The Coldest Book in the World

A project by Marjorie Garry, a student from Ecole Estienne, together with the « Physics Reimagined » team (LPS, Université Paris-Sud et CNRS).

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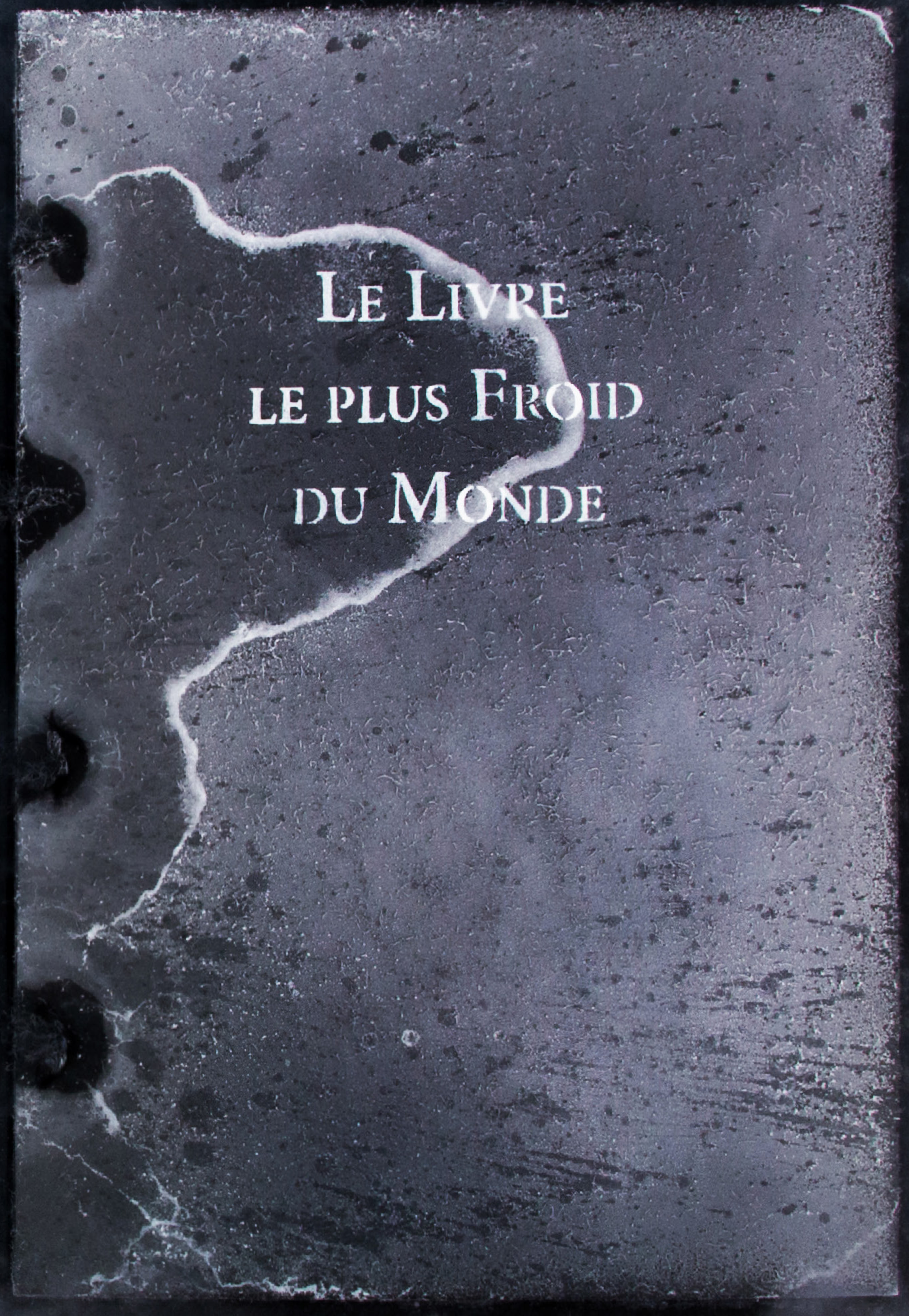
Discover the video and the book at www.PhysicsReimagined.com



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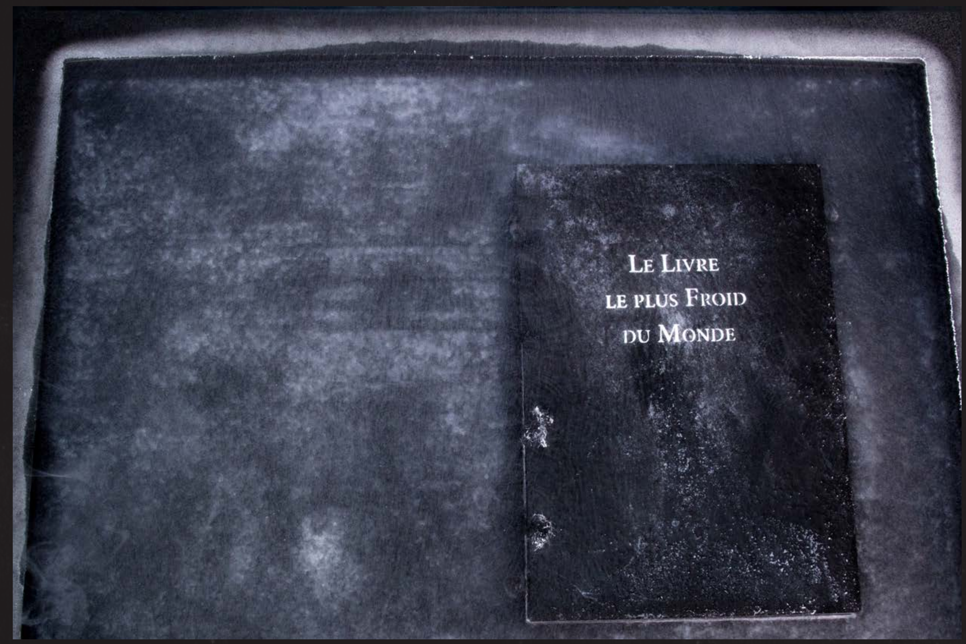

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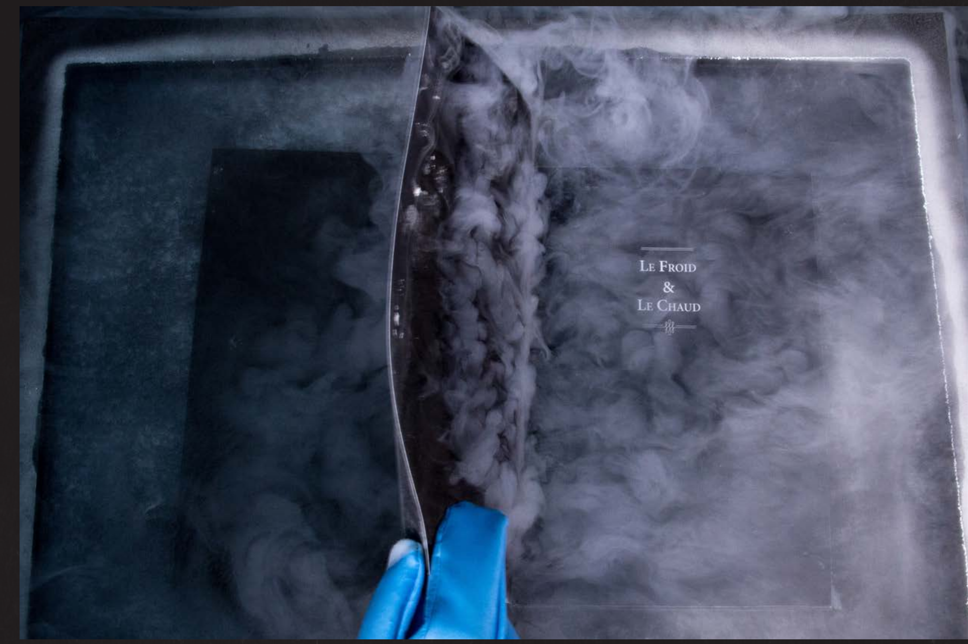

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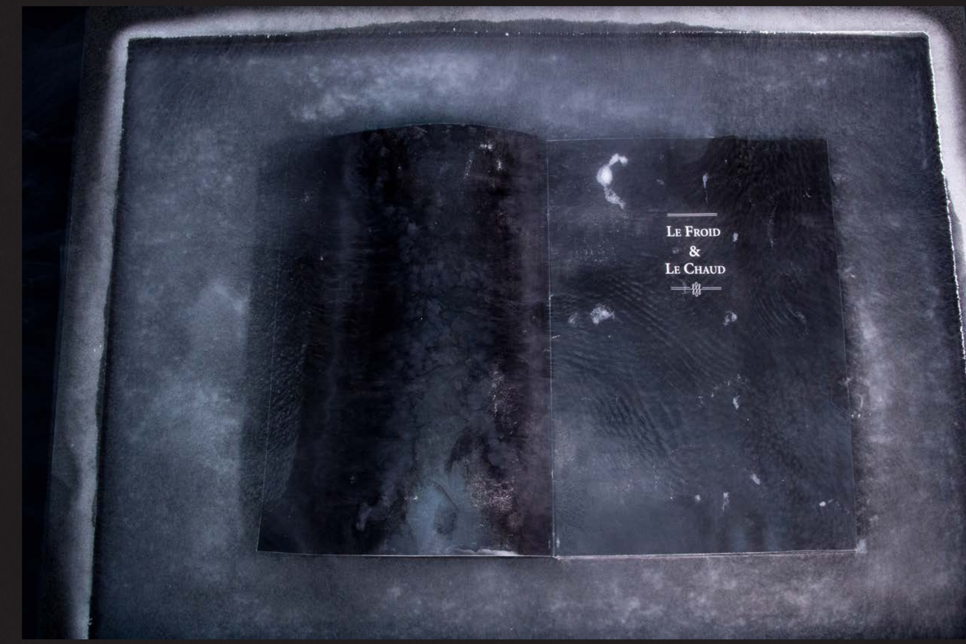

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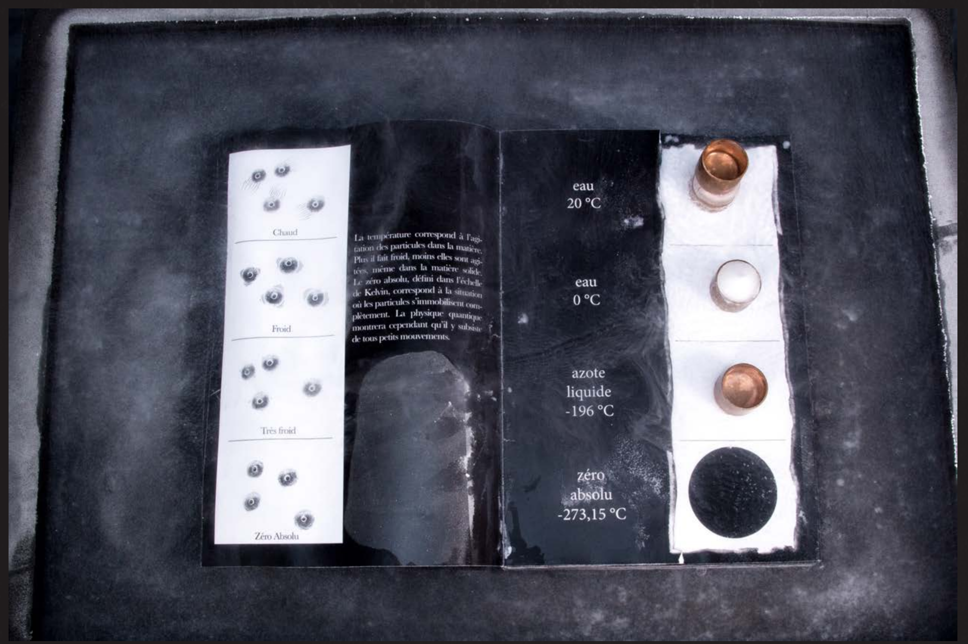

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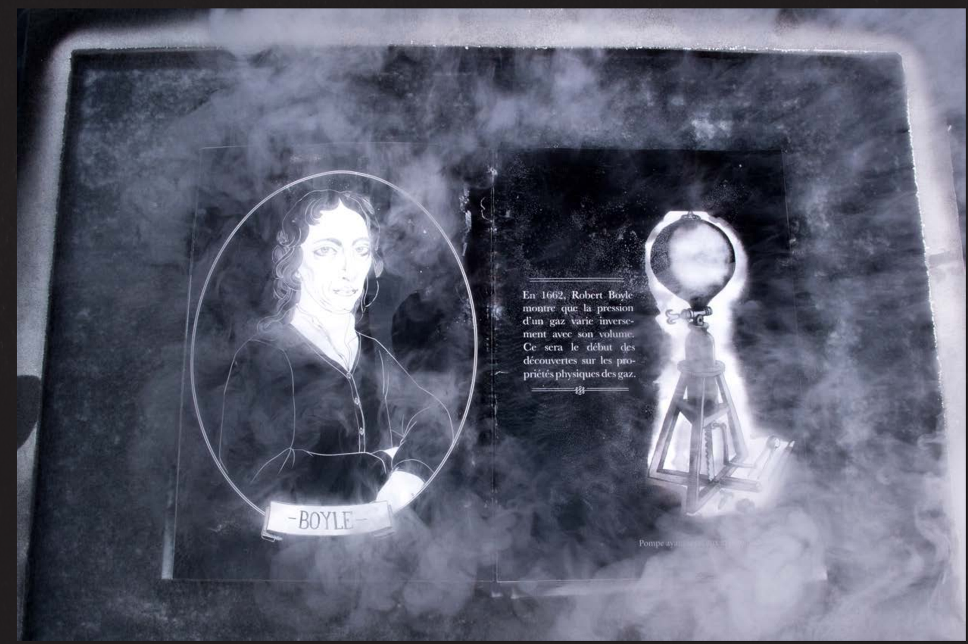

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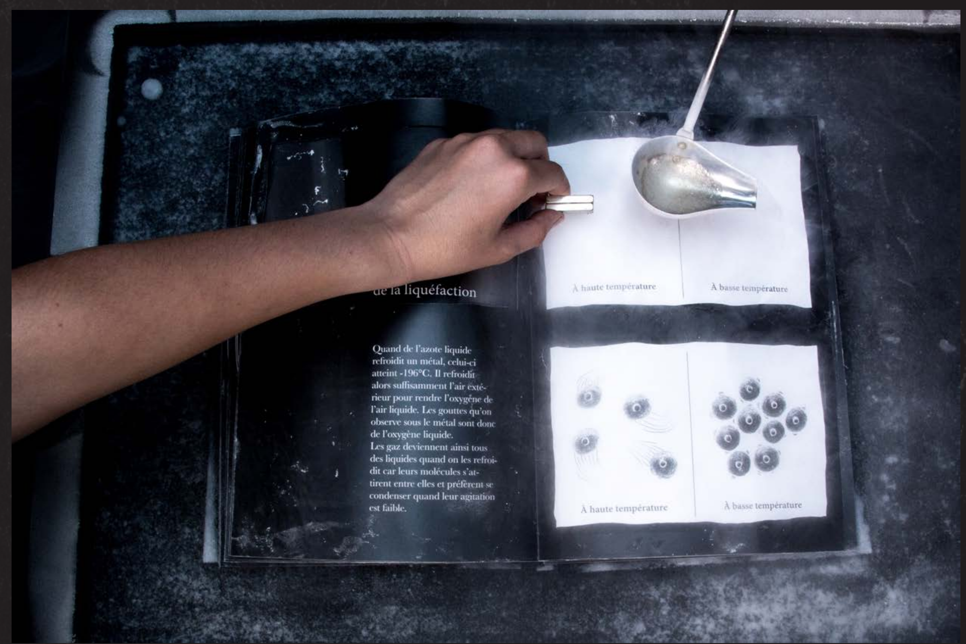

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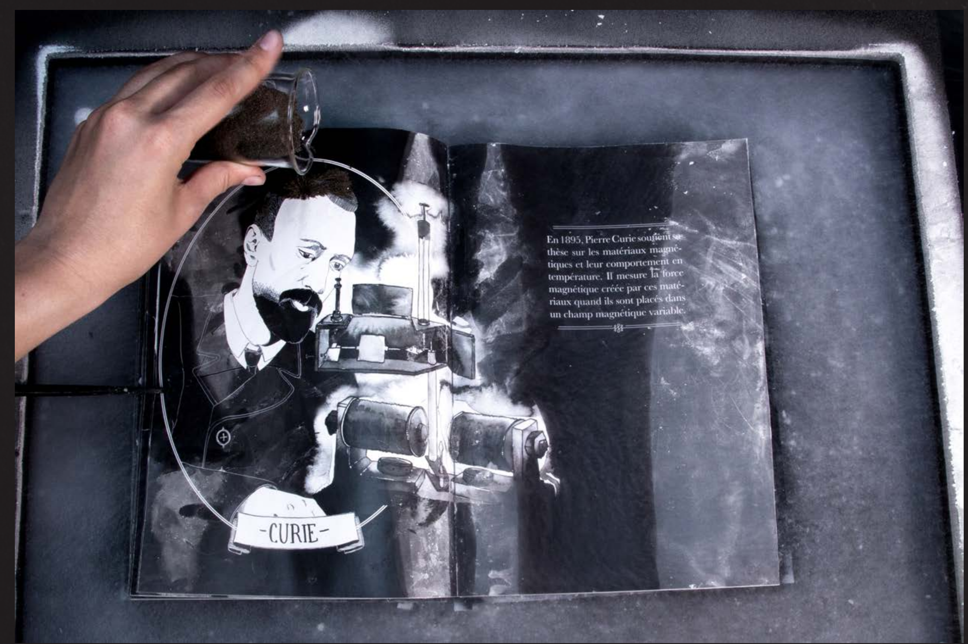

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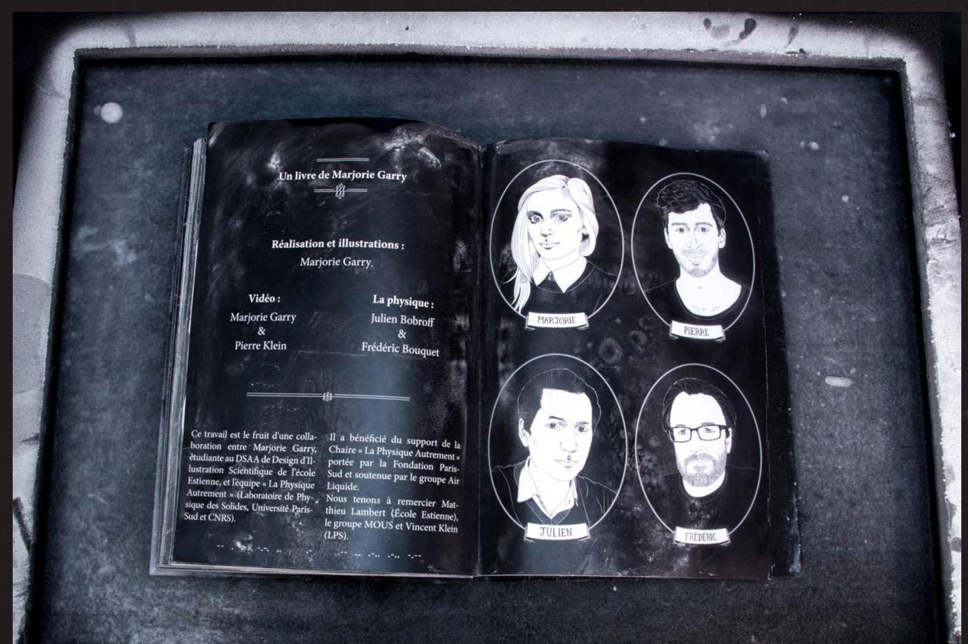

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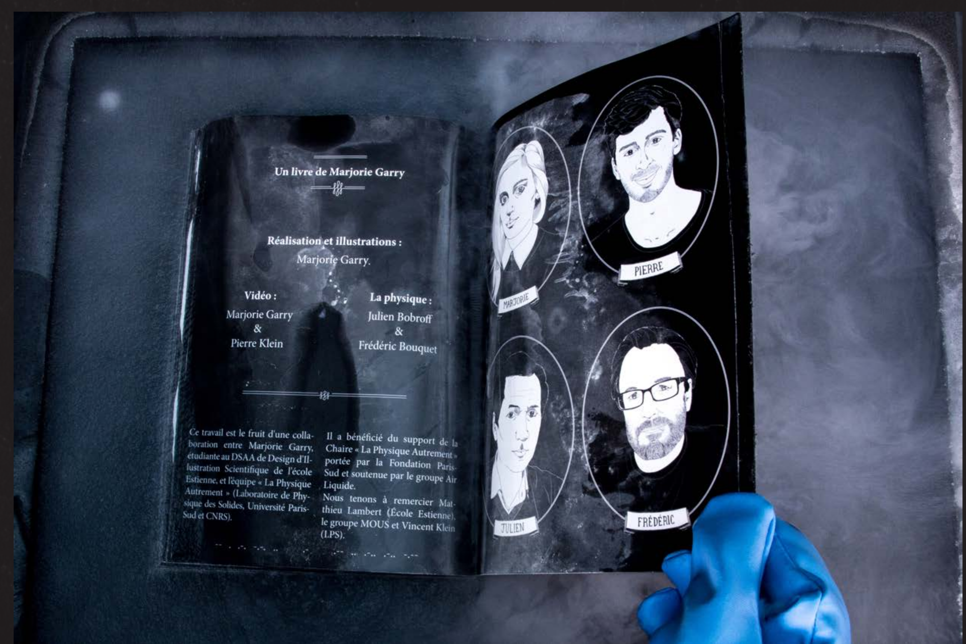

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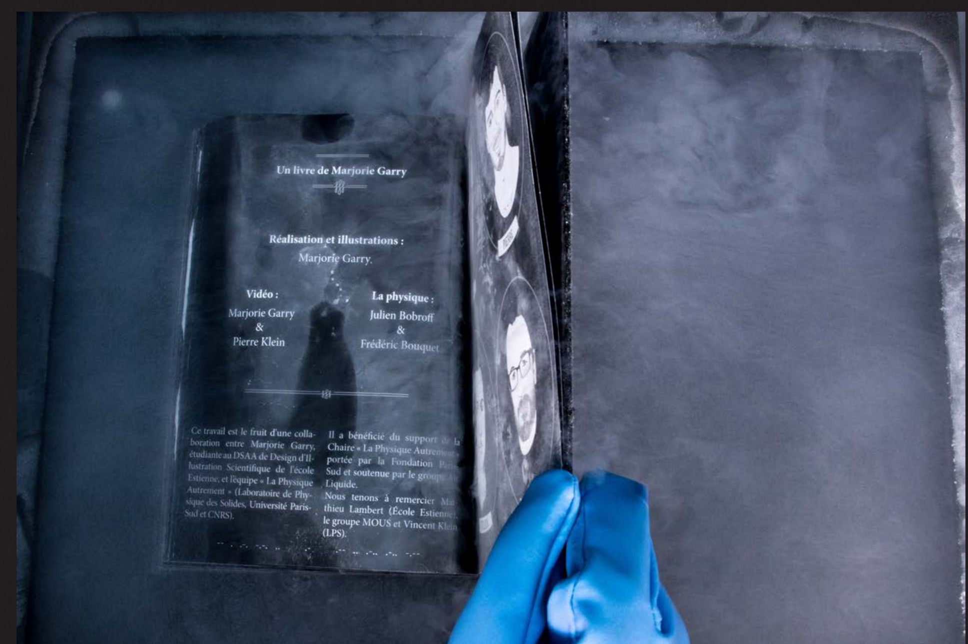

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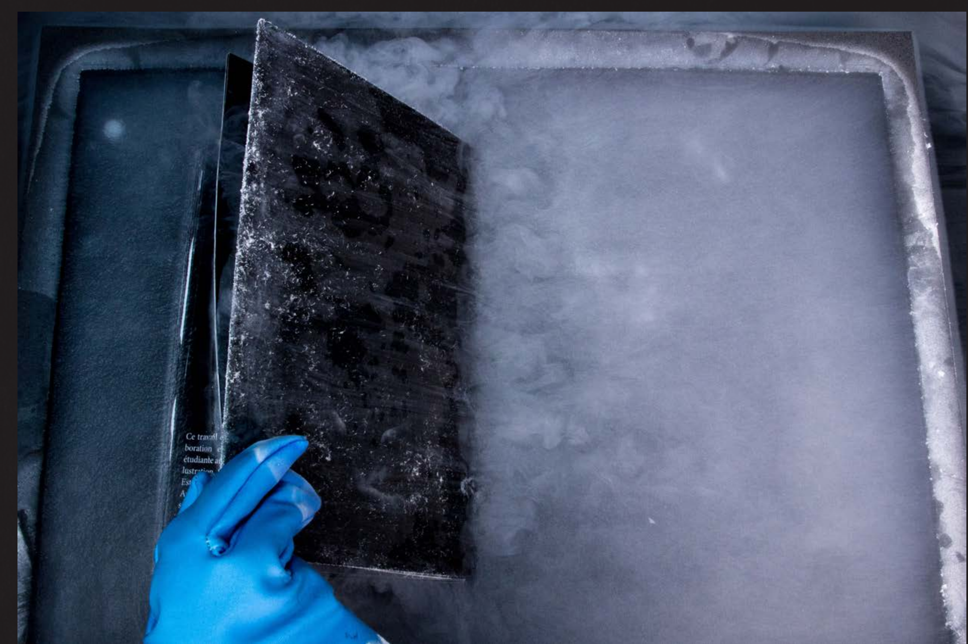

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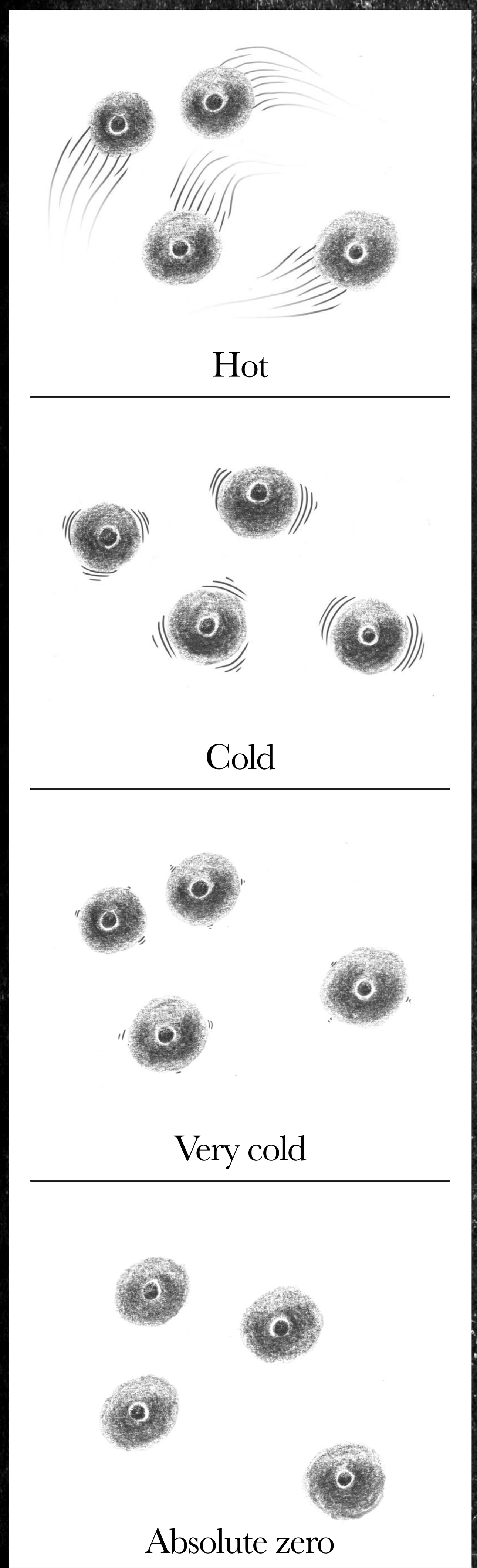
Cold and Heat

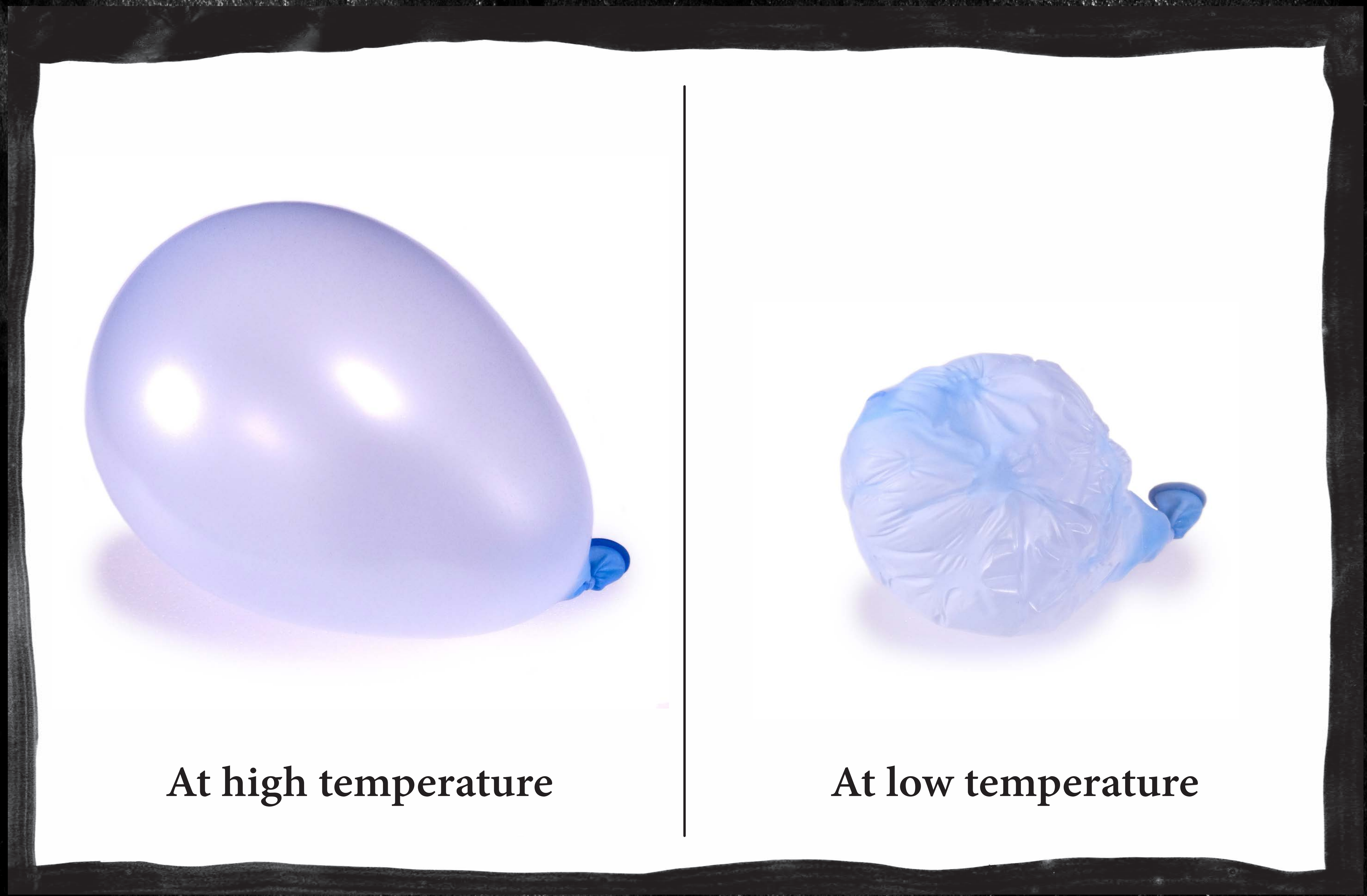


Temperature is related to the agitation of particles in matter. The colder it is, the less agitated the particles, even in solid matter. The absolute zero, as defined by the Kelvin scale, corresponds to the state in which particles stop moving completely. Quantum physics would proceed to show that they still can move a little.

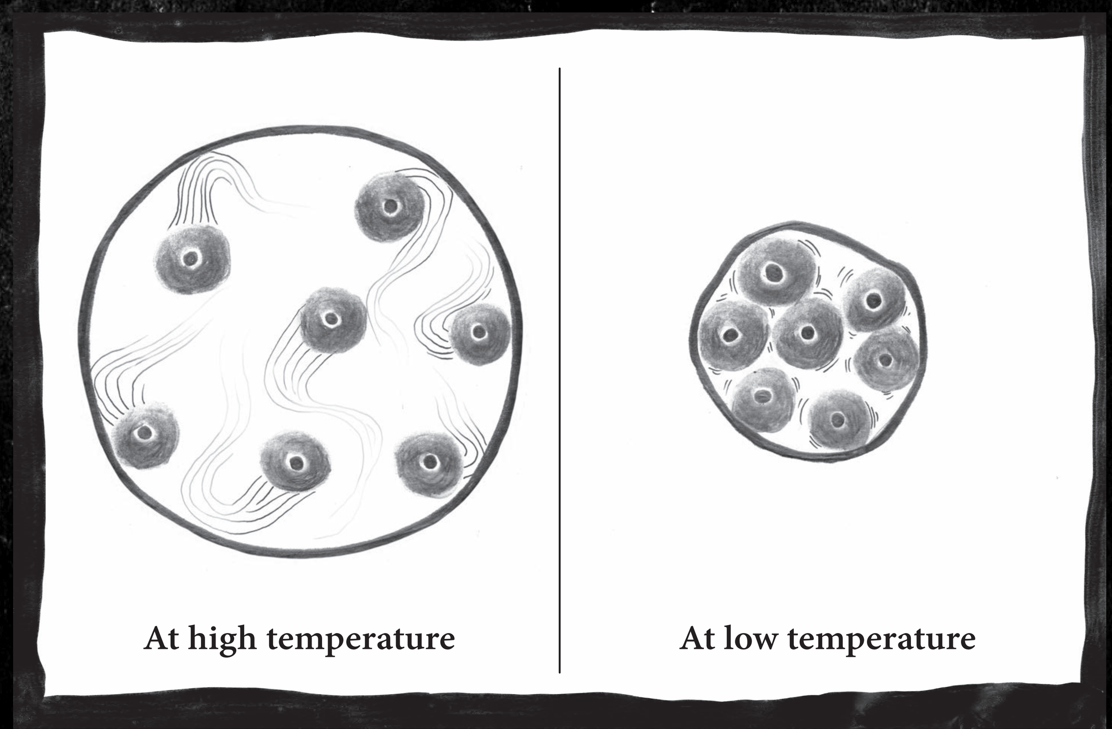
In 1742, Anders Celsius invented a temperature scale in which 0° and 100° respectively correspond to the freezing and boiling points of water. In 1848, Lord Kelvin introduced the concept of “absolute zero”, which corresponds to the lowest possible temperature.

Cold and Gases

The volume experiment



When you lower the temperature of a gas (here with cold nitrogen vapors), its particles become less agitated and its volume decreases.

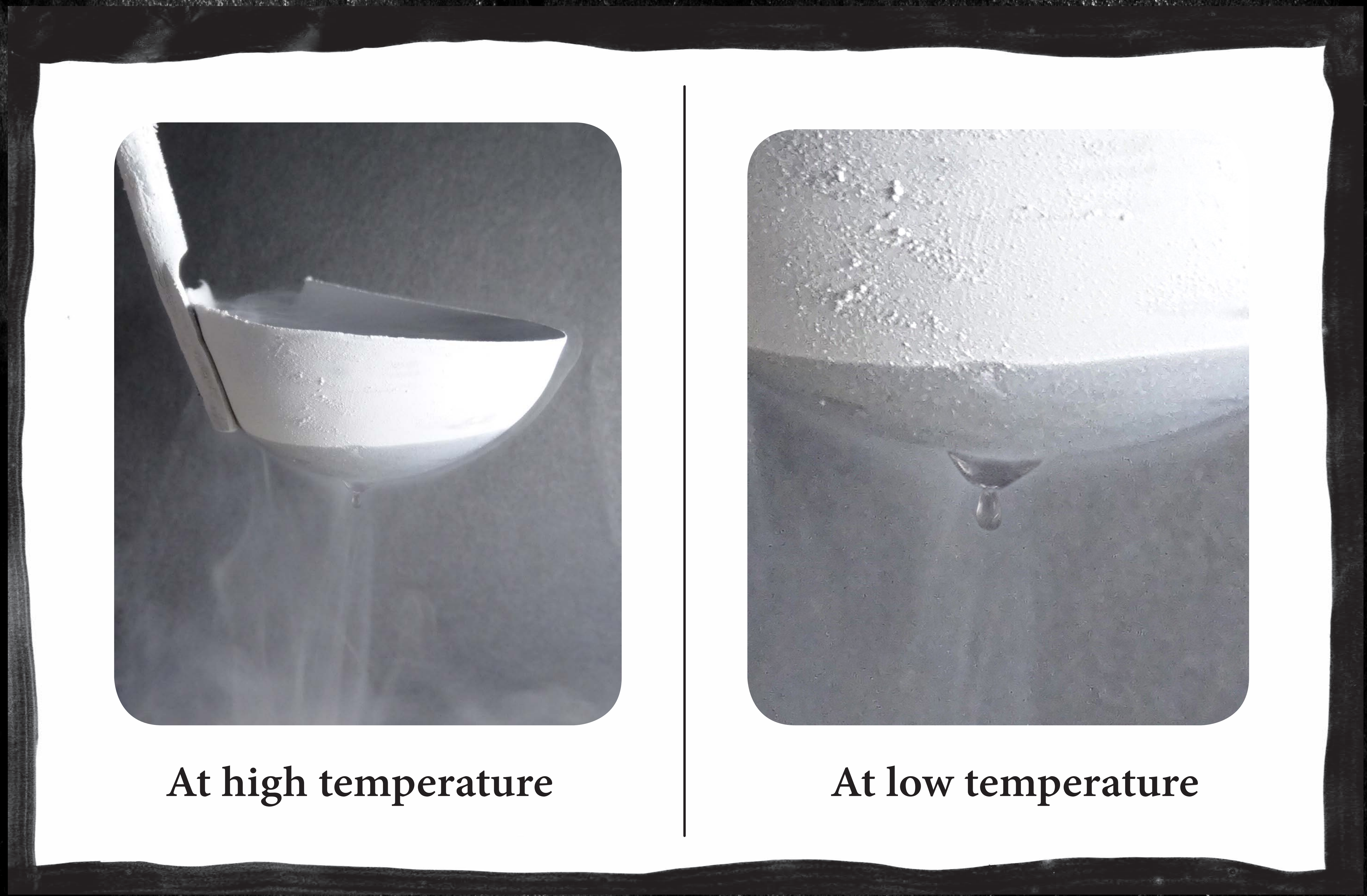


Vacuum pump used by Boyle for his experiments.

In 1662, Robert Boyle showed that the pressure of a gas is inversely proportional to the volume it occupies. This was the first of many discoveries in the field of physical properties of gases.

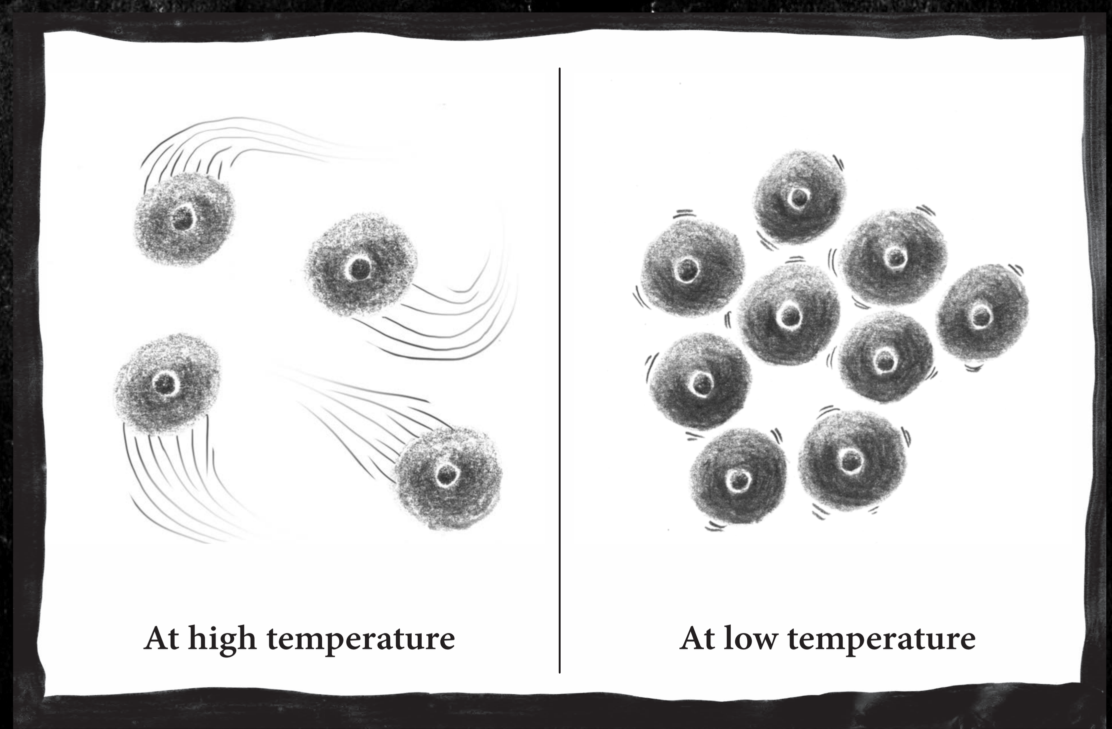
Cold and Liquids

The liquefaction experiment

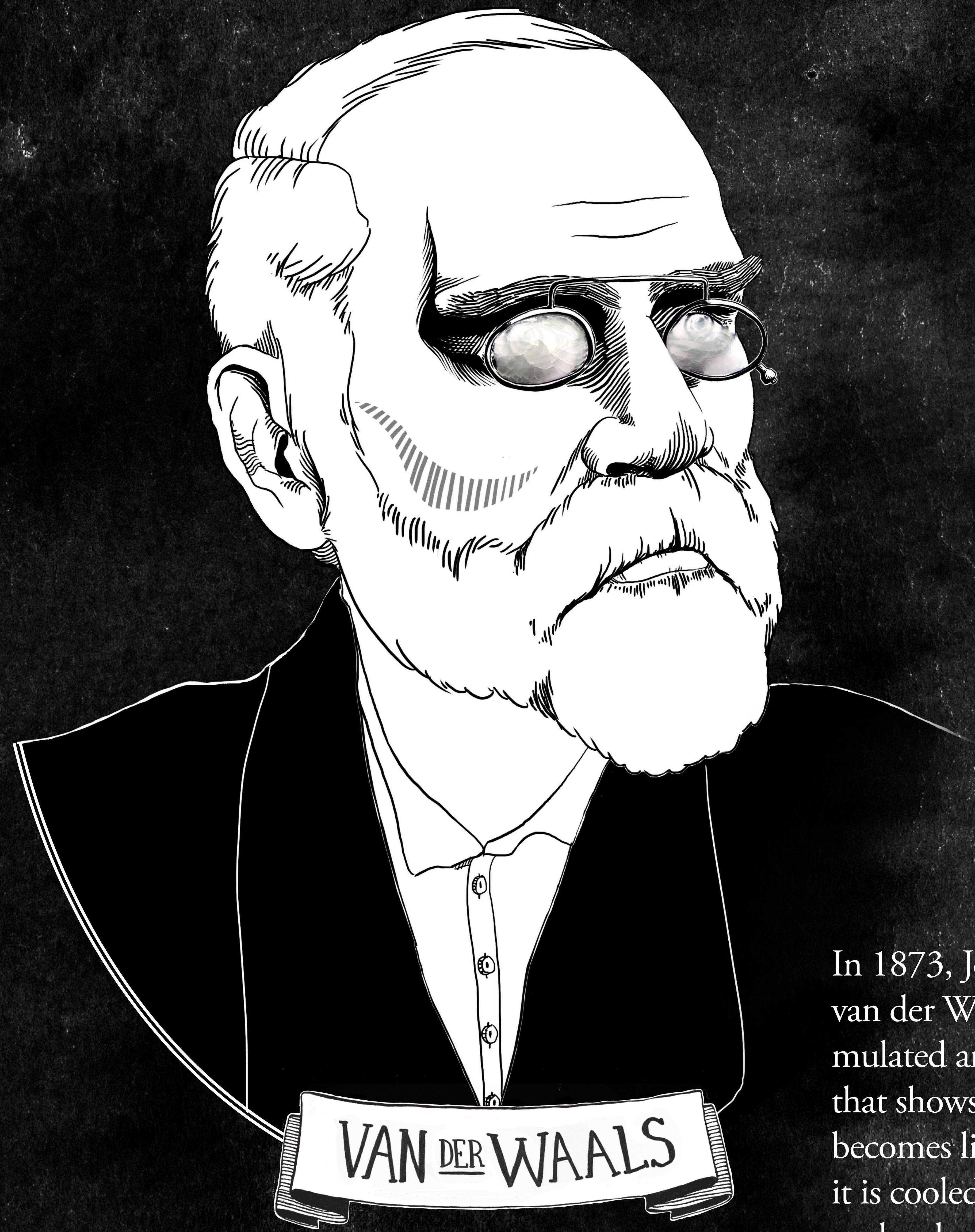


At high temperature | At low temperature

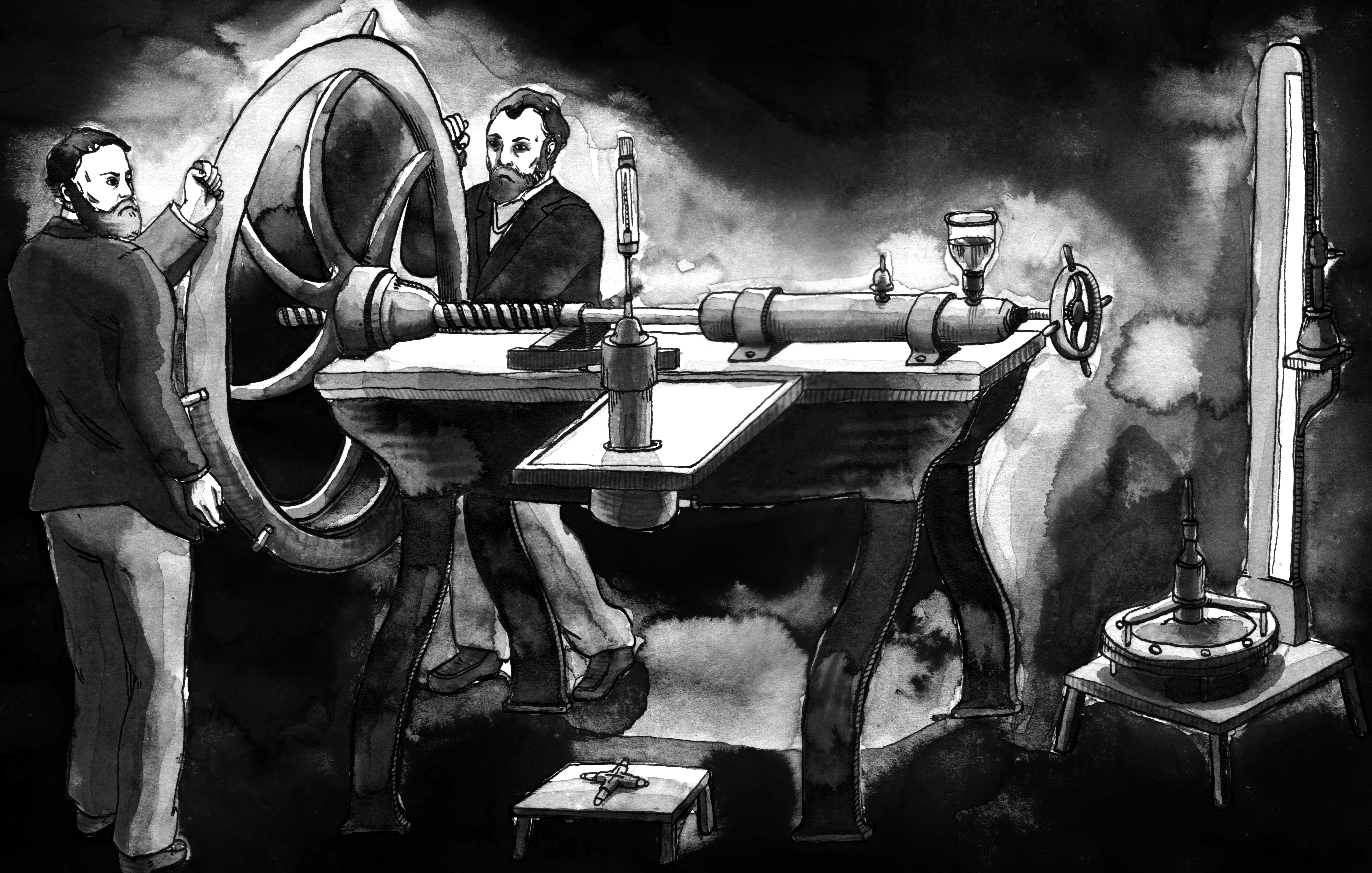
All gases become liquid when cooled because their molecules become attracted to each other and prefer to condense when they move less. This is the case here of oxygen which liquefies just below a spoon cooled with liquid nitrogen.



At high temperature | At low temperature



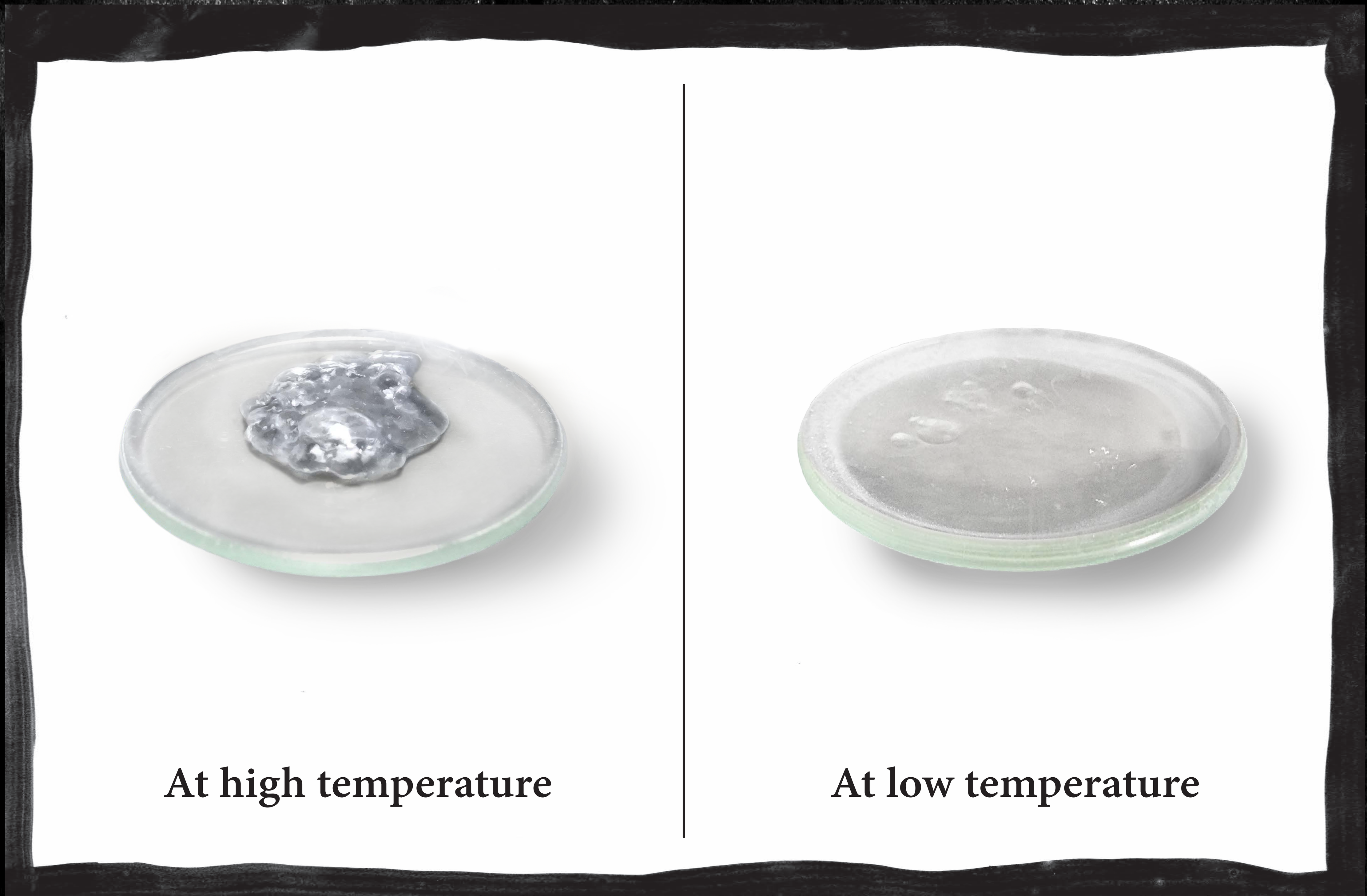
In 1873, Johannes van der Waals formulated an equation that shows that a gas becomes liquid when it is cooled because its molecules are attracted to each other.



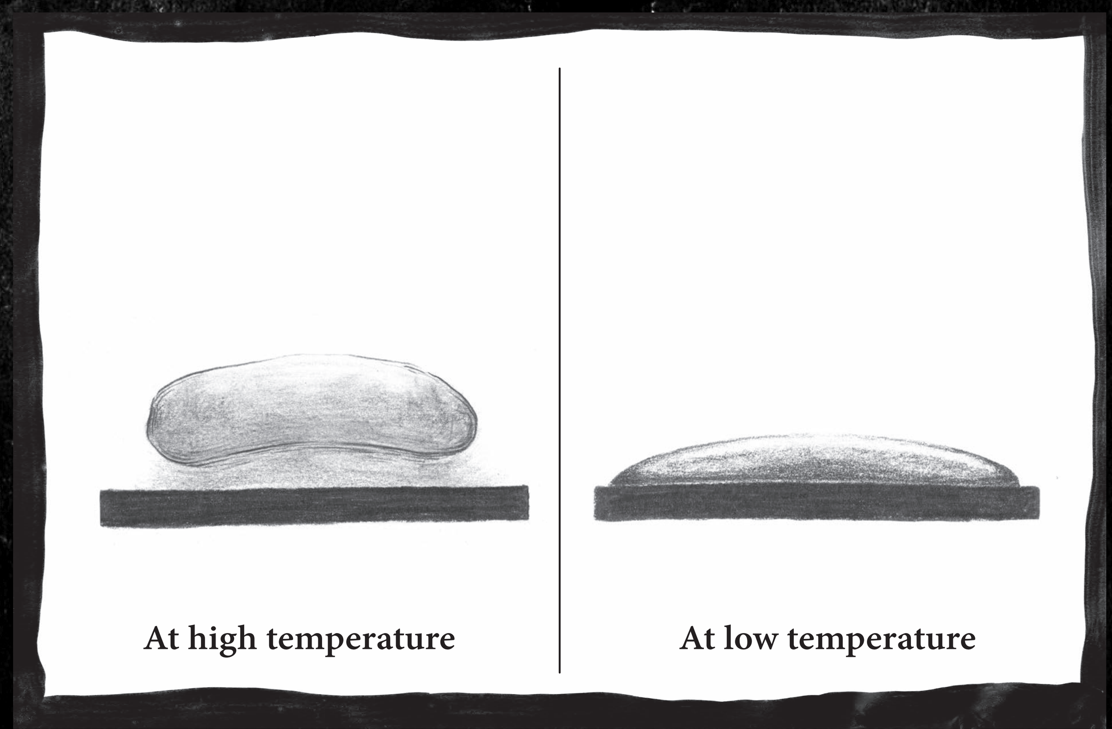
In 1877, Raoul Pictet, in Switzerland, and Louis Cailletet (in the picture), in France, independently came up with distinct methods to produce liquid oxygen.

Cold and the Leidenfrost Effect

The Leidenfrost experiment



When liquid nitrogen is placed on a hot plate, it partly evaporates and levitates on its own vapor.

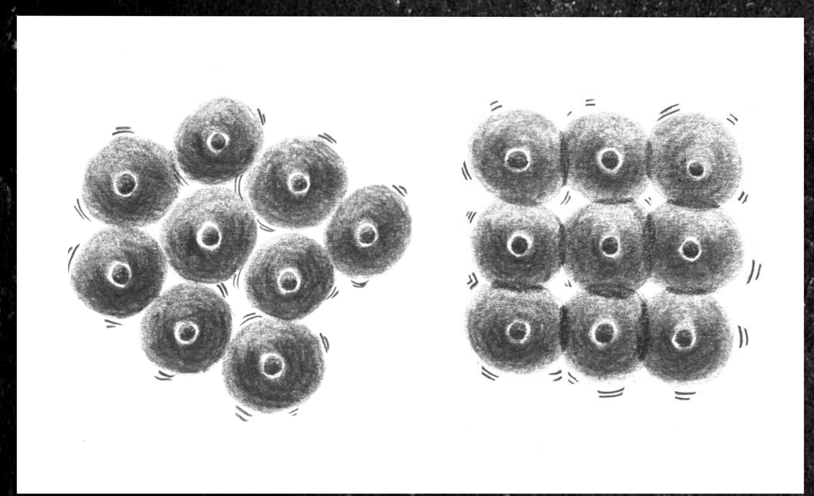


In 1756, Johann Leidenfrost wrote a treatise about some of the properties of water, amongst which the strange behavior of a drop of liquid that is placed on a hot plate.

Cold and Solids

The fragility experiment

Most solids do not become fragile when cooled. Except plastics and rubbers where long molecules cannot move around anymore, and plants because the water they contain turns to ice and becomes brittle.

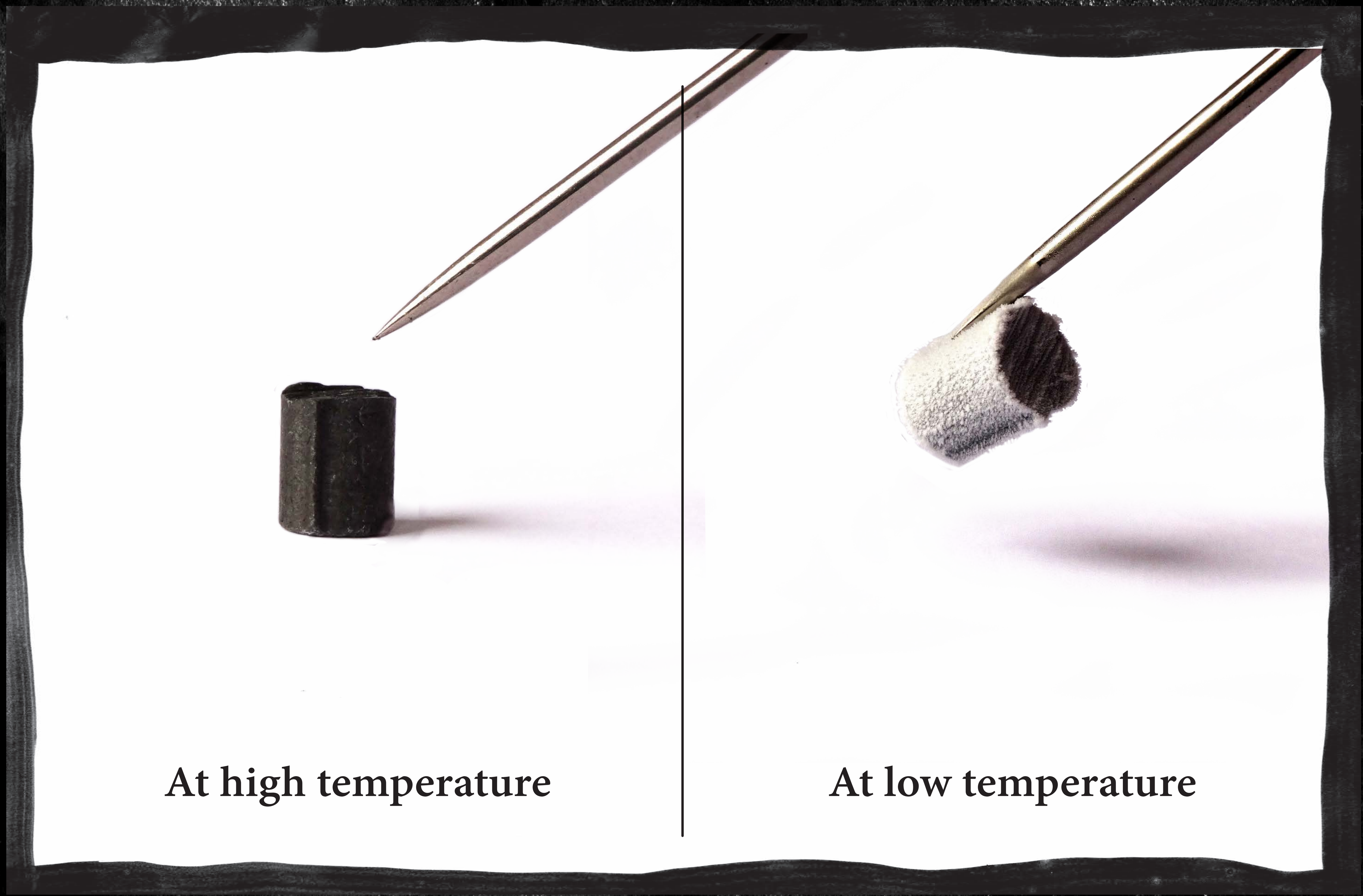


When a liquid has sufficiently cooled, it becomes a solid (except for helium). Its atoms arrange themselves in a more or less orderly and vibrate in a fixed position. When cooled more, the solid contracts because its atoms come closer together.

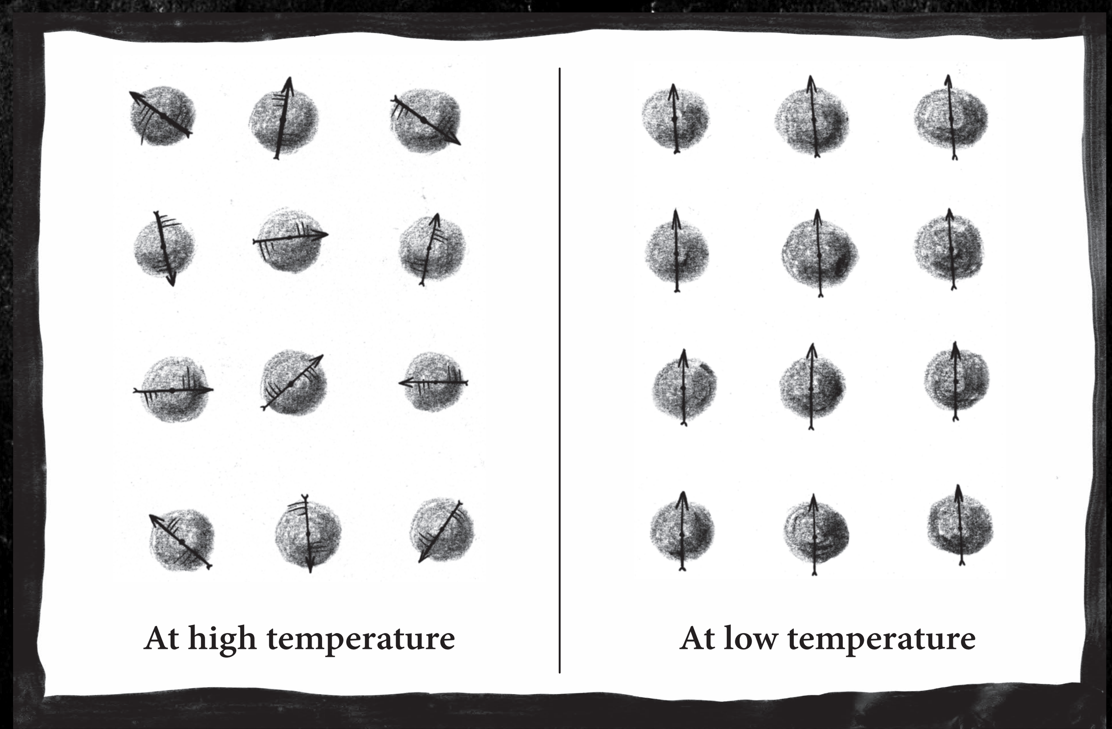
Among other things, Thomas Young is renowned for his work at the beginning of the 19th century on the mechanical properties of solids, their elasticity and the deformation they undergo under stress.

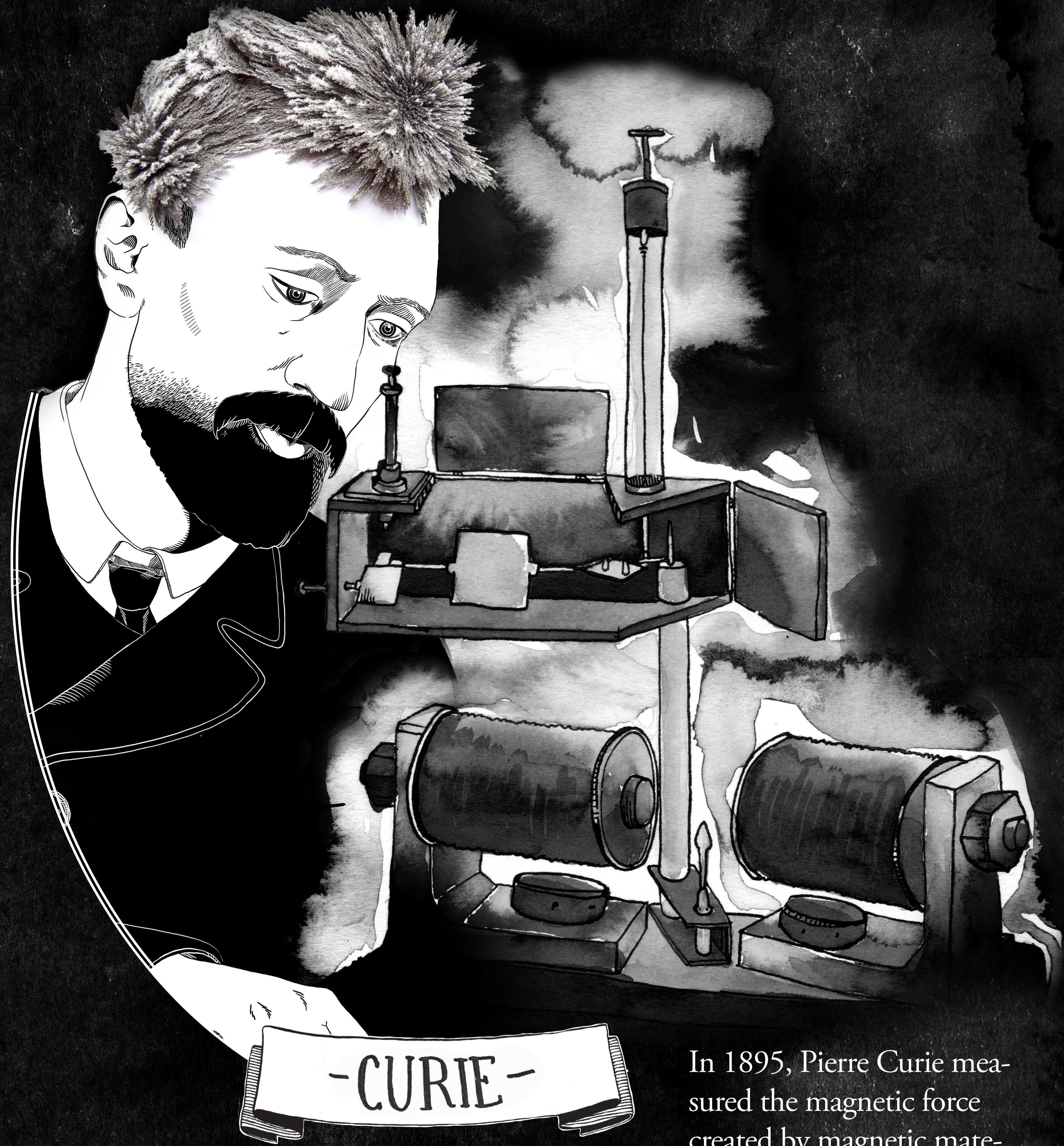
Cold and Magnets

The magnetic experiment



In magnets, atoms carry small quantum magnets called spins. When a magnet is cooled, all the spins align creating North and South poles. But when it's heated above Curie temperature, its spins become disorganized and the material stop being magnetic.

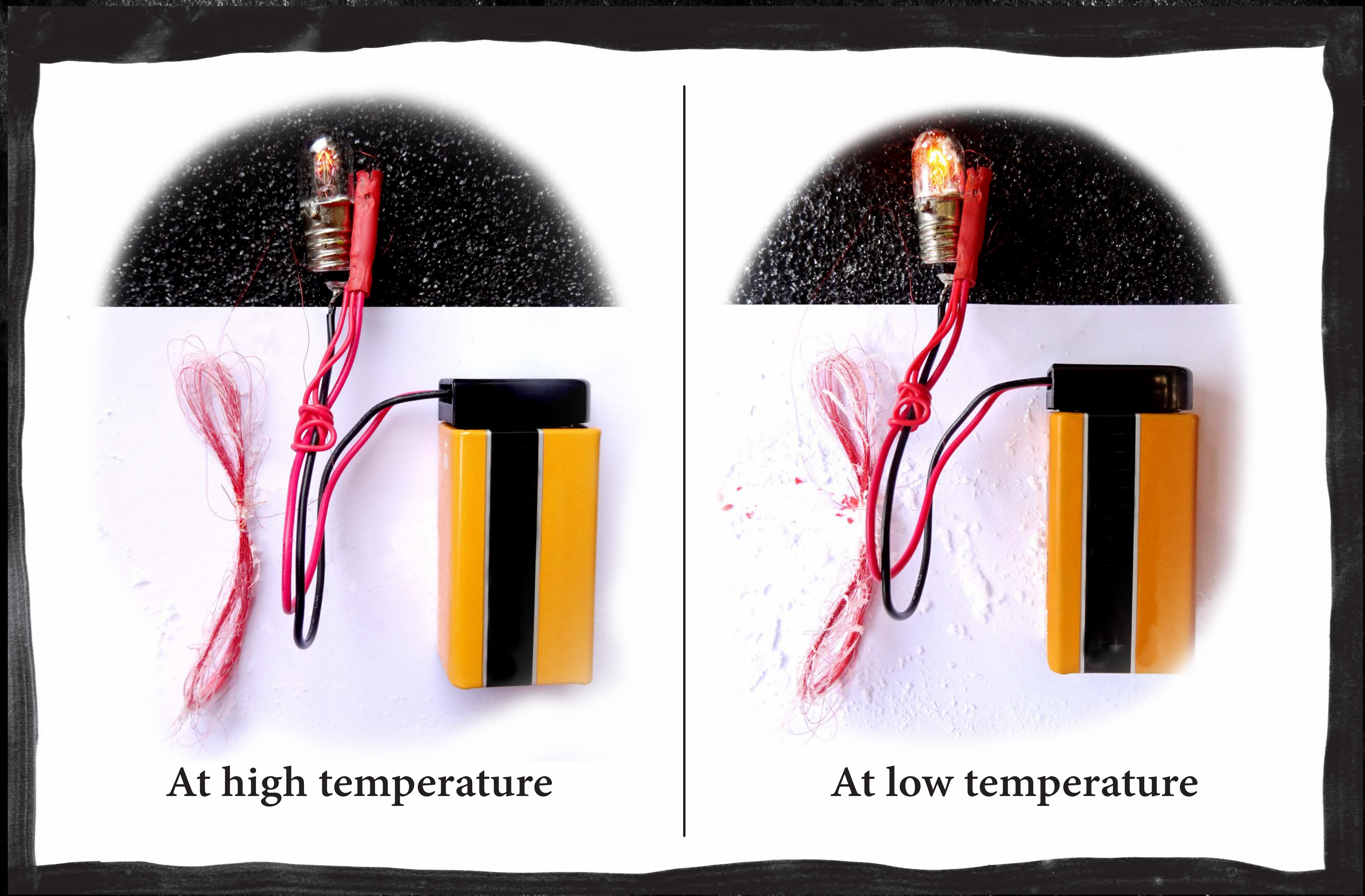




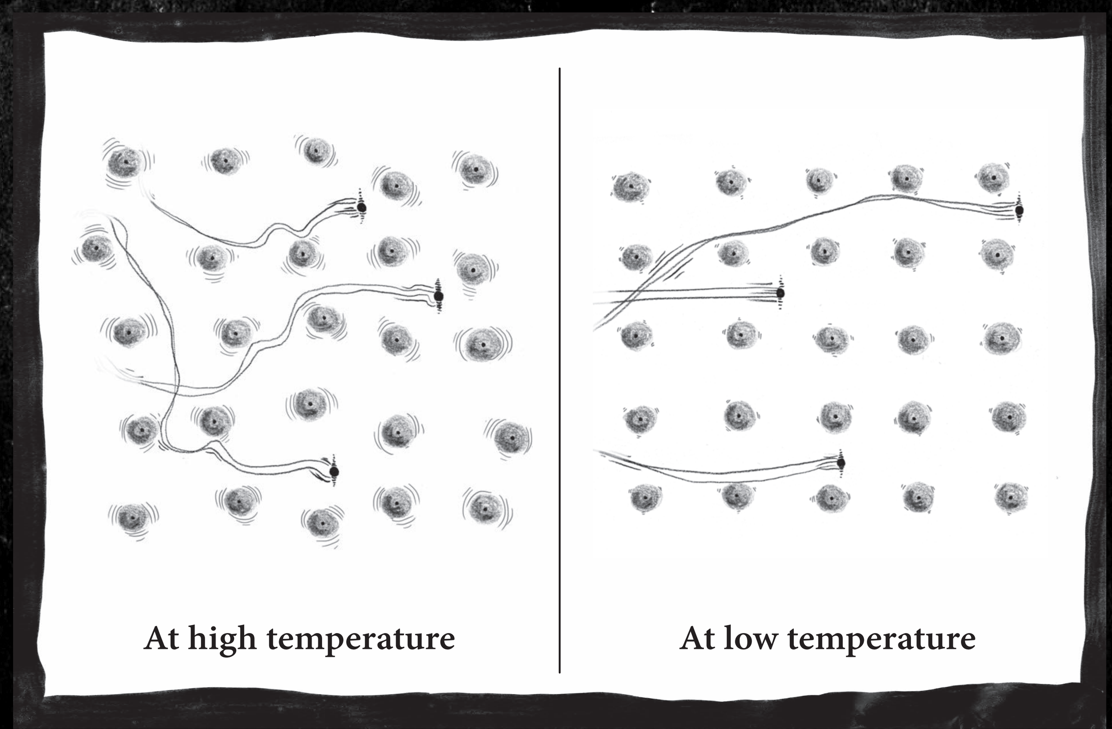
In 1895, Pierre Curie measured the magnetic force created by magnetic materials put in a varying magnetic field.

Cold and Metals

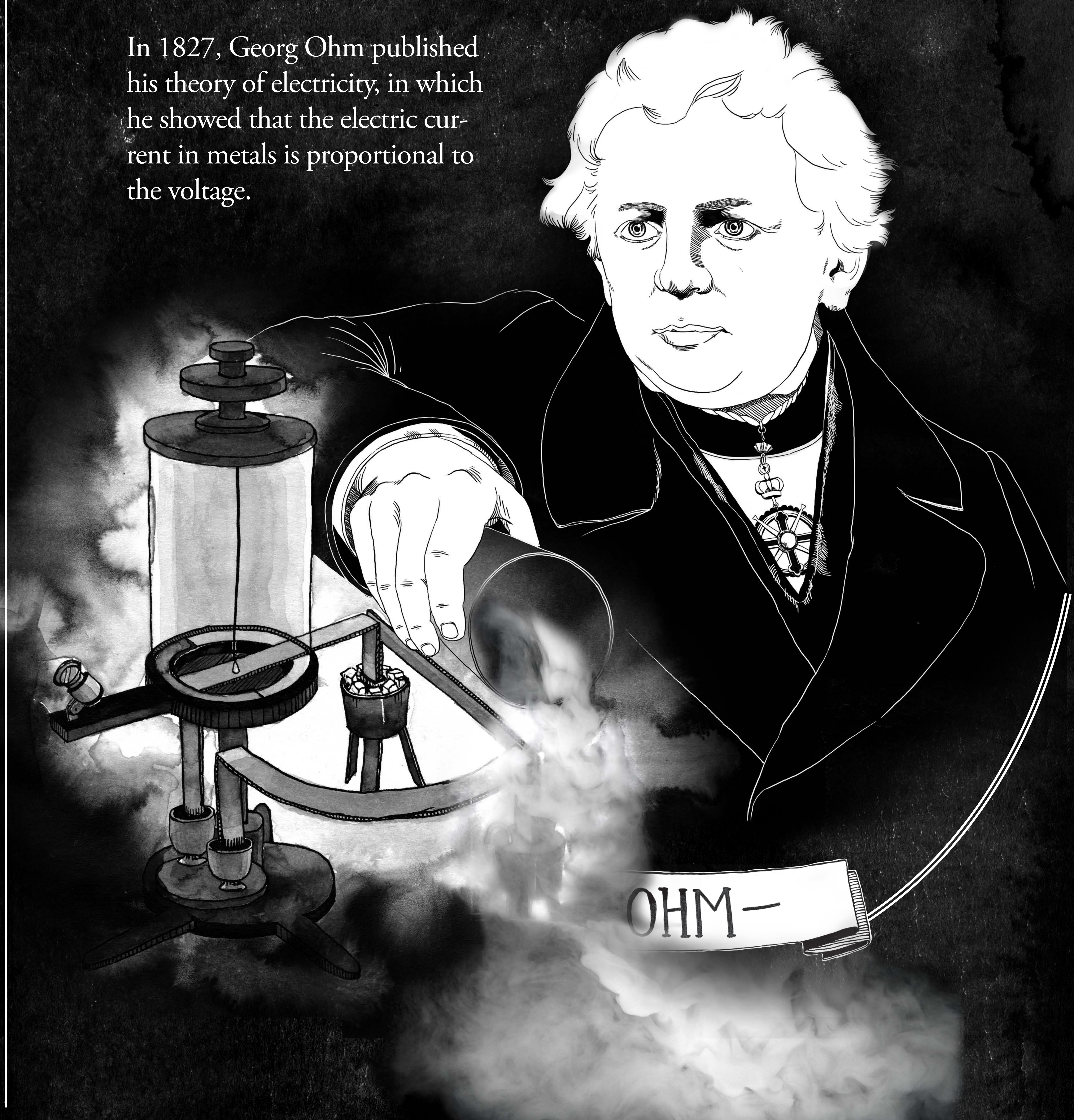
The conductivity experiment



When a metal is cooled, its electrons move more freely and are less slowed down by the atom vibrations. The electrical resistance of the wire decreases and bulb gets more electricity and lights up.

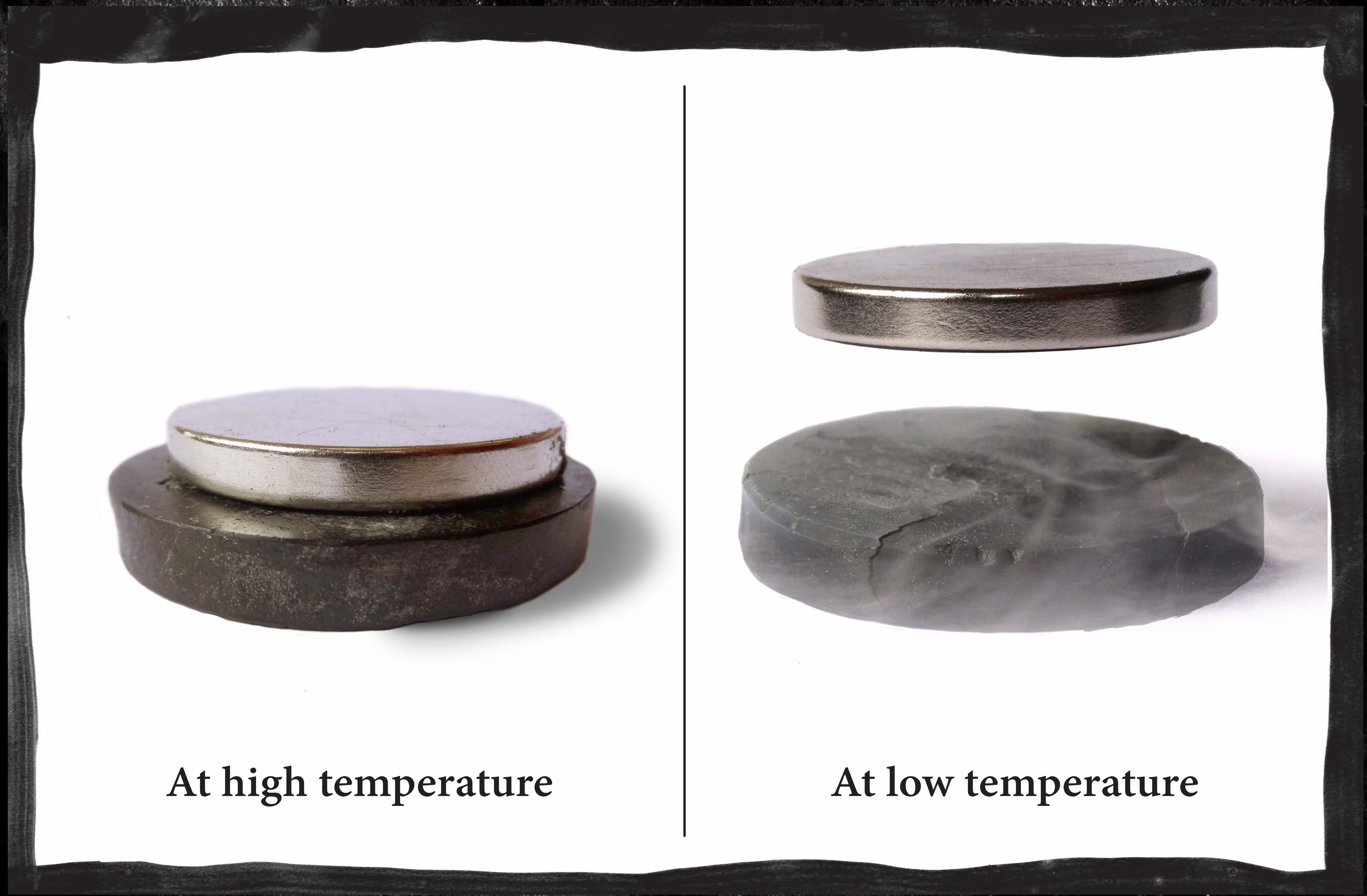


In 1827, Georg Ohm published his theory of electricity, in which he showed that the electric current in metals is proportional to the voltage.

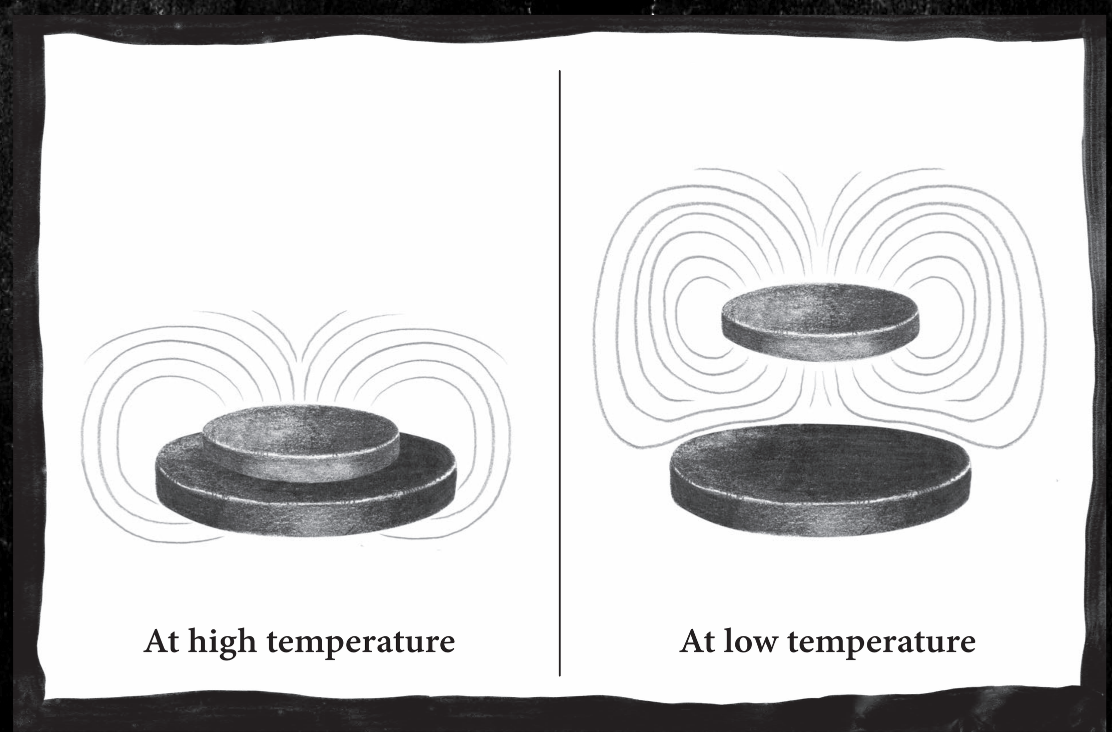


Cold and Superconductivity

The superconductivity experiment



At very low temperature, some metals become superconductors. Their electrons suddenly form a sort of gigantic quantum wave. These materials then conduct electrical current perfectly, but they also expel their magnetic fields. That's why they make magnets levitate.



In 1911, Kammerlingh Onnes discovered superconductivity while studying mercury.