THE STRUCTURE OF THE EARTH

The Earth is made up of several layers:

1. At the Earth’s centre, 6378 km below the surface, is a solid inner core of iron and nickel which is 1278 km thick. The inner core has a temperature of 4500°C.

2. Around this is the outer core, which is 2200 km thick, and consists of liquid iron and nickel.

3. The next layer is the mantle, which is semi-liquid and is 2900 km thick. The mantle is made up of two parts, an upper mantle, and a lower mantle which lies below it. The temperature of these layers is around 1200°C.
4. On top of the mantle is the crust, which is solid and is up to 50 km thick. The upper mantle and crust are referred to as the ‘lithosphere’. The Earth’s crust is made of several distinct tectonic plates, also called lithospheric plates. These plates float on the semi-liquid mantle. The landmasses that lie on top of the plates move as the tectonic plates move. This is called continental drift.

![Diagram of tectonic plates](image)

(a) Major plates

5. From the diagram above you can see that some of the tectonic plates are larger than some continents. These plates move at rates of several centimeters per year, in response to heat convection in the mantle.

The motions between rock masses are generally termed ‘tensional’ (pulling apart), ‘compressional’ (squeezing together), or ‘shear’ (parallel sliding). Factors such as magnitude and direction of the force, temperature and pressure on the rock, composition of the rock, as well as the rate at which the rock is deformed, determines how the rock changes in length, shape or volume.

6. Major geological events, such as earthquakes, volcanic eruptions and mountain building, result from the movement of these lithospheric plates. The crust, made up mainly of sedimentary and granitic rock, is relatively thick under the continents. The oceanic crust, found under the oceans is approximately 7km thinner than it is under the continents. The oceanic crust is made up mainly of basalt rocks, which form when molten magma from deep within the Earth’s mantle reaches the surface as a volcanic eruption.

Landforms, which form as a result of tectonic processes, include mountain ranges, rift valleys, ridges, faults, fractured rock, and folded rock masses. In the oceans, mid-oceanic ridges and deep ocean trenches may form.
Flat land becomes mountains and valleys when portions of the land are uplifted. Varying forces within the Earth’s crust can cause this uplift. Forces pushing toward each other can make the rock fold or fault (break and move). Fault-block landforms (mountains, hills, ridges, etc.) may form when large areas of bedrock are widely broken up by faults. In geology, the term ‘fault’ or ‘fault line’ refers to a fracture in a rock, in which the rock on one side of the fracture has moved position relative to the rock on the other side, creating large vertical or lateral displacements of the continental crust.

Volcanic action can also form mountains. Molten rock, called magma, erupts from the Earth’s surface as flowing lava, cinders, or ash, to form volcanic mountains or cones. Melted rock that pushes up the layered rock, but does not erupt, cools into igneous rock beneath the surface, forming dome-shaped mountains. Erosion of the land surface over millions of years may result in the exposure of these igneous rocks. Tectonic features have been observed on all the terrestrial planets, the Moon, and the icy satellites of the outer planets.

**Activity 1: Practical investigation (Group work)**

**Aim:** To investigate how and why rock layers are folded and faulted by creating folded mountains.

**Materials:**
1. Smocks to protect clothing.
2. Wooden blocks.
3. A knife to cut the play dough.
4. Four colours of play dough to represent four different rock layers.
   To make play dough: Mix 6 cups flour, 2 cups salt, 4 tablespoons oil and approximately 2 cups water together. Divide the mixture into four and add four different food colours e.g. green, red, yellow and blue.

**Method & observations**
1. Layer the four colours (yellow, blue, green and red) of play dough to represent a horizontally layered rock mass. The bottom layer represents the oldest layer.
2. Use small wooden blocks (similar to blackboard duster) to push on the layered play dough from two opposite sides.
3. Once you have applied the compressive stress, what happens to the dough?
4. Cut off the top, and draw a map of the surface that they see, and note which layers are where and label them from oldest to youngest.
5. Make a vertical cut through the play dough to represent a fault.
6. Now slide the two halves of the play dough block horizontally in opposite directions. What movement does this represent?
7. Join the two halves together and draw a ‘cross section’ of the different layers. Label them from oldest to youngest.
250 million years ago, all the continents were connected into one super-continent called Pangaea. Pangaea separated into two supercontinents, known as Laurasia and Gondwana.

As early as 1596, the Dutch map maker Abraham Ortelius suggested that the Americas, Eurasia and Africa were once joined and have since drifted apart “by earthquakes and floods”. His “evidence” was the jigsaw fit of the continents. This fit is especially close when the continental shelves of the continents are considered.

About 165 million years ago, the great southern landmass called Gondwana, split up to form some of the continents we know today. As each landmass moved away from the others, populations of plants and animals were carried along with them.

Over time, these populations adapted to local environmental conditions and many new species developed. These different species shared many similarities as they had all evolved from their common ancestor which had inhabited Gondwana. There are many examples of plant and animal fossils of the same species and age, but which are found on different continents, to provide proof for the continental drift theory.

Questions:

1. Name the land masses that made up Gondwana.

2. Research one example of evidence that the continents were once joined together in the great southern landmass called Gondwana. Use the library and/or the Internet to get information, e.g find species (plant or animal) which are common to different continents.

3. How would different plant and animal species be affected as a result of continental drift? Discuss how they would adapt to these changes, and how populations which were once together, might evolve and follow different evolutionary pathways. Give an example of a group of animal or plant which is unique to a particular continent, and if possible explain how this has come about.
Teacher notes

Activity 1:
1. Practical investigation - assess with rubric.

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<thead>
<tr>
<th>RUBRIC 2 - PRACTICAL INVESTIGATION</th>
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<tr>
<td><strong>Assessment Criteria</strong></td>
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<tr>
<td>2A - &quot;ON THE SPOT&quot;</td>
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<td>Ability to follow instructions</td>
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<td>RUBRIC 2B - GUIDED EXPERIMENTAL INVESTIGATION</td>
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<td>(Experiment is given to the learner with guidelines in a handout)</td>
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<td>Organisation - work through procedure in orderly manner</td>
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<td>Ability to use apparatus or equipment</td>
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<td>Result / Final product</td>
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<td>Responses to questions based on experimental work</td>
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<td><strong>Total = 15 marks</strong></td>
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Activity 2: Research
1. Gondwanaland is made up of South America, Africa, Antarctica, Australia, part of India, and part of Arabia.
2. Learners own answer.

Plants:
Africa and India where the first to break away from Gondwana, some 125 million years ago. Consequently, the present flora of Africa and India have fewer remnants of the Gondwanan flora than those continents that remained connected for a longer period such as South America and Australia. Nonetheless, there are some similarities among the older plant families such as the Proteoaceae.
Plants that reveal a common history with the Gondwanan supercontinent, often called the Antarctic flora, include conifers in the families Podocarpaceae, Araucariaceae and the subfamily Callitroideae of Upressaceae, and angiosperms such as the families Proteaceae, Griseliniaeae, Cunoniaceae and Winteraceae, and genera like southern beech (Nothofagus) and fuchsia (Fuchsia). Many other families of flowering plants and ferns, including the tree fern Dicksonia, are characteristic of the Antarctic flora.

Fossil evidence suggests that temperate rainforest was widespread in Australia, Antarctica, South America and New Zealand around 45 million years ago. Such fossils and the surviving species in Tasmania provide evidence of the ancient link to Gondwana.

**Animals:**
There are numerous examples of animals in Tasmania that have their closest relatives living today in land masses that were once part of the Gondwanan supercontinent.

The Mountain Shrimp, *Anaspides spp.*
The invertebrates provide abundant evidence of Gondwanan ancestry. Possibly the best known example is the mountain shrimp (*Anaspides tasmaniae*) which is very similar to Triassic (230 million year old) fossils. Currently, its closest relatives are found in New Zealand and South America.

The Tasmanian cave spider is considered to be one of the most primitive spiders in the world, and is the only member of its family outside Chile.

Another fascinating discovery in recent time was the vertebrate and invertebrate marine fauna of the Port Davey/Bathurst Harbour area in Southwest Tasmania, which are also considered Gondwanan relics. One of these animals, the Port Davey skate, is unique, as it is the worlds only brackish water skate. Its closest relatives are found in New Zealand and Patagonia.

Platypus and Echidnas evolved from ancient ancestors which inhabited Gondwana. Close relatives of marsupials thrive in South America and fossil platypus have also been discovered in South America.

Other vertebrates with strong Gondwanan affinities include the parrots, the two families of frogs within Tasmania (Myobatrachidae and Hylidae) and the major family of freshwater fish which occurs in Tasmania, the Galaxiidae.
3. A population of a particular species may become geographically isolated from the parent population due to events such as climatic change, the formation of a physical barrier (such as a mountain range or river), or the invasion of a new habitat or island by the off-shoot population. The isolated populations may over time evolve characteristics different from the parent population (due to genetic isolation) and therefore will eventually differ genetically as a result of following a different evolutionary pathway over time. The separated populations will continue to evolve independently, and eventually may become so differentiated that they are unable to successfully mate with each other. At this point, a new species has emerged. Geographical isolation is thus a key factor in speciation, the formation of new species - also termed allopatric speciation.

The African Elephant, for instance, has always been regarded as a single species previous to genetic studies being made. Because of morphological and DNA differences, however, some scientists classify the elephants into three subspecies. Researchers at the University of California, San Diego (UCSD) have argued that divergence due to geographical isolation has gone further, and the elephants of West Africa should be regarded as a separate species from either the savanna elephants of Central, Eastern and Southern Africa, or the forest elephants of Central Africa.