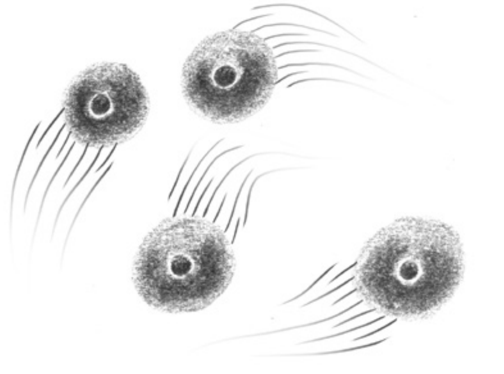
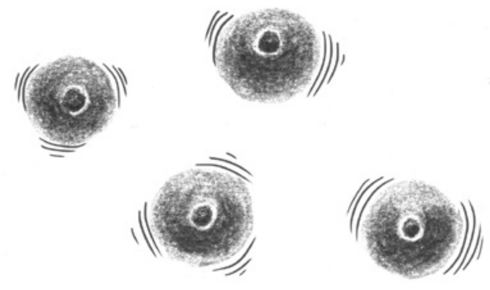
The Coldest Book in the World

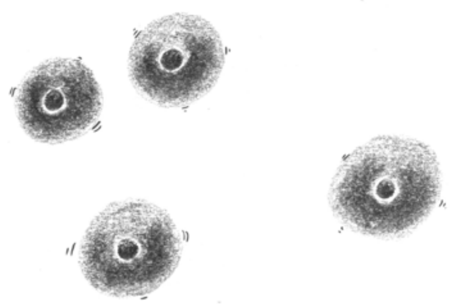
Cold & Heat



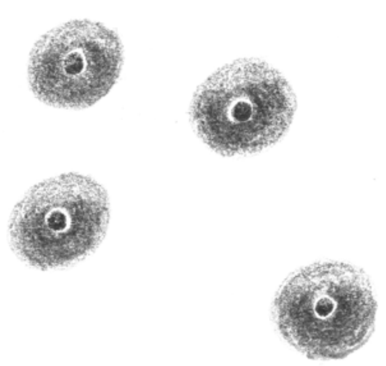
Hot



Cold



Very cold



Absolute zero

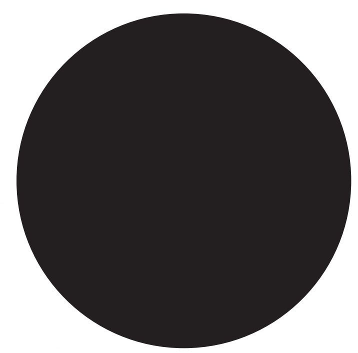
Temperature is related to the agitation of particles in matter. The colder it is, the less agitated the particles, even in solid matter. The absolute zero, as defined by the Kelvin scale, corresponds to the state in which particles stop moving completely. Quantum physics would proceed to show that they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

Water
20 °C
293 K

Water
0 °C
273 K

Liquid nitrogen
-195,8 °C
77,4 K

Absolute zero
-273,15 °C
0 K



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.

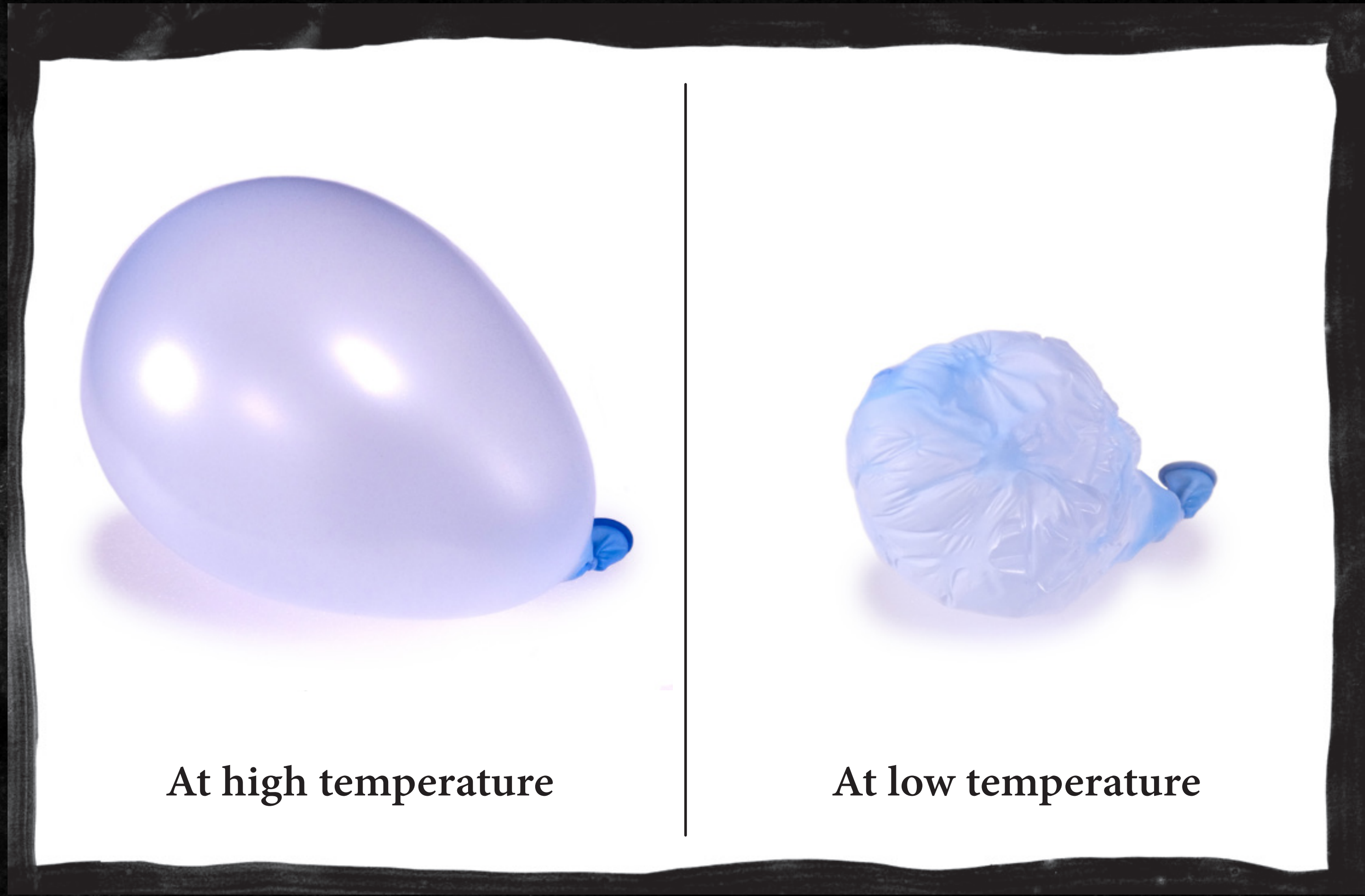
Cold & Gases

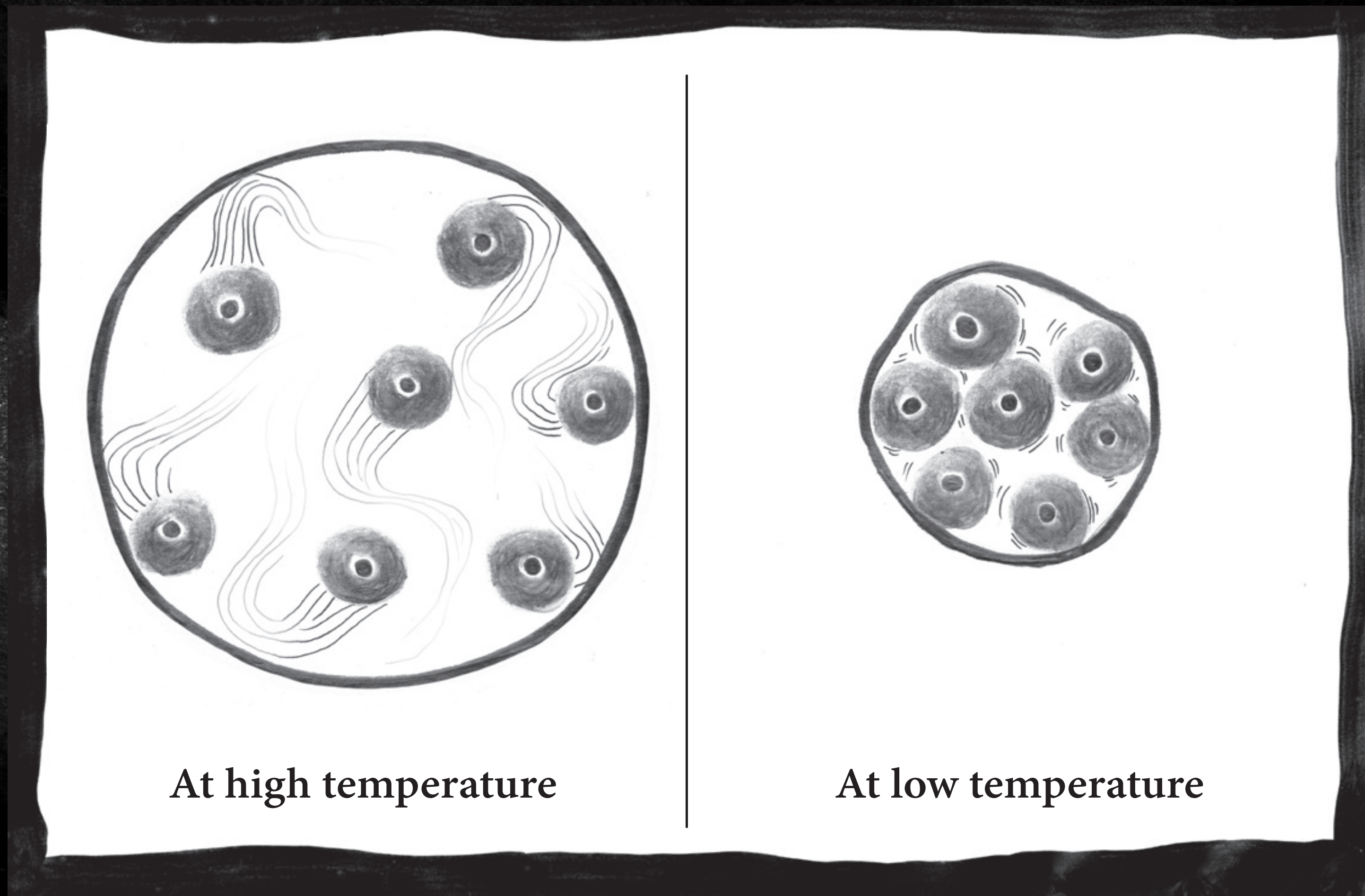
In 1662, Robert Boyle showed that the pressure of a gas is inversely proportional to the volume it occupies. This was the first of many discoveries in the field of physical properties of gases.

Vacuum pump used by Boyle for his experiments.

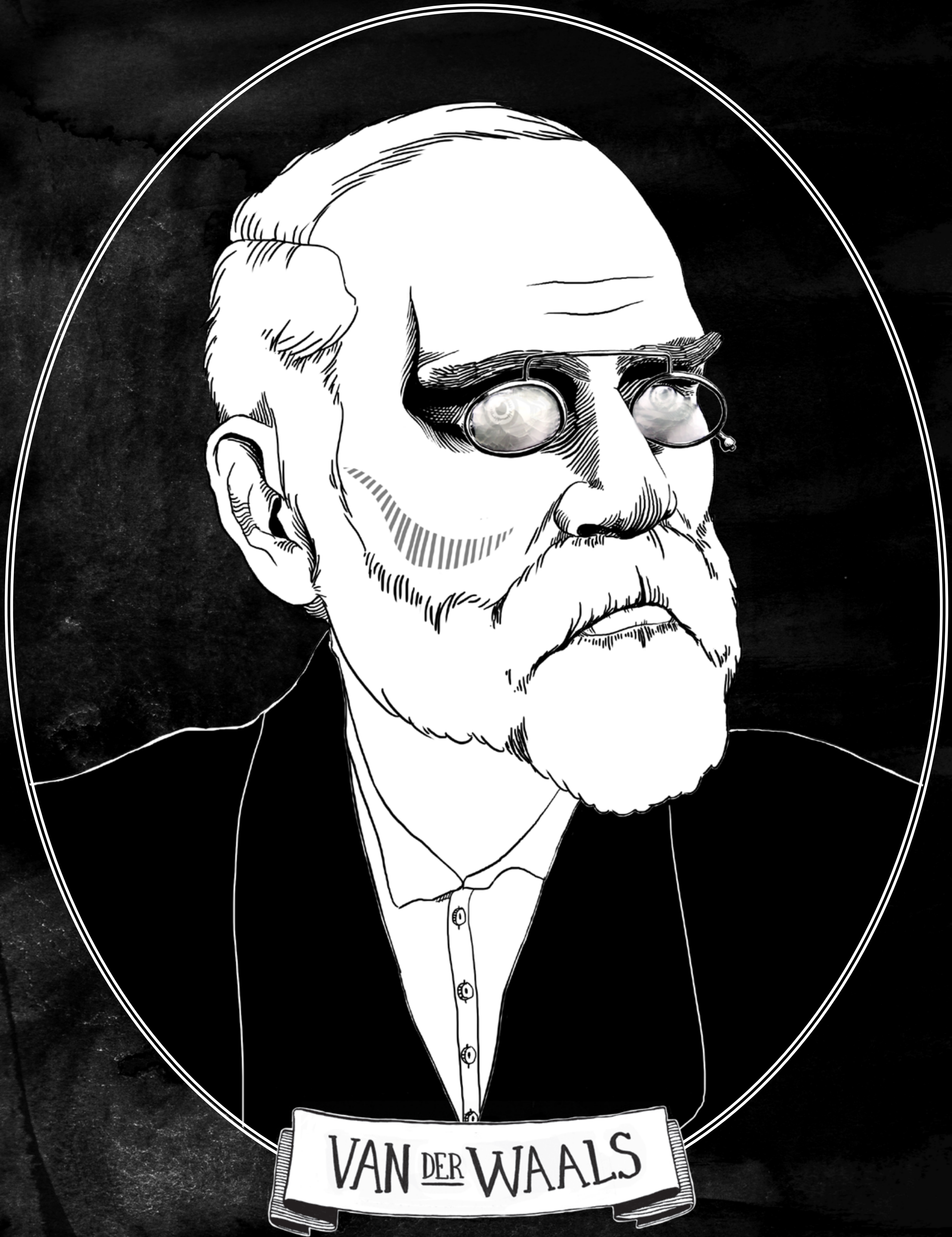
The volume experiment

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





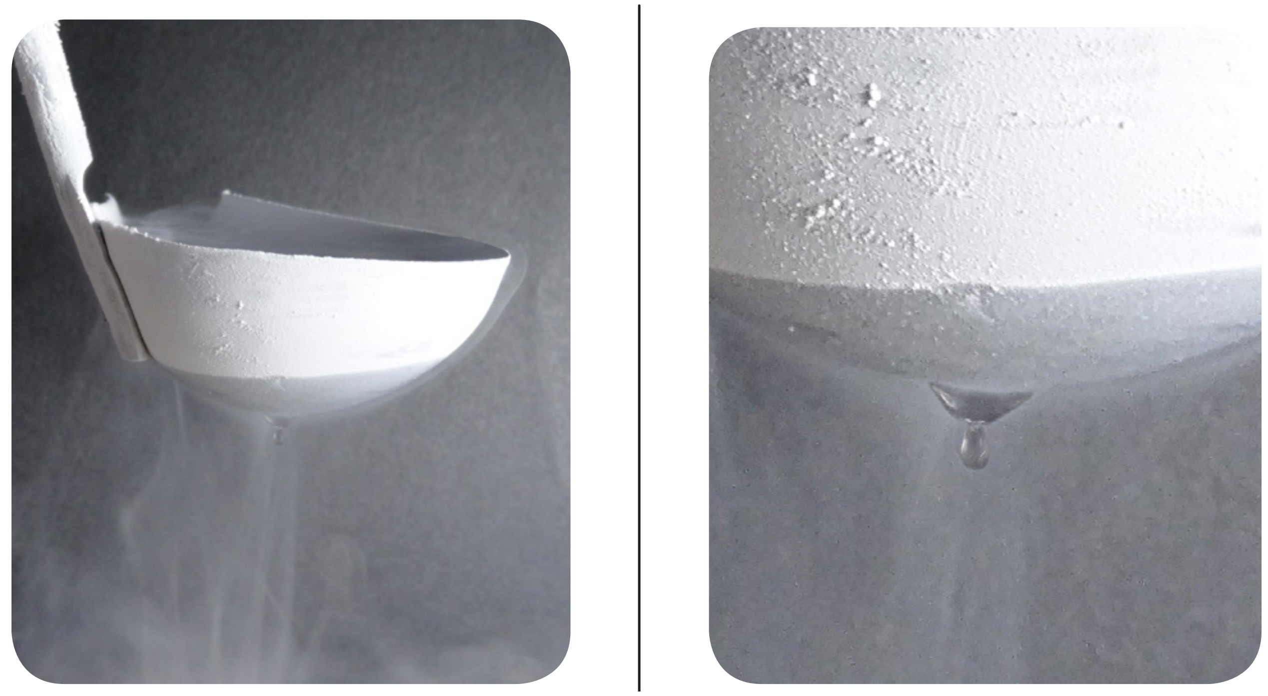
Cold
&
Liquids



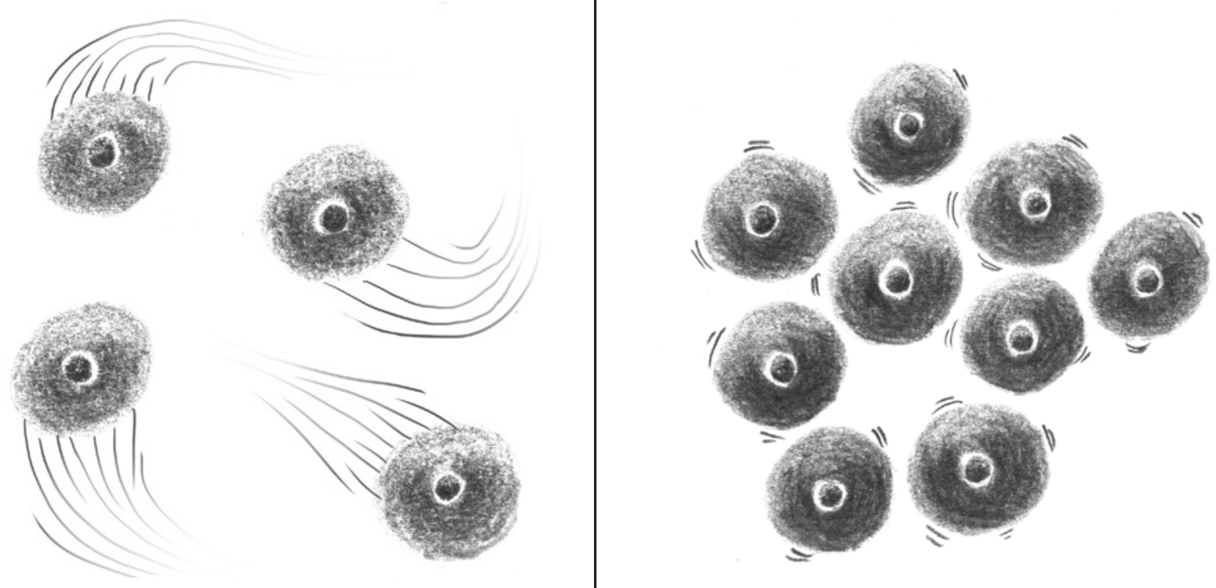
In 1873, Johannes van der Waals formulated an equation that shows that a gas becomes liquid when it is cooled because its molecules are attracted to each other.

The liquefaction experiment

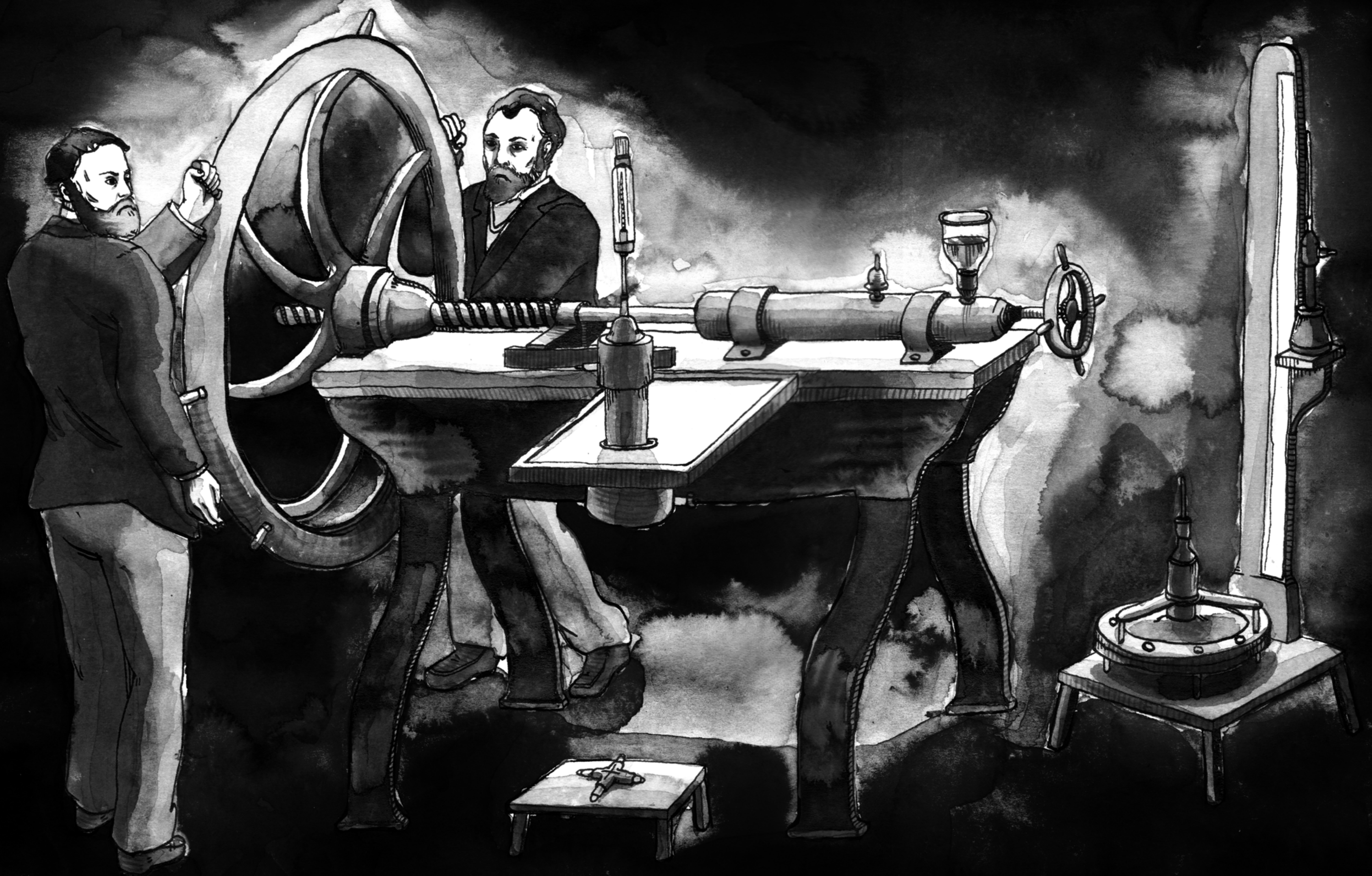
When a metal is cooled with liquid nitrogen, it reaches a temperature of -196 °C and the air around it becomes cold enough for its oxygen to liquefy. The drops that form on the metal surface are liquid oxygen. All gases become liquid when cooled because their molecules become attracted to each other and prefer to condense when they move less.



Air liquefaction



At high temperature | At low temperature



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

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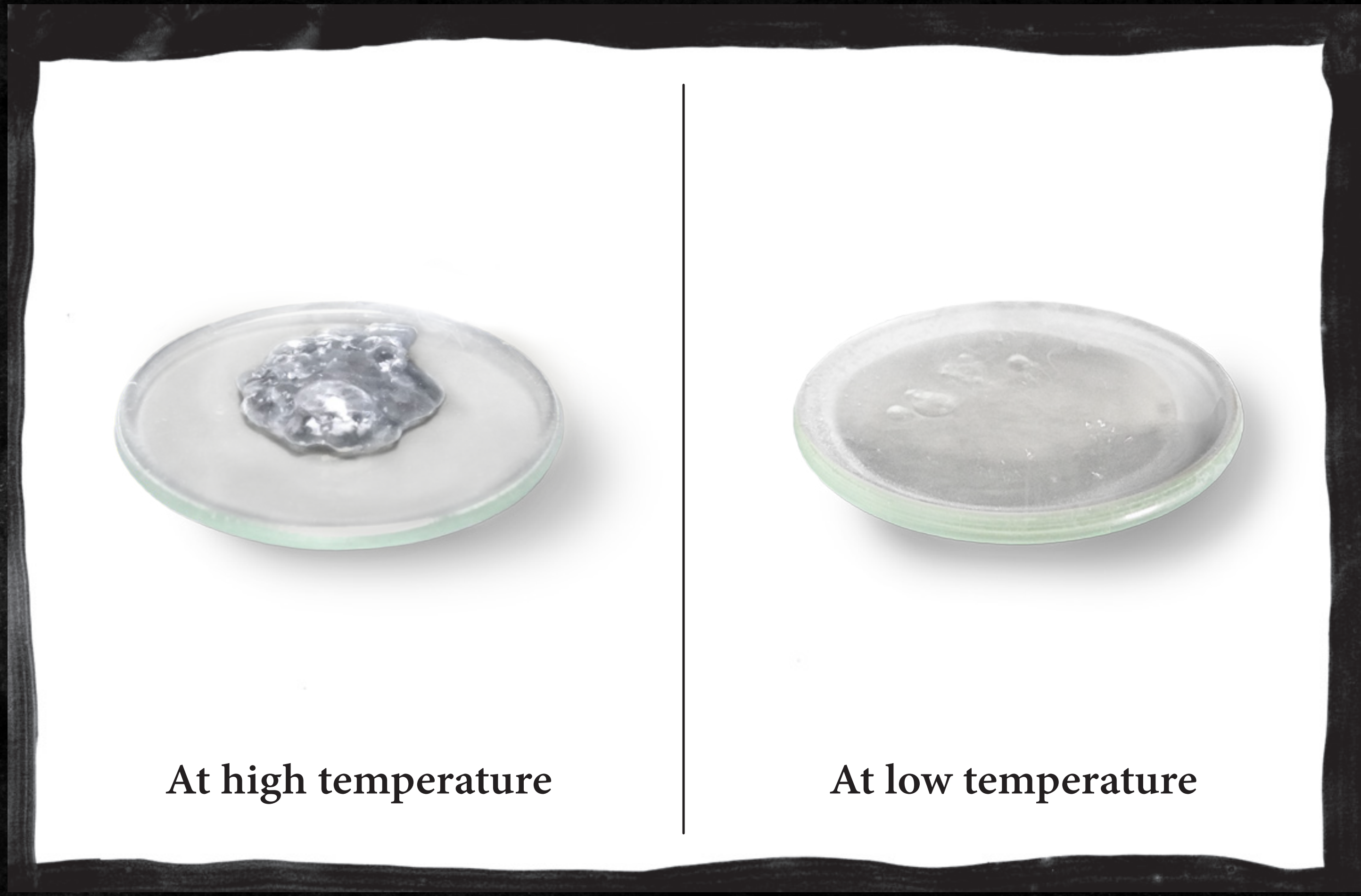
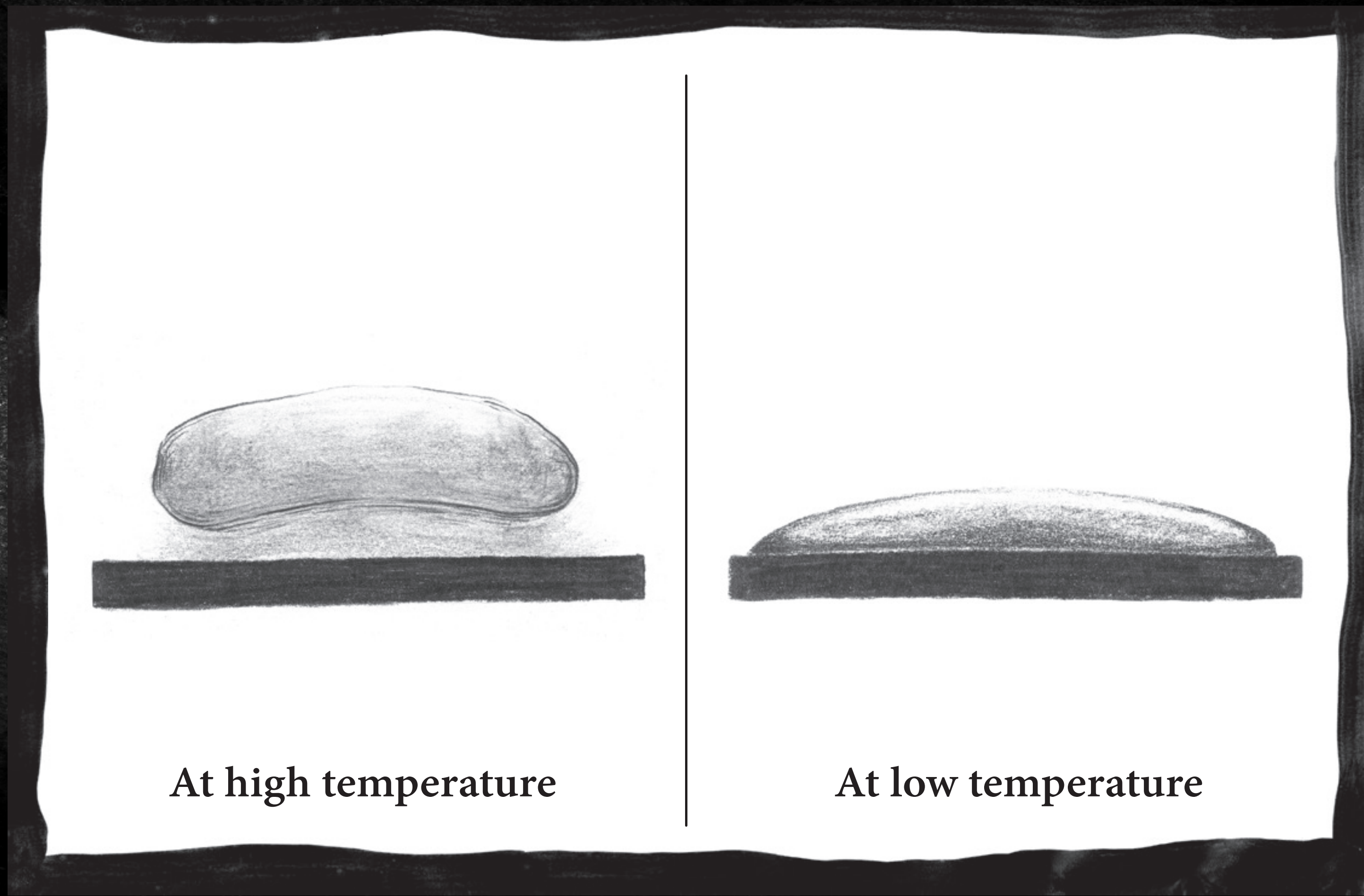
The Leidenfrost Effect

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.

The Leidenfrost experiment

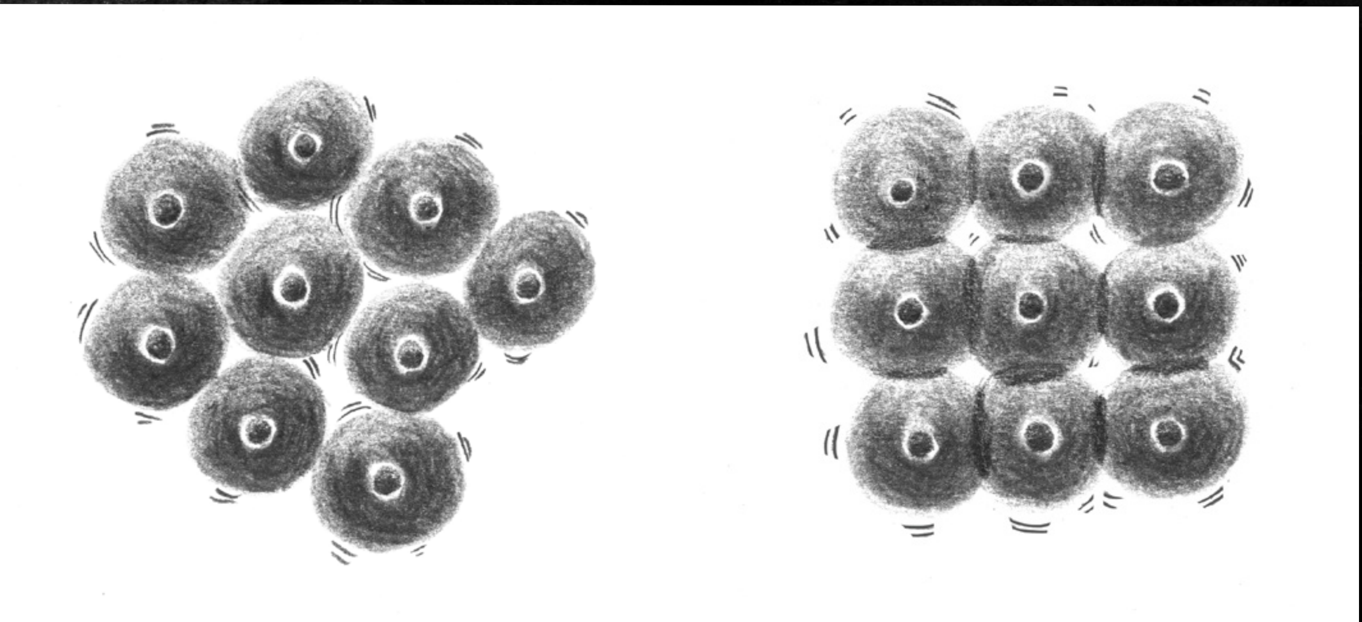
When a drop of liquid is placed on a plate that is at a much higher temperature, it evaporates. A thin layer of vapor then forms under the drop. This layer isolates the drop from the heat and suspends it above the surface. That is what happens when drops of liquid nitrogen get in contact with a hot plate that is at room temperature.





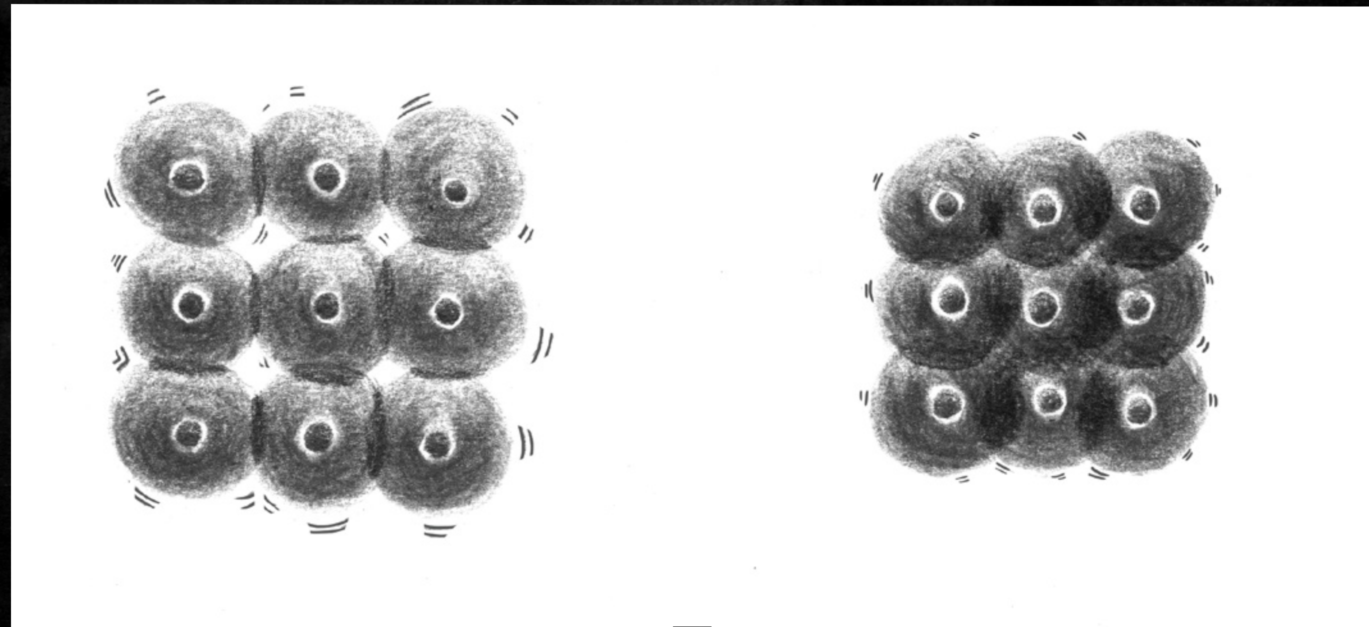
Cold & Solids

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.



When a liquid has sufficiently cooled, it becomes a solid (with the exception of helium).

Indeed, at low temperature, the particles are not agitated enough for atoms to move freely.



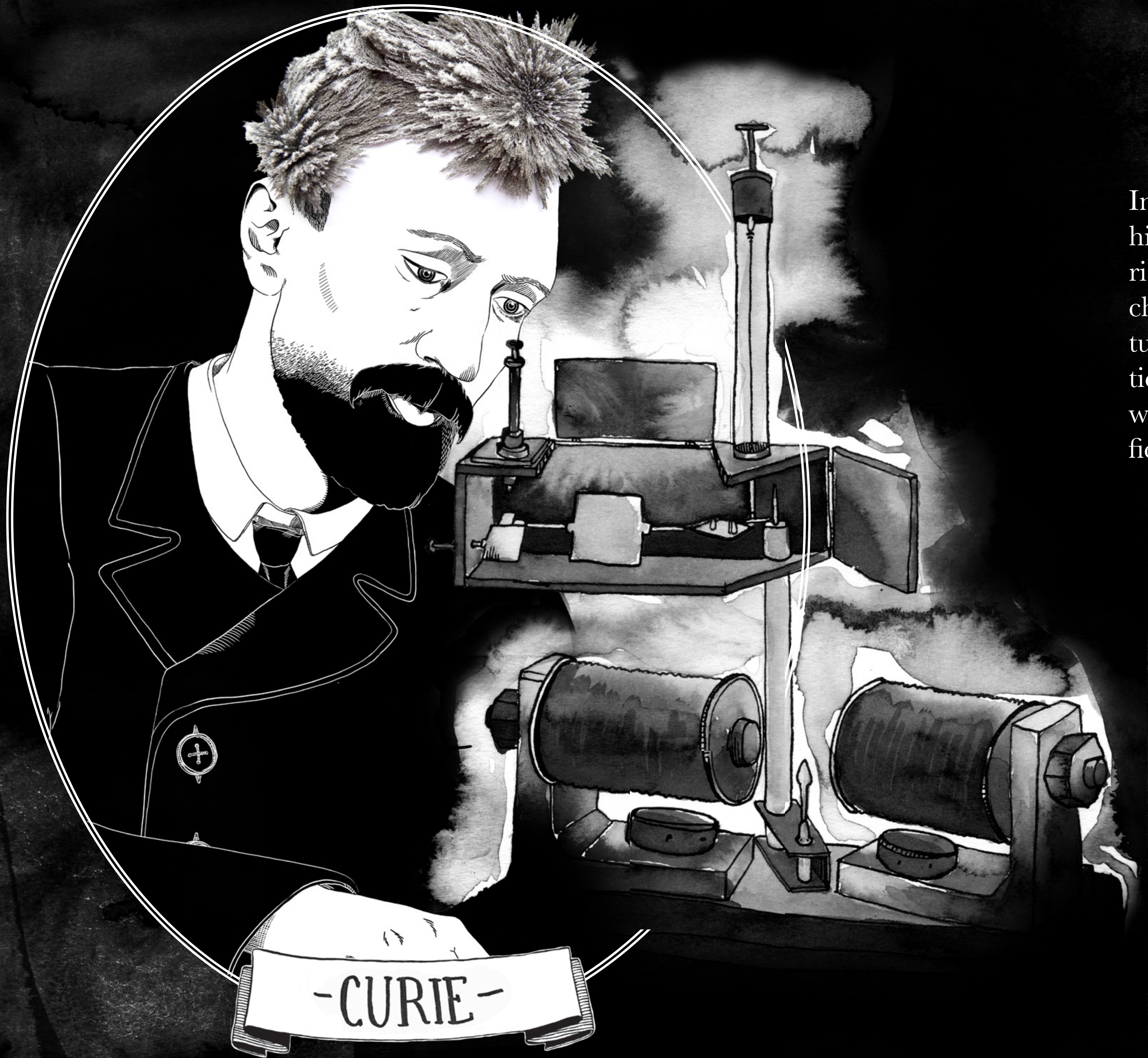
They stop moving, arranging themselves in a more or less orderly fashion according to the material. But they keep vibrating in a fixed position. When a solid is cooled, it contracts because its atoms move less and come closer together.

Most solids contract when cooled, but do not become fragile.

Only a few solids become breakable, rubber for instance: its long molecules cannot move around or glide along each other any longer.

Cold plants are very fragile as well because the water they contain turns to ice and becomes brittle.

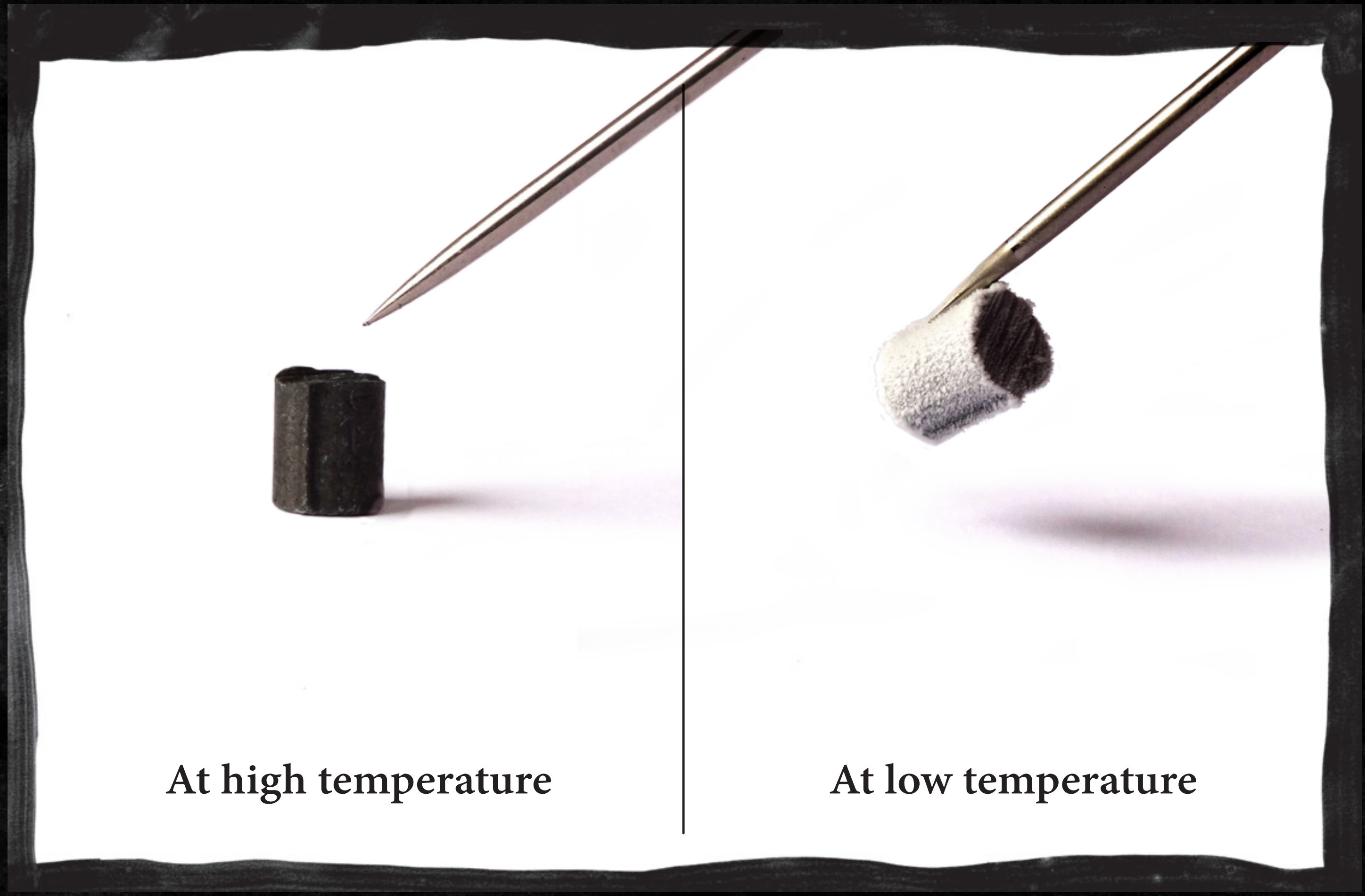
Cold & Magnets

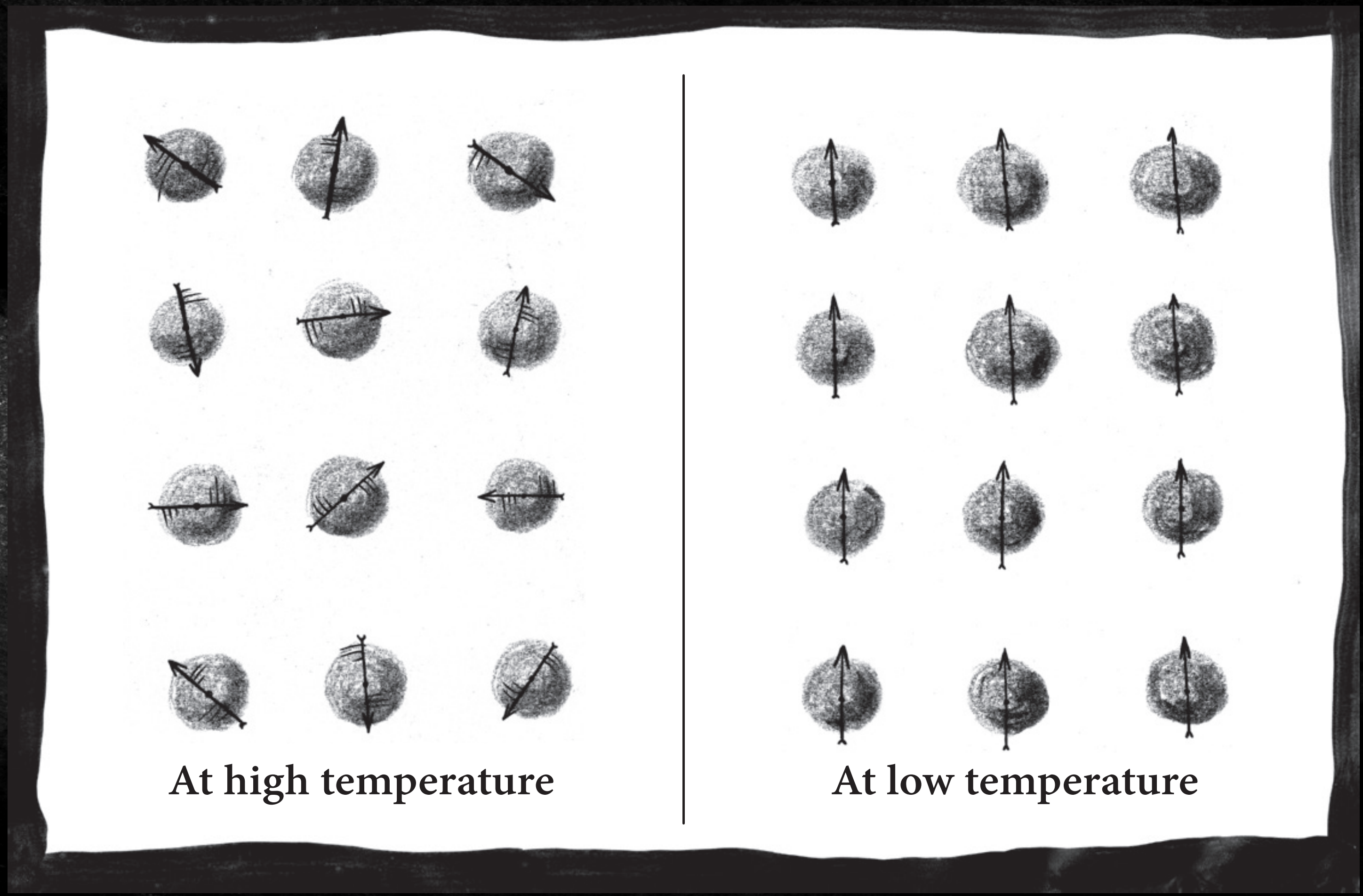


In 1895, Pierre Curie defended his thesis on magnetic materials and their behavior, which changes according to temperature. He measured the magnetic force these materials created when put in a varying magnetic field.

The magnetic experiment

In magnets, atoms carry small quantum magnets called spins. These spins are all arranged in parallel, which explains the existence of the North and South Poles and the magnetic properties of magnets. But when a magnet is heated above Curie temperature, its spins become disorganized and fluctuate. Its magnetization then disappears; the material is no longer magnetic. This is what happens here to gadolinium at temperatures above 20 °C.



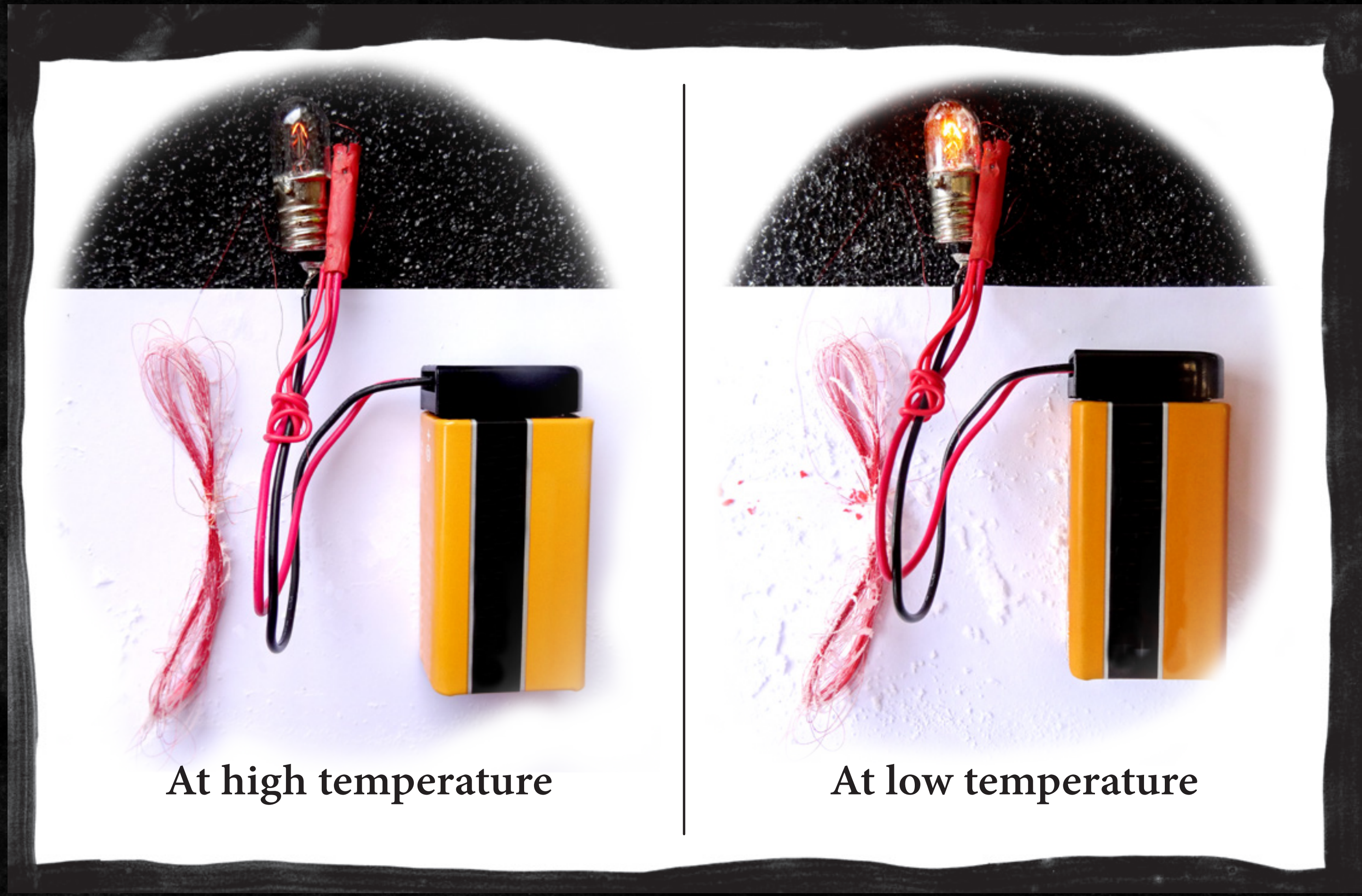


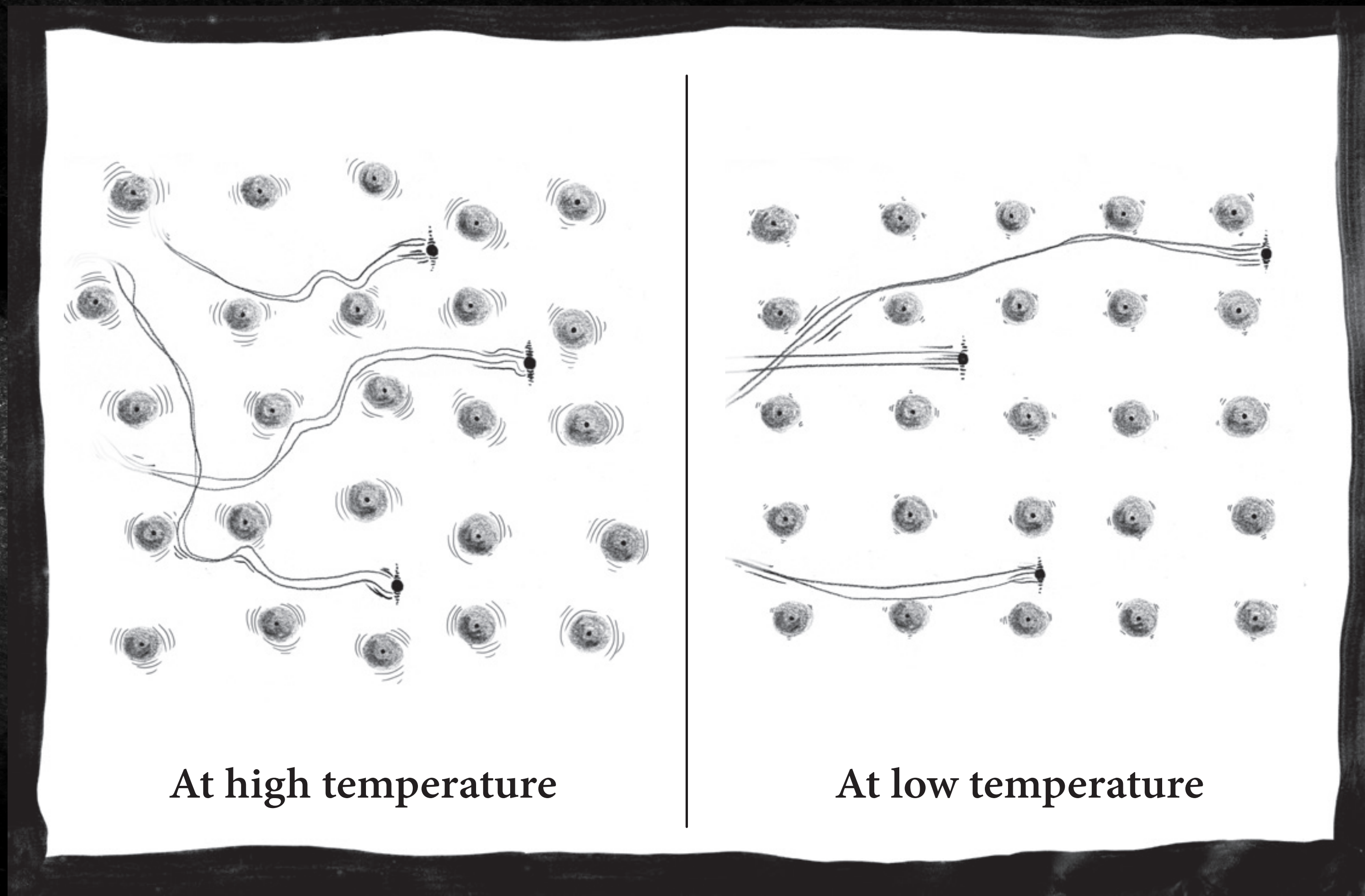
Cold & Metals

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

The conductivity experiment

In metals, electrons behave as waves among atoms. But the vibrations of atoms caused by heat slow them down. When metals are cooled, their atoms vibrate less and the electrons can therefore move more freely. The electrical resistance of the wire then decreases. That is why a bulb will light up more easily when its wire is cooled.



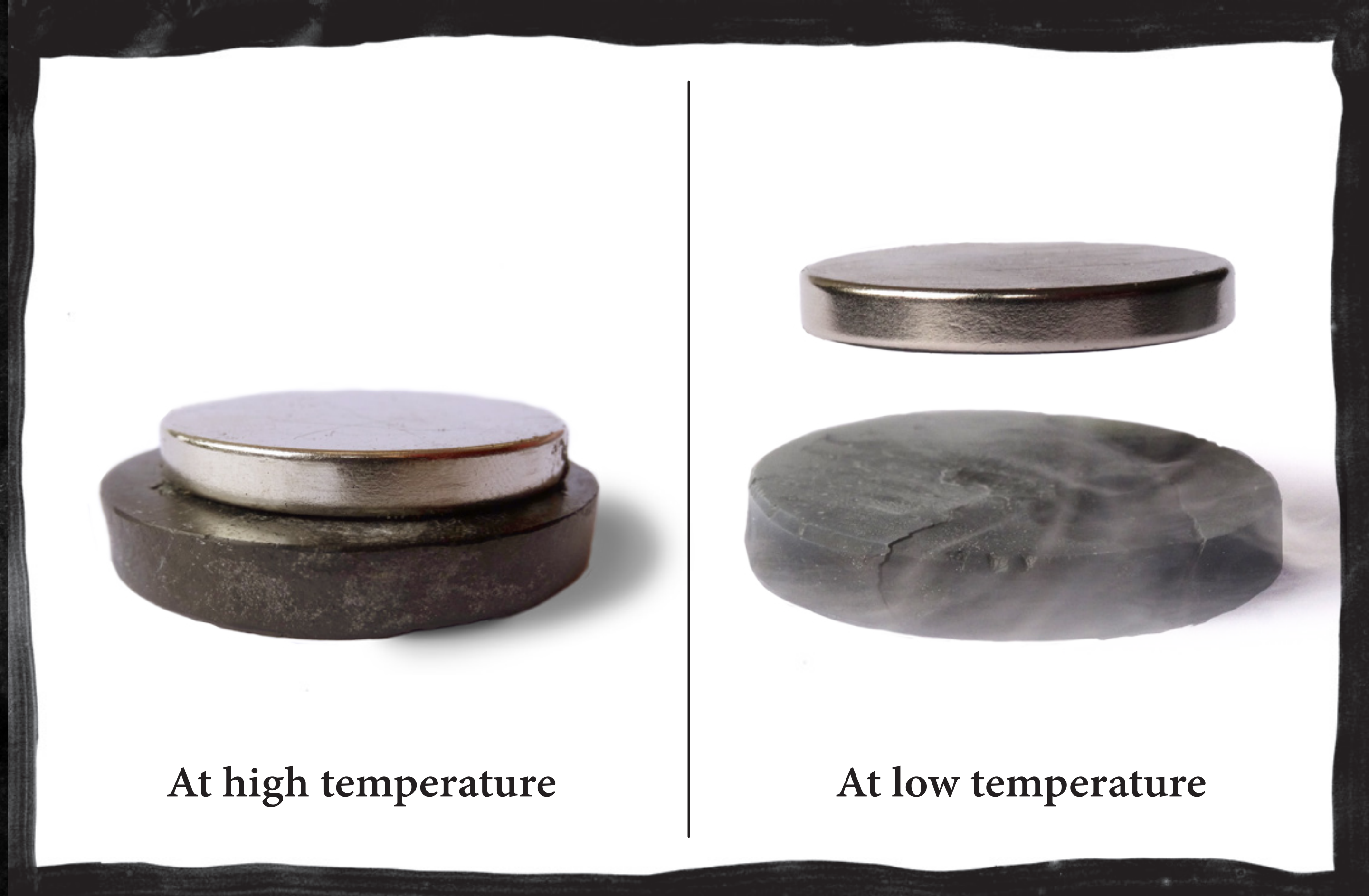


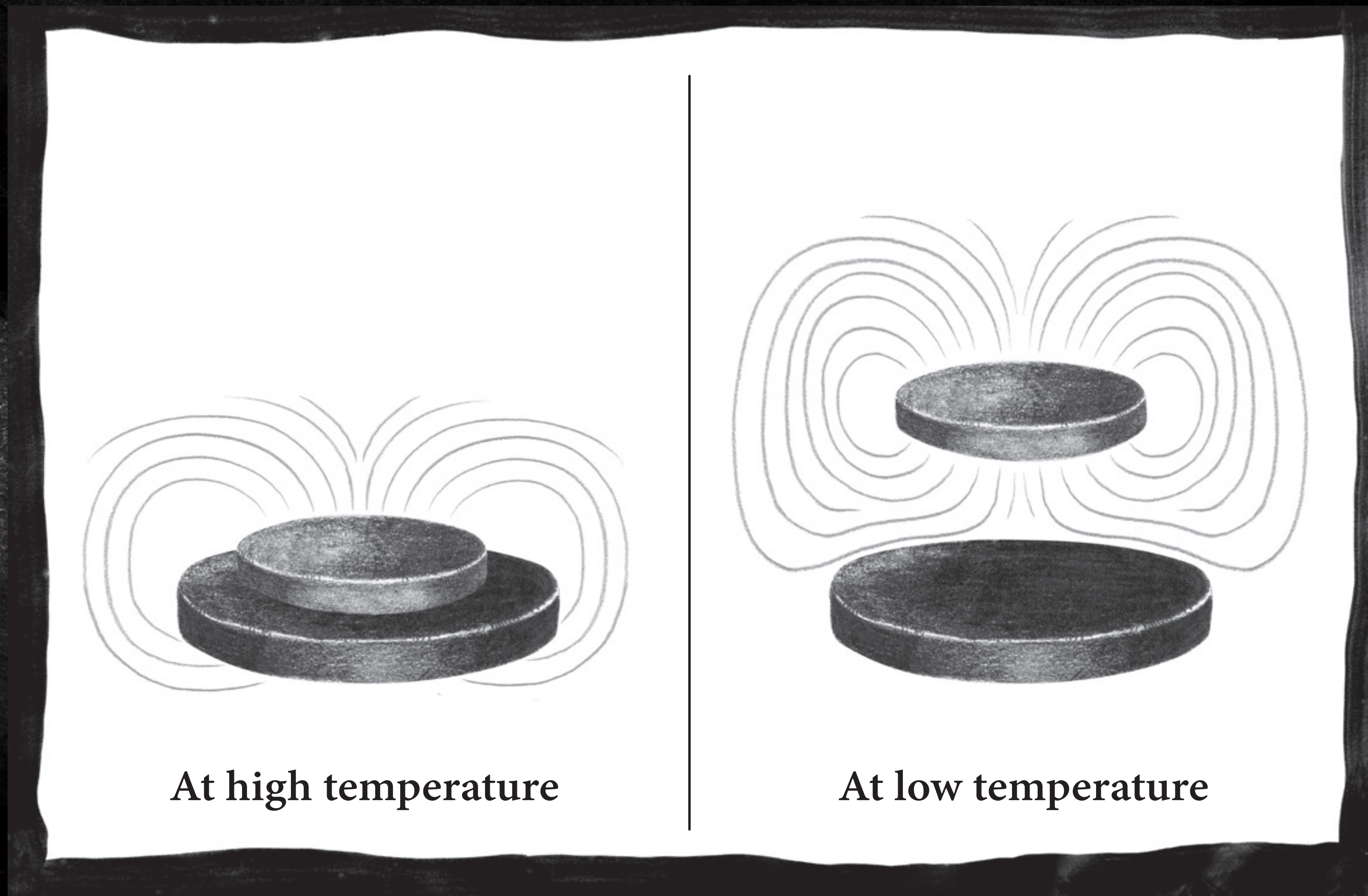
Cold & Superconductivity

In 1911, Kammerlingh Onnes discovered superconductivity while studying mercury.

The superconductivity experiment

At very low temperature, some metals become superconductors. Their electrons suddenly form a sort of gigantic quantum wave. Not only do these materials then conduct electrical current perfectly, but they also expel their magnetic fields. That is why they are able to make magnets levitate. This phenomenon can be observed here in cuprate, which behaves as a superconductor at a much higher temperature than is usual for metals.





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