Banana benders
Using a banana to simulate geological structures

Rocks can be folded into many shapes and can be broken by faulting. These fold and fault structures can be seen in mountain ranges, cliffs and even in small hand specimens. Try using bananas to see how these structures may be formed.

Give each pair or group of pupils one banana.

Ask the pupils to:-
- Peel the banana, hold both ends firmly and then slowly push their hands together along the length of the banana until the banana begins to be squashed (deformed). *Note:* it is important that they push their hands together. It requires considerable horizontal force at first.
- Draw or photograph the structures as they form. Add as many labels as you can to your drawings /photos from the following diagrams.

Try to label the following;-
- fold, fold axial plane trace, fold limb, maximum angle achieved before breaking occurs. Is this an upfold (anticline) or a downfold (syncline), a symmetrical or an asymmetrical fold?
- tension crack(s), area of deformation
- faults, fault plane, heave (horizontal displacement), throw (vertical displacement). Are these normal or reverse faults? Which is the upthrow side?

- Try to compare the structures with natural ones in real rocks and think about the conditions needed to produce them. Compression, tension or shear forces could be involved.
- Eat the banana!

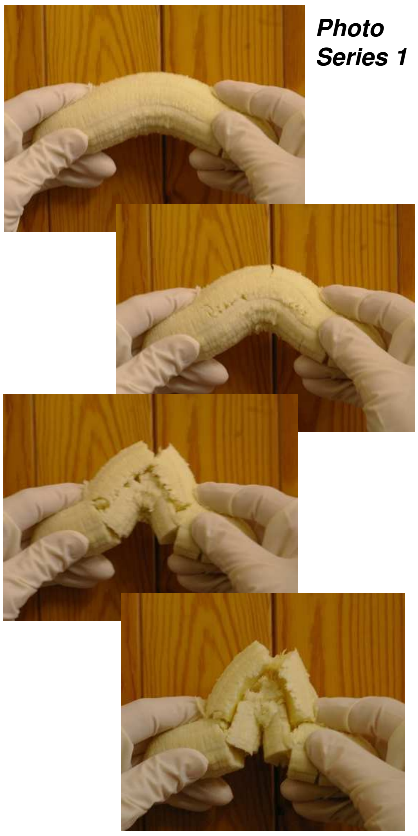


Photo Series 1

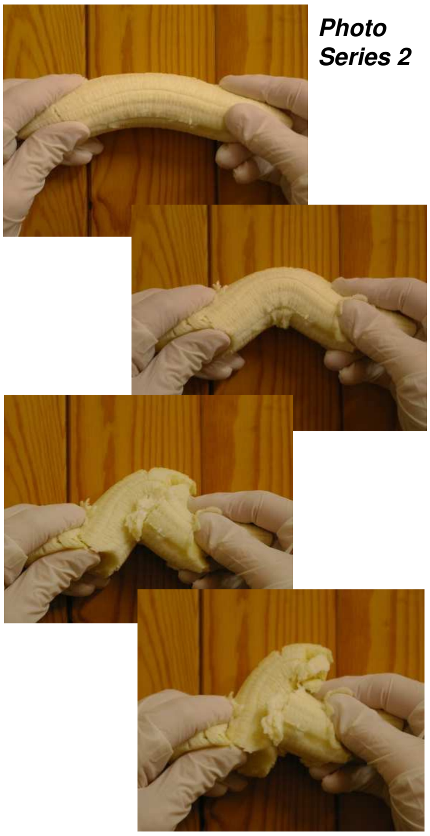
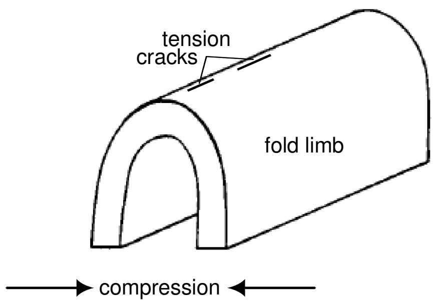
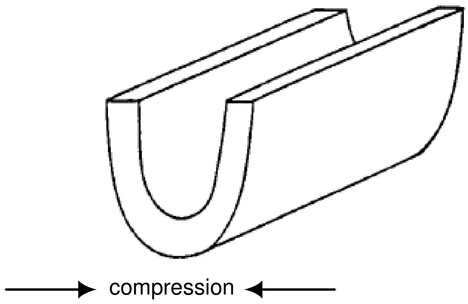
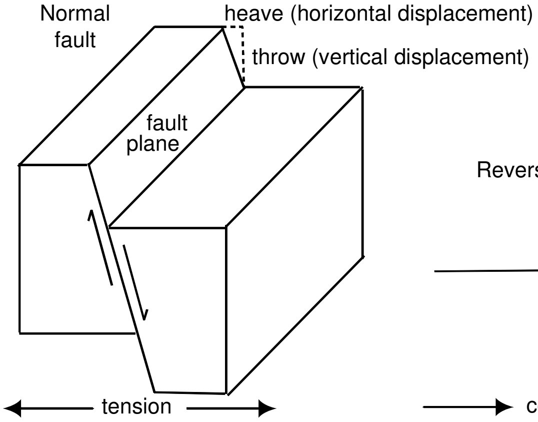
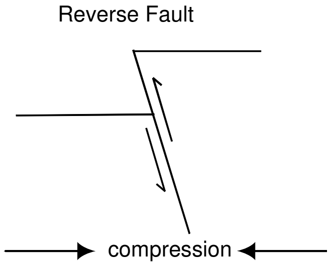


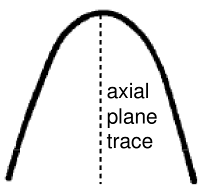
Photo Series 2



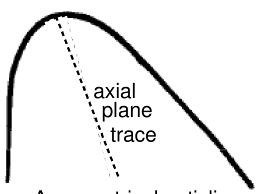








Symmetrical anticline (fold limbs equal length)



Asymmetrical anticline (one fold limb longer than the other)

The back up:

Title: Banana benders

Subtitle: Simulating geological structures by bending and breaking bananas

Topic: This simulation could be used in any lesson where deformation of rocks is being discussed, whether small-scale, in a hand specimen or rock exposure, or large-scale as in mountain building.

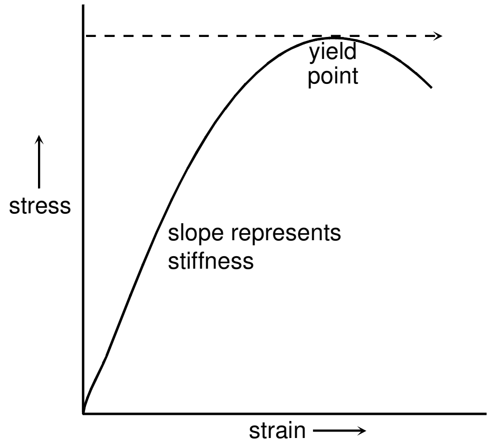
Age range of pupils: 8 - 80 years

Time needed to complete activity: 30 minutes

Pupil learning outcomes: Pupils can:-
- see a range of structures being produced by compressive deformation;
- produce, describe, analyse and report on these types of structures;
- apply the correct labels to drawings/photos of these structures;
- appreciate that the banana is a model for a much larger system and different materials;
- realise that in order for rocks to be folded they must have been at higher temperatures and pressures than are experienced at the surface;
- appreciate that the banana is in unconfined conditions whereas rocks will be confined by the rock mass above and around them;
- appreciate that the banana is representing only one rock layer. When layers of different rocks are folded and faulted, each layer can behave differently. Some are weaker (incompetent) than others (competent) and are deformed more readily;
- realise that the deformation rate shown by the banana is extremely fast compared with the rate of rock deformation. However, faults can occur very quickly, often resulting in devastating earthquakes.

Context
Bananas are commonly available, linear bars of material which deform readily and repeatedly to produce a whole series of natural fold and fault structures. They can be deformed at room temperature and will yield varying responses depending upon age and ripeness, but consistent results will be obtained.

Compression is applied to the banana along its length, resulting in bending due to the natural curvature of the fruit. Geologists and engineers use similar experiments to test the strength and resilience of rocks and of components used in building and construction, made of materials such as steel or timber. The theory of how components respond to combined compression and bending was formulated towards the end of the 19th century by Euler, (refer to diagram opposite). Euler showed that the limiting stress in components which buckle depends on the stiffness (slope of the stress/strain curve) of the material, not its compressive strength (stress at the yield point). Before failure the deformed shape is half a sine wave.



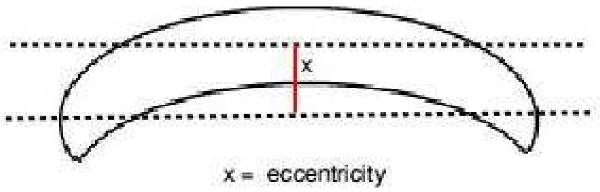
Note: The diagrams of simple fold structures assume that the beds have not been overturned. In such cases, an upfold is a true anticline and a downfold a true syncline. Strictly speaking the terms antiform and synform should be used, until it can be established that the beds are the right way up. The best definition of an anticline is a fold where the oldest rock crops out in the core of the fold: in the case of a syncline, the youngest rock crops out in the core of the fold.

Results shown by the sequence of photos in series 1 and 2
- At first, the banana resists the force applied along its length.
- As the force increases, the banana begins to bend. At this stage, the banana is simulating an antiform (upfold). The curvature increases rapidly. Soon, tension cracks appear at the top of the fold. Depending on the ripeness of the banana, two or more tension cracks may appear.
- Nearly simultaneously, the material starts to crumple on the inside of the curve and a knee-shaped bend or kink zone occurs.
- As the compressive force continues, faulting occurs and pieces of the banana move upwards on fault planes, (on either side in photo series 1 and on just one side in photo series 2).
- It is possible to see tiny arc-shaped radial faults just above the maximum bend.

Following up the activity
The pupils could repeat the activity with bananas at different stages of maturity to see if the results are predictable.
Using the internet, they could find images of folds and faults and describe how they were formed using their banana activity as an analogue.

Underlying principles:
- Materials behave in a predictable way under compression.

- The compressive force results in a uniform compressive stress over the whole cross-section of the body being compressed.
- Because bananas are naturally curved the compressive force creates a bending effect (moment) equal to the applied force multiplied by the eccentricity of the banana. (Eccentricity is the distance between the centre lines at the ends and the centre of the banana.)



- This bending effect causes an additional compressive stress on the inside of the curve and an equal and opposite tensile stress on the outside.
- As the force is increased, the eccentricity also increases and thus the stresses due to bending increase faster that the increase in the applied force.
- When, at the outside of a curve, the tensile stress due to bending exceeds the compressive stress due to axial compressive force, tension cracks appear on the outside of the curve.
- When, at the inside of the curve, the compressive stress due to bending and that due to axial compressive force together exceed the compressive strength of the material, the material fails (fractures) along one or more planes of principal (maximum) stress.
- Compressive failure of rocks in large structures (such as mountains) can be modelled fairly accurately on a small-scale using ‘Banana benders’.

Thinking skill development
Repeatable and similar patterns emerge as the various structures develop. Cognitive conflict is caused when it is realised that rocks, in order to be folded, must have once been at high temperatures and pressures. Discussion of what is happening involves metacognition. Relating the structures seen in the banana to folded and faulted rocks seen in mountain-building and in small hand specimens requires bridging skills.

Resource list:
- bananas
- disposable gloves (optional)
- photos of folds and faults (optional)
- specimens demonstrating small scale structures (optional).

Useful links:
To put this activity into context, try ELI ‘Plate tectonics through the window’ and ‘Continents in collision’. Related ELIs include ‘Margarine mountain-building’ and ‘Himalayas in 30 seconds’.

Source:
Adapted by Elizabeth and Martin Devon from an idea by Patrick James and Ian Clark, School of Natural and Built Environments, University of South Australia.
All photos and diagrams: Martin and Elizabeth Devon