

**I happen to have discovered a direct relation between magnetism and light, also electricity and light, and the field it opens is so large and I think rich.**

**Michael Faraday**



**Arizona State University**  
**SES 194**

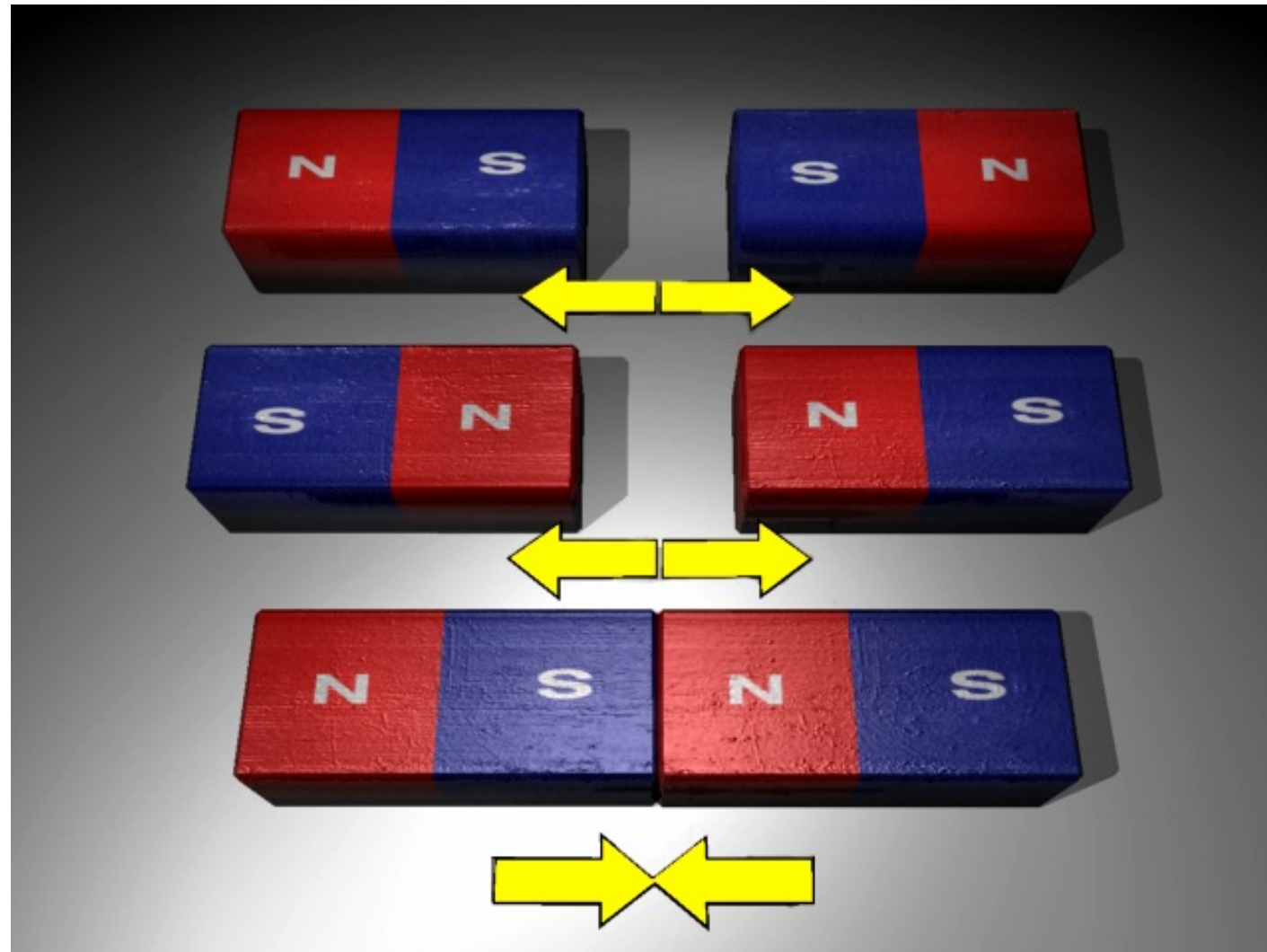
# **Energy in Everyday Life**

## **Magnets**

**Frank Timmes**

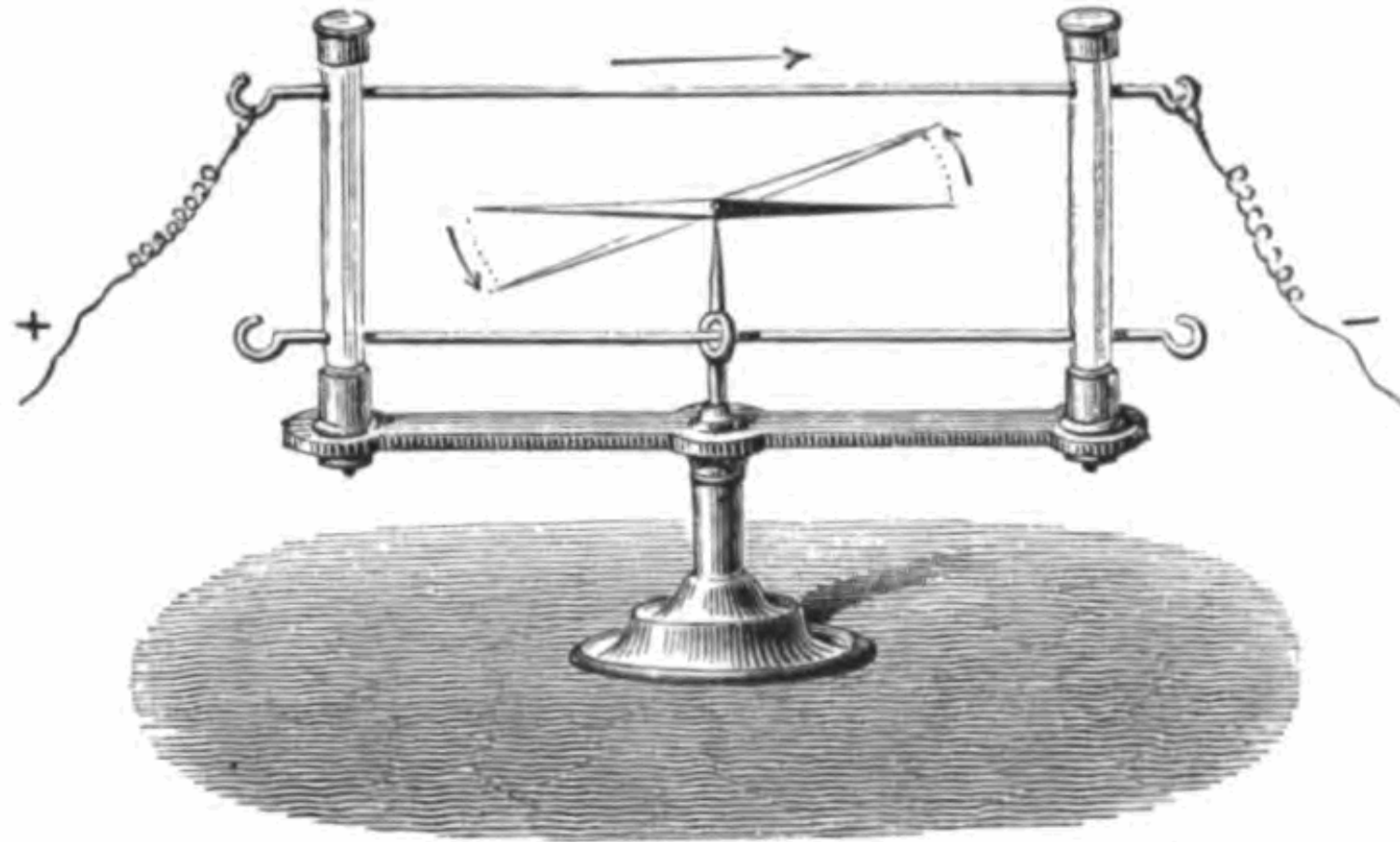
**[ftimmes@asu.edu](mailto:ftimmes@asu.edu)**

**We've all played with little magnets. We found we could exert forces and pick up some metals.**



**We saw the North end repelled other North ends and attracted the South end, and likewise the South ends repel one another.**

**The modern uses of magnets and magnetic forces date to Christian Oersted's discovery in 1819 that a current carrying an electric current can act as a magnet.**



**The greater the current, the stronger the magnetic field. This was the beginning of the recognition that electricity and magnetism were just different aspects of the same phenomena (heads and tails of the same coin).**

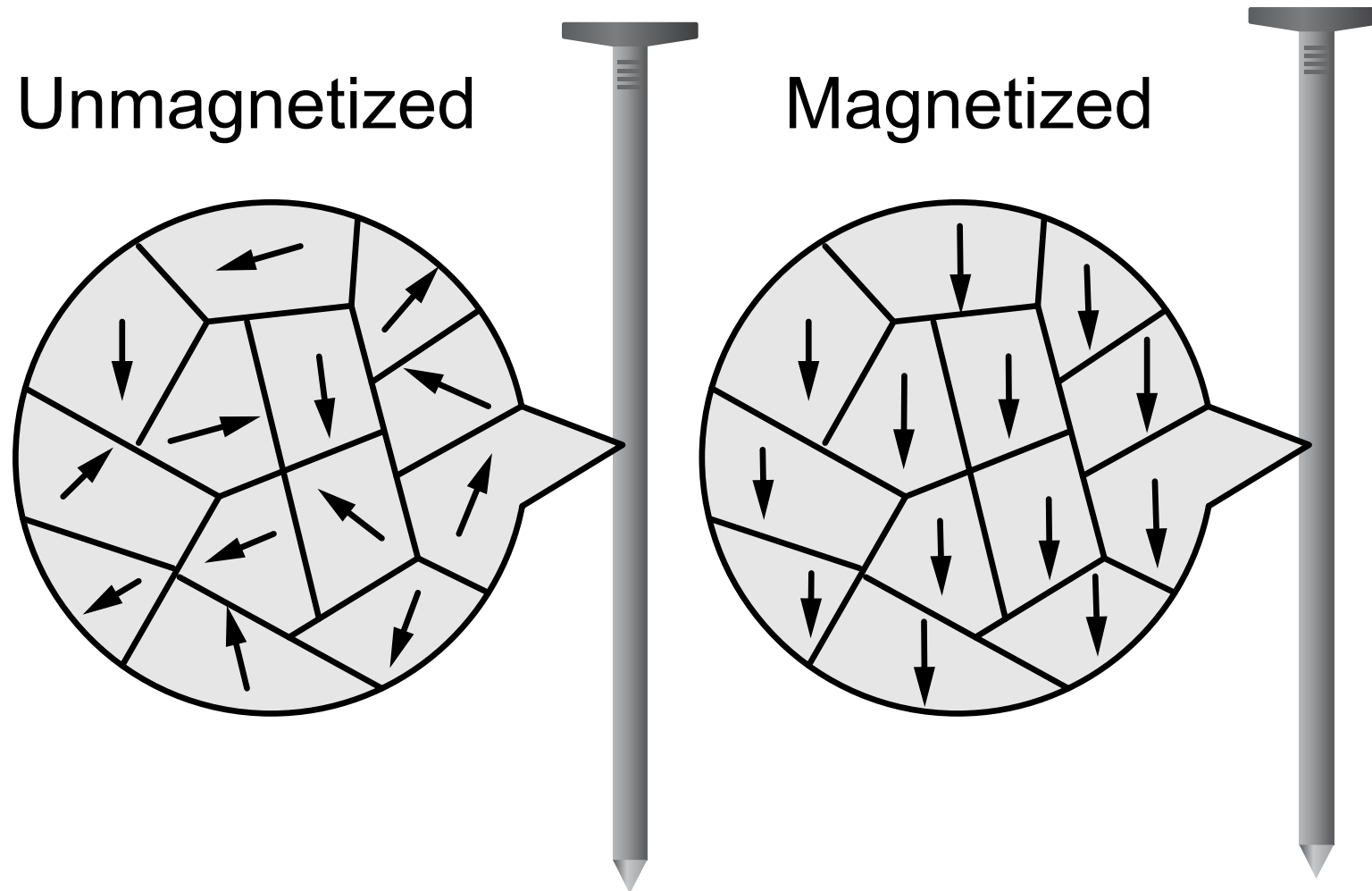
**Circulating electrons in atoms can cause magnetic fields.**



**In materials known as ferromagnets - iron for example - these little magnetic fields can line up in the same direction to give a macroscopic magnet.**



**Ordinary iron is not a magnet because the atomic magnetic fields are randomly oriented; the effects cancel each other.**

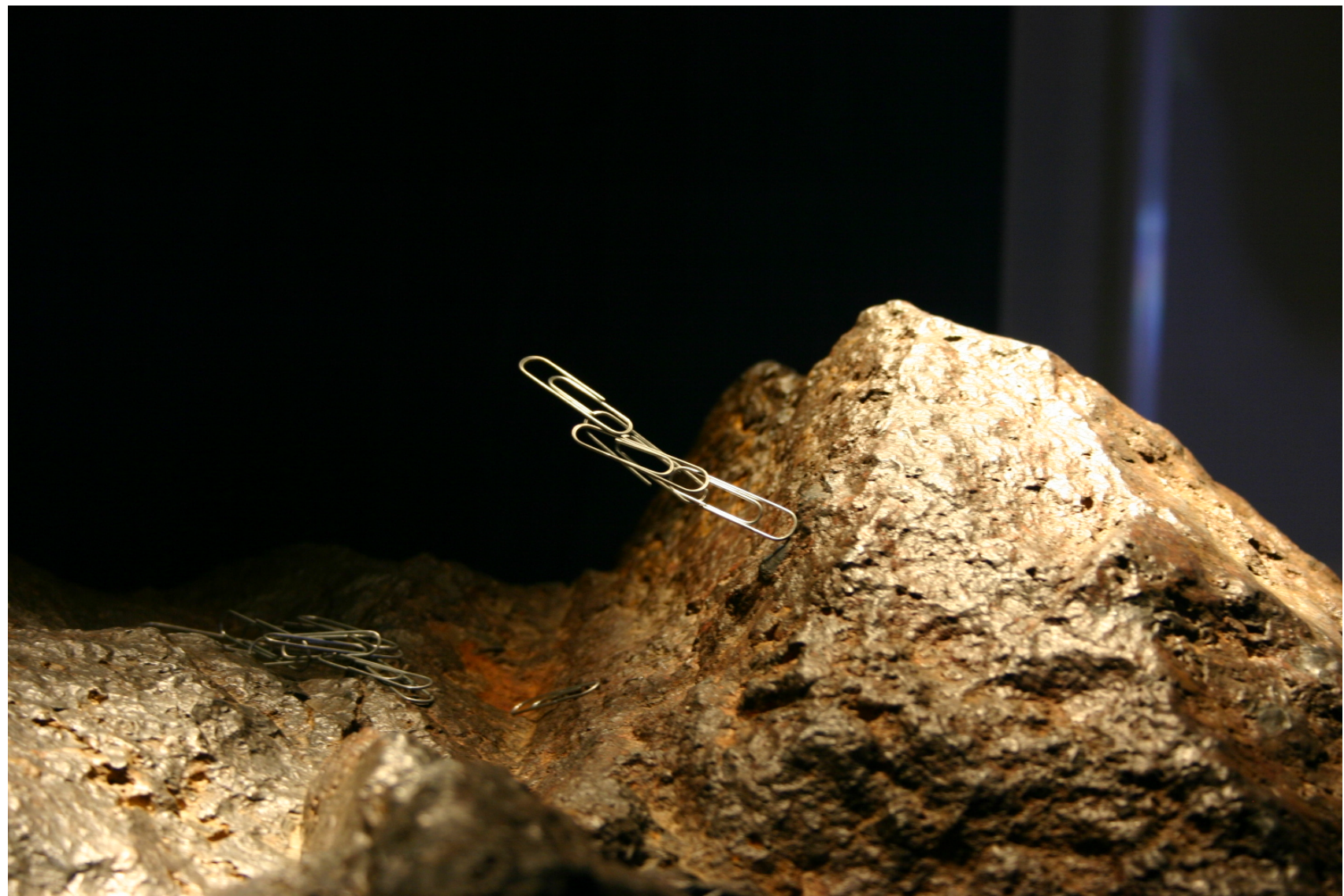


**In the presence of an externally imposed magnetic field, the little magnets are forced to point in the same direction. The piece of iron becomes a magnet.**

**In permanent magnets, the atomic magnets are lined up.**

**For example, rocks from Magnesia in Asia Minor (town of Tekin in modern day Turkey), from which the term “magnet” is derived, became magnets by being heated inside the Earth and then cooled.**

**Earth’s magnetic field caused the atomic magnetic fields in the cooling iron-rich rock to line up.**





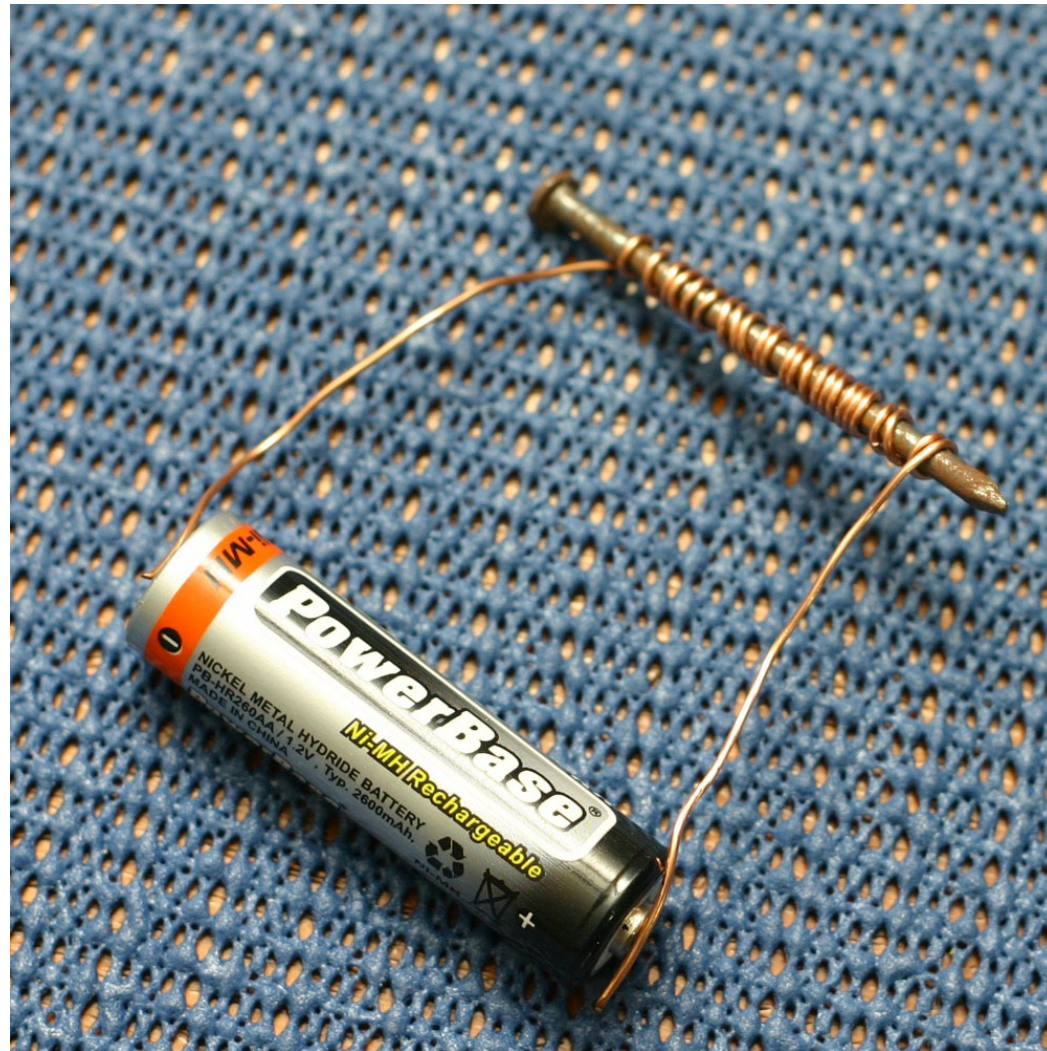
**Another way to make a permanent magnet is subject a piece of iron to a very strong external magnetic field.**

**When the external field is removed, there is a residual ordering of the atomic fields and the iron becomes a permanent magnet.**





**An electromagnet is constructed by wrapping a wire around a piece of iron. The wires are connected to a battery, so current flows in the wires.**



**The current produces a magnetic field. The magnetic field causes the atomic magnetic fields in the iron to line up and presto - we have a magnet.**



**The amplification of the magnetic field in electromagnets can be very large. Electromagnets are used to pick up entire cars in junkyards.**



**When the current is turned off, the piece of iron will return to its random magnetic orientation.**