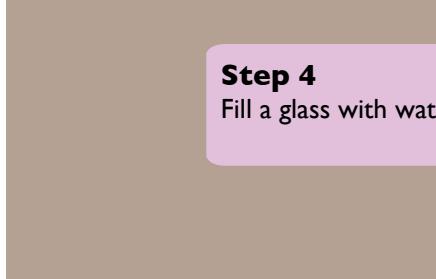
## Step 1

Hold a needle in one hand and stroke the north end of a magnet along its length 50 times from point to eye



## Step 2

Using scissors, cut a piece of thin card in an arrow shape, just a little longer than your needle.



## Step 3

Thread the needle through the thin card making sure the point is at the same end as the arrow.

## Step 4

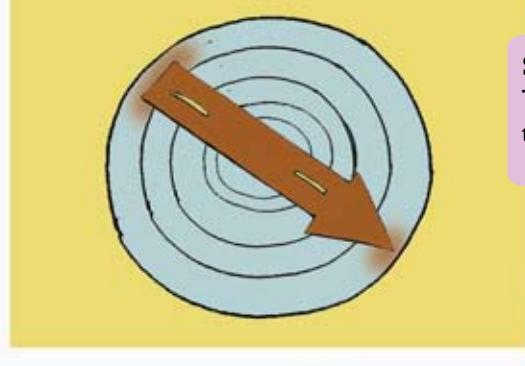
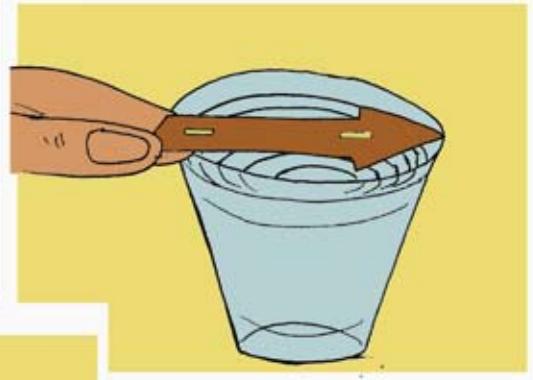
Fill a glass with water

## You will need

- A glass
- water
- A sewing needle (be carefull of the point)
- Thin card
- Scissors
- A pencil
- Coloured markers
- A bar magnet

**Step 5**

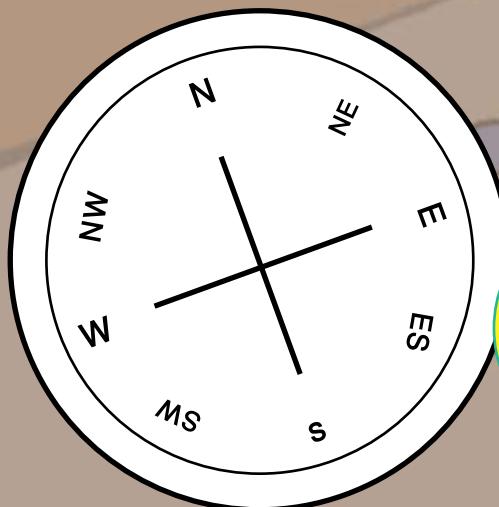
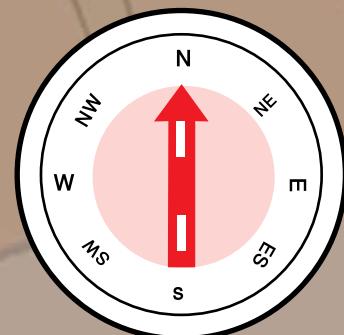
Gently lower the arrow onto the water.

**Step 6**

The arrow should point towards the north

**Step 7**

Now you know which direction is north, write all the other compass points on a piece of card, just a little larger than your glass



Place your  
glass  
on top of  
this card

# JUMPING COIN

Amaze your family and friends by making a coin jump into the air without touching it!

## WARNING!

Ask an adult to help you pour hot water in the bowl.

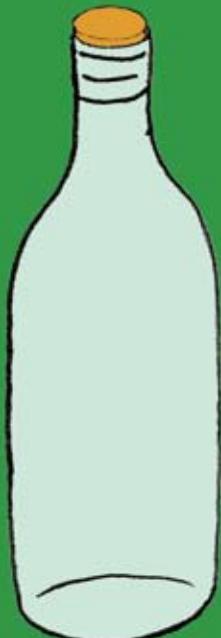


## You will need

- A glass bottle with a narrow neck
- A coin - the right size to fit on the mouth of the bottle
- Hot water
- Ice cubes
- 2 bowls - big enough for the bottle to stand in

## Step 1

Put the empty bottle with the lid off in a bowl and pack ice cubes around it. Allow it to cool for a few minutes. While you are waiting , ask an adult to pour some hot water into the bowl.



## Step 2

Take the cold bottle out of the bowl. Put a coin on the mouth of the bottle

### **Step 3**

Carefully lift the bottle and put it in the bowl of hot water.



### **Step 4**

After a little while , the coin jumps off the bottle!

# How Big are Your Lungs?

Try out this simple experiment to see exactly how much air your lungs can hold.

## You will need

- An empty 2 litre plastic bottle
- A medium-sized bowl
- A big bowl
- A bendy straw
- Water



## Step 1

Fill a bottle with water right to the top.



## Step 2

Screw the cap on

### **Step 3**

Put the smaller bowl in the bigger bowl. Add water to the smaller bowl until it is 3/ 4 full.



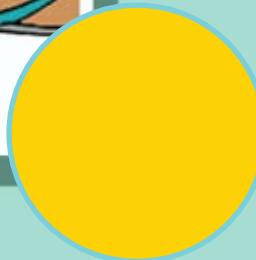
### **Step 4**

Hold the bottle in the bowl with the neck in the water and take off the cap.



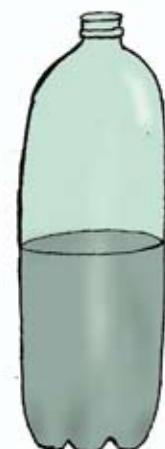
### **Step 5**

Put the end of the straw in the bottle and blow out one big breath!



### **Step 6**

You will be able to see how much air you can store in your lungs! Ask a friend or family member to try the experiment.

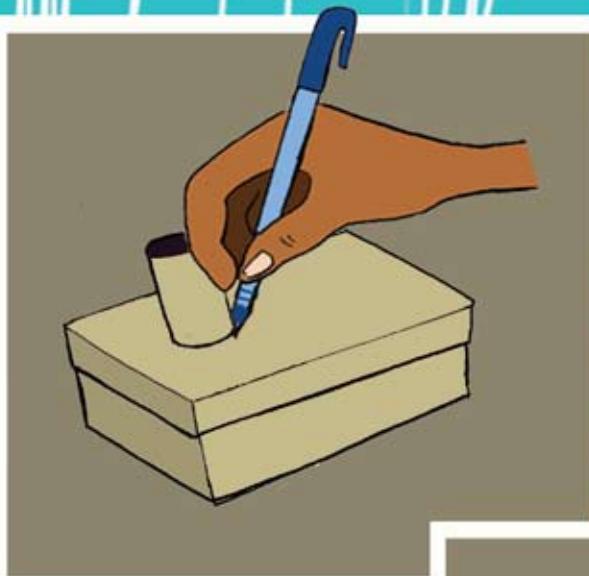


# MOVING STORY: CONVECTION

The way that heat is carried through liquids and gases is called convection. An example of this is a radiator heating up a whole room. We are going to show a convection current in air by using smoke.

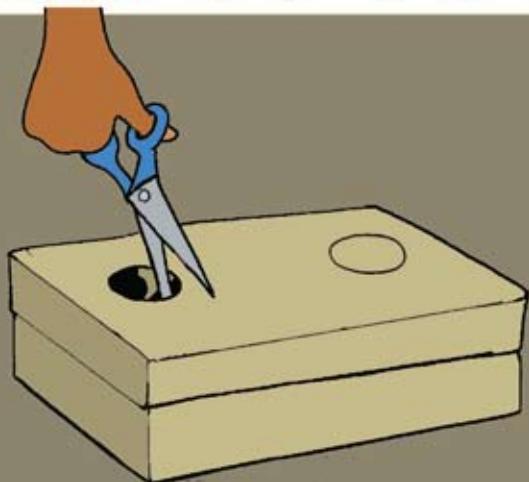
## You will need

- Shoe box with a lid
- 2 kitchen roll tubes
- Night light in a holder
- A lolly stick
- Sticky tape
- Scissors
- Thin card
- Matches
- Thread



### Step 1

Draw two circles on the lid of the shoe box, one towards each end. Draw round the end of the kitchen roll end.

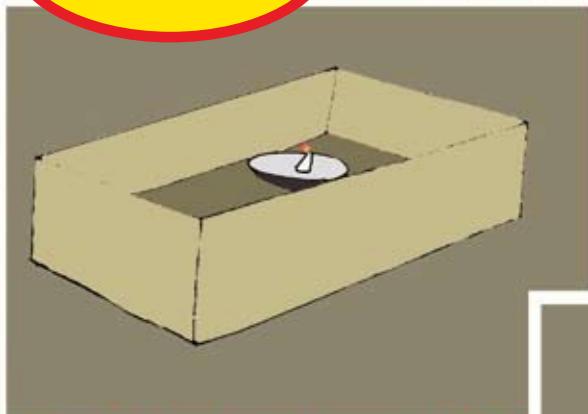


### Step 2

Cut the holes out and stick the tubes in place with sticky tape.

## **WARNING!**

Ask an adult to help you light the candle and lolly stick.

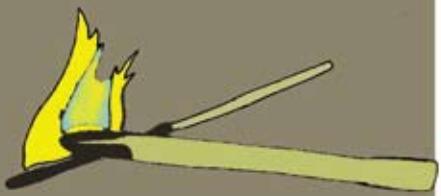


## **Step 3**

Light the night light and put it in the shoebox so that it is under one of the tubes when the lid goes on.

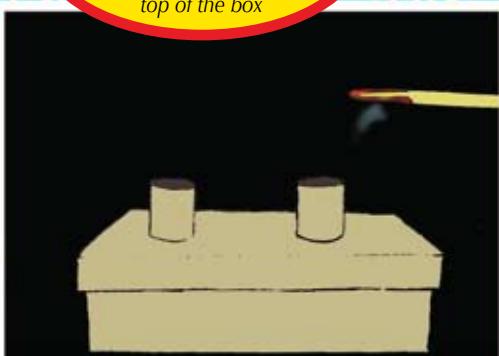
## **Step 4**

Light the end of the lolly stick with a match. (Ask an adult to help.) Then blow the flame out.



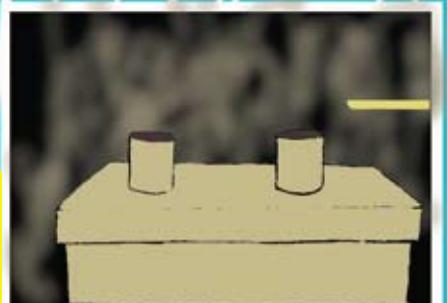
## **WARNING!**

Make sure your candle does not touch the sides or the top of the box



## **Step 5**

Hold the glowing stick over the tube that does not have the night light under it.



## **Step 6**

Smoke goes down the tube and eventually comes out of the other. Make sure you blow out the candle once the experiment is over.

# The Perfect Place for Plants

Have you ever wondered if plants like some kind of soil more than others? By testing with seedlings, we try to find out where they grow best. We are going to see how seedlings develop when planted in different types of growing material.



## You will need

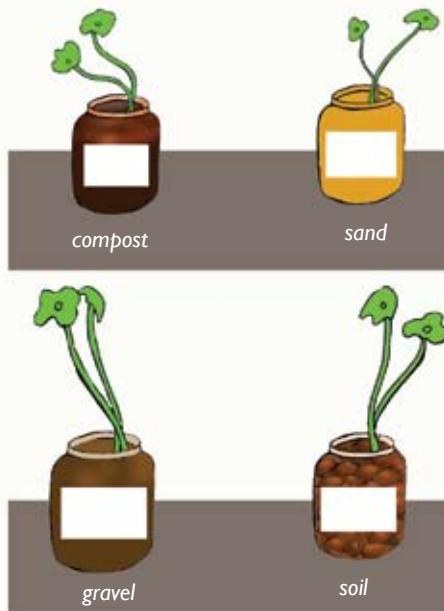
- 4 same-size seedlings
- 4 similar containers
- Compost, sand, gravel, soil
- water
- Labels
- Notebook and pen

### Step 1

Put compost, sand and garden soil into similar sized containers. We have used clean glass jars

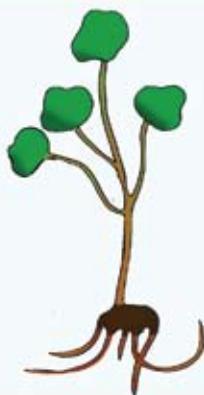
### Step 2

Transplant four seedlings from their pots to the containers. Keep in identical conditions with light and warmth. Give each plant half a cup of water. Label each jar.



### Step 3

After a week you should be able to see clearly which plants are thriving or failing .  
Do you know why?



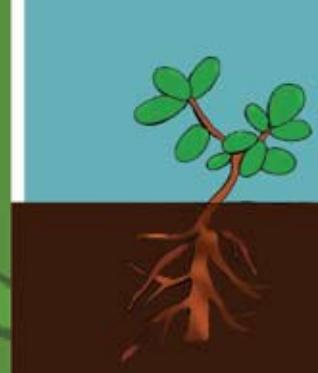
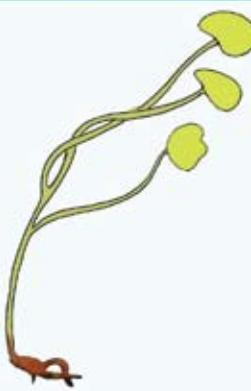
### Step 4

Remove the BEST plant from the jar to check the root structure.

Notice that both the leaves and the roots are developing well.This plant likes the conditions you have provided.

### Step 5

Remove the WORST plant from the jar to check the root structure.  
The plant is week. Notice that both the leaves and the roots are not developing well.This plant does not like the coditions you have provided.

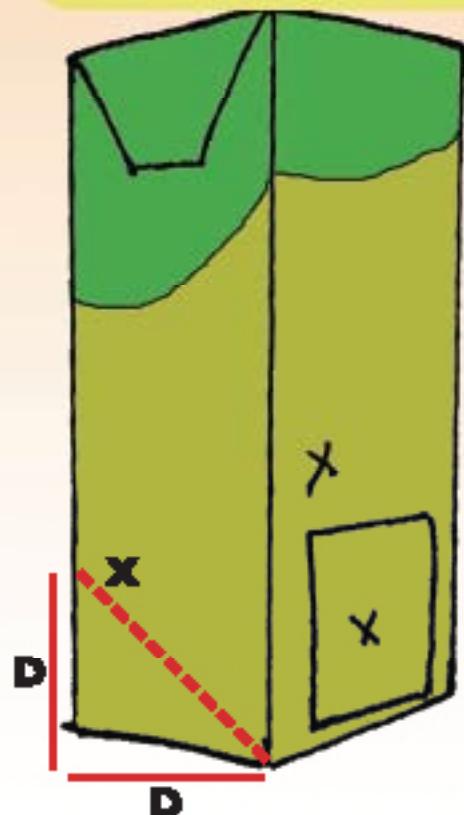


# Seeing Round Corners

The periscope is a device that uses mirrors to let us see round things. It's a good way to see over the heads of crowds! We're going to make a simple periscope.

## Step 1

Remove any plastic spout and seal the box with tape. Measure the depth of the box (D) and mark the same distance up the side.



## You will need

- An empty, clean fruit juice carton
- Universal glue
- 2 plastic mirrors -each about 7x5cm
- A ruler
- Scissors
- Parcel tape
- Marker pen

## Step 2

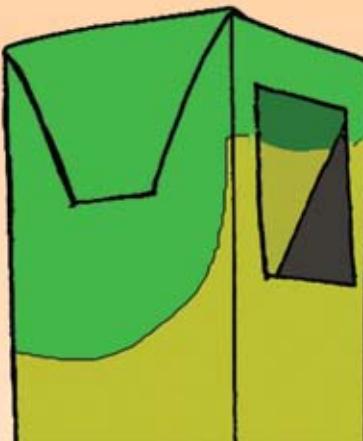
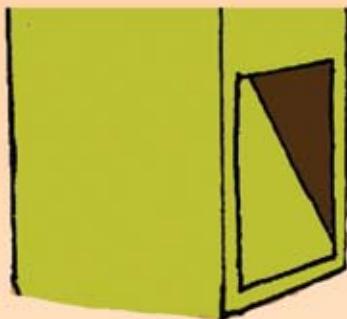
Measuring the diagonal (X). Using the ruler, draw the outline of a square flap on the bottom of the front of the box (black line). Take care to use the same measurement (X) for the height and width of the flap.

### **WARNING!**

Ask an adult to help you cut into the carton.

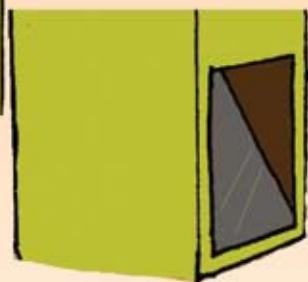
### **Step 3**

Carefully cut three sides of the flap and fold inwards. Use sticky tape to fix the flap at  $45^{\circ}$  slant.



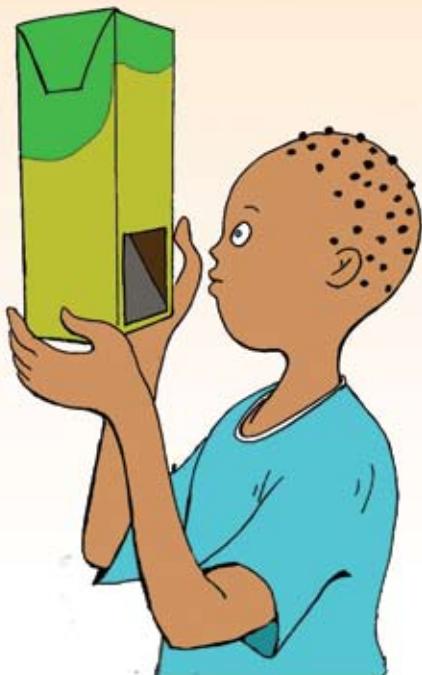
### **Step 4**

Cut a flap at the top of the box on the other side, the same size(X by X) as before. Fix this flap, again at  $45^{\circ}$  slant, with tape.



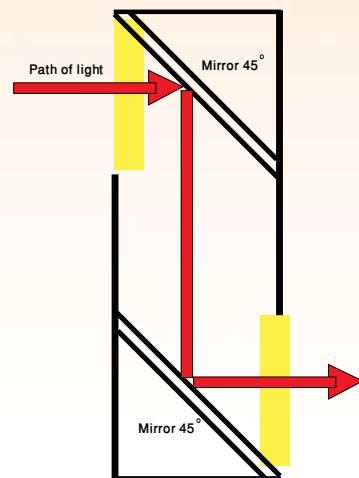
### **Step 5**

Stick one mirror to each flap with some universal glue



### **Step 6**

Now test your periscope

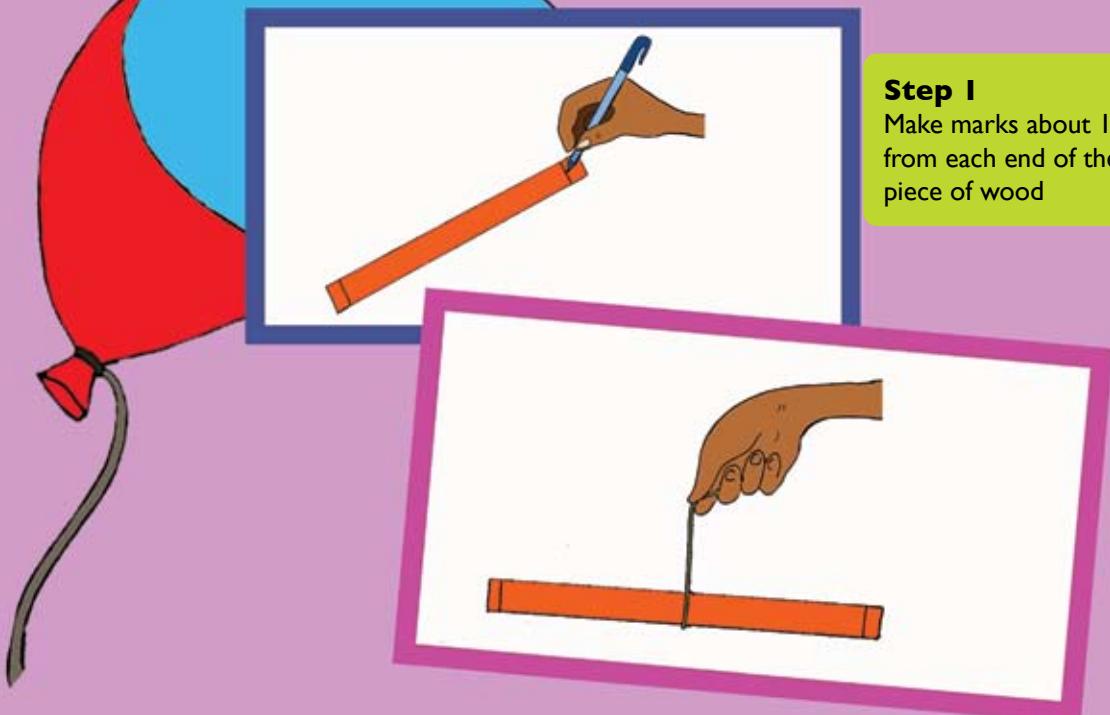


# Does Air Weigh Anything?

Air doesn't weigh anything... or does it? Let us find out.  
What air consists of?  
Gases, Nitrogen, Oxygen, Carbon Dioxide and these are formed of atoms.

## You will need

- 2 balloons
- String
- Scissors
- Thin piece of wood about 60 cm long
- Balloons
- A marker pen

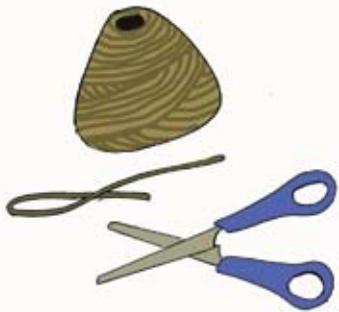


### Step 1

Make marks about 1cm from each end of the piece of wood

### Step 2

Suspend the wood by a piece of string, so that it hangs horizontally. This is our weighing balance.

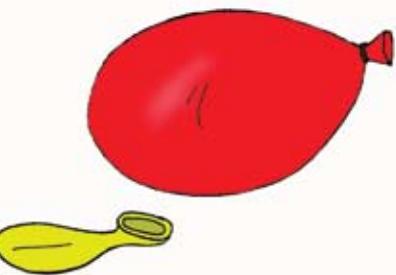
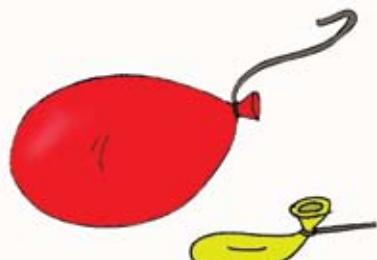


### Step 3

Ask the adult to help you cut two pieces of string the same length - about 15 cm. Make a loop at the end of each piece, just big enough to slip over the wood

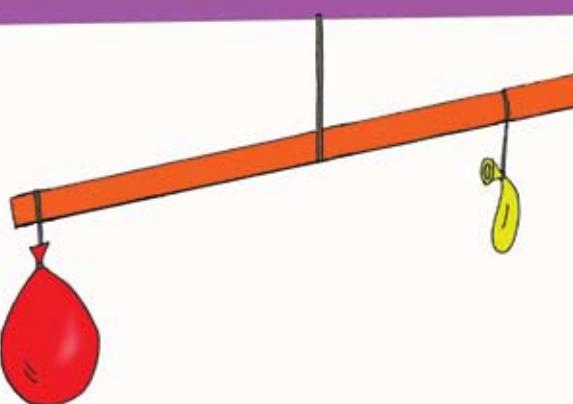
### Step 4

Take two similar balloons.  
Blow them both up, tie off  
the neck of one, but let  
the air out of the other.



### Step 5

Tie each balloon to one of the strings.



### Step 6

Slip the strings onto the stick, exactly  
on the 10mm marks.

# YEAST BALLOON



Yeast is a tiny microorganism that has a massive impact on your life. See the amazing power of yeast by using it to blow up a balloon.

## Step 1

Pour 300 ml of water into a bowl. Add a packet of dry yeast and 2 tablespoons of sugar and stir the mixture until the yeast and sugar have dissolved.



## You will need

- Warm water
- A packet of dry active yeast
- A spoon
- A jug
- Sugar
- A small plastic bottle
- A balloon

## Step 2

Pour the mixture into the bottle.

## Step 3

Warm up the balloon in your hands. To soften the rubber more, grip the ends of the balloon and stretch it.



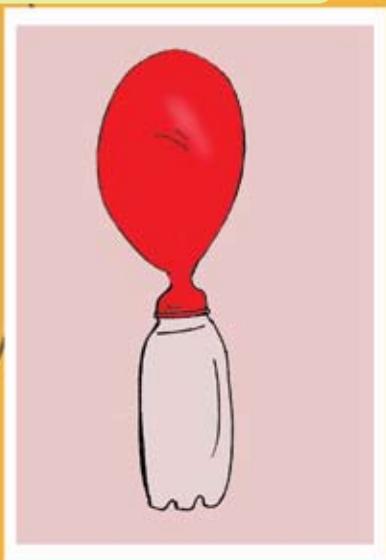
### **Step 4**

Stretch the open end of the balloon over the neck of the bottle. Make sure it is pulled down over the top of the screw threads on the top of the bottle to prevent air from leaking.



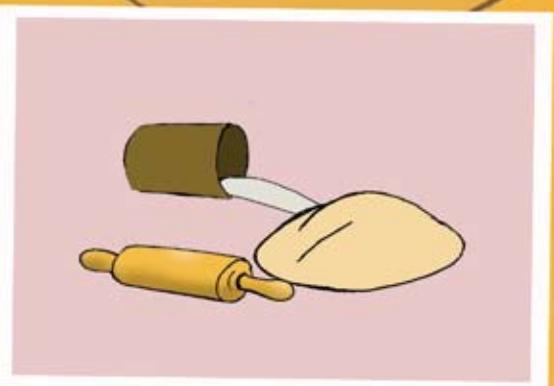
### **Step 5**

Leave the bottle upright with the balloon fitted for one hour, then check the result!



### **Step 6**

Leave the bottle undisturbed overnight.  
In the morning the balloon will be even bigger!



### **How does it work?**

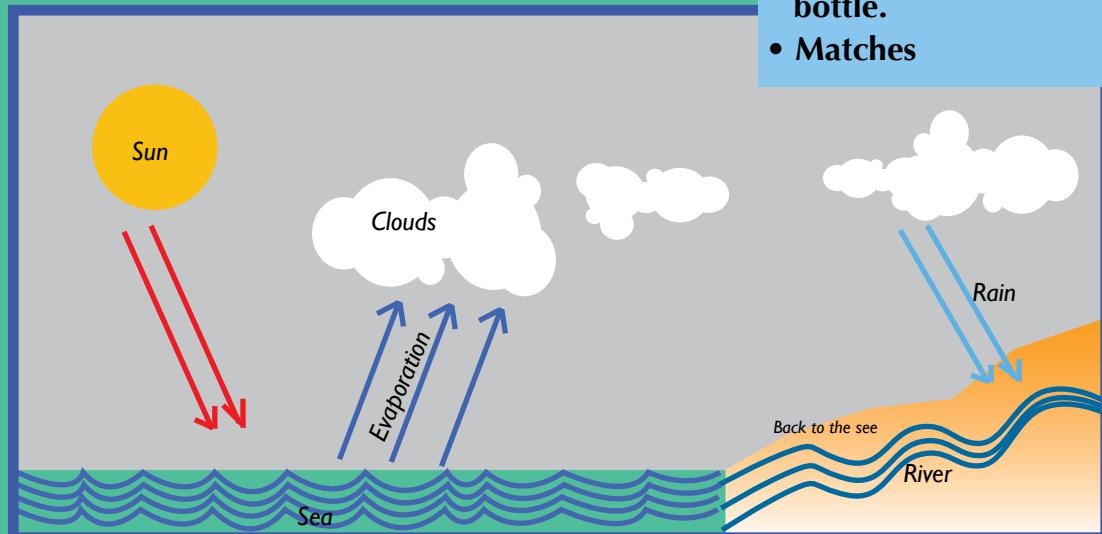
The yeast needs sugar and water to activate it and it begins to respire (breathe). As it does this, it creates the gas carbon dioxide, which is what blows up the balloon. Yeast is what we use to make bread rise, so it is a very important little creature!

# The Water Cycle

Nature has its own water cycling system we call water cycle. We are going to see how water evaporates and condenses. Then we are going to make our clouds.

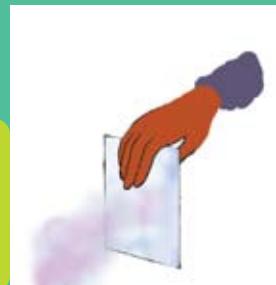
## You will need

- Kettle
- Hand mirror
- Oven gloves
- Clear one-litre plastic bottle
- Matches



### Experiment 1

- Step 1**  
Fill a kettle half full of water and start heating it



### Step 3

You should soon see water droplets on the surface of the mirror



### Step 2

When heating to boil, turn the kettle off, and use the oven gloves to hold the mirror in the steam.

## Experiment 2

### Step 1

Put enough warm water in a bottle to cover the bottom. Light a match and let it burn for a few seconds before blowing it out.



### Step 2

Immediately , hold the match in the neck of the bottle to catch as much smoke as you can.



### Step 3

Quickly put the cap on the bottle so as not loose any smoke.



### Step 5

When you release the bottle, you should see little clouds forming inside.

# INVISIBLE INK

It's easy to send secret messages when you write them in top secret invisible ink! This is a super-cool experiment to try out with friends.

The 'secret' lies in the combination of lemon juice and heat from a light bulb or an iron. Let's try drawing a treasure map first!



## You will need

- A toothpick
- A lemon
- A small knife
- A paper
- A bowl
- Heat source, such as light bulb or iron



### Step 1

Ask an adult to cut a lemon in half for you. Squeeze the lemon juice into a small bowl.

### WARNING!

Ask an adult to help you cut the lemon in half.

### Step 2

The lemon juice is your 'ink'! Dip the round end of a toothpick into the bowl.



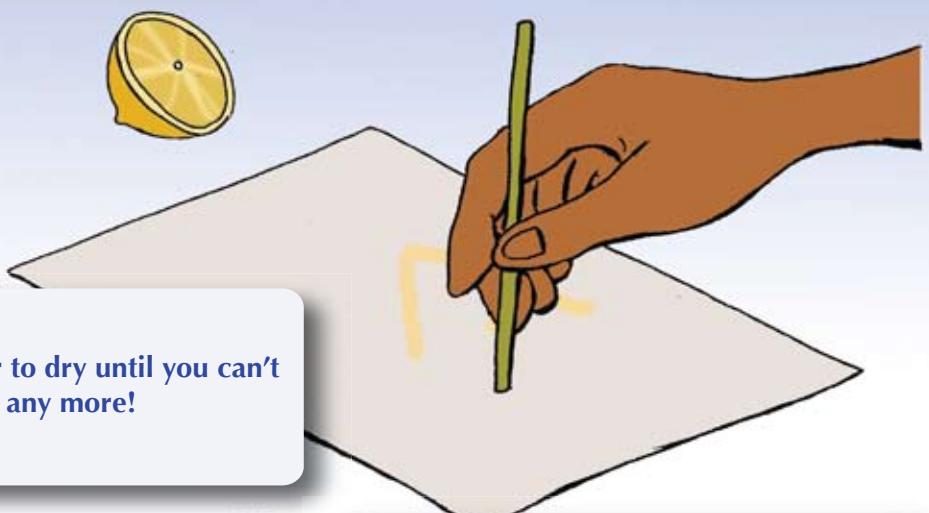
### Step 3

Draw a secret map on some paper.  
Use lots of lemon juice for each part of  
the map you draw.



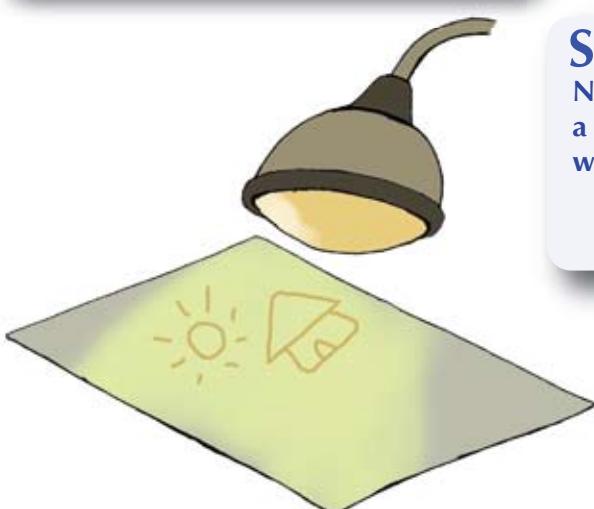
### Step 4

Allow the paper to dry until you can't  
see the drawing any more!



### Step 5

Now move the paper back and forth under  
a heat source. As the lemon juice 'ink' gets  
warm, your secret map is revealed.



### How does it work?

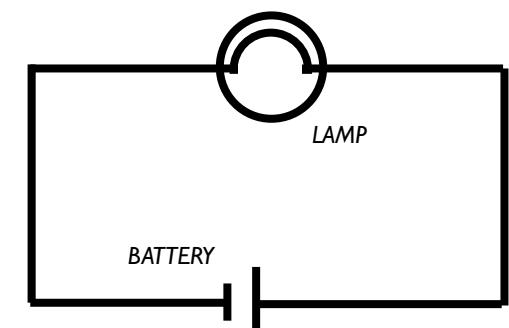
The acid in the lemon juice breaks down  
the cellulose of the paper into sugars.  
The heat source tends to caramelise the  
sugars, making them brown and revealing  
your secret drawing.

# Making a circuit

Electricity is carried in circuit. A circuit is a kind of loop through which electricity flows. We are going to make our own circuit.

## You will need

- Insulated wire
- MES bulb
- Sticky tape
- AA battery
- Board
- Scissors
- Paper clip
- Drawing pin

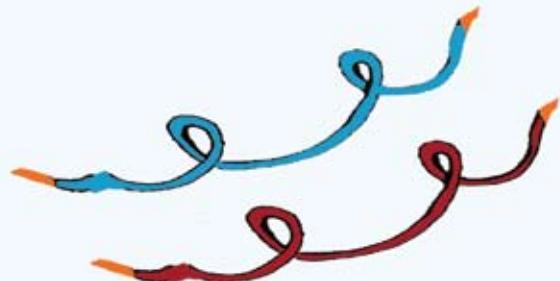


### Step 1

We need a piece of board to build our circuit on. This is a piece of softboard. You could use wood or plywood. Make it about 30x20cm.

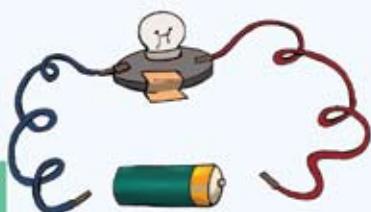
### Step 2

Prepare your wire by stripping the coloured insulation from both ends. You can do this with a pair of scissors, but you will need an adult to help.



### Step 3

We have fixed the lamp to the board with some sticky tape to make things tider.



### Step 4

Fix one end of each wire to the lamp and the other end to the battery using stick tape.



Make a battery holder

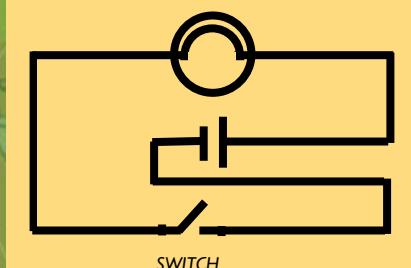
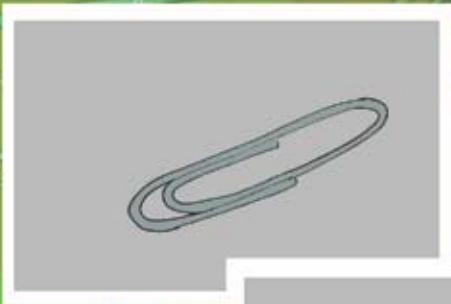


# Switch On!

We have made a circuit that lights lamps but we probably don't want it to be on all the time. Let's make a simple switch to turn the lamp on and off.

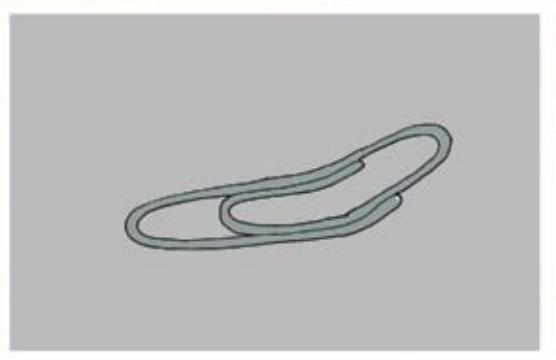
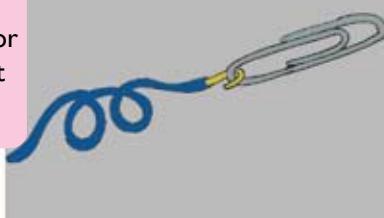
## Step 1

Your paper clip must be made of metal and not painted or coated with plastic.



## Step 2

Test the paper clip as a conductor by the method we used in the last experiment.



## Step 3

Bend the paper clip a little in the middle.

## You will need

- The circuit we made in the previous pages
- 2 drawing pins
- A paper clip

**Step 4**

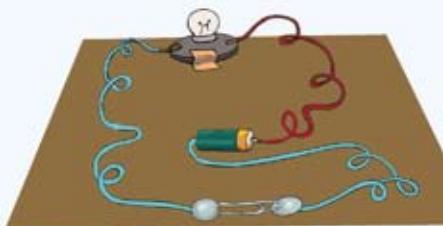
Bend the bare wire end of one of the wires round a drawing pin and press it into the softboard.

**Step 5**

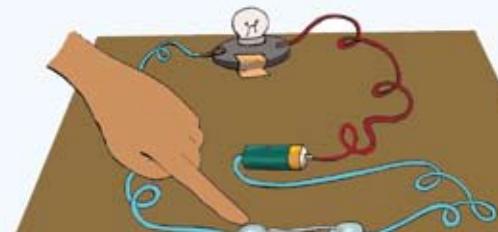
The other drawing pin holds the other wire and the paper clip in place

**Step 6**

Here is the switch in the circuit.

**Step 7**

Press the switch to turn the lamp on!



# BIOGAS

Biogas may be produced from various organic (living) waste. Bacteria produce methane gas that we use in cooking by fermentation of carbohydrates.

You could employ a variety of recycled material e.g empty plastic bottles to perform this simple procedure.

