**Study Guide for**

**Journey to the Centre of the Earth**

**About the Author: Jules Gabriel Verne**

Jules Gabriel Verne (1828 -1905) was a French author and a pioneer of the science fiction genre. Verne was noted for writing about cosmic, atmospheric and underwater travel before air travel and submarines were commonplace and before practical means of space travel had been devised. He is the third most translated author in the world.

**About the Playwright: Mark Penzak**

Working under the company name of BlueBoat, I've been creating theatre for children for over 30 years and estimate that I've performed to over half a million children. My theatrical style features innovative sets and puppets combined with playwriting, storytelling and characterisation. I like the audience to go on a theatrical voyage – to be transported into imaginative worlds and leave at the conclusion, feeling or thinking differently to when they started. Sometimes this voyage is pure comedy or action/adventure but at other times, the exploration is thematic or allegorical. Either way, I like my theatre to be fun, exciting, picture building and magical. My productions have toured festivals and schools around Australia and overseas. [**www.markpenzak.com**](http://www.markpenzak.com/)

**The Inspiration for this production**

Probably like most kids in the audience, my introduction to this story came through film, although in my case that film was released in 1959 and starred that great actor James Mason. I think it is by far the best of the film adaptations and well worth viewing. That film prompted me to read the book although that occurred a few years later in early high school.

In making this play I wanted to capture, or indeed generate a sense of wonder. I recall vividly as a kid thinking about what might be under my feet and what would happen if I went down there? What would I see? What would I find or what might find me?

Generating a sense of wonder in children is not mere entertainment. I think it is one of the main motors that drives learning. Indeed when I work with kids who aren't engaged with school, it is often the lack wonder that's immediately apparent and one of the feelings, that I as an artist, try to replenish.

**The Science – So what *is* in the centre of the Earth?**

I often get asked this question after the performance so here's some interesting information.

Hollow Earth Hypothesis

Silly as it now appears, the idea that the world is hollow was once considered a serious scientific theory. In 1692 the famous English astronomer and mathematician, Sir Edmond Halley (1656-1742), presented to the Royal Society an idea that the earth consisted of an outer crust, 500 miles thick, and a hollow interior containing three smaller spheres, one within the other, approximately the size of Venus, Mars, and Mercury. Halley speculated that the inner spheres might be inhabited. Leonhard Euler (1707-1783), the noted Swiss mathematician and physicist, proposed in 1767 that the earth's hollow interior contained at its centre a small glowing core which served as a miniature sun for the inner world's hypothetical inhabitants. Sir John Leslie (1766-1832), a Scottish physicist and mathematician, proposed that the earth had a hollow interior containing two suns, Pluto and Proserpina. It is thought that Jules Verne's Journey to the Centre of the Earth was partly inspired by Leslie's ideas.

So what’s really in the interior of our Earth?

*'We know amazing little about what happens beneath our feet. It is fairly remarkable to think that Ford has been building cars and Noble committees awarding prizes for longer than we have known that the Earth has a core. And of course the idea that the continents move about on the surface like lily pads has been common wisdom for much less than a generation. 'Strange as it may seem,' wrote Richard Feynman, 'we understand the distribution of matter in the interior of the sun far better than we understand the interior of the earth.'*

Bill Bryson A Short History of Nearly Everything 2003

**At its simplest divisions, the Earth consists of four** ***concentric* layers: inner core, outer core,** ***mantle* and** ***crust*. The crust is made up of** ***tectonic plates*, which are in constant motion. Earthquakes and volcanoes are most likely to occur at plate boundaries.**

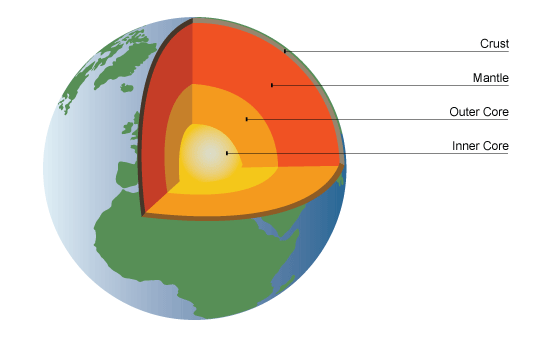
# **The structure of the Earth**

The Earth is made up of four distinct layers:

1. **The inner core** is in the centre and is the hottest part of the Earth. It is solid and made up of iron and nickel with temperatures of up to 5,500°C. The high temperature is thought to be a combination of residue heat from the initial formation of the Earth, friction, and radiative decay. With its immense heat energy, the inner core is like the engine room of the Earth.
2. **The outer core** is the layer surrounding the inner core. It is a liquid layer, also made up of iron and nickel. It is still extremely hot, with temperatures similar to the inner core.
3. **The mantle** is the widest section of the Earth. It has a thickness of approximately 2,900 km. The mantle is made up of semi-molten rock called magma. In the upper parts of the mantle the rock is hard, but lower down the rock is soft and beginning to melt.
4. **The crust** is the outer layer of the earth. It is a thin layer between 0-60 km thick. The crust is the solid rock layer upon which we live.

There are two different types of crust: **continental crust**, which carries land, and **oceanic crust**, which carries water.

The diagram below shows the structure of the earth. In geography, taking a slice through a structure to see inside is called a **cross section**.



**How deeply have we drilled or travelled?**

Given that the distance from the surface of Earth to the middle is 6,370 kilometres, measured in terms of physical exploration, we've barely scratched the surface. The deepest known cave is Voronja Cave in Georgia at 2080m. The deepest mine is TauTona, a South African gold mine which is presently 3.5 kilometres deep. The deepest ever penetration is a Russian scientific bore located in Kola Peninsula which drilled to 12,262 meters. Our understanding of what is happening under our feet is based on studies in several inter-related disciplines including meteorology, geomagnetism and astrophysics and especially:

Geology: The science that deals with the history of the earth as recorded in rocks. In particular we get some idea of underground composition by looking at Kimberlite pipes. These are huge upward explosions of magma that originate as far as 200 kilometres below and so contain mineral samples from that region. (It is in these solidified pipes that diamonds are sometimes formed during the cooling process.)

Geophysics: Which is Geology that uses physical principles to study properties of the earth viewed globally.

Volcanology: The study of volcanos.

Seismology: Is the study of earthquakes and seismic waves that move through and around the earth.

It is largely through the interpretation of seismic waves as they are reflected from inside the planet that leads scientists to generally agree that the world is composed of four layers - a rocky outer crust, a mantle of hot viscous rock, a liquid outer core and a solid inner core. It is estimated that the temperature of the inner core 4000 degrees to over 7000 degrees Celsius - about as hot as the surface of the sun and that the pressure at the core is 3 million times the surface pressure.

We know the surface is dominated by silacates, which are relatively light and not heavy enough to account for the planets overall density. Therefore there must be heavier stuff inside. We know that to generate our magnetic field somewhere in the interior there must be a concentrated belt of metallic elements in a liquid state. That much is universally accepted - how the layers interact, what causes them to behave in the way they do, what they will do at any time in the future - is a matter of uncertainty.

Hopefully some new light will be thrown on the subject by the Deep Sea Drilling Vessel (D/V) CHIKYU. This is the first riser equipped scientific drilling vessel. It is capable of drilling up to 7,000m deep sea floor and aims to reach the mantle and seismogenic zone. CHIKYU explores the Earth as the main platform of the Integrated Ocean Drilling Program (IODP) which aims to explore earthquakes, global changes and the origin of life. (www.jamstec.go.jp/chikyu/)

**How do we know what's probably underneath the ground?**

This is taken from a BBC site which is very good and suitable for children.

http://www.bbc.com/earth/story/20150814-what-is-at-the-centre-of-earth

'When an earthquake happens, it sends shockwaves throughout the planet. Seismologists record these vibrations. It's as if we hit one side of the planet with a gigantic hammer, and listened on the other side for the noise.

"There was a Chilean earthquake in the 1960s that generated a huge amount of data," says Redfern. "All the seismic stations dotted all over the Earth recorded the arrival of the tremors from that earthquake."

Depending on the route those vibrations take, they pass through different bits of the Earth, and this affects how they "sound" at the other end.

Early in the history of seismology, it was realised that some vibrations were going missing. These "S-waves" were expected to show up on one side of the Earth after originating on the other, but there was no sign of them.

The reason for this was simple. S-waves can only reverberate through solid material, and can't make it through liquid.

They must have come up against something molten in the centre of the Earth. By mapping the S-waves' paths, it turned out that rocks became liquid around 3000km down.'

**A seismology game**

To explain the above concept, collect 6 objects that are made from different substances that make different sounds when struck. For example: plastic – hard & soft, metal – aluminium and steel, glass, book. You also need a solid object to strike them with.

Step 1: With the class watching and listening – strike each object so the children have a pretty good idea of how each substance sounds when struck.

Step 2: Ask the kids to imagine that these objects are placed in layers, like the layers inside the Earth, and that you can only guess the order of these layers by hearing the sound they make when struck.

Step 3: Now the kids shut their eyes, or the objects are hidden from view. Now the objects are struck in different orders and the kids have to write down what they think is the correct order.

Step 4: Use that as game as a way to explain how the principals of seismology work. Just as they were able to guess the correct order of substances, so seismologists can deduce what's under our feet.

**Writing Or Cartoon Drawing Exercise:**

Jules Verne is considered one of the first writers of the science-fiction genre. So what is Science-fiction? Author Theodore Sturgeon wrote that "a good science-fiction story is a story about human beings, with a human problem, and a human solution, that would not have happened at all without its science content."

The following could be done either as a writing exercise in 5 paragraphs or as a cartoon based on 5 panels.

1/ First Panel or Paragraph. The story starts in a science lab or exploration. For example, it could start with scientists trying to create a time machine or journeying on a spaceship to Mars. Decide what are the scientists trying to achieve or discover? Do they have any special equipment such as a super computer?

2/ In the second paragraph or panel, make something go seriously wrong. Maybe the scientists create a dangerous new animal? Maybe equipment malfunctions and puts everyone in danger? (For example, the spaceship's rockets misfire and it is now heading straight into the sun.)

3/ In the third paragraph/panel show that the situation is becoming critical. For example, a monster goes on a rampage or the spaceship is about to burn.

4/ In the fourth paragraph, show the scientist discovering a way to fix the situation using *science*. For example, if a monster needs to be defeated, it requires a scientific solution. Perhaps a fire breathing monster could be defeated through freezing caused by rapidly expanding gas. Could they use one piece of equipment to do an unexpected job? A rocketship motor was made to propel a spaceship, but it could also be a blowtorch. Maybe they could find a way to make friends with the monster rather than fight? If so, what science would enable them to communicate or make the alien happy?

5/ In the final paragraph/drawing we see the danger is over. Maybe everything was as it was before the emergency but if possible, show that things are now different. Maybe the once dangerous monster is now going to school? Maybe the scientists have learnt from their mistakes and are about to launch a new, better rocket?

Discussion Topics

1/ Caves, tunnels and underground passages seem to resonate in our imagination. Milton's Paradise lost. Orpheus and Eurydice, Dante's Divine Comedy all feature underground worlds and tunnels. Some examples children might know are Alice in Wonderland - where Alice enters through a rabbit hole. Aladdin's Cave. Batman's Cave.

2/ Can you think of other examples of famous caves? Harry Potter has several examples where the characters descend into caves, dungeons or tunnels.

3/ Ask the children why they think underground places are used in stories? What is the imaginative appeal? Is it because they are dark and hidden from sight? (Maybe there's a tunnel under your feet right now?) Is it because they connect one place to another and characters can travel unseen?

4/ What kind of real animals live in caves? (Troglofauna are ground dwelling cave animals and stygofauna are aquatic cave fauna.)

*Examples of troglobites include the Kauaʻi cave wolf spider, Texas blind salamander, olm, cave salamanders, Nelson cave spider, Tumbling Creek cavesnail, Phantom cave snail, Alabama cave shrimp, etc. The Alabama cave shrimp live in aquatic environments in caves and obtains nutrients from detritus and feces of bats and other cave dwelling animals. (*[*www.worldatlas.com/articles/animals-that-live-in-caves.html*](http://www.worldatlas.com/articles/animals-that-live-in-caves.html)*)*

5/ How does the environment cause them to evolve differently?

*Several physical and physiological adaptations are exhibited by troglobites. Some examples of these adaptations include loss of body pigmentation (as the animals are hardly exposed to sunlight), loss of sight (the darkness of the caves renders eyes as unnecessary sense organs), slow metabolic activity (low availability of food and less scope of movement), etc. Not all adaptations are related to loss of function, but some lead to the gain of function. For example, the troglobites often possess extreme sensory adaptations for stimuli such as touch or other stimuli that are light-independent. These animals might have highly sensitive sensory hairs and long antennae. Auditory and chemosensory organs of these animals are also often highly specialized. Since troglobites hardly survive outside the cave system, they are usually endemic to a particular cave system.* *(*[*www.worldatlas.com/articles/animals-that-live-in-caves.html*](http://www.worldatlas.com/articles/animals-that-live-in-caves.html)*)*

6/ What kind of imaginary or mythological creatures live in caves?

7/ What objects can you really find in a cave? Limestone Stalactites (growing down from the ceiling) and & Stalagmites (growing from the bottom to ceiling.). Rubies. Diamonds? Rivers. Bones. Prehistoric campsites.

8/ What could you imagine finding in a cave? Pirate treasure? The city of Atlantis. A villain’s hidden lair.

Idea for Illustration

A/ Let the children draw a picture of a cave filled with either real or imaginary objects, monsters or animals. The pictures are then hung on the wall and then linked by a series of tunnels so that they forms giant maze.

B/ These pictures can be used for maths game where the children have to work out the number of caves they would need to pass through to move from one particular cave to another.

**Two Interesting Internet Sites**

Excellent BBC Animation of a scientific Journey to the Centre of the Earth

<http://www.bbc.com/future/bespoke/story/20150306-journey-to-the-centre-of-earth/>

A map that shows where you'd end up if dug straight down into the Earth

<http://www.livephysics.com/simulations/mechanics-sim/dig-hole-earth/>

**Applied Science**

**Applied science** is a discipline of **science** that applies existing scientific knowledge to develop more practical applications, like technology or inventions.

Design a machine that could take you into the Centre of the earth.

What abilities would it need? - How would it drill itself down? How would you get rid of the spoil? (The material that you remove from the front of the machine has to go somewhere.)

The "popular" estimates range of the centre of Earth vary from about 4,000 kelvins up to over 7,000 kelvins (about 7,000 to 12,000 degrees F). 7000 kelvin is 6726 Celsius which is about 20 times hotter than the temperature we bake a cake at. Indeed at 1528 degrees celsius, the iron in the stove would melt. How is your machine cooled? (ice, refrigerators, water jets?)

It would take a long time to drill down there – what living quarters would you need?

What scientific experiments would you like to perform down there? How would you perform them in that heat?

How would you see anything? Glass melts at 1400 to 1600 degrees celsius. How could you keep the glass cool?

Pressure – the pressure in the centre of earth is vast – 3.6 million atmospheres – the same as 47,700 elephants balances on your heads. Can your machine withstand that pressure. Maybe have a look at the shape of deep ocean submarines. Why are they shaped they way they are?

**Drama Exercises**

Going on a Journey

At the start workshop with the kids a list of possible states you could find on an imaginative Journey to the Centre of the Earth. For example, it might be hot, cold, icy, windy, sticky. Also emotional states – scary, dangerous, exciting, awesome.

Divide the class into groups of 4 or 5.

Starting with everyone standing in their groups on one side of the room, a student or the teacher, calls out a state. Then one member from each group (so that 4 or 5 people start at the same time), moves across the space as if experiencing the state. For example, if the floor was sticky, the kids step as if their feet were sticking to the floor or if it was icy, then the participants would slide. After the first person has taken a few steps, the next wave of participants starts

Human Chain across the space.

Staying in the groups. One member from each group, steps into the space and freezes with their arm, or other body extremity such as a leg, outstretched towards the far wall. The next person in the group links to the first person. This could be simply hold hands but try to be imaginative as to how the people link. A person could extend their leg or lean against the first person. After that link occurs, a third person from the group joins in, followed by the 4th and so on forming a human chain across the space. When all members of the group are joined together, the first person breaks from the rear and joins the front so that the human chain moves across the space.

Writing and Drawing Exercise for younger students

Referring to the template on the next page, firstly explain to the students what's meant by ‘characters', 'setting' and 'props’ using examples from the play.

Characters are the people in the play – there's Axel, Professor Lidenbrock. Hans, Gertrude (the duck) and Gretchen.

Setting – The setting comprises everything on stage that isn't hand held. We have a volcano, the centre of the world, the posters that spin into view, salt cave and glittering rocks.

Props: Props are hand held objects. There were puppets of the characters, sea-monsters, exploding rock, special umbrellas that create a snow storm, giant vulture, whirlpool, erupting volcano and 'getting married'.

The children can draw their favourite objects and answer the questions as indicated.

