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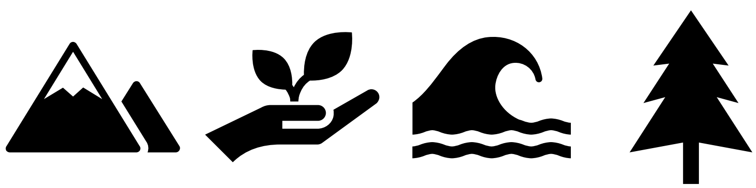
RESOURCES FOR SCHOOL TEACHERS

GEOGRAPHY EXPEDITION



The *Atlas of Human Imagination* and its many pioneers played a huge role in our understanding of the natural world around us. The study of Planet Earth is not just interesting, but it is essential to our own future survival.

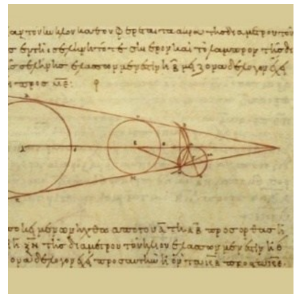
Geography involves many different interconnected topics such as geodesy, magnetism, cartography, oceanography, plate tectonics, volcanology, seismology, erosion, atmosphere, weather, climate, soil, mountains, hydrology, conservation and weather modelling.

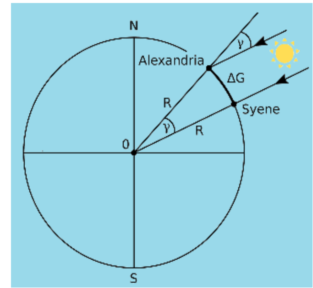
This document gives some examples of the historical discoveries and concepts on display in the poster and how they are relevant to our understanding of physical geography today.

Geodesy

Planet size – *Eratosthenes, Aristarchus*

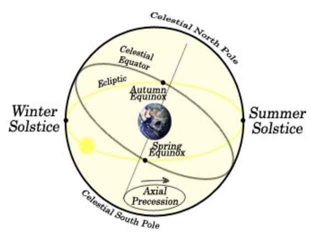
Using mathematics and logic, a number of Greek philosophers were busy, around 250 BC, measuring and calculating the size of Planet Earth. Remarkably, Eratosthenes calculated Earth's equator to have a circumference of 40,000 km – only about 1% off today's value.





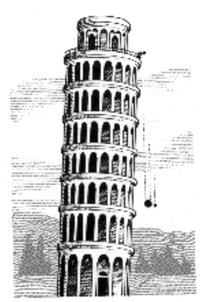
Planet axial tilt – *Eratosthenes*

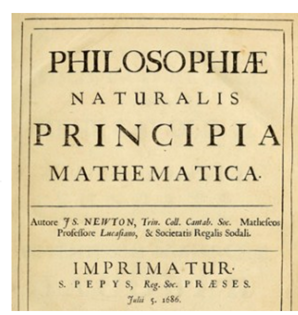
Again, using brilliant logic and basic measuring tools, Eratosthenes also worked out the axial tilt of the planet ("the reason for the season"). He measured an angle of 23°51', which is incredibly close to the modern-day value of 23°26'. This was later refined by Hipparchus in 150 BC.



Planet gravity – *Galileo, Newton*

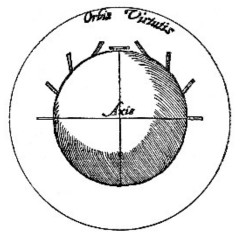
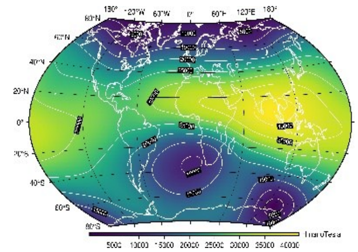
Together, Galileo and Newton are responsible for most of our understanding about gravity on Earth. Galileo conducted experiments from the Leaning Tower of Pisa, and proved that all objects fall at the same rate, irrespective of their mass or density. Newton then took the gravitational mathematics further and calculated that acceleration due to gravity on Earth is approximately $g = 9.8\ m/s^2$.



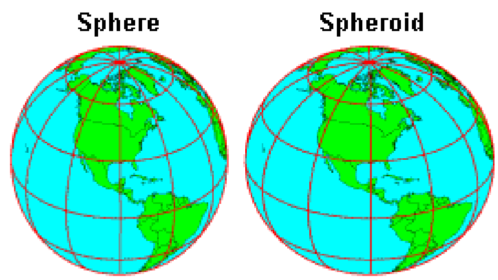


Planet magnetism – *Gilbert, Gauss*

Between 1600-1800, scientists like Gilbert and Gauss were actively studying magnetism on Earth. William Gilbert was the first to realise that the Earth itself was a giant magnet with a North and South Pole, as published in his book *De Magnete* in 1600. Carl-Friedrich Gauss took it even further by establishing the mathematical framework and measurement standards for modern geomagnetism.

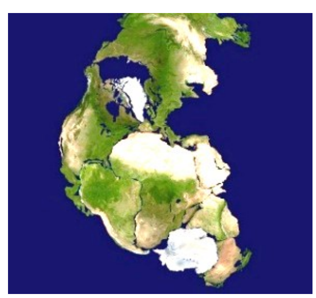
Planet shape – oblate spheroid– *Newton*



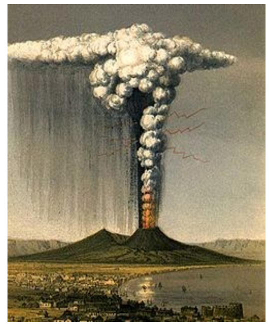
In 1687 in his book *Principia*, Newton was the first to define the shape of the Earth, not as a perfect sphere, but slightly flattened at the poles due to the planet's rotation. He called that an "oblate spheroid". This idea was later confirmed by measurements from French expeditions to Lapland and Peru in the 18th century.

Plate tectonics and continental drift – *Wegener*

In 1912, Alfred Wegener proposed that the Earth's surface is an active and slowly moving array of interlocking plates. He was also the first to propose a unified landmass called *Pangaea,* in his book *The Origin of Continents and Oceans* in 1915. Although not accepted in his lifetime, Wegener was later proved correct.

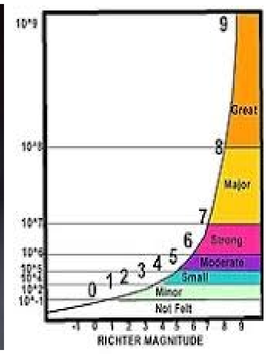



Volcanology – *Plato, Pliny, Mercalli*



Plato took an interest in volcanoes and discussed them in his dialogues in 400 BC. Pliny the Elder also studied them and actually died witnessing a volcanic eruption at Mount Vesuvius in 79 AD. Later, Giuseppe Mercalli studied them more scientifically in the late 1800s, developing an eruptive classification system and seismic scale. Volcanic eruptions are often defined in three parts: eruption column, ash fall and pyroclastic flows.

Seismology – *Zhang Heng, Gutenberg, Richter*



In seismology, the science of earthquakes, the story stretches from ancient ingenuity to modern precision. In the 2nd century AD, the Chinese scholar Zhang Heng invented the first known seismograph, a remarkable bronze device that could detect the direction of distant earthquakes long before modern instruments existed. Nearly eighteen centuries later, Charles Richter and Beno Gutenberg developed the Richter magnitude scale in the 1930s, allowing scientists to measure earthquake strength quantitatively.

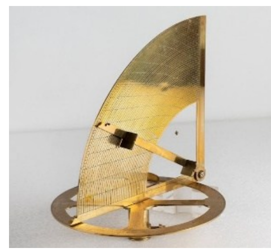
Tsunamis – *Pliny, Hokusai*

Closely related to earthquakes, tsunamis are a terrifying force of nature, that have inspired both scientific inquiry and artistic expression. Pliny the Younger provided one of the earliest written descriptions of a tsunami following the eruption of Mount Vesuvius in 79 AD, noting the sudden retreat and violent return of the sea — a phenomenon not yet understood in his time. Centuries later, the Japanese artist Katsushika Hokusai captured the immense power of the ocean in his iconic woodblock print *The Great Wave off Kanagawa* (1831), symbolising both nature's beauty and its destructive force.

Cartography

Map-making and geo-navigation – *Henry the Navigator, Da Vinci, Nunes, Mercator*

Cartography has a long history and several key players were involved in the development of accurate maps. In the 1400s, Henry the Navigator set up a dedicated centre in Sagres, Portugal to improve map-making. A century later, Pedro Nunes developed much of the mathematics of navigation on a spherical planet, including loxodromes and great circles.

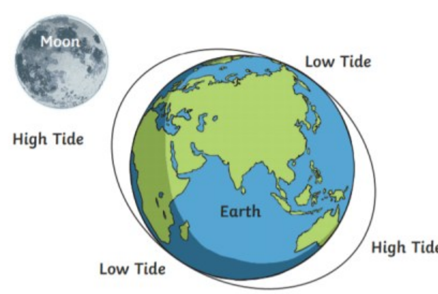


This was then further developed by Gerardus Mercator, whose projection we still use today on all our modern maps. Interestingly, Da Vinci was one of the first people to conceive and draw *birds-eye* perspective maps, including of cities like Imola in Italy.

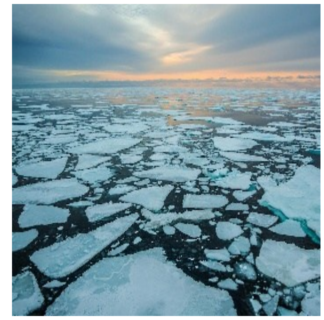
Oceanography

Tides – *Galileo, Newton, Laplace, Kelvin*

Tides are a natural phenomenon that have fascinated humans for thousands of years. Galileo incorrectly assumed that tides were not affected by the Moon, but by Earth's rotation. Newton later corrected this by introducing a lunar influence, and provided the first correct gravitational theory of tides. Pierre-Simon Laplace then provided the mathematical framework for modern tidal mechanics, whilst Lord Kelvin in the late 1800s developed a harmonic analysis and became the first person to develop practical methods to predict tides.



Polar oceans and sea ice studies – *Nansen*



While he is often remembered for his Arctic expeditions, Fridtjof Nansen's scientific contributions to oceanography were profound and foundational. On his *Fram* expedition, he proved that sea ice even near the North Pole is constantly drifting. He also showed that the Arctic Ocean is deep, not a shallow sea as previously thought. The Nansen bottle revolutionised deep-water sampling and made possible vertical profiling of ocean properties. Nansen also explained major oceanic currents for the first time.

Deep-sea exploration – *Verne, Cousteau*

The two most influential people regarding deep-sea exploration are Jules Verne and Jacques Cousteau – the former more fictional and the latter scientific. Verne wrote adventure stories like *Twenty Thousand Leagues Under the Sea* (1870), inspiring millions of readers with his imagination. Cousteau took the brave leap into the undersea world with his co-invention of the *AquaLung* in 1943, and his numerous deep-sea expeditions aboard *Calypso* from the 1950s to the 1980s.

Fossils, Minerals, Ground and Soil

Strata, fossils and ichnology – *Da Vinci, Hooke, Leakey*

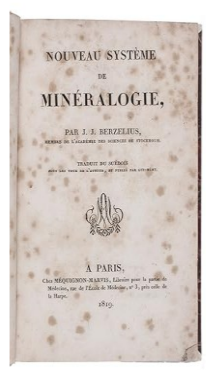
The study of rocks, and their layering, goes back to the times of Da Vinci who studied different areas in the Italian Alps. Not only did he use the mountains as a backdrop to his paintings, like in the *Mona Lisa*, but he was also curious about the rock formations and strata and how they originated. He took numerous fossils from the area and concluded they formed naturally from old sea animals, rather than from the Great Flood as stated in the Bible.

The British scientist Robert Hooke was also interested in fossils. He had a vast collection and made many drawings devoted to ichnology.

Mary and Louis Leakey in the 1960s made great strides understanding human evolution. They found hominid fossils dating back over 3 million years, which showed that human origins began in East Africa.

Minerals and geochemistry – *Agricola, Berzelius, Goldschmidt*

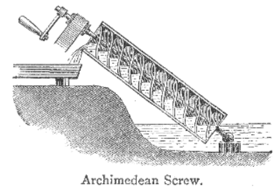
The fields of geochemistry and the study of minerals have a long history. Georgius Agricola was one of the first to document and collate information about minerals and their uses, in his book *De Re Metallica* in 1556.



Jöns Jacob Berzelius took the field to new heights when he systemised chemistry, chemical notation, atomic weights and discovered numerous elements within minerals.

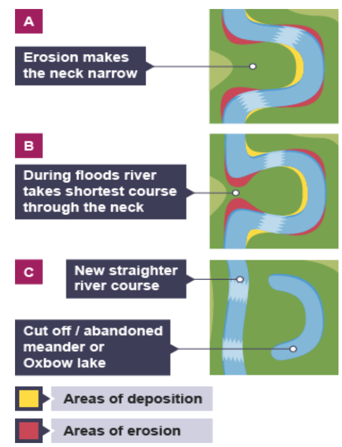
Later, Victor Goldschmidt developed a geochemical classification system for elements in magma. He created four main groups: lithophile ("rock-loving"), siderophile ("iron-loving"), chalcophile ("sulfide-loving") and atmophile ("gas-loving").

Hydrology and erosion in rivers – *Archimedes, Da Vinci, Leopold*


Archimedean Screw.

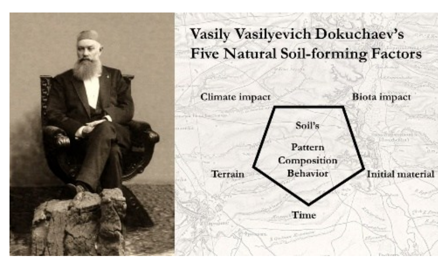
The flow of water in rivers is a major part of physical geography and some of the first people to study and document hydrology were Archimedes and Da Vinci. Archimedes spent time in Egypt analysing the hydrology of the River Nile, and that is where he also invented the *Archimedean screw* for pulling fresh water out of the Nile to irrigate the fields on the bank of the river.

In his notebooks, Da Vinci sketched the flow of water in rivers and basins, often showing transitions between laminar and turbulent flow. He also attempted to alter the flow of the River Arno, running through Florence, as part of a military strategy. The attempt ultimately failed and proved too difficult, even for Da Vinci.



This work inspired modern-day scientists to better understand drainage patterns, river courses and geographic features like ox-bow lakes. Luna Leopold in the mid-20th century was a central figure in the development of modern fluvial geomorphology.

Permafrost and soil – *von Lösch, Dokuchaev*

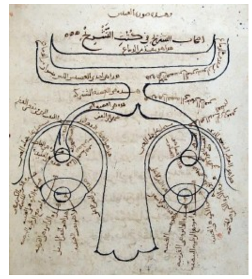


Permafrost and soil science owe much to pioneers like Vasily Dokuchaev and Gustav von Lösch. Dokuchaev, the *father of soil science*, defined soil as a natural body shaped by climate, organisms, parent material, relief and time, laying the foundation for recognising permafrost soils as unique systems.

Later, von Lösch studied frozen ground in cold climates, detailing how permafrost forms and affects soil structure. Their work underpins modern cryopedology and our understanding of soils in cold regions, like the Arctic Circle.

Weather Phenomena

Rainbows – *Alhazen, Descartes, Newton*

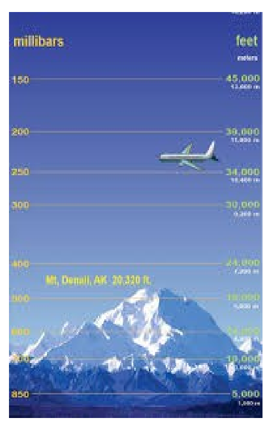


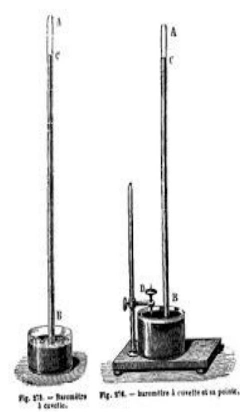
The scientific study of rainbows evolved over centuries, beginning with Alhazen (Ibn al-Haytham, 965–1040), who correctly identified that rainbows result from the refraction and reflection of sunlight in water droplets.

In the 17th century, René Descartes expanded on this work, using geometric ray tracing to calculate the angle of deviation for refracted and reflected light. Later, Isaac Newton added a deeper understanding by demonstrating that white sunlight is composed of different colours with distinct refractive indices, showing that the rainbow's spectrum arises from dispersion of light.

Together, these thinkers traced a flow from observation and geometry to the modern physical theory of colour and optics, establishing the rainbow as both a natural and scientific marvel.

Pressure change – *Pascal, Torricelli*





The study of pressure change began with Blaise Pascal, who demonstrated that pressure in a fluid is transmitted equally in all directions (Pascal's principle) and that it varies with height, laying the foundation for understanding fluid mechanics.

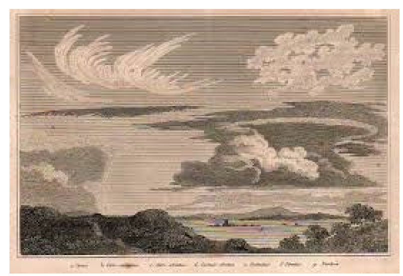
Building on this, Evangelista Torricelli invented the mercury barometer in 1643, showing that air has weight and that changes in atmospheric pressure can be measured. Together, their work established the principles linking fluid pressure, height and atmospheric forces. This plays a major role in meteorology and weather prediction (later in this document).

Blue skies – *Da Vinci, Tyndall*

In the 1500s, Leonardo da Vinci sought to explain the origin of blue skies. As both a painter and a scientist, he had a keen understanding of colour and conducted experiments using smoke, observing that fine particles appeared blue against a dark background. This highlighted the effect of light scattering by small particles.

Centuries later, John Tyndall refined this understanding, demonstrating experimentally that suspended particles in air or water scatter light — a phenomenon now known as the *Tyndall effect* — laying the groundwork for the modern explanation of why the sky appears blue.

Cloud formation and shape – *Howard, Mandelbrot*



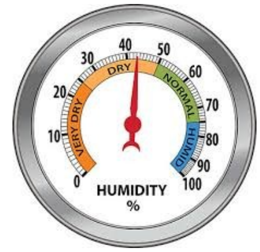
Cloud formation and shape have been studied from both meteorological and mathematical perspectives. In 1803, Luke Howard developed the first systematic classification of clouds based on their appearance, introducing terms like *cumulus*, *stratus*, and *cirrus*, which remain in use today.

In recent times, Benoit Mandelbrot applied fractal geometry to clouds, showing that their complex, irregular shapes exhibit self-similarity across scales, providing a mathematical framework to understand cloud patterns beyond simple classification. He even made a documentary about fractals entitled: “Clouds are not spheres.”

Atmosphere & Climate

Humidity and precipitation – *Dalton, Tyndall*

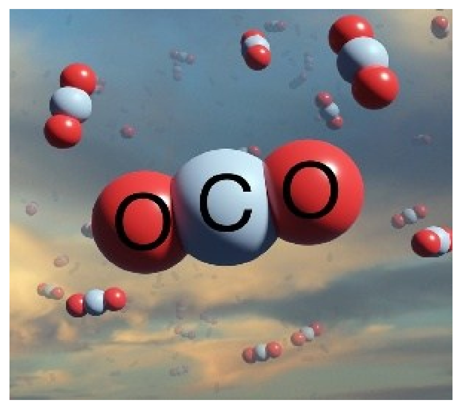
Humidity and precipitation were clarified through the work of early scientists studying water in the atmosphere. John Dalton (18^{th}–19^{th} century) developed the concept of partial pressures, explaining how water vapour contributes to air pressure and saturation.



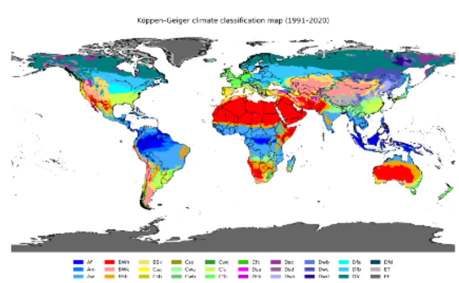
Later, John Tyndall investigated the absorption and condensation of water vapour, showing how it interacts with heat and radiation, helping to explain processes like cloud formation and rainfall.

Atmospheric chemistry, CO_2 and climate change – *Tyndall, Arrhenius, Lovelock, Köppen*

Atmospheric chemistry and climate change have been shaped by a series of important studies. In the mid-19^{th} century, John Tyndall discovered that gases like carbon dioxide and water vapour absorb infrared radiation, identifying them as key greenhouse gases. Building on this, Svante Arrhenius in 1896 quantitatively linked CO_2 concentrations to global temperature, making the first prediction of human-induced climate change.

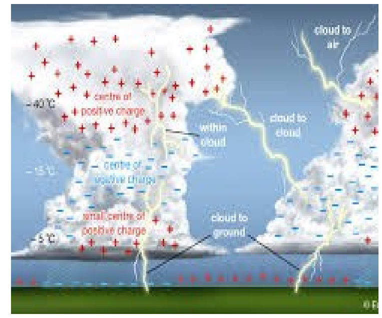


In the 20^{th} century, Wladimir Köppen developed climate classification systems that helped contextualise climate zones, while James Lovelock proposed the Gaia hypothesis, emphasising the dynamic feedbacks between life, atmospheric chemistry and climate. Together, their pioneering work traces the scientific understanding of how CO_2 and other factors shape Earth's climate.



Thunderstorms and lightning – *Franklin, Coulomb*

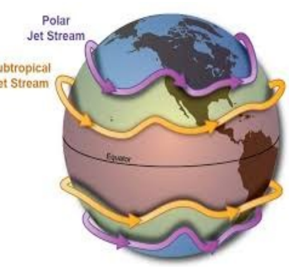
While fascinating and awe-inspiring, the study of thunderstorms and lightning strikes is a very risky undertaking. In 1752, Benjamin Franklin famously demonstrated the electrical nature of lightning with his kite experiment. Soon after, Charles-Augustin de Coulomb studied the behaviour of electric charges, providing the theoretical foundation for understanding how charge separation in clouds leads to lightning.



Jet streams – *Nansen, Ooishi, Coriolis*

Jet streams were gradually understood through observations and theory in the early 20th century. Fridtjof Nansen's Arctic expeditions revealed large-scale wind patterns, ocean circulation and ocean-atmosphere interactions, hinting at persistent high-altitude winds. In the 1920s, Wasaburo Ooishi recorded strong upper-air westerlies using weather balloons over Japan, providing the first systematic evidence of jet streams.

Meanwhile, the Coriolis effect explained the deflection of these high-altitude winds, accounting for their characteristic eastward flow in both hemispheres. These combined contributions established the basis for understanding fast, narrow air currents in the upper atmosphere.



Conservation – *von Braun, Sagan, Tansley, Goodall, Lovelock*

Conservation of the planet has been shaped by science, exploration and ecological philosophy. In 1935, Arthur Tansley introduced the concept of the "ecosystem", framing humans as part of interconnected ecological networks.

In the space age, the *Apollo* missions led by Wernher von Braun provided humanity with the first striking views of Earth from space, highlighting its fragility against the black void of space. Similarly, Carl Sagan's *Pale Blue Dot* imagery reinforced this perspective, inspiring a sense of planetary stewardship.

Pioneers like Dame Jane Goodall demonstrated the intelligence and social complexity of wildlife, emphasising the ethical and practical need to conserve species. Later, James Lovelock's *Gaia* hypothesis highlighted Earth as a self-regulating system, reinforcing the idea that human activities must respect global ecological balance. These pioneers have all had a huge impact on conservation thinking.

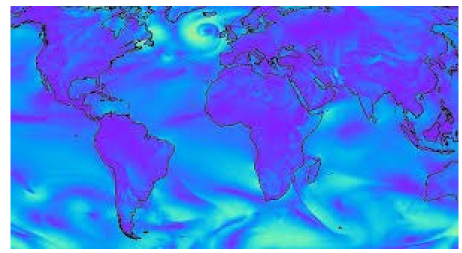
Weather Modelling – *Thales, Newton, Pascal, Euler, Laplace, Kelvin, Navier, Stokes, Lovelace, Turing, von Neumann, Hopper, Bjerknes, Richardson, Rossby, Poincaré, Lorenz, Mandelbrot*

This final topic deserves a special mention for two reasons: firstly, it is an extremely cross-disciplinary field involving over a dozen of the pioneers profiled in the *Atlas*; and secondly, it is often overlooked in modern society, since we have all become very used to weather forecasts.

By zooming in on weather modelling, we can hopefully build up a deeper understanding of how it came about, over many centuries. This particular field can be split into five sub-areas:

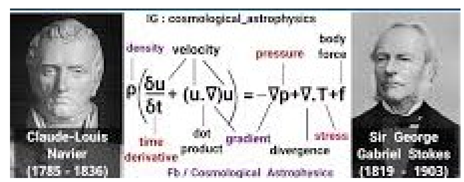
Foundational physics of modelling – *Thales, Newton, Pascal, Euler, Laplace, Kelvin*

These pioneers helped define the key physics of motion, forces, pressure, gravity and tides, essential to weather modelling.



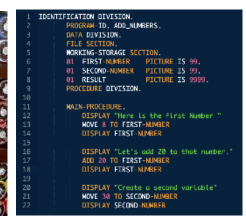
Fluid dynamics – *Euler, Navier, Stokes*

These scientists formulated the core equations for atmospheric motion, notably the Euler and Navier–Stokes equations of flow.



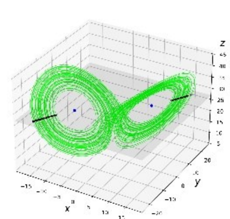
Computational Pioneers – *Lovelace, Turing, von Neumann, Hopper*

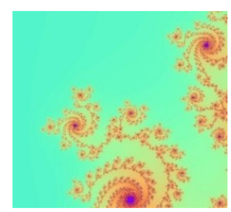
These computer scientists developed algorithms, early computing and programming languages to permit weather modelling.



Meteorology – *Bjerknes, Richardson, Rossby*

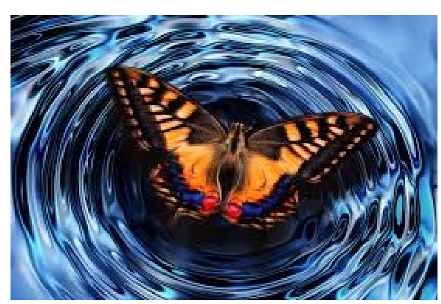
These three meteorologists formulated the weather systems theory and practical forecasting techniques that underpin the models.





Chaos and complexity – *Poincaré, Lorenz, Mandelbrot*

These pioneers discovered and understood the non-linear dynamics and fractal structures involved in weather, as exemplified by the “butterfly effect” in chaos theory.



Conclusion

Geography is the story of human curiosity and discovery, shaped by centuries of pioneers from the *Atlas of Human Imagination*. From astronomers like Eratosthenes measuring Earth, to Newton explaining gravity and tides, to Nansen and Cousteau exploring polar seas and the ocean depths, each thinker revealed bold new ways of understanding our planet.

Scientists, explorers and artists alike uncovered the patterns of clouds, currents, mountains and climates, helping us understand and protect the world around us. Their combined legacy shows that curiosity, observation and creativity are often the keys to discovery.

We hope you have enjoyed this geography expedition and we invite every student to become part of the ongoing journey to explore and understand our one and only planet – *Earth*.

David Jarvis

FOR TEACHERS

Using the *Atlas of Human Imagination* in Lessons: Some Classroom Ideas

Planet Earth & Geodesy

Explore how ancient and modern scientists measured, mapped and understood our planet.

1. Measure the Earth (à la Eratosthenes):
   Students recreate Eratosthenes' experiment using shadow lengths at local noon to estimate Earth's circumference — coordinate with another school in a different latitude.

2. Gravity Field Mapping (à la Newton):
   Use smartphone sensors or online gravity datasets to explore how gravity varies with latitude and elevation.

3. Magnetic Field Tracker (à la Gauss):
   Build a simple compass-based instrument and record local magnetic declination, comparing it with online geomagnetic maps.

Tectonics, Volcanoes & Earthquakes

Investigate how our dynamic planet moves and changes beneath our feet.

4. Build a Seismograph (à la Zhang Heng):
   Construct a basic homemade seismograph and test its sensitivity using small vibrations or simulated tremors.

5. Volcanic Eruption Model (à la Plato):
   Think how you could create a safe, physical model showing eruption stages (eruption column, ash fall, pyroclastic flow) and film it in slow motion.

6. Tectonic Plate Puzzle (à la Wegener):
   Use printed global maps to reconstruct *Pangaea* and track how continents drifted over time — compare to modern GPS data.

Oceanography & Hydrology

Dive into how water shapes our world, from ocean currents to river systems.

7. Model Ocean Currents (à la Nansen):
   Use tanks with dyed warm and cold water to visualise convection and thermohaline circulation.

8. Tide Simulator (à la Kelvin):
   Recreate the effect of lunar and solar gravity on tides using pendulums or digital models — explain spring and neap tides.

9. Water Quality and River Flow Survey (à la Da Vinci):
   Measure pH, temperature and flow rate of a local river, then analyse sediment transport and erosion.

10. Ice Floe Experiment (à la Nansen):
    Create a "drifting ice" model using floating platforms in water with a current, to show how ice moves with ocean flow.

Atmosphere & Weather

Experiment with the physics of air, light and energy that shape our weather.

11. DIY Barometer and Pressure Study (à la Pascal, Torricelli):
    Build a *mercury-free* barometer using water or air pressure sensors to observe weather changes.
12. Cloud Classification Journal (à la Howard):

Students photograph local clouds over several weeks, classify them using Howard's system, and create a digital atlas.

13. Rainbow in a Bottle (à la Descartes, Newton):
    Recreate Descartes' and Newton's optics experiments using prisms, droplets, and sunlight to explain light dispersion.

14. Simulate the Greenhouse Effect (à la Tyndall):
    Compare temperature changes in sealed jars with different gas mixtures (air, CO_2 from vinegar/baking soda).

15. Turbulence and Chaos Experiment (à la Mandelbrot):
    Use smoke or dye in water to explore fluid flow patterns and relate them to Mandelbrot's fractals and Lorenz's chaos theory.

Geology, Soil & Permafrost

Discover the science of the ground beneath us — rocks, fossils and frozen earth.

16. Soil Profile Analysis (à la Dokuchaev):
    Collect soil samples from different sites, analyse texture, moisture and organic content — relate results to Dokuchaev's soil-forming factors.

17. Freeze–Thaw Weathering Simulation (à la von Lösch):
    Use small rocks in a freezer and thaw cycles to show physical weathering similar to permafrost effects.

18. Fossil Impressions Project (à la Da Vinci, Hooke):
    Make plaster casts of modern shells or leaves to understand fossilisation processes like those studied by Hooke and Da Vinci.

19. Fractal Earth (à la Mandelbrot):
    Find locations on *Google Earth*, such as mountain valleys, fjords and river basins, that exhibit fractal-like properties, as studied by Mandelbrot.

Conservation & Climate

Connect planetary science to sustainability and ethics — caring for our shared world.

20. Gaia Systems Map (à la Lovelock):
    Students create a visual systems map showing how Earth's biosphere, atmosphere, oceans and human activities interact as a self-regulating system. Using arrows, feedback loops,

and examples (e.g. deforestation → CO_2 rise → temperature increase → ice melt), they illustrate positive and negative feedbacks in the Gaia model.

21. Ecosystem in a Bottle (à la Lovelock, Tansley):
    Build self-contained terrariums to demonstrate Tansley's ecosystem concept and Lovelock's *Gaia* ideas.

22. "Pale Blue Dot" Reflection Project (à la Sagan):
    Have students create short visual or written pieces showing what Earth means to them — linking Sagan's message with modern sustainability.