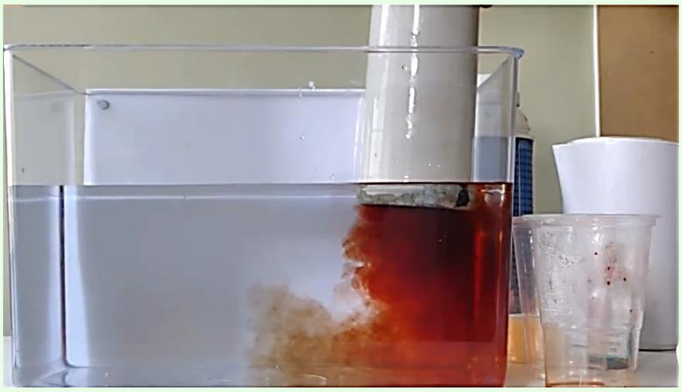
Teaching Earth Science to develop thinking skills: the CASE approach

The CASE Programme

Read out loud the colour you see:

Red

Earth science to develop thinking skills



Earth science to develop thinking skills

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Teaching Earth Science to develop thinking skills: the CASE approach

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Summary

Use Earth science concepts to develop thinking skills using the Cognitive Acceleration through Science Education (CASE) approach. The CASE approach, shown by research to be very effective in developing the thinking skills of pupils, is developed in two classroom contexts, using a tank to teach about the atmosphere and oceans and using a circular bowl and tank for learning about the movement of sand by water currents. All Earthlearningideas, including those used in this workshop, can be found at: http://www.earthlearningidea.com/.

Earthlearningidea workshops

These workshops have been devised for teachers and trainee teachers. They are intended to provide participants with a range of activities that can be used in the classroom and out-of-doors, whilst helping them to develop the skills for using the activities in an engaging and motivating way that will enthuse and educate their pupils, whilst developing their critical thinking skills. The workshops should also develop the background Earth science knowledge and understanding of the teachers involved.

The workshop format may be transposed directly into a classroom or outdoor situation, but often this is not appropriate. Similarly, individual activities, and the worksheets on which these are based, may be transferable directly into a classroom/outdoor situation, but will often require modification for the classes and situations in which they are used, during which suitable risk assessments are undertaken.

Workshop Outcomes

The workshop and its activities provide the following outcomes:

- the development of thinking skills through CASE principles: concrete preparation, construction, cognitive conflict, metacognition and bridging;
- understanding of how fluids are driven by density differences in the atmosphere and oceans;
- understanding of how water currents move sand and form ripples.

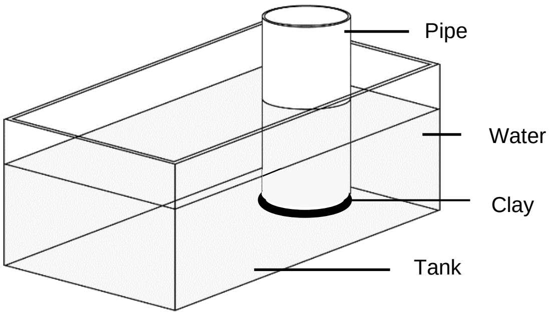
Approach

This booklet comprises a series of full Earthlearningideas taken from the Earthlearningideas website at: https://www.earthlearningidea.com/

High flow, low flow?: atmosphere and ocean in a tank
Hot, cold and particle-filled density currents as they flow in the atmosphere and ocean

Cloud photograph copyright free. Found on: http://yotophoto.com/search?page=10&kw=clouds

The set up
Half fill a transparent container with water (any size container will do – but the bigger the better – a plastic fish tank is ideal). Stand a piece of pipe, or something similar, at one end, as in the diagram.



The demonstration is more effective if a circular ribbon of clay or Blu Tak™ is used as a seal between the pipe and the base of the tank – but this is not essential.

Hot current
Boil water and pour some (e.g. about a quarter of a cupful) into a cup or similar container. Add some dye so that the water can be seen when it is added to the tank. Red-coloured dye is best (since the water is hot), but any dye will do, e.g. food dye, ink, coffee, tea. Pour the dyed water into the pipe, stir the water in the pipe, then still it by stirring in the opposite direction. Then slowly and carefully remove the pipe and observe the effect.

The hot water will rise and then flow across the top, hitting the far side and 'bouncing back'. This hot layer can remain at the surface for some time – perhaps more than an hour.

Cold current
Leaving the hot layer as undisturbed as possible, repeat the demonstration with cold water. Pour cold water from a mixture of ice and water into a separate cup and add dye (e.g. blue – cold).

When the pipe is removed, the cold water sinks and flows along the base of the tank, hitting the far side and bouncing back to form a stable layer at the base of the tank.

Milk current
Again, leaving the layers as undisturbed as possible, repeat the demonstration using milk.

The milk flows in a billowing cloud along the base of the tank, under the cold layer, bounces and forms another stable layer at the base of the tank.

To the real world
If the tank were representing the ocean:
- the hot water would be a warm current, flowing across the ocean surface like the North Atlantic Drift (or Gulf Stream) or like the warm surface waters in the Pacific Ocean during the El Niño effect;
- the cold water would be a cold current, as generated near the poles, that flows down and across the deep ocean floors;
- the milk would be a turbidity current, like the currents of water with sand and mud triggered by earthquakes, that flow down continental slopes and across thousands of km^2 of ocean floors.

If the tank were representing the atmosphere:
- the rising hot 'air' would be a low pressure area, with the hot 'air' flowing across the upper atmosphere;
- the sinking cold 'air' would be a high pressure area, with the cold 'air' flowing across the 'land surface' (base of tank) as 'wind'. As the cold 'air' flows across the foot of the tank, it displaces the warm 'air', like a cold front.
- the milk is like the density currents of solid particles in air produced by avalanches (ice crystals in air), volcanic nuées ardentes (white hot ash in air) or collapsing buildings, such as the Twin Towers of the World Trade Centre (dust in air).

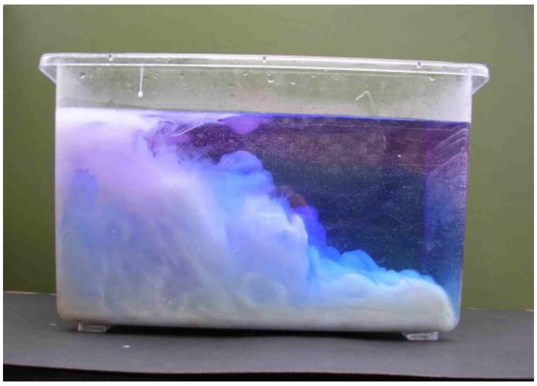
An interactive approach
Pupils become much more involved and watch much more closely if they are asked to predict what will happen before each demonstration. They also learn more effectively that the results are controlled by density, and that the density 'ladder' eventually produced is: milk, most dense; cold dyed water, less dense; clear room-temperature water, even less dense; hot dyed water, least dense.

The back up

Title: High flow, low flow?: atmosphere and ocean in a tank

Subtitle: Hot, cold and particle-filled density currents as they flow in the atmosphere and ocean

Topic: A demonstration of how density currents flow in a tank of water, used as an analogy to the oceans and atmosphere.



The tank in action. (*Peter Kennett).*

Age range of pupils: 10 – 18 years

Time needed to complete activity: 20 mins

Pupil learning outcomes: Pupils can:

- describe and explain what will happen to: a hot body of fluid within cooler fluid; a cold body of water within a warmer fluid; a denser particle-rich fluid within a less dense fluid;
- describe how fluids of different densities can form discrete and separate bodies;
- use the demonstration to explain ocean processes: warm currents; cold currents; turbidity currents;
- use the demonstration to explain atmospheric processes: rising warm air low pressure areas, sinking cold air high pressure areas; wind; cold fronts; avalanches, nuées ardentes and dust density currents.

Context:
This activity can be used to introduce or reinforce understanding of atmospheric and/or ocean processes or, if used interactively, as an effective way of developing thinking skills, as outlined below.

Following up the activity:
Ask what will happen to dyed salty water if added to the apparatus. The salt water may be even denser than the milk, and flow along the bottom. This is why, in estuaries, a layer of fresh water is often found above a wedge of salt water beneath.

Ask what might happen in a pond to hot and cold water at different times of the year, and to muddy water introduced by a stream during a storm.

Ask why ‘heat rises’. What phrase would describe what happens to ‘cold’?

Underlying principles:

- Less dense fluids rise above and ‘float on’ less dense fluids.
- Bodies of fluid retain their integrity for long times, days and weeks in the context of the atmosphere and oceans.
- Much of vertical atmospheric and oceanic circulation is controlled by the different densities of the fluids involved, and much of this is controlled by their relative temperatures.

Thinking skill development:
A ‘pattern’ is constructed of water density and its effects being controlled by temperature; when milk is introduced (of unknown composition and so unknown effect), this causes cognitive conflict, and most think it will flow along the middle or top of the tank. Carefully controlled discussion involves ‘metacognition’ and then ‘bridging’ takes place from the tank to the real world of atmosphere and ocean.

Resource list:

- a transparent container – a plastic or glass fish or reptile tank is ideal, but any container, such as used in food packaging or food storage can be used; rectangular containers are best
- a piece of pipe or plastic tubing or a plastic cup with the base removed
- clay, modelling clay or Blu Tak™ as a seal (optional)
- three containers (e.g. cups, beakers)
- dye (e.g. food dye, ink, coffee or tea)
- boiling water
- ice
- water
- stirring rod

Useful links:
See, for the atmosphere:
https://www.metoffice.gov.uk/weather/learn-about/weather/atmosphere/global-circulation-patterns
and for the oceans:
http://seawifs.gsfc.nasa.gov/OCEAN_PLANET/HTML/oceanography_currents_1.html

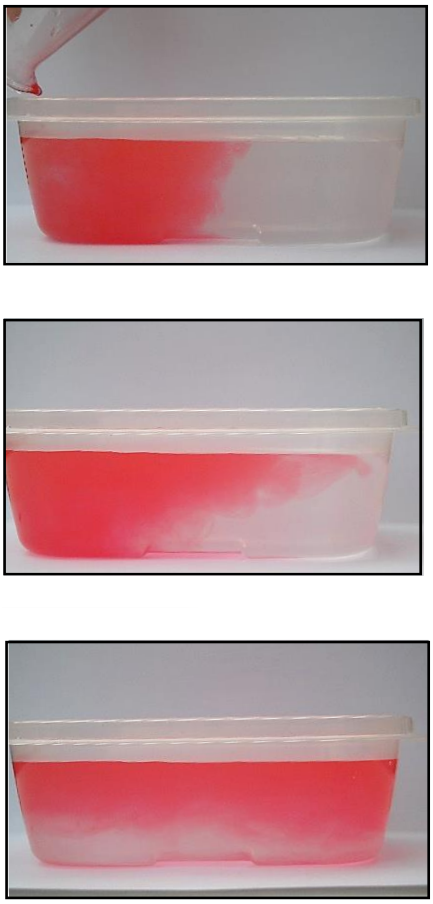
Source:
King, C. & York P. (1995) *‘Atmosphere and ocean in motion’* in *Investigating the Science of the Earth, SoE1: Changes to the atmosphere*. Sheffield: Earth Science Teachers’ Association, GeoSupplies.

Atmosphere and ocean in a lunchbox
A model for all pupils – of hot, cold and cloudy density currents

You can demonstrate hot, cold and cloudy density currents, as in the Earth's atmosphere and oceans by using a tank, as shown in the '*High flow, low flow?: atmosphere and ocean in a tank*', Earthlearningidea …
…. or, you can ask groups of pupils to model these currents for themselves in a lunchbox or small food container

Ask them to fill their lunchbox to near the top with water and then to test their model with:

A hot current
First ask them to predict what will happen when red-coloured hot water is added to the water in their lunch box. Then ask them to collect recently-boiled water from a kettle in their plastic cup. WARNING: burning and scalding danger. They should colour their hot water red, stir it, pour it into one end of their container and watch what happens – the flow will be as seen in the photos below:



Near-boiling water, coloured with washable red paint, added to the left of the lunchbox – flowing along the top from left to right.

- Ask why the current flows along the top and does not mix with the cooler water below.
  A. Hot water (even when mixed with a little red colouring) is less dense than the cooler water below – and so flows along the upper surface.
- Ask where this might occur in the oceans.
  A. The warm Gulf Stream or North Atlantic Drift current flows north east from the Caribbean Sea towards Northern Europe across the surface of the Atlantic Ocean; meanwhile, in the El Niño effect, a warm water current flows across the surface of the southern Pacific Ocean from west to east.

- Ask where this might occur in the atmosphere.
  A. Warm air from the Earth's surface rises in small-scale thermals. When larger bodies of warm air rise, they cause low pressure at the Earth's surface and rise into spinning cyclones; when the air reaches the upper atmosphere it flows outwards.

A cold current
Using what they have learned from the first run, they should predict what will happen when cold water, coloured blue, is added. Ask them to refill their lunchbox with clean water, collect some ice-cold water (without ice cubes), colour it blue, add it to the lunchbox and watch the result.

Iced water, coloured with blue food colouring, added to the left of the lunchbox – flowing along the bottom from left to right.

- Ask why the cold current flows along the bottom. *A. Because it is more dense than the warmer water above.*

- Ask where this might occur in the oceans.
  A. Cold water sinks in polar areas of the oceans and flows across the deep sea floor

before upwelling nearer the Equator; this upwelling brings nutrients to the surface, so these areas are very rich in sea life.

- Ask where this might occur in the atmosphere.
  A. Cold dense air sinks in anticyclones producing high pressure at the Earth's surface. When the cold air reaches the ground, it spills over the ground surface; this air flow is called wind. The 'front' or boundary between the flowing cold water in the model and the warmer water is a cold front.

A current with particles

Using what they have learned, ask what they think will happen when they add a current of milk, in the same way as before. Then ask them to refill their box with clean water and try it, to find out what does happen. *A. Many people think that, because milk contains fat, it will flow along the top.*

Milk added to the left of the lunchbox
– flowing along the bottom from left to right.

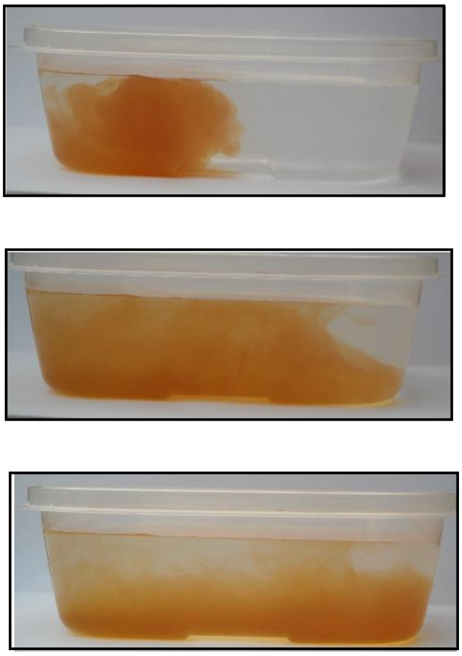
- Ask why the milk flows along the bottom.
  A. Milk is an emulsion of fat and water which is denser than water; this is why it flows along the bottom.

- Ask where this might occur in the ocean.
  A. Sand and mud settle and build up at the top of the continental slope; when an earthquake triggers a slump in the sediment, it flows down the slope in a density current and then out across millions of km^2 of deep ocean floor, depositing sand and mud as it flows; these density flows are called turbidity currents.

- Ask where this might happen in the air.
  A. Currents of air which are denser than normal air, because of the fine particles in them, include:
  - *dust storms;*
  - *ice/snow avalanches of particles of ice/snow in air;*
  - *nuée ardentes, or glowing clouds of ash flowing down the sides of volcanoes during explosive eruptions;*
  - *the cloud of dust from the collapsing Twin Towers of the World Trade Centre;*
  - *the base surge of nuclear explosions.*

Does the colour matter?

Ask what would happen if the water were coloured by different coloured dyes. *A. The colour of the dye makes no difference, it is the density of the current which controls what happens.*



A current of ice-cold water coloured by coffee.

All lunch box photos by Chris King.

The back up

Title: Atmosphere and ocean in a lunchbox.

Subtitle: A model for all pupils – of hot, cold and cloudy density currents.

Topic: The teacher demonstration of density currents in a tank in the '*Atmosphere and ocean in a tank*' Earthlearningidea developed into a smaller-scale model for pupil group use.

Age range of pupils: 14 years upwards

Time needed to complete activity: 20 minutes

Pupil learning outcomes: Pupils can:
- describe and explain what will happen to: a hot body of fluid within cooler fluid; a cold body of fluid within a warmer fluid; a denser particle-rich fluid within a less dense fluid;
- describe how fluids of different densities can form discrete and separate bodies;
- use the demonstration to explain ocean processes: warm currents; cold currents; turbidity currents;
- use the demonstration to explain atmospheric processes: rising warm air low-pressure areas, sinking cold air high-pressure areas; wind; cold fronts; avalanches, nuées ardentes and dust density currents.

Context:
This activity can be used to introduce or reinforce understanding of atmospheric and/or ocean processes or, if used interactively, as an effective way of developing thinking skills, as outlined below.

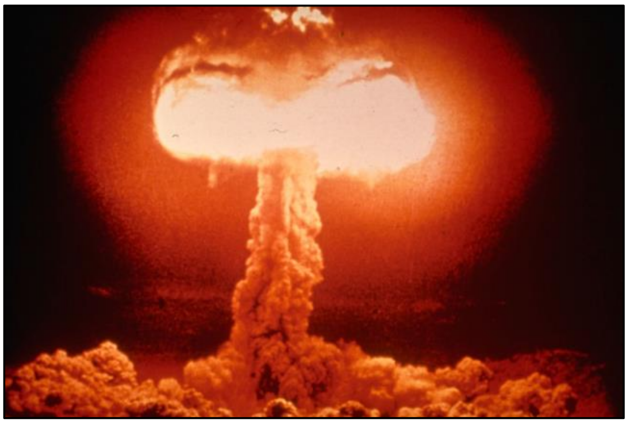
Density currents of fine particles in air are shown in the photos below:

A dust storm in Iraq.

An avalanche.

A nuée ardente flowing down Mayon Volcano.

Dust cloud from the collapse of the World Trade Centre.



The base surge of a nuclear explosion at night.

This image is a work of a Federal Emergency Management Agency employee; all FEMA images are in the public domain.

Following up the activity:
Ask what will happen to dyed salty water if added to the apparatus. The salt water may be even denser than the milk, and flow along the bottom. This is why, in estuaries, a layer of fresh water is often found above a wedge of salt water beneath.

Ask what might happen in a pond to hot and cold water at different times of the year, and to muddy water introduced by a stream during a storm.
A. Pond and lake water can become stratified, with a layer of warm water at the surface or a layer of cold water at depth; muddy water can flow across the bottoms of lakes or ponds as density currents.

Ask why 'heat rises'. What phrase would describe what happens to 'cold'?

Underlying principles:
- Less dense fluids rise above and 'float on' more dense fluids.
- Bodies of fluid retain their integrity for long times, sometimes days and weeks in the context of the atmosphere and oceans.
- Much of vertical atmospheric and oceanic circulation is controlled by the different densities of the fluids involved, and much of this is controlled by their relative temperatures.

Thinking skill development:
A 'pattern' is constructed of water density and its effects being controlled by temperature; when milk is introduced (of unknown composition and so unknown effect), this causes cognitive conflict, and most think it will flow along the middle or top of the tank. Carefully controlled discussion involves 'metacognition' and then 'bridging' takes place from the tank to the real world of atmosphere and ocean.

Resource list:
- transparent food container or lunchbox per group
- 2 plastic cups (one inside the other, for insulation) or beaker per group
- dye e.g. washable paint, food dye or ink (Note that these will stain fingers), coffee or tea
- stirrer, e.g. a pencil
- boiling water, e.g. from a kettle
- ice to make iced water
- milk (any type will do)
- water

Useful links:
See, for the atmosphere:
https://www.metoffice.gov.uk/weather/learn-about/weather/atmosphere/global-circulation-patterns
And for the oceans:
http://www.noaa.gov/resource-collections/ocean-currents

Source: Modified from King C. & York P. (1995) *'Atmosphere and ocean in motion'* in *Investigating the Science of the Earth, SoE1: Changes to the atmosphere*. Sheffield: Earth Science Teachers' Association, GeoSupplies Ltd.

Sand ripple marks in a washbowl
How asymmetrical ripple marks form in sand

Put a mug of water, or large glass of water, into the middle of a washbowl, as shown in the diagram opposite.

Fill the bowl about half full with water. Add a few table-spoonfuls of washed sand as evenly as possible around the washbowl. It is best to use washed sand as otherwise the water will be cloudy and it will be difficult to see what is happening. Wash the sand by rinsing it in water several times and pouring off the cloudy water.

Stir the water around and around the mug, or glass, fairly fast with a tablespoon until the sand grains move into a pattern on the floor of the washbowl. Remember to stir in one direction only and don't let the spoon touch the bottom.

Ask the pupils:
- Why do you think the sand forms these shapes?
- How are the shapes linked to the speed of the water flow and its direction?
- How could we use 'fossilised' ripple marks like these in an ancient sandstone to work out the speed and direction of the water when the sand was laid down?

Creating asymmetrical ripple marks in a circular bowl

Asymmetrical ripple marks in Devonian Old Red Sandstone

Photographs: Peter Kennett

The back up:

Title: Sand ripple marks in a washbowl.

Subtitle: How asymmetrical ripple marks form in sand.

Topic: Ripple marks can indicate the direction of flow of the water. Direction of flow can then be worked out when 'fossil' ripple marks are studied.

Age range of pupils: 10 - 18 years.

Time needed to complete activity: 30 minutes.

Pupil learning outcomes: Pupils can:-
- explain why water flowing in one direction creates asymmetrical ripples marks in sand;
- describe how, when the flow of the water reaches a certain velocity, sand grains are picked up by the water and start to move;
- interpret 'fossil' ripple marks often seen in sandstones as being formed by a uni-directional flow of water, e.g. in a river or the sea;
- explain the direction of flow, which created asymmetrical 'fossil' ripple marks.

Context: The activity could form part of a lesson about looking at sedimentary rocks and their structures to find evidence for how the rocks formed.

- Why do you think the sand forms these shapes? *The water is fast enough to form undulations, then to move sand grains up the shallow backs of ripple marks and deposit them on the steeper fronts - but not too fast to destroy the ripple marks and move all the sand to the middle.*
- How are the shapes linked to the speed of the water flow and its direction? *They only form at certain speeds - too slow, and the water does not have enough energy to move most of the grains, too fast and the ripple marks are destroyed. They form with the shallow slope up-current and the steeper slope down-current.*
- How could we use ''fossilised' ripple marks like those in an ancient sandstone to work out the speed and direction of the water when the sand was laid down? *The ancient ripple marks must have been formed by a current flow of similar speed and direction to those in the washbowl.*

Notes:
- Asymmetrical ripple marks form in water in many places - in rivers, on beaches (as water drains off) and in shallow seas (by tidal currents). They even form in deep seas.
- Asymmetrical ripple marks can be formed by winds in sand dunes too – and give clues to the wind direction in ancient wind-deposited sandstones.

Following up the activity:
Try stirring the water even faster - - -
Try the next Earthlearningidea which is about how symmetrical ripple marks are formed.

Underlying principles:
- Many sedimentary rocks are formed of sediments like gravels, sand and mud which have been weathered and eroded from other rocks.
- These sediments were mostly laid down by rivers and the sea in the geological past.
- These sedimentary rocks contain clues, such as sedimentary structures like asymmetrical ripple marks, about how they were formed.
- The sand that is carried up the shallow slope of the ripple mark is then carried over the top and is deposited by eddies travelling up the front (steep slope) of the ripple mark, depositing sand on this steeper slope.
- The ripple marks migrate downstream by sand being eroded from the upstream side and being deposited on the downstream side.
- Asymmetrical ripple marks form in the washbowl and it can be observed that gradually, they move in the direction of the flow of water. If the velocity of flow is increased by faster stirring, the structures are destroyed.
- Medium sized sand grains of about 0·3mm in diameter are picked up by water flowing at about 0·25 ms^{-1}.
- Most sedimentary rocks are formed from loose sediment which in the past was carried by currents of water. These currents transport vast quantities of previously weathered and eroded material from one place to another.

Thinking skill development:
- How does ripple mark shape indicate flow direction (pattern, construction).
- Explanation of how the ripple marks form i.e. the reasoning behind the answers (metacognition).
- If 'fossil' asymmetric ripple marks are preserved in local rocks with the steeper slope dipping north, which way was the water flowing? (bridging).

Resource list:
- circular washing-up bowl
- mug, or large drinking glass
- washed sand
- tablespoon.

Useful Links:
http://www.geology.pitt.edu/GeoSites/sedstructures.htm
http://www3.interscience.wiley.com:8100/legacy/college/levin/0470000201/chap_tutorial/ch03/chapter03-5sedstr.html

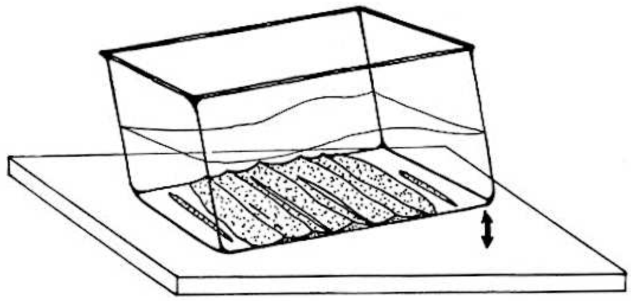
Source: Association of Teachers of Geology (1988) Science of the Earth, Unit 4. *Building Sedimentary Structures - in the Lab and Millions of Years Ago.* Sheffield: Geosupplies.

Sand ripple marks in a tank
How symmetrical ripple marks form in sand

Put some water into a tank or similar, preferably transparent, container, e.g. a cut-off, large drinks bottle, as in the diagram opposite. Add a few table-spoonfuls of washed sand as evenly as possible. Use only half a table-spoonful of washed sand in a drinks bottle. It is essential to use washed sand as otherwise the water becomes cloudy and it will be difficult to see what is happening. Wash the sand by rinsing it several times and pouring off the cloudy water.

Gently lift one side of the container up and down, as illustrated in the diagram opposite, until the sand has formed a pattern on the base of the container.

Ask the pupils:
- Why do you think the sand forms these symmetrical shapes?
- How are the shapes linked to the direction and speed of the water flow?
- How could we use ''fossilised' symmetrical ripple marks, like those in an ancient sandstone, to work out the speed and direction of the water when the sand was laid down?
- What can 'fossilised' symmetrical ripple marks tell us about the ancient coastline?
- What was it like to be there - when the ripple marks were forming?



Symmetrical ripple marks
Drawing: Chris King Photograph: Peter Kennett

The back up:

Title: Sand ripple marks in a tank.

Subtitle: How symmetrical ripple marks form in sand.

Topic: Ripple marks can indicate flow conditions produced by waves. This can then be used to give clues about the environment in which 'fossil' symmetrical ripple marks formed.

Age range of pupils: 10 - 18 years.

Time needed to complete activity: 20 minutes.

Pupil learning outcomes: Pupils can:-
- explain why a two-way (oscillating) current of water creates symmetrical ripple marks in sand;
- describe how, when the flow of the water reaches a certain velocity, sand grains are picked up by the water and start to move;
- interpret 'fossil' symmetrical ripple marks, often seen in sandstones, as being formed by a two-way oscillating current of water e.g. on a beach;
- relate the trend of the 'fossilised' symmetrical ripple marks to wave trend and coast alignment;
- describe a beach/shallow sea environment in which ripples like these probably formed.

Context: The activity could form part of a lesson about looking at sedimentary rocks and their structures to find evidence for how the rocks formed.
- Why do you think the sand forms these symmetrical shapes? *The water is moving fast enough to form undulations. As the water moves in one direction, sand grains are moved up the ripple marks and deposited on the other side. The same process occurs when the water moves in the opposite direction. Symmetrical ripple marks result. These are common on sandy beaches and in shallow seas where waves are active.*
- How are the shapes linked to the direction and speed of the water flow ? *Because a two-way oscillating current is created, the ripple marks are symmetrical in shape.*
  They only form at certain wave speeds - too slow, and the water does not have enough energy to move most of the grains, too fast and the ripple marks are destroyed.

Note: *It is difficult to destroy the ripple marks in the tank without spilling the water!*

- How could we use ''fossilised' symmetrical ripple marks, like those in an ancient sandstone, to work out the speed and direction of the water when the sand was laid down? *The ancient ripple marks must have been formed by a two-way oscillating flow of water of similar speed to that produced in the tank.*
- What can 'fossilised' symmetrical ripple marks tell us about the ancient coastline? *The trend (particular direction) of the 'fossilised' symmetrical ripple marks indicates wave trend and therefore coast alignment. For example, if the majority of 'fossilised' symmetrical ripple marks were east - west, you would know that they were made by waves that were either coming from the north or from the south and that the coastline was also east - west. You would need further evidence to say definitely whether the sea or lake was to the north or to the south.*
- What was it like to be there - when the ripple marks were forming? *The pupils should describe a sandy beach or shallow sea area. The beach could be yellow (if the sand came from eroded rocks), white (if of tropical coral sand), black (if of volcanic sand) or a mixture.*

Following up the activity: Try the 'What was it like to be there - rock?' activity with symmetrical ripple marks or other structures.

Underlying principles:
- Many sedimentary rocks are formed of sediments like gravels, sand and mud which have been weathered and eroded from other rocks.
- These sediments were mostly laid down by rivers and the sea in the geological past.
- Other sedimentary rocks that form in tropical areas are made of calcium carbonate (lime) sediments.
- These sedimentary rocks contain clues, such as sedimentary structures like symmetrical ripple marks, about how they were formed.
- The sand grains are carried up one slope of the ripple mark, carried over the top and deposited. Almost immediately, they are picked up by the flow of water from the other direction, carried up the slope and deposited on the other side. As this process continues, a symmetrically shaped ripple mark is created.
- If the velocity of two-way flow is increased by faster movement of the tank, the structures are destroyed.
- Medium sized sand grains of about 0·3mm in diameter are picked up by water flowing at about 0·25 ms^{-1}.
- Most sedimentary rocks are formed from loose sediment which in the past was carried by currents of water. These currents transport vast quantities of previously weathered and eroded material and/or carbonate sediments from one place to another.

Thinking skill development:
- Ripple mark shape indicates flow character, (pattern, construction).
- Ripple mark trend indicates wave trend and coast alignment, (cognitive conflict)
- Explanation of how the symmetrical ripple marks form i.e. the reasoning behind the answers, (metacognition).
- 'Fossil' symmetric ripple marks give clues about the environment in which they formed, (bridging).

Resource list:
- tank or container e.g. large cut-off drinks bottle
- washed sand
- water.

Useful Links:
http://www.geology.pitt.edu/GeoSites/sedstructures.htm
http://www3.interscience.wiley.com:8100/legacy/college/levin/0470000201/chap_tutorial/ch03/chapter03-5sedstr.html

Source: Association of Teachers of Geology (1988) Science of the Earth, Unit 4. *Building Sedimentary Structures - in the Lab and Millions of Years Ago.* Sheffield: Geosupplies.

Symmetrical ripple marks in a drinks container
Photograph: Elizabeth Devon