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RESOURCES FOR SCHOOL TEACHERS

Art, Science and Nature Intertwined

One of the key messages of the *Atlas of Human Imagination* is that there are many strong links between art, science and nature. This is the main reason for the visual representation of human knowledge in a single poster - shown as an interconnected narrative, rather than in the usual isolated silos.

For various historical, practical and convenience reasons, school education is typically divided up into lessons per subject (English, maths, science, art, geography, history, languages, computer science etc.) Often there is little formal overlap between them, and sometimes they are even presented as being mutually-exclusive. Some systems, however, like *Theory of Knowledge* in IB try to encourage cross-disciplinarity amongst the subjects – which can only be a good thing.

However, one could argue that in the modern world, even more emphasis should be placed on seeing the linkages between traditional subjects. Understanding how art, nature and science intertwine helps students think creatively about real-world problems – from sustainability to technology and design. As Leonardo da Vinci said in the 1500s: "Realise that everything connects to everything else."

Therefore, one area worthy of further analysis is the connectivity between arts and the sciences. By studying this in more detail, one can build up an appreciation of the ripple effects that these cultural breakthroughs have on each other. Visual arts can influence the way we think and visualise science; likewise, science can have its effect on arts, triggering new movements and techniques. This document provides a visual guide for students and teachers to better understand this cross-fertilisation. The following sections give a brief snapshot of some very interesting connections between art, nature and science.

Zoology & Botany

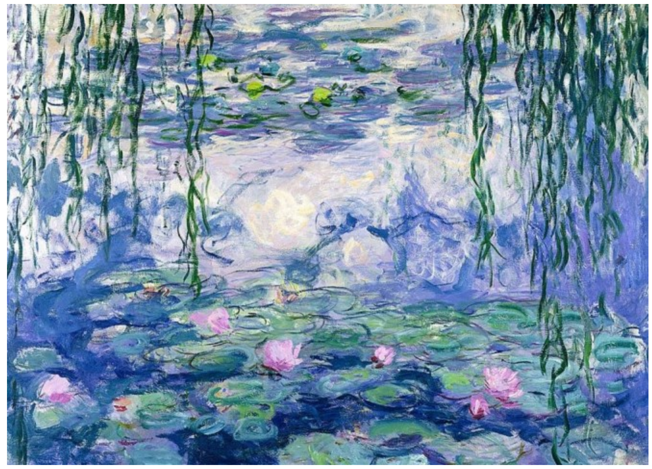
In life sciences, like zoology and botany, there are many examples where art, nature and science have become intertwined – to the point where it is difficult to see any boundaries between them at all. The pictures below show some examples. Maria Sibylla Merian was a German entomologist who drew scientific drawings of insects in the 1670s. Her butterfly drawings (below - left) are so exquisite and detailed that they are works of art in themselves – which later would inspire artists in the modern era like Damien Hirst's butterfly collages (below - right).

(CREDIT: Maria Sibylla Merian)

(CREDIT: Damien Hirst)

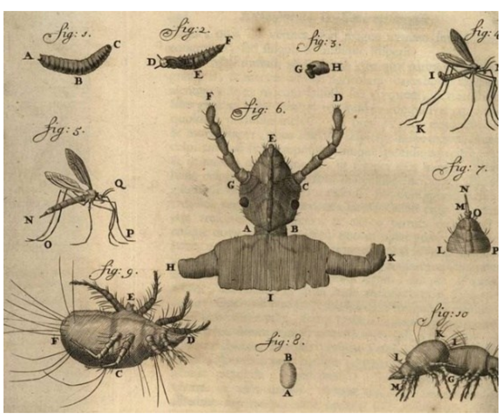
In a similar vein, the botanical world has been well documented and drawn by Goethe (below - left), Darwin and others – highlighting the colour, diversity and beauty in the plant world. These botanical studies would later inspire artists like Monet who painted dozens of canvases with waterlilies and other flowers and trees at his house in Giverny, France.

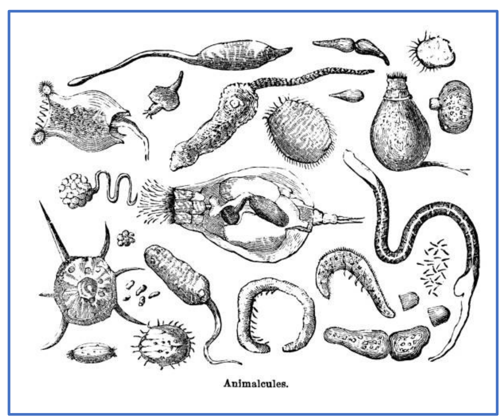
(CREDIT: von Goethe)



(CREDIT: Claude Monet)

The microscopic and underwater worlds are no less interesting. As soon as the Dutchman Antonie van Leeuwenhoek had invented the precision microscope in the late 1600s, he was making precise drawings to record the shape and size of the various minute 'animalcules' that he observed in pond water, drinking water and inside the body (below - left and right). Science had given us a brand-new way to see the natural world.





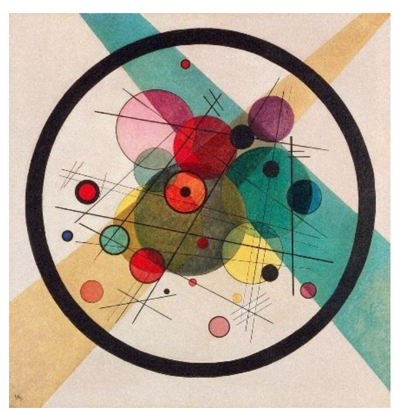
(CREDIT: Leeuwenhoek)

Two hundred years later, the published artwork of Ernst Haeckel included over 100 detailed, multi-colour illustrations of animals and sea creatures, collected in his *Kunstformen der Natur*. Again, the colour, shapes and diversity of creatures are artistic in their own right. Below one can see examples of sea anemones (below - left), as well as micro-organisms (below - right).

(CREDIT: Haeckel)

More recently, in 2017, Sarah Adkins et al from the University of Alabama, USA, did a combined Art-STEM study involving the growth of spores on agar jelly and recording the colours and patterns that formed. Below are some of the petri dishes from that school project (below - left). Even Sir Alexander Fleming, discoverer of penicillin antibiotics, was fond of making art by growing microbes on agar jelly. In fact, it is no coincidence that the name penicillin comes from the Latin for "paint-brush" – showing a clear cultural overlap between art and science. We are not sure if Kandinsky (below - right) was a fan too, but his 1923-piece *Circles in a Circle*, certainly bear a strong resemblance to a petri dish with striations of microbial growth.

(CREDIT: Adkins)



(CREDIT: Kandinsky)

One other artist worth mentioning for sheer imagination and surrealist fantasy is the Dutch painter Hieronymus Bosch, who painted various triptychs in the early 1500s. His religious artwork often depicted strange landscapes filled with birds and mammals, as well as a whole host of hybrid animals and chimeras. A few from *The Garden of Earthly Delights* are shown below, including a two-legged dog, a crocodile-bird, a turtle with antlers, a three-headed lizard and a white amphibian with insect-like feelers. This showed remarkable imagination for medieval times.

While modern zoology does indeed feature hybrid animals, like a grolar bear, a zorse, a beefalo, a wholphin or a liger, it will take a while for natural breeding to catch up with Bosch's fantasy world.

(CREDIT: Bosch)

Animal Patterns

Building on the previous section, another area of interesting overlap between art, nature and science can be found in animal patterns. Artists and designers have been fascinated by these patterns for millennia, and similarly scientists have long pondered why certain animals have such distinctive visual patterns – including spots, stripes, patches, scales, iridescence and in some animals, changing patterns in real-time. Some diverse examples of patterning are shown below, including a spotted tropical fish and a stripy tabby cat.

(CREDIT: Knowable Magazine)

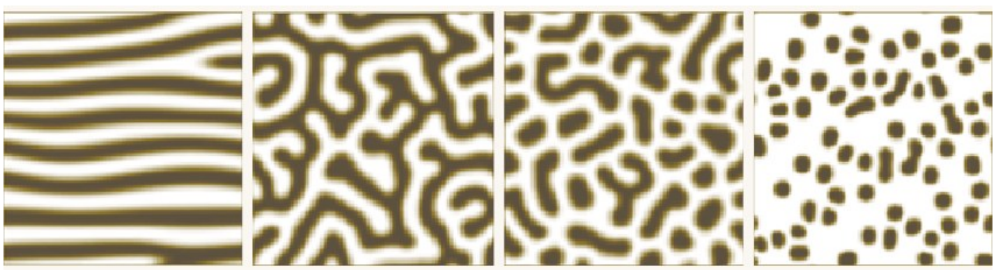
(CREDIT: imogenisunderwater)

(CREDIT: cats.com)

Alan Turing was one of the first scientists to directly work on the underlying mechanisms of pattern formation in animals. He developed a diffusion-based model to explain the transition from lamellar stripes, to random stripes, to broken patches to spots. Using his reaction–diffusion model, proposed in his 1952 paper *"The Chemical Basis of Morphogenesis",* Turing suggested that complex biological patterns could arise spontaneously from the interaction of simple chemical substances (which he called morphogens) that:

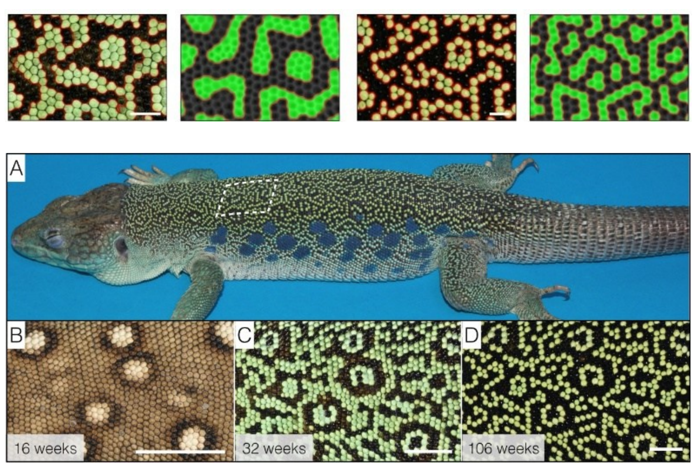
1. *React* with each other (chemical reactions) and
2. *Diffuse* through space (spread out over time).

Even if the system starts uniformly (say, with equal concentrations everywhere), small random fluctuations can grow into stable, repeating spatial patterns — a process called a Turing instability. Some examples of that process are shown in the diagram below, which look remarkably realistic of animal patterns.



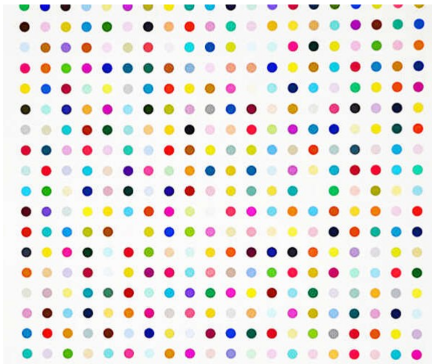
(CREDIT: Mike Paulin)

In a similar but more recent study of animal patterns, researchers in Switzerland have developed a new type of reaction-diffusion model. Combining work by Alan Turing with work by John von Neumann, they developed a cellular automaton that can mimic the same stripy labyrinthine patterns as a lizard, which evolves with time. This is another great example of visual art, nature and science coming together.



(CREDIT: Nature, Milinkovitch et al)

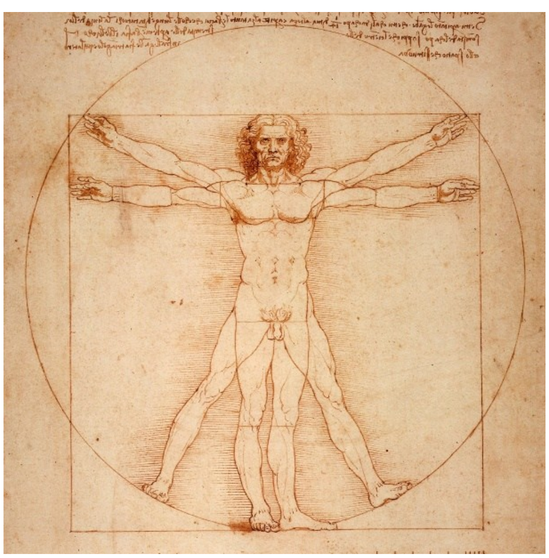
Seeing these developments, one can appreciate why artists, like Damien Hirst (below), have spent most of their careers fascinated by the patterns we see in nature, including spots and stripes.




(CREDIT: Damien Hirst)

Anatomy & Dissection

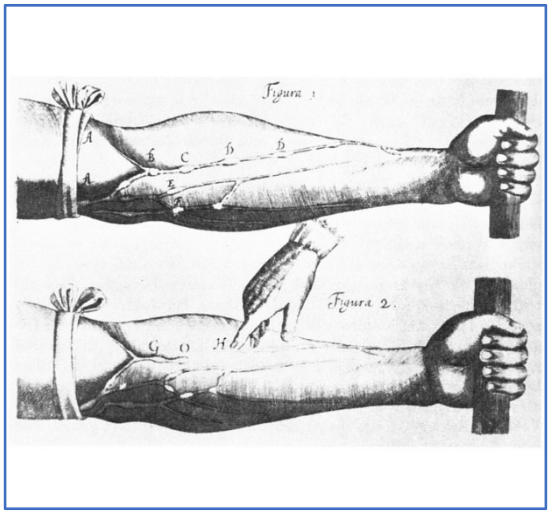
One of the earliest mergers between art, nature and science appeared in Renaissance Italy in the 1500s, notably by Da Vinci and Michelangelo. Da Vinci's *Vitruvian Man* is still considered a masterpiece in anatomical drawing, with its focus on bodily proportions and ratios; while the 3D equivalent of *David* by Michelangelo pushed the study of anatomy to whole new levels of science and artistic beauty.



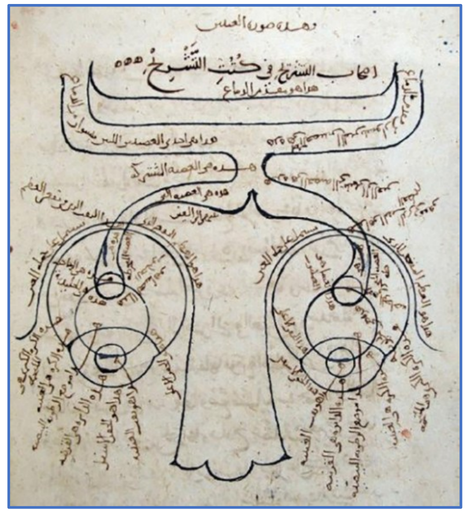
(CREDIT: Da Vinci)

(CREDIT: Michelangelo)

The physicians William Harvey and Alhazen also used dissection, anatomy and drawing as a way of studying and understanding the human body, leading to major discoveries such as blood flow (below - left) and eyesight (below - right), respectively.

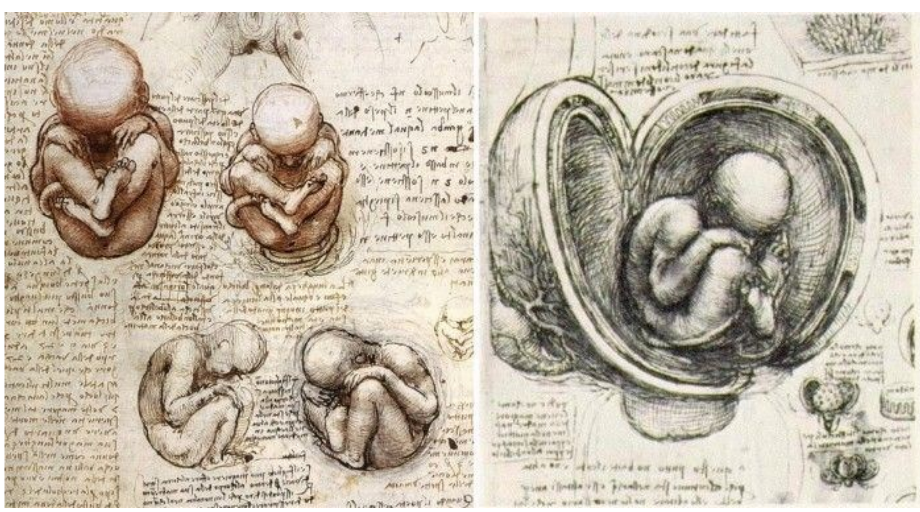


(CREDIT: Harvey)



(CREDIT: Alhazen)

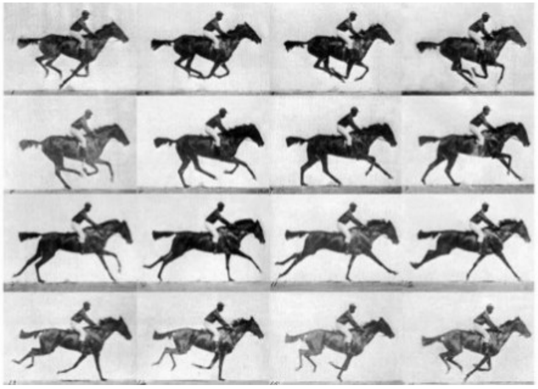
In addition to Vitruvian Man, with its external analysis of the human body, Da Vinci also spent several years performing detailed dissections and drawings of internal organs like the heart. He was one of the first people to appreciate the atria structure of the heart and its valve system. Moreover, he is probably the first person ever to draw a foetus in the womb, in astonishing detail (see below).



(CREDIT: Da Vinci)

Time & Motion

Chronophotography is an interesting area to explore next. In 1878, Eadweard Muybridge pioneered a new way of recording successive photographs of a galloping horse (see below). This was a world-first and it unlocked an understanding of equine motion – something not known until then. Again, science was now giving us a new way of seeing the natural world, which in turn gave rise to new artistic movements.



(CREDIT: Eadweard Muybridge)

Bringing this new time-resolved perspective into the art world, Marcel Duchamp painted several paintings that create a sense movement, like his piece (below - left): *Nude Descending a Staircase*. Similarly, Robert and Sonia Delaunay experimented with rotational motion in the whirling propellers of early aircraft (below - right).

(CREDIT: Duchamp) (CREDIT: Delaunay)

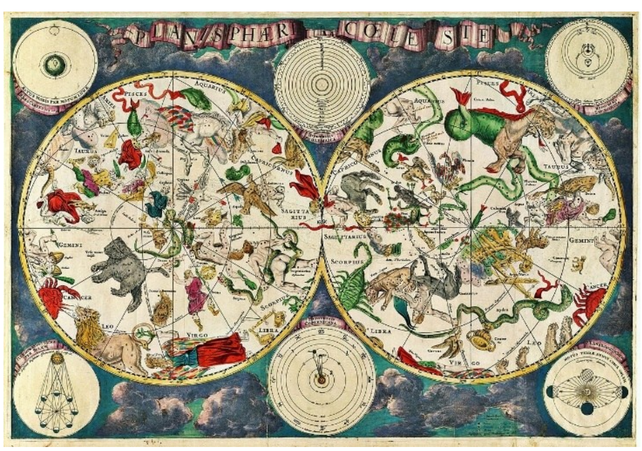
On the other hand, elongated blurry brush-strokes give a clear sense of motion in Franz Marc's painting of a running dog (bottom - left). Even in photographic art, chronophotography is being actively used by artists like Jean-Yves Lemoigne to study the movements of athletes and dancers (bottom - right).

(CREDIT: Marc)

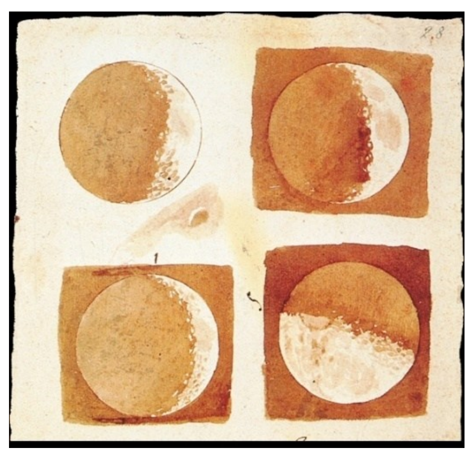
(CREDIT: Jean-Yves Lemoigne)

Astronomy & Space

Looking at the night sky and stars has always been a source of awe and wonder for humans. From Greek and Roman times, we have imagined shapes and patterns in the stars, giving rise to constellations like the Plough, or Orion's belt, or the twins of Gemini. Early celestial maps like the one here (below - left), from 1670, were considered great works of art in themselves. The drawings of Galileo were also very impressive, in particular the phases of the Moon (below - right) and his drawings of Saturn's rings and moons.



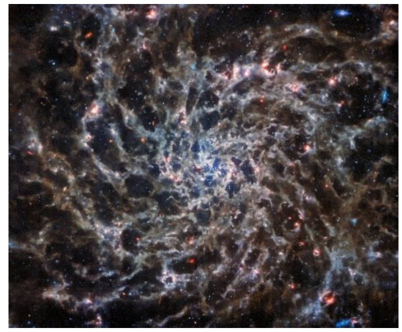
(CREDIT: de Wit)



(CREDIT: Galileo)

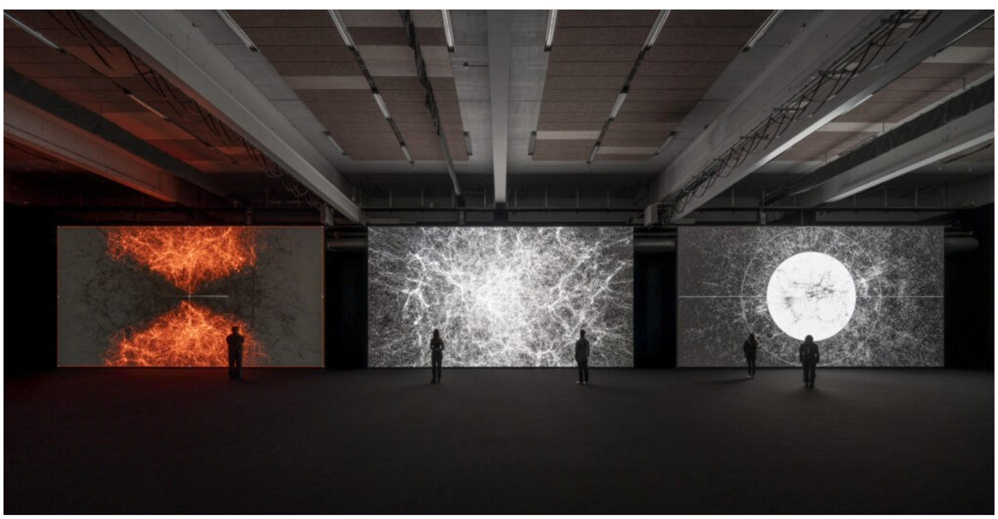
More recently, in the modern age of satellites and sophisticated telescopes like the Hubble and James Webb Telescopes, we are now able to see even further into the night sky, observing vast gas clouds, spiral galaxies and black holes with incredible resolution (below).

(CREDIT: NASA, Hubble)



(CREDIT: ESA, James Webb)

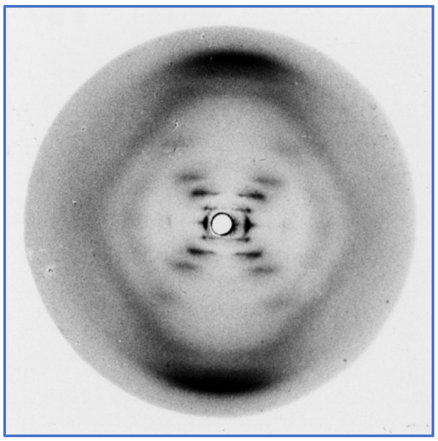
These scientific developments are triggering artists to conceive massive audiovisual installations in galleries, such as the abstract landscapes by Japanese artist Ryoji Ikeda (below).



(CREDIT: Ikeda)

DNA & Genetics

When the structure of DNA was revealed in the 1950s by Franklin, Crick and Watson, this had a big influence on the art world. Franklin's diffraction pattern 51 (below - left) was the key experimental data for understanding the structure. The unusual shape of life's molecule was then identified to be a double helix which joins various protein molecules together (below - right).

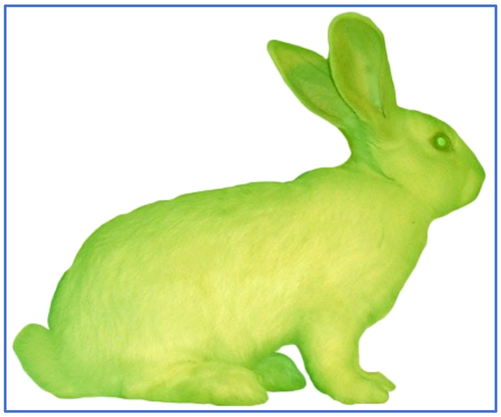


(CREDIT: Franklin)

One of the first artists to pick up on this fascinating breakthrough was Spanish artist, Salvador Dalí (see below). He tried to visualise molecules and their 3D structure in his elegant stereoscopic artwork from 1973.

(CREDIT: Dalí Foundation)

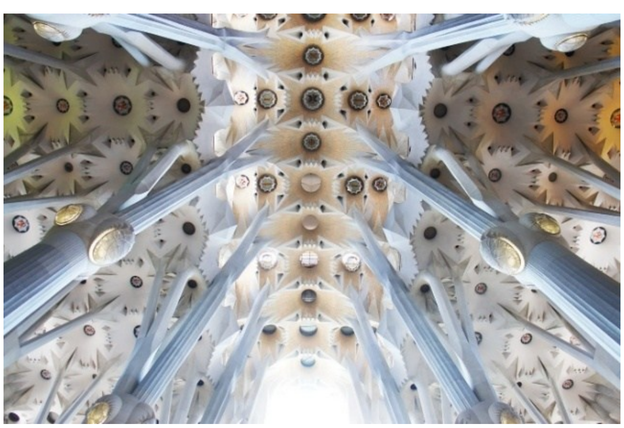
Taking DNA and genetics to another level, Brazilian artist Eduardo Kac, in 2000, modified the genetic makeup of an albino rabbit by introducing the genes of a fluorescent jellyfish to make the rabbit glow green when exposed to blue light. This triggered a sensation in the media and many debates about the ethics of "bio-art". More benign forms of underwater bio-art can also be found in the later section on ecology.



(CREDIT: Kac)

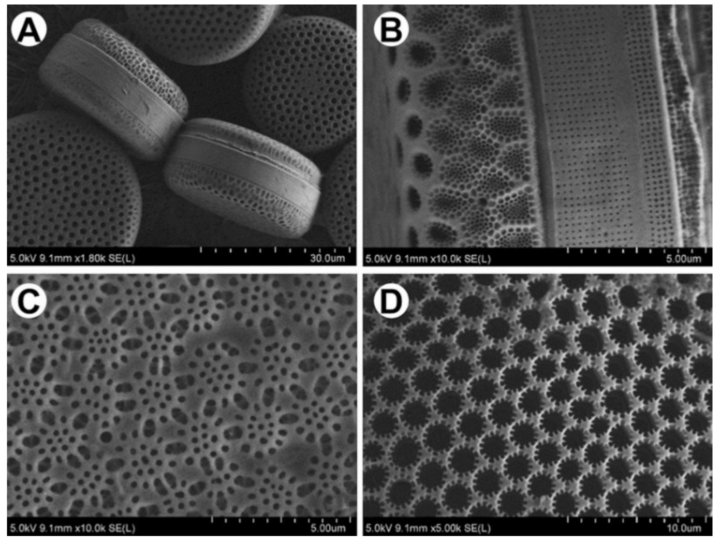
Organic Structure

The organic structures of Gaudi, in particular the buildings at *Park Güell* and *Sagrada Familia* (below - right) are beautiful examples of his natural architectural style. Chambers, rounded beams, holes, curves and branching (below - left) give a unique style that few have been able to replicate.



(CREDIT: Gaudi, Rocheleau)

However, when it comes to organic shapes and structures that maximise stiffness and minimise weight and material usage, nature is almost always there first. Recently, microscope work on *diatoms* (miniature living creatures in the oceans) have revealed structures highly reminiscent of Gaudi's towering spires and open lattices – albeit on a microscopic length scale (below).



(CREDIT: Science Photo Library, Gschmeissner) (CREDIT: Nature, Zglobicka et al)

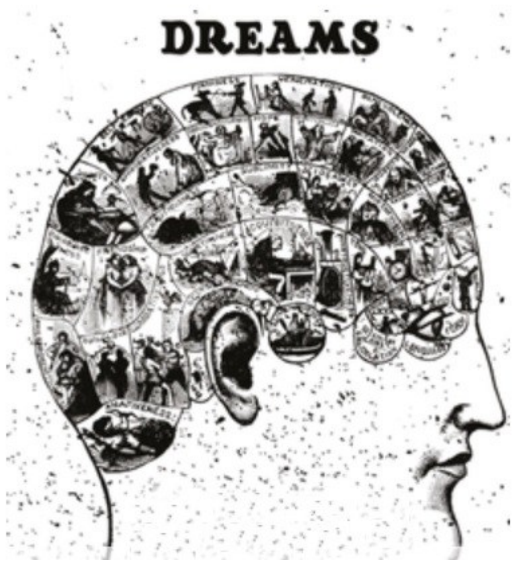
Other open structures like *geodesic domes*, invented by American architect Buckminster Fuller, have given us new ways of making large structures and buildings (below - left). Interestingly, the bridge between art and science was united once again, when in the 1980s a new form of carbon (C_{60}) was discovered with its 60 atoms of carbon forming a perfect geodesic sphere – now called buckminsterfullerene (below - right). This won the Nobel Prize for Chemistry in 1996.

(CREDIT: Buckminster Fuller)

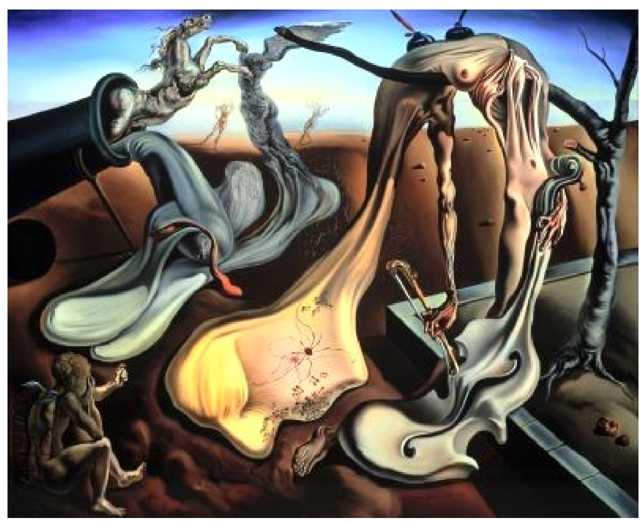
Psychology & Neurology

At the turn of the 20th century, the brain and the mind were being studied by scientists for the first time. Sigmund Freud initiated the topic of psychoanalysis with his book the *Interpretation of Dreams*, which led to a deeper exploration of the unconscious mind and thoughts (below - left).

At the same time, artists like the surrealists Salvador Dalí and René Magritte were exploring the dream-like state in their paintings. Dalí famously used to doze off in a chair, just prior to drawing, so he could capture what was in his unconscious mind. The hallucinatory symbolism of melting forms, liquified clocks and impossible landscapes blurred the boundary between waking reality and the world of sleep (below - right). In essence, Dalí was a dreamer who turned dreaming into a profession.

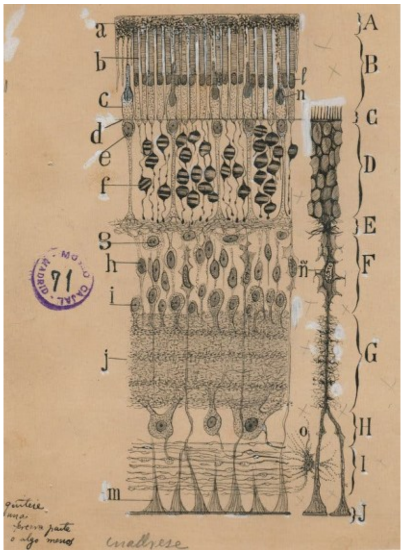


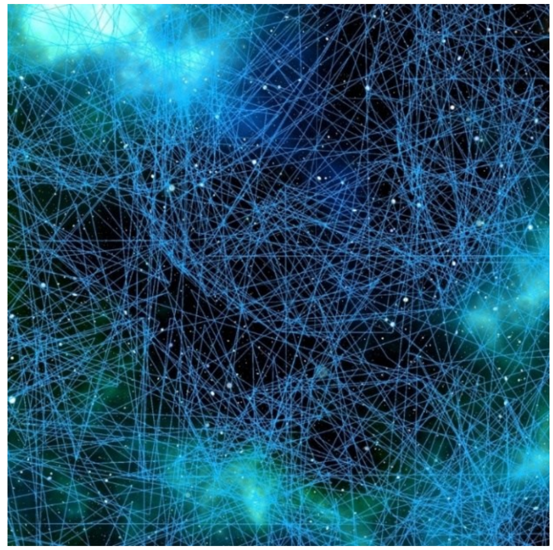
(CREDIT: Freud)



(CREDIT: Dalí Foundation)

At a very similar time to Freud and Dalí, the Spanish scientist Ramón y Cajal was using his microscope to look at brain cells for the first time. He perfected a dye-staining technique that allowed him to visualise and draw the structure of neurons in unprecedented detail. Ramón y Cajal had artistic flair and great patience and he captured hundreds of images of these complex networks (see below - right). This led to the important neurological concept that the brain was a giant neural network of individual neuron cells connected by synapses – something that is now replicated computationally in the form of *artifical intelligence* (AI). Again, we see art, nature and science working in unison.

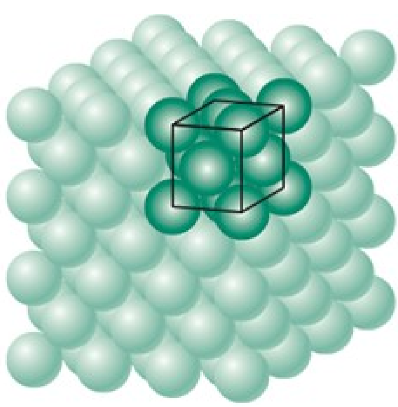




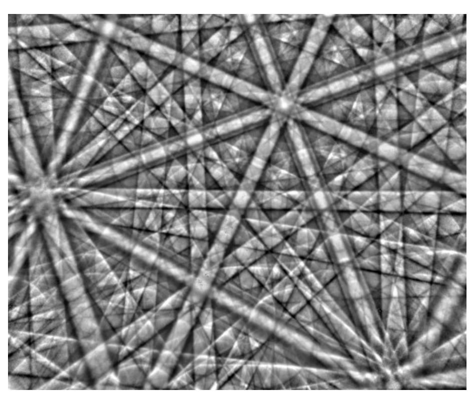
(CREDIT: Ramón y Cajal)

Atoms & Crystals

As the 20th century progressed, major breakthroughs were being made in the field of materials and crystallography. Understanding how materials and crystals formed were important to engineering, metallurgy, geology and science in general. By the 1960s, techniques like X-ray crystal diffraction and electron microscopes were being used regularly to penetrate materials and reveal their inner structure – right down to the atomic level. The close packing of atoms in crystal lattices was discovered (below - left), as well as crystal orientation using EBSD Kikuchi lines (below - right), reminiscent of Picasso and Braque's cubist deconstructions in art.



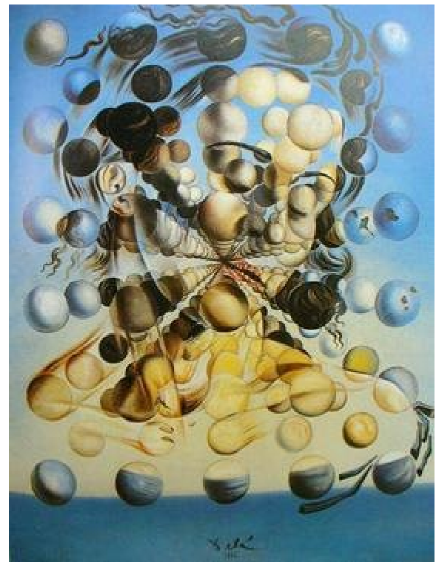
(CREDIT: Callister & Rethwisch)



(CREDIT: Oxford Instruments)

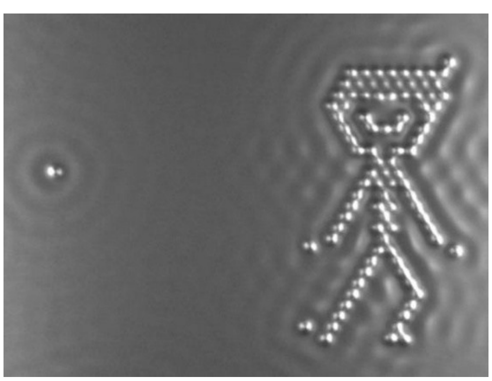
Artists, sculptors and architects were quick to pick up on these new discoveries. The *Atomium* sculpture in Brussels, with its body-centred cubic structure accurately represents the precise arrangement of atoms in a crystal of iron (below - left). Dalí, again, was inspired by these structures and painted a number of 'atomic' pieces, such as *Galatea* in 1952 (below - right).

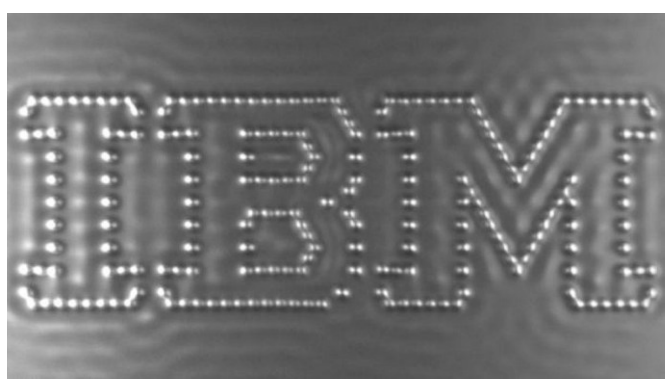
(CREDIT: Atomium, Brussels)



(CREDIT: Dalí Foundation)

Scientists working at IBM in California took art, nature and science to a new level when they used a scanning tunnelling microscope to place and move molecules of carbon monoxide on a flat surface of copper. With careful manipulation at the nano-scale, they created a short film of a boy kicking a football. This is officially the smallest piece of art ever made – proving that even nanotechnologists need to have a bit of fun.

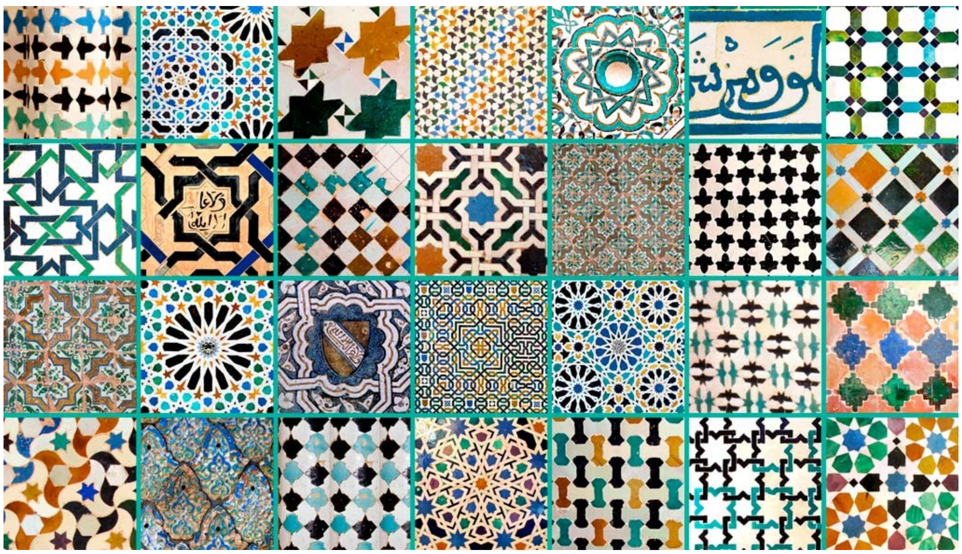




(CREDIT: IBM)

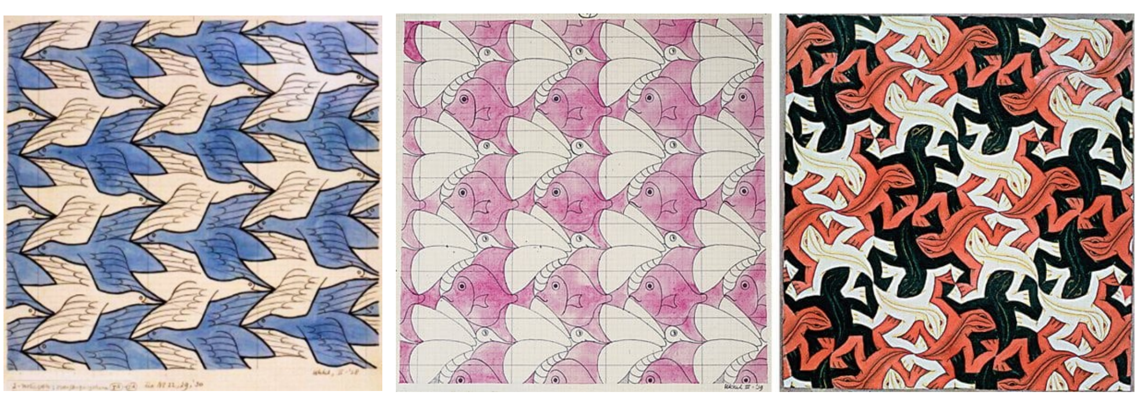
Mathematics & Geometry

A rich source of inspiration for humans has always been mathematics, and geometry in particular. The way that shapes can be drawn and fitted together (*tessellation*) fascinated philosophers in Ancient Persia and Ancient Greece alike. The Alhambra in Granada, Spain is a great example of geometric pattern-making (below), with hundreds of different tile designs adorning the walls of the ancient palace.



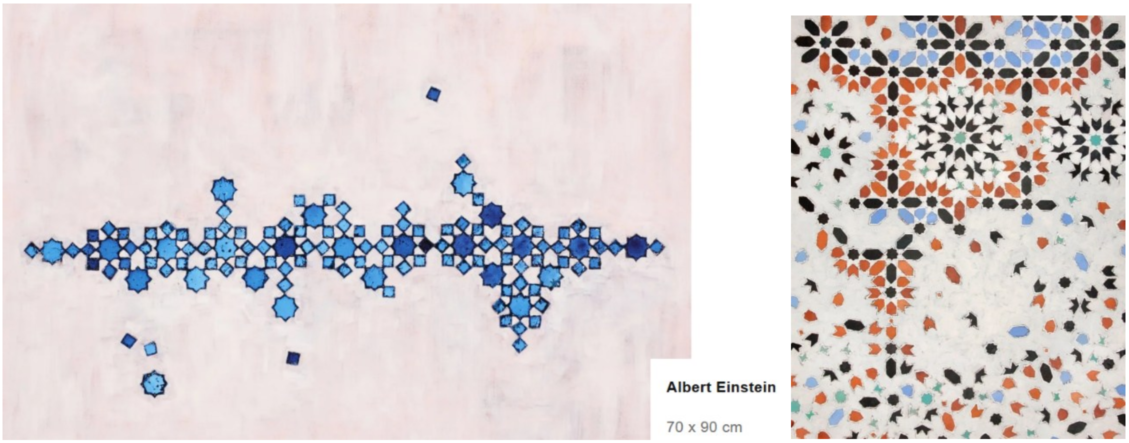
(CREDIT: Alhambra, Andalusia Travel)

Many artists have drawn inspiration from these patterns and the Dutch artist MC Escher eventually turned them into a mathematical paradox with tessellations of animals. Some wonderful examples of flying birds, butterflies, fish and interconnected lizards are shown below.



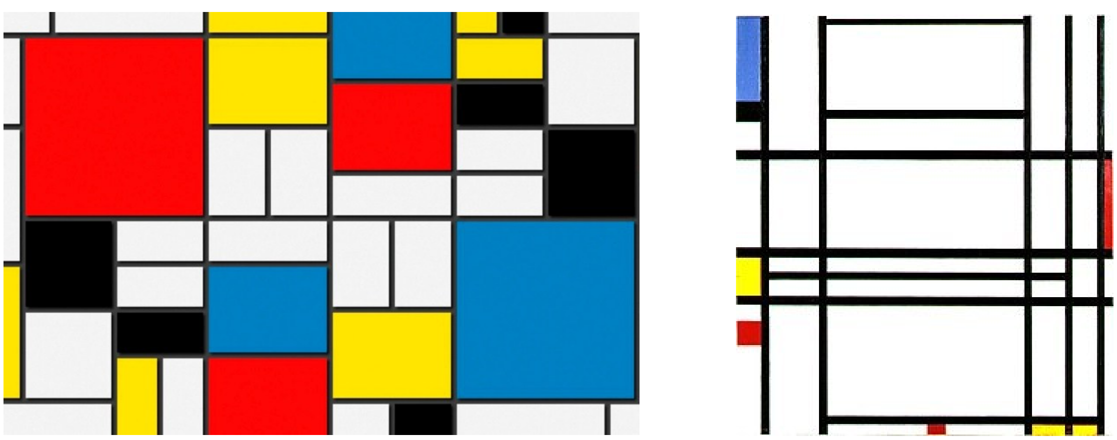
(CREDIT: MC Escher)

Most recently, the British artist John Squire (and lead guitarist of the Stone Roses) developed an Alhambra-style of painting in his works entitled, *Albert Einstein* (below).



(CREDIT: Squire)

Another Dutch artist Piet Mondrian was also inspired by geometry and shape, by making tessellations of brightly-coloured rectangles. His 1930s artwork (below) was abstract and minimalist, and represented a *Modernist* culture, similar to *Bauhaus* architecture in Germany at the time.



(CREDIT: Mondrian)

Another blend of mathematics and art can be seen in the recent work by Prof. Erik Demaine from MIT. He makes computer-designed *origami* art pieces (see below) – a totally new form of 3D art aided by science and computing.

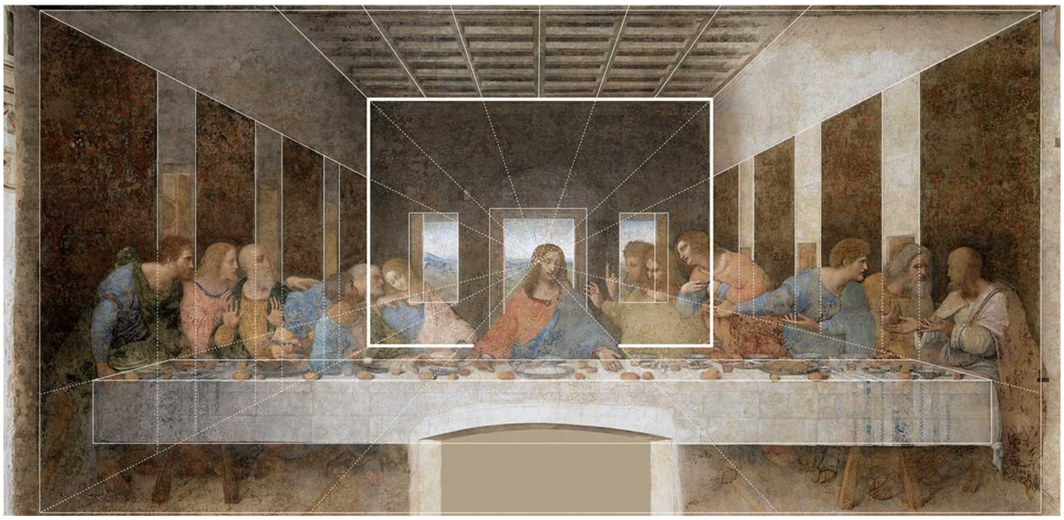
(CREDIT: Demaine)

Perspective

Historically, it is interesting to mention the development of perspective and vanishing points in art. During medieval times, the only way to draw paintings was to draw them flat, without any sense of depth or perspective. Brunelleschi in Renaissance Italy saw things differently and in 1420 he developed a scientifically-based system of vanishing points that allowed paintings to look significantly more realistic, now with a sense of depth (below). This revolutionary new method took off and medieval flatness was finally relegated.

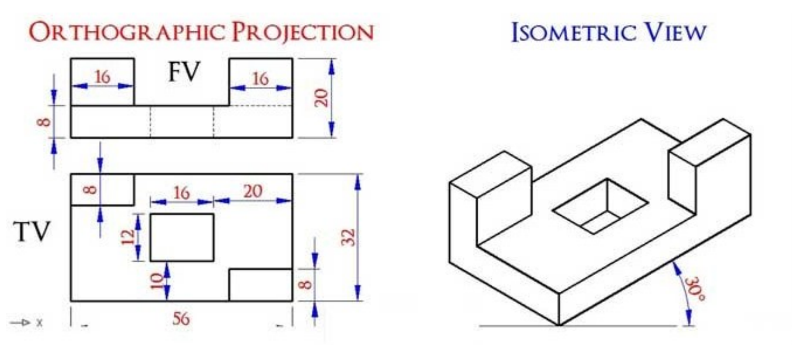
(CREDIT: Brunelleschi)

Almost a century later, Leonardo Da Vinci employed perspective as a key feature in many of his paintings, most famously in his piece *The Last Supper* in Milan, Italy (below). As shown below, the vanishing point is just behind Jesus's head and the lines of the walls and ceiling guide the eyes to that point - creating a distinct feeling of realism.



(CREDIT: Da Vinci)

These techniques of turning a 2D surface into a 3D representation are used all the time in the design and engineering world today. The whole basis of draughtsmanship is to represent solid objects in 3D form, often in isometric view, as well as face views and top views for extra information (below). With the advent of *computer-aided design* (CAD) in modern design bureaux, perspective and 3D rendering are certainly here to stay and have become an indispensable tool for engineers and artists alike.



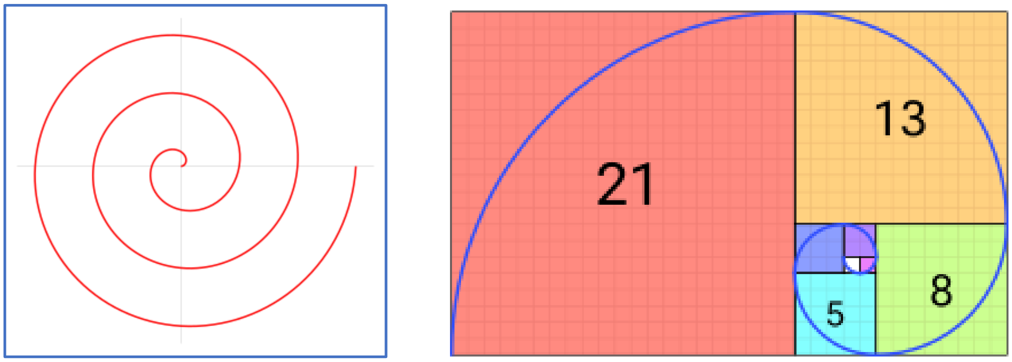
(CREDIT: Roy)

Spiral Geometry

One specific shape that appears a lot in nature is the spiral. It appears naturally in sea creatures like the shell compartments of nautilus and ammonites (below - left), in the tail of chameleons (below - right), in the tips of fern plants, in coiled-up millipedes and many other unusual places. It is little wonder that spirals have fascinated scientists, architects and artists over time. As shown below, ancient rock art from 3200 BC in Ireland featured spirals, as did more recently the staircase of the Vatican Museum in Rome.

(CREDIT: Harding)

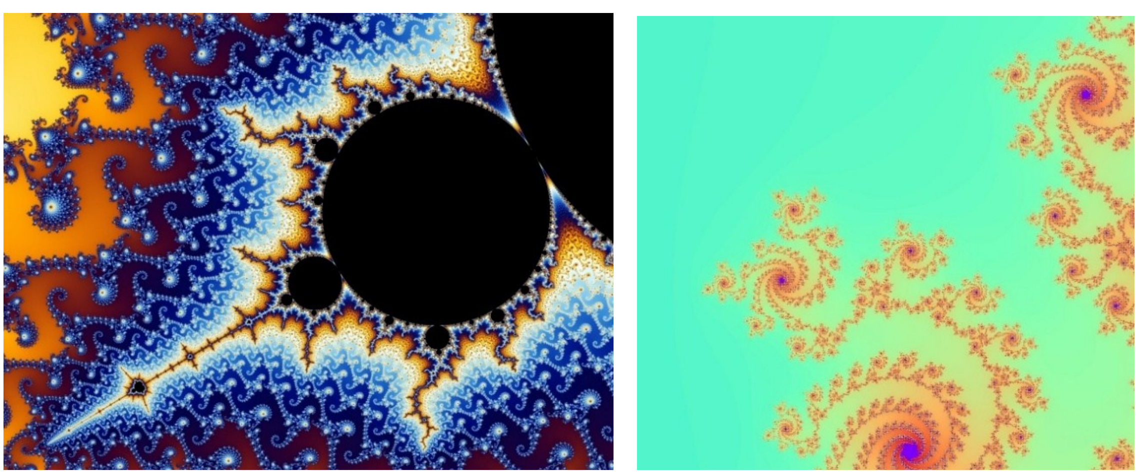
Spirals have inspired awe for thousands of years amongst mathematicians. The *Archimedean spiral* (below - left) was first described in 300 BC, and the *Fibonacci spiral* (below - right) came a millennium later. Interestingly, one can see that the areas of the squares follow the Fibonacci sequence (1, 1, 2, 3, 5, 8, 13, 21, 34, 55…) and this is an example of a logarithmic spiral. The ratio of these areas eventually converges to the *golden ratio* $\Phi = 1{,}618034$. Numerous artists and architects, including Michelangelo, Salvador Dalí and Le Corbusier, have used the golden ratio in their works, owing to its aesthetically pleasing effects.



(CREDIT: Romain)

Chaos & Fractals

At the start of the 1900s, mathematicians like Henri Poincaré were making great strides in understanding chaotic systems in physics. Later work by Lorenz and then eventually Mandelbrot brought chaos theory into the mainstream. In the 1980s, when Mandelbrot discovered his computer algorithm for generating *Mandelbrot sets* (below) a completely new shape was born - a *fractal*. This shape was highly unusual because it had a finite area, but an infinitely long perimeter on the outside edge. In fact, when you keep zooming in to a fractal it always looks the same.

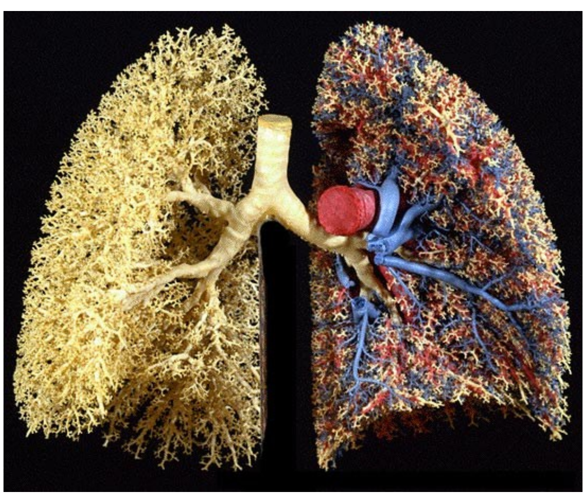


(CREDIT: Mandelbrot)

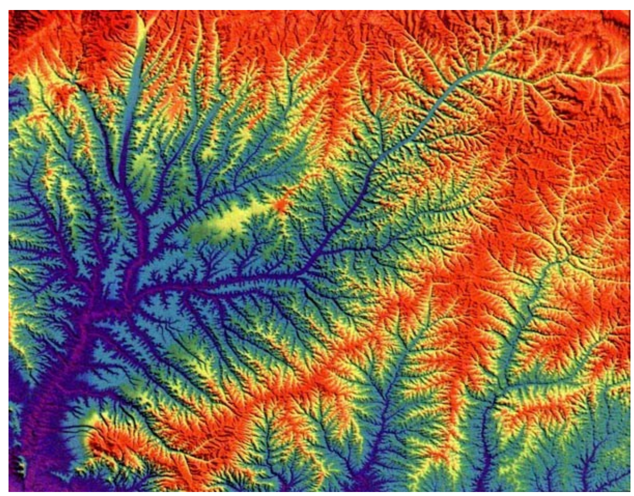
It was soon discovered that fractals appeared everywhere in the natural world. They emerge in cloud shapes, in snowflakes, in broccoli, in coastlines, in wave formations, in river drainage patterns and in the branching of alveoli in the lungs. Some examples are shown below, in art and in real-life.

(CREDIT: Hokusai)

(CREDIT: Wired)

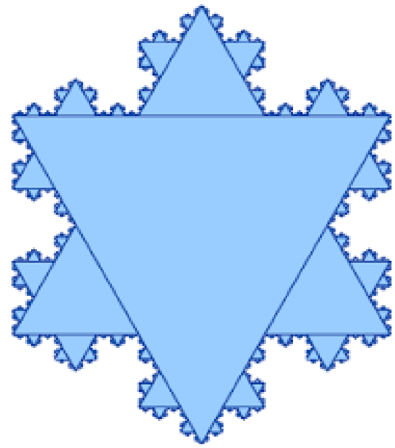


(CREDIT: Weibel)



(CREDIT: Malamud)

(CREDIT: V&A Museum)



(CREDIT: Koch, Encyclopedia Britannica)

While Da Vinci did not explicitly mention fractal shapes in his notebooks, he was very much interested in the natural chaos, turbulence and fractal geometries one can see in nature. He made careful observations of water flowing in rivers and waterfalls, drawing these turbulent patterns of large waves turning into smaller vortices. These are phenomenally detailed and fractal-like when one zooms in: more evidence of art, nature and science blending together.

(CREDIT: Da Vinci)

Geology & Geography

The natural world also includes geological and fossil records, and these too have been a source of inspiration for artists and scientists. As we've just seen, spirals occur in the fossilised remains of ammonites (below - left). This particular example is somewhat fractal with large spirals nesting smaller and smaller spirals. Similarly, the deposition of manganese oxide in rock fissures can lead to dendritic growth patterns (below - right). Even though this looks like a fossil of a former living plant, it is in fact totally inanimate and produced by chemical and physical reactions rather than biological ones.

(CREDIT: ammonites.com)

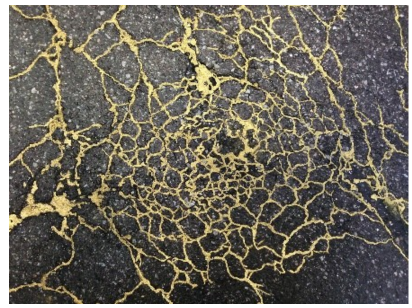
(CREDIT: Sandatlas.org)

More unusual patterns can be found when looking at the hexagonal basalt columns in volcanic rock plugs, such as Giant's Causeway in Northern Ireland. These giant rock formations have a *cubist* structure (below - left). Likewise, the random, cracked patterns on the surface of freezing lava (below - right) have a very pleasing aesthetic quality.

(CREDIT: giantscausewaytour.com)

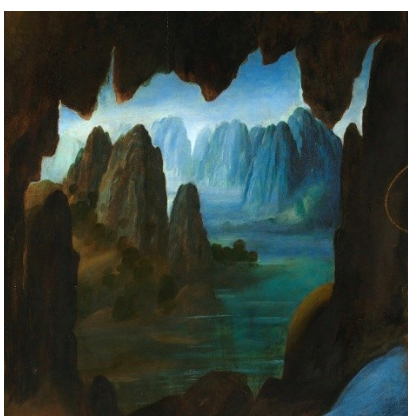
(CREDIT: Shutterstock)

With an abundance of interesting shapes and forms in the geological world, it is no surprise that artists can be inspired to paint, photograph and turn them into art. Photographer and artist Rachel Sussman has done several exhibitions involving rock formations including *stromatolites* in Western Australia (below - left) and alien-like plants in the Atacama Desert, Chile (below - middle) and cracked rock patterns (below - right).



(CREDIT: Sussman)

The art world is full of wonderful examples of rock formations and mountain landscapes. Da Vinci was fanatical about unusual mountain forms, as can be seen in his piece "*Virgin of the Rocks*" (below - left) from around 1500. In the modern era, British artist David Hockney has been inspired by the Californian mountains and coastline in his colourful piece "*Pacific Coast Highway and Santa Monica"* in 1990. In both cases, natural beauty has been captured on canvas.

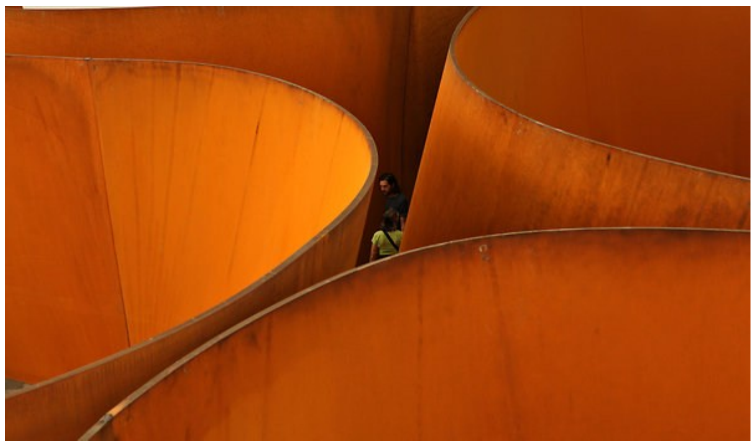


(CREDIT: Da Vinci)

(CREDIT: Hockney)

Metals

While watercolour and oil paintings are still very common in the art world, some artists like to experiment with new methods and materials. The use of '*metallic canvases*', made of copper and steel for example, have been trialled in recent years. In his 1978 creation, Warhol used the random chemical oxidation of copper as a way of generating art. These art pieces are still corroding and changing colour to this day (below - left). Richard Serra has also experimented with oxidation and pickling of large steel panels, making bright-orange giant structures like the one at the Guggenheim Museum in Bilbao (below - right).



(CREDIT: Warhol Foundation) (CREDIT: Serra, Guggenheim)

The ancient Japanese method of *Mokume-Gane* is also worth noting. This is a forging technique where two different metals are forged together into a laminated billet and further deformed to make randomised stripy patterns. Polishing, pickling and chemical etching brings out the colour difference even more, as can be seen in the two examples below. *Mokume-Gane* jewellery and kitchen knives have become very sought after in recent years.

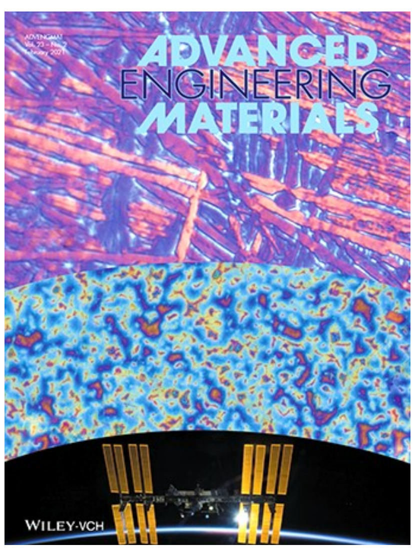
(CREDIT: Brisa) (CREDIT: Jacob)

Stainless steel is also of great interest in the art world because it can be polished to a mirror, creating shiny sculptures such as those created by Jeff Koon (below - left) and Andy Warhol (below - right).

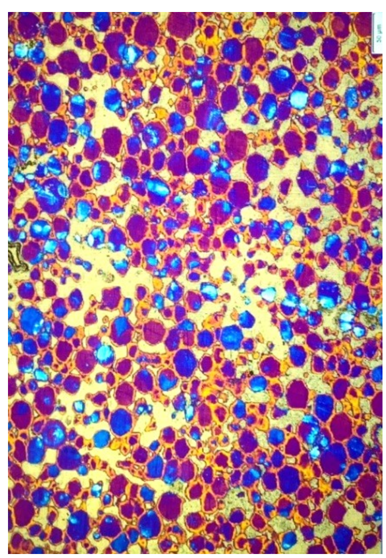
(CREDIT: Koons)

(CREDIT: Warhol Foundation)

The author has also experimented with pattern formation in titanium and zirconium alloys. In the examples below a novel heat tinting method was developed to bring colour to the surface of the metal. The etched titanium alloy was chosen as the front cover of a prominent journal in 2021 (below - left). Meanwhile, recent metallographic work on zirconium composites has led to even more striking visual patterns under the optical microscope (below - right), with a vivid mixture of blue, red, purple and yellow circles.



(CREDIT: Wiley, Jarvis)



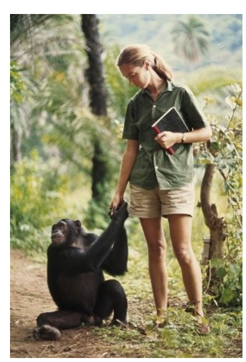
(CREDIT: Jarvis)

Ecology & Conservation

The topics of environment and biodiversity have become increasingly important in recent times. The period from 1960-1975 was crucial for ecology in the minds of the public. The Moon landings had given us a unique perspective of Planet Earth as a 'pale blue dot' with a fragile ecosystem. The Gaia hypothesis by James Lovelock showed that the planet's physical systems of soil, ocean, and atmosphere were much more interconnected than we thought. Meanwhile, Jane Goodall was observing and living with chimpanzees, putting a strong emphasis on conservation work and protecting species and their habitats. This became a major theme for some artists, including Warhol who made a portfolio called *Endangered Species* in 1983 (below).

(CREDIT: Warhol Foundation)

In order to document the work of Jane Goodall, Dutch filmmaker and photographer Hugo van Lawick (who became her husband) was sent to Tanzania. Through his still photographs and films, published by National Geographic, van Lawick helped to popularise the study of chimpanzees. In turn, this helped create awareness of the ecosystems in which apes in Africa live and how fragile these habitats are.



(CREDIT: van Lawick, National Geographic)

In a similar vein, the oceans are undergoing considerable changes in temperature and acidity due to global warming. This puts pressure on all sea life, in particular coral reefs and fish. To create awareness of oceanic ecosystems, the British sculptor Jason deCaires Taylor has built the first underwater sculpture park in the Caribbean, off the west coast of Grenada (see below). Working together with marine biologists and conservationists, Taylor is integrating contemporary art with an ecological message aimed at saving our ocean's biodiversity and rehabilitating the coral reefs.

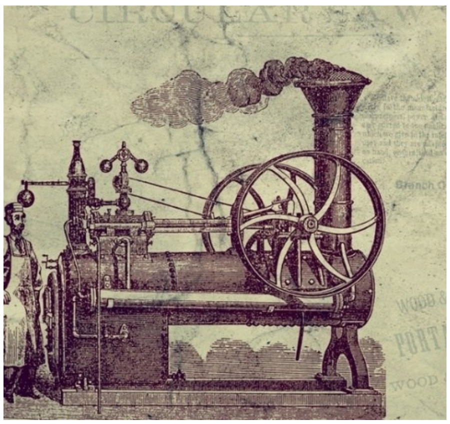

(CREDIT: de Caires Taylor)

Industrial Revolution

Back in the early days of the Industrial Revolution in the 1700s, concerns were being raised by artists and poets about the ecological damage that industry and capitalism were causing. Cities like London and Manchester became crowded, polluted and smoggy fairly quickly, as coal became the new fuel of choice for homes and factories. One of the first artists to voice concern was William Blake, who lived in London his whole life. As a poet, but also an artistic engraver, he likened industrialisation and urban pollution to *Dante's Inferno* with fiery imagery of hot, smoky furnaces (see below).


(CREDIT: Blake)

As industrialisation continued apace, other artists like the British painter Turner captured the haziness and indistinctness very well with a new style of painting. In 1844, Turner painted an atmospheric masterpiece of industrial art with a painting called "*Rain, Steam and Speed*". This depicted a rain storm and the Great Western Railway engine passing at high speed through the countryside (see below). This was an interesting allegory of the power of nature and the power of technology in one image.



(CREDIT: Turner)

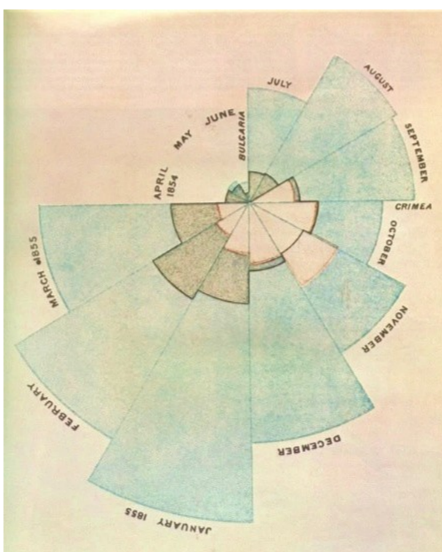
A century later in Paris, the French artist Claude Monet was also fascinated by the industrialisation happening in France at that time. Monet often painted skylines of ports, dockyards and railway stations with clouds of steam, smoke and haziness (see below). He took some of the indistinctness of Turner and turned it into a new art movement called *Impressionism*, which had a huge influence on modern art and on other painters like Renoir, Sisley, Pissarro, Van Gogh, Gauguin, Cézanne and Matisse.

(CREDIT: Monet)

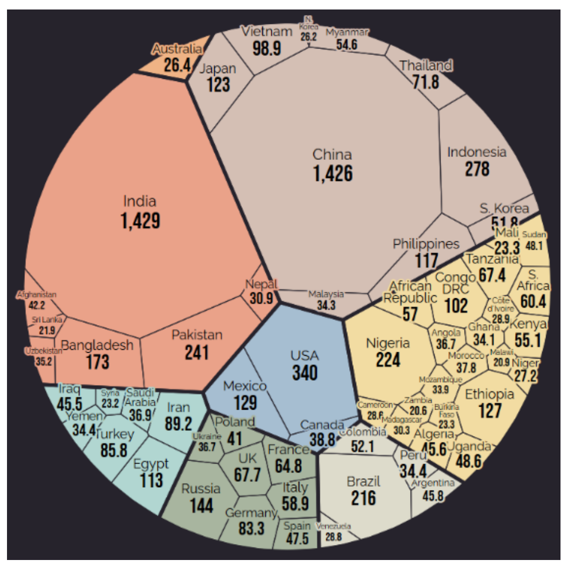
Data Visualisation

In the final section, it is useful to outline some of the ways that artistic visualisation has been used in science communication. Scientific data coming from experiments is often only numbers in a spreadsheet. Finding a way to analyse and interpret that data visually is extremely important in any scientific endeavour. This allows trends to be spotted and statistics to be applied. Importantly it also permits communication with other scientists to discuss the data.

Many graphs and data-plots have been developed over time from bar-charts, histograms, pie charts to scatter graphs. In the mid-1800s, the British nurse Florence Nightingale was gathering data from hospital wards and needed a way to summarise all the data in a quick visual diagram and to communicate that to her hierarchy. Being mathematically inclined, she invented her own pie chart (still used today) and, because of its clear message, it led to action and healthcare reform (below - left). Data visualisation is improving all the time and the website "*Information is Beautiful*" shows many examples of artistic yet scientifically-valid charts, including population distribution in the world (below - right).

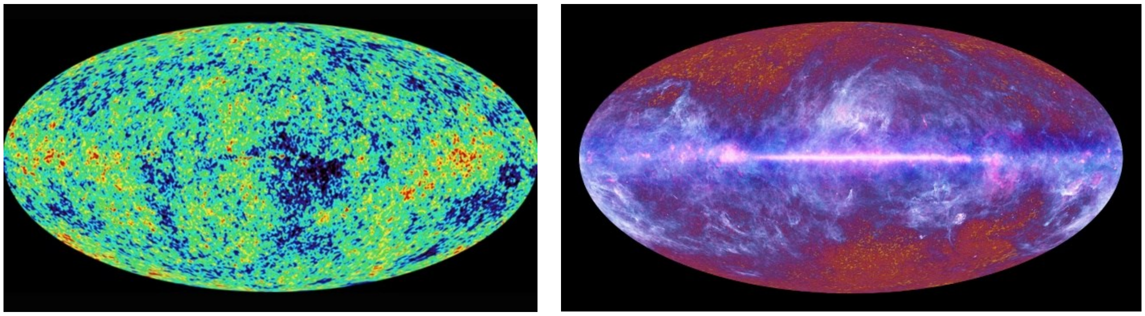


(CREDIT: Nightingale)



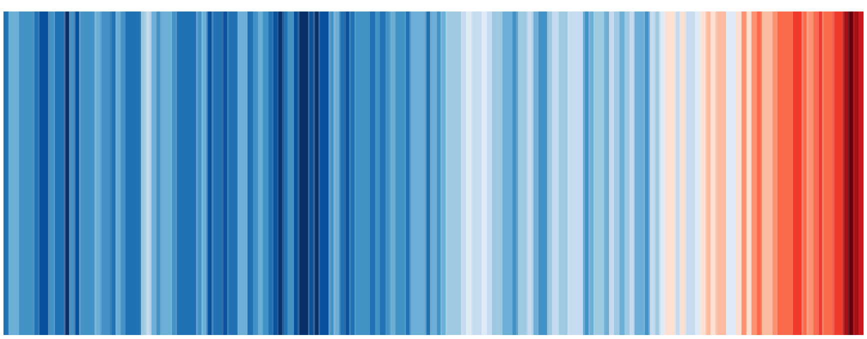
(CREDIT: Informationisbeautiful.net)

In the completely different field of space science, satellites acquire vast amounts of data and need some convenient way of visualising the data. One of the ESA space missions in 2009, was called Planck, and it measured the microwave radiation coming from deep space. This data tells us how the Universe came to life after the Big Bang. The mission scientists needed a way of explaining the data to the public, who ultimately were paying for the mission, and they devised *sky map* plots (see below) to show the uneven distribution of background microwaves – the ancient echoes from the Big Bang itself.



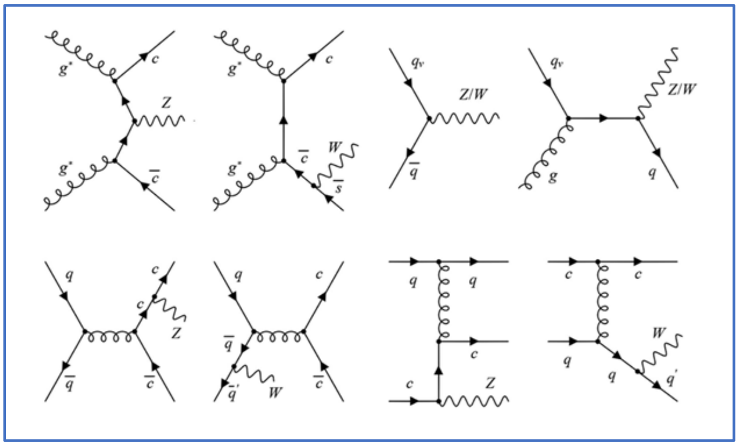
(CREDIT: ESA)

Even more iconic is the next chart which shows the average temperature on Earth from 1850 on the left to the present day on the right. Just by using simple blue and red shades in the style of a barcode, the British climate scientist Ed Hawkins created a simple yet elegant plot showing the progressive temperature increase we are witnessing with anthropogenic climate change (see below). Note that the graph has no numbers or data at all, yet is fully understandable once the context is given.



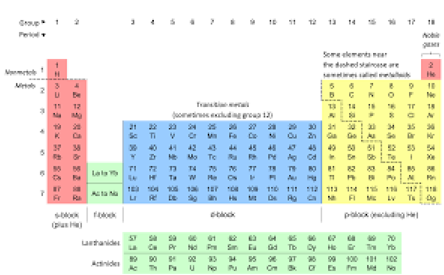
(CREDIT: Hawkins)

Another example of good visualisation of information is the way that Richard Feynman, the quantum physicist, was able to draw diagrams of processes that were happening inside atoms at the level of quarks. Quantum physics is a difficult field of research, by any standards, but *Feynman diagrams* made it more accessible. The interaction of subatomic particles is depicted by solid and curly lines, with vertices and arrows representing collisions, spin and the flow of time – which can go forwards and backwards. By visualising the particle-particle interactions in a diagram, it was no longer necessary to display it as a huge mathematical equation. This helped teach the subject to students at university and made scientific conferences a lot easier by giving a visual language to quantum processes. Feynman won the Nobel Prize in Physics in 1965 for these contributions.



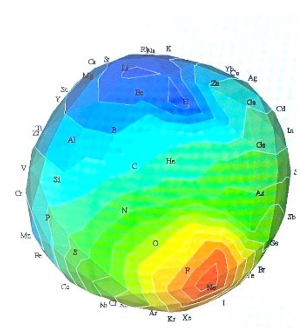
(CREDIT: Feynman)

The final thought on visualising science is the example of the *Periodic Table of Chemical Elements*. Having initially devised this in 1869, Mendeleev managed to put some order to the rather chaotic array of known chemical elements. Cleverly, Mendeleev left blanks where he thought new elements would eventually be discovered. His systematic ordering of elements into the iconic Periodic Table (below - left) is one of the best examples of visualisation in chemistry and has stood the test of time. Other efforts are emerging to display the same information in spiral form (below – middle) and the author's own effort to construct a 3D spherical Periodic Table, a *Chemisphere* (below - right).



(CREDIT: Sandbh)

(CREDIT: Longman)



(CREDIT: Jarvis/Brown)

Conclusion

Across centuries, artists and scientists have shared the same goal: to observe, to understand and to represent the beauty of the natural world. By exploring their connections, we cultivate imagination — the bridge between knowledge and creativity.

The *Atlas of Human Imagination* places cross-disciplinarity at its heart, revealing our intellectual heritage as an interconnected narrative rather than a collection of isolated silos. It is hoped that readers will take inspiration from the many fascinating links between the worlds of art and science, and continue to explore the endless dialogue between creativity and discovery.

David Jarvis

Additional Reading

- *"Patterns in Nature"* by Philip Ball
- *"Information is Beautiful"* at: https://informationisbeautiful.net/
- *"Building Science Graphics"* by Jen Christiansen
- *"Visualizations"* by Martin Kemp
- *"Leonardo da Vinci"* by Walter Isaacson
- *"The Chemical Basis of Morphogenesis" by* Alan Turing at: https://royalsocietypublishing.org/doi/pdf/10.1098/rstb.1952.0012
- *"Race Horse - First Film Ever"* by Eadweard Muybridge at: https://www.youtube.com/watch?v=zIQBfQuLXDY
- *"Interdisciplinary STEM education reform: dishing out art in a microbiology laboratory",* by Sarah Adkins et al. at: https://academic.oup.com/femsle/article/365/1/fnx245/4631078

FOR TEACHERS

Using the *Atlas of Human Imagination* in Lessons - 30 Art & Science Projects

I. Life & Biology (The Living World)

1. **Petri Art** — Prepare agar plates and create colourful microbial growth patterns (following local biosafety rules and using non-pathogenic teaching strains).
2. **DNA Sculpture** — Build a 3D double helix from twigs and branches.
3. **Hybrid Beasts** — Imagine and draw mythical animals inspired by *Hieronymus Bosch*.
4. **Animal Pattern T-Shirt Design** — Choose a biological pattern (zebra, butterfly, fish scales) and design vivid wearable art.
5. ***Gaia* Installation** — In groups, design a 3D sculpture symbolising Earth's interconnected systems.
6. **Fossil Casting** — Make your own "fossilised" ammonite using modelling clay.

II. Matter, Chemistry & Materials

7. **Crystal Art** — Grow alum crystals on a string or stick in a beaker.
8. **Mineral Collage** — Collect images of colourful minerals from *Mindat.org* and build a giant mosaic of the best ones.
9. **Rust Painting** — Create oxidised patterns on steel or copper sheet using vinegar and salt.
10. **Geodesic Dome** — Build a miniature Buckminster Fuller-style dome from spaghetti and glue.
11. **Light Spectrum Show** — Use glass prisms to make overlapping rainbow patterns on a white screen, and photograph it.
12. **Camera Obscura** — Build a simple pinhole camera to explore optics and light projection in the style of *Vermeer*.
13. **Chromatography Landscapes** — Use chemical chromatography paper to separate inks into rainbow images.

III. Mathematics, Geometry & Patterns

14. **Fractal Generator** — Use *FractalNow* or online tools to generate digital fractals.
15. **Koch Snowflake** — Draw or code a fractal snowflake with several iterations of triangles.
16. **Fibonacci Spiral** — Construct a spiral from squares and calculate the golden ratio.
17. **Tessellating Tiles** — Design repeating animal patterns in the style of *Escher*.
18. **Origami Geometry** — Fold large-scale geometric origami from A3 sheets.
19. **Geographic Fractals** — Explore *Google Earth* for fractal features in mountains, rivers, and coastlines.

IV. Mind, Perception & Psychology

20. **Neural Networks** — Draw a neuron web and connect it to ideas in computing and AI.
21. **Optical Illusions** — Explore classic illusions and design your own perception trick.
22. **Pixel Portraits** — Pixelate a photo of a face until it becomes abstract and cubist, then re-interpret artistically.
23. **Dream Art** — Record a dream and transform it into a surreal *Dali*-style artwork.
24. **Spot Painting** — Make your own Damien Hirst-inspired pattern using colour and rhythm.

V. Physics, Astronomy & the Cosmos

25. **Star Maps** — Invent and draw new constellations, naming and connecting imaginary stars.
26. **Motion Blur Photography** — Capture motion blur during dance, sport or movement.
27. **Slow-Motion Science** — Record slo-mo videos of dynamic actions (balloon popping, water splash, dance movement).
28. **Feynman Diagrams as Art** — Create visual or abstract renditions of physical interactions.
29. **Data Poster Design** — Visualise global data (e.g., population or energy) using graphing resources available on *Information is Beautiful*.
30. **Chladni Patterns** — Observe what happens when sand particles are vibrated on a speaker and record the patterns that form when sound waves and granular material interact.