For the full, classroom-ready, visual experience, please **send your A1 poster orders here:**

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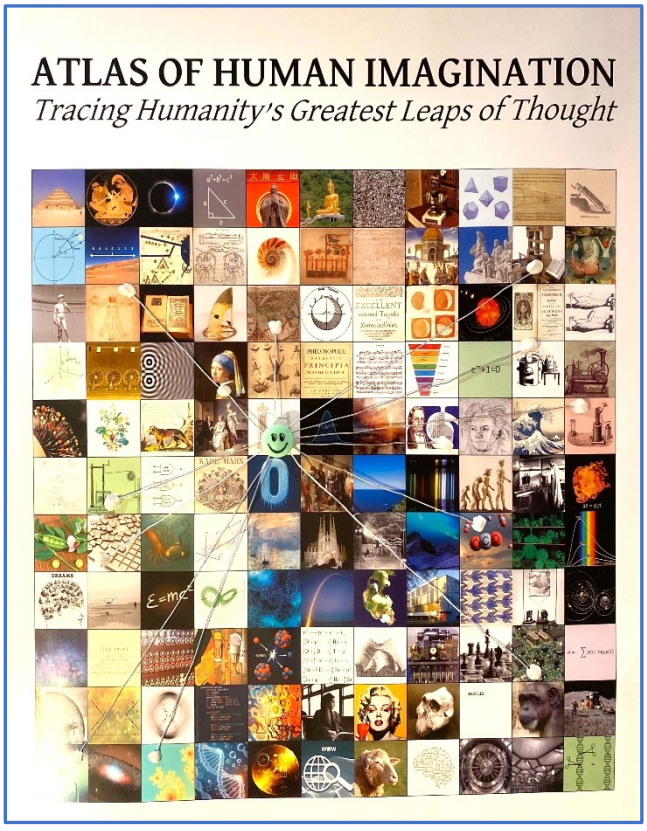
# RESOURCES FOR SCHOOL TEACHERS

## "Constellations of Concepts"

Students can use the *Atlas of Human Imagination* to describe complicated topics and technologies, in completely new ways.

Here is an example of such a novelty. Imagine you wanted to understand the key knowledge that has gone into lithium-ion batteries (LIBS) - the little energy-storage devices that go into all our smartphones, tablets, laptops, power tools, e-cars - which literally power our modern lives.




We start with Volta, the Italian scientist who first invented the electrochemical cell in 1800. On the right, one can see the A1 poster with a green smiley face in the middle, representing Volta's place in the *Atlas*. From that point, one can then find, discuss and add relevant links to other concepts, technologies and inventions that played a role in LIBS, before or after Volta's time. Using poster tack, elasticated string or board magnets (as you wish), a **"Constellation of Concepts"** can thus be created directly on the poster. Here's one that students did recently 👉

In the process of developing this “constellation of concepts”, students are asked to use their imagination and think deeply about the direct and indirect links between various things - sometimes making surprising connections that they didn’t think would be relevant at first glance.

The poster therefore provides a vibrant, visual framework for this kind of mapping, and it gets students to work in teams and to explore the history of knowledge systems. At the end of their imaginative synthesis, they will be able to identify the main intellectual milestones beautifully, and be able to generate a summary table - like the example shown below for batteries.

**The constellation of concepts that make up something as “small and simple” as a battery is remarkable. Core concepts from chemistry combine with those from the world of art and printing, with a dash of physics, geo-economics, fractal mathematics, electronics, ecology and business. This highlights the need for a cross-disciplinary approach when analysing topics well.**

## *The Atlas Lineage of Lithium-Ion Technology*

| Pioneers | Era | Concept/Discovery in the *Atlas* | Relevance to Li-ion Batteries (LIBS) | Useful Image |
|---|---|---|---|---|
| **Johannes Gutenberg (DE)** | 1400–1468 | Invented the printing press; chemistry of slurries; mechanical deposition of inks and films | Precursor to screen printing, slurry coating and roll-to-roll manufacturing of Li-ion electrodes, used in the manufacture of all LIBS |  Printing of LIBS |
| **Leonardo da Vinci (IT) & Johannes Vermeer (NL)** | 1452–1519 | Roasted, ground and mixed oxide paint pigments (Fe, Mn, Co, Ni); studied oxidation and metal colour changes; early solid-state chemistry | Even though used in artwork, the pigment chemistry of minerals was critical. Da Vinci (and Vermeer) observed the same transition-metal redox principles that would later drive Li-ion cathode reactions |  Pigments for LIBS |

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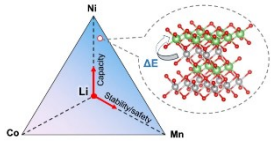
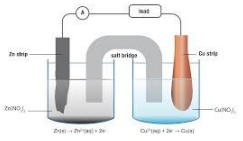
| **Gerardus Mercator (BE/NL)** | 1512–1594 | Created the first proper *Atlas* of the world and mapped mineral and pigment sources globally, through the VOC (Dutch East India Company) in the 1600s | Laid the foundation for geological resource mapping, critical to Li/Co/Ni material supply chains that we see today |  Geo-mapping |
| **Antoine Lavoisier (FR)** | 1743–1794 | Defined chemical elements, conservation of mass, and stoichiometry | Enabled stoichiometric control in oxide synthesis (Li:Co:O ratios etc.) |   Stoichiometry |
| **Alessandro Volta (IT)** | 1745–1827 | Built the first electrochemical cell (Cu–Zn stack) | Conceptual ancestor of the multi-layer electrode stack in Li-ion batteries |   First-ever battery stack |
| **Jöns Jakob Berzelius (SE)** | 1779–1848 | Coined the chemical symbols, isolated many elements, and first studied lithium salts | Identified $Li^+$ compounds, setting the stage for intercalation chemistry needed in LIBS |  Li salts |
| **Michael Faraday (GB)** | 1791–1867 | Discovered laws of electrolysis, coined the term “ion,” and studied many metal oxides | Formalised ion transport and electrochemical kinetics, the core of battery operation |  Faraday’s laws of electrolysis |

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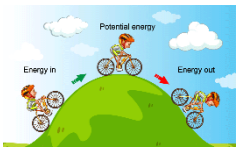
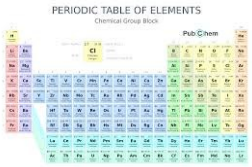
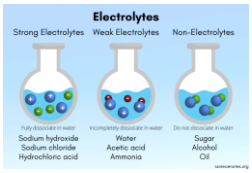
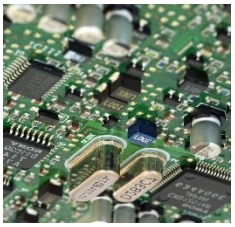
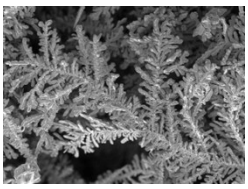
| **James Joule (GB)** | 1818–1889 | Established energy conservation and mechanical equivalence of heat | Provided quantitative energy framework (Wh, J) for battery energy density |  Energy conservation |
| **Dmitri Mendeleev (RU)** | 1834–1907 | Created the *Periodic Table*, giving order and grouping to the chemical elements | Helped establish group relationships for the alkali metals, such as Li, as well as transition metals like Ni, Co, Fe, Mn needed in LIBS |  Periodic Table |
| **Svante Arrhenius (SE)** | 1859–1927 | Developed ion dissociation theory in electrolytes | Foundation of ionic conductivity and electrolyte design; predicted $CO_2$-driven warming — linking to the green transition motive |  Electrolytes |
| **John Bardeen (US)** | 1908–1991 | Co-invented the transistor | Enabled battery control and management systems, sensors and power electronics for safe Li-ion operation |  Transistors |
| **Benoit Mandelbrot (FR/US)** | 1924–2010 | Discovered fractal geometry in mathematics, and its relevance to physical systems | Fractal dendrite growth on Li metal surfaces — a direct modern research area in battery degradation |  Li fractals |

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| **James Lovelock (GB)** | 1919–2022 | Proposed the *Gaia* Hypothesis and eco-feedback systems; early stage of environmental movement | Framed the ecological imperative for sustainable energy technologies — including Li-ion batteries for decarbonisation |  Eco-policy |
| **John Goodenough (US)** | 1922-2023 | Won the Nobel Prize for Chemistry in 2019 for research on LIBS chemistry | This know-how was then later transferred to Yoshino, who created the first safe, production-viable LIB in the 1980s |  The final LIB product |

David Jarvis

# FOR TEACHERS

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

**Equipment:** A1 posters, poster-tack, blu-tack, post-its, string, board magnets (whatever is available)

Create student teams to discuss, develop and draw on the poster their "constellations of concepts" for a selected topic. Some ideas for topics could be:

- Evolution
- Mars space mission
- Art & science
- Climate change
- 3D printing
- Oceanography
- Musical expression
- Cryptography
- Weather prediction
- Light and colour
- Ecology
- Microscopy
- Computing

- Aircraft
- Artificial intelligence
- Social inequality
- Science fiction
- Perception and senses
- History of art
- Communication technology
- Cryptocurrency etc.