



The Search for the Smallest Thing

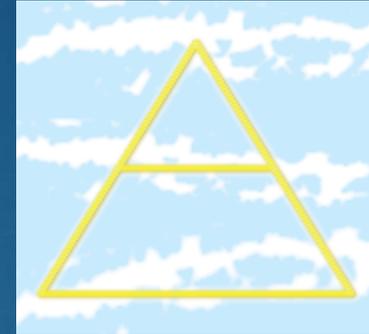
AN INTRODUCTION TO PARTICLE PHYSICS

When you think of alchemy, what do you think of?

Fire



Air



Earth



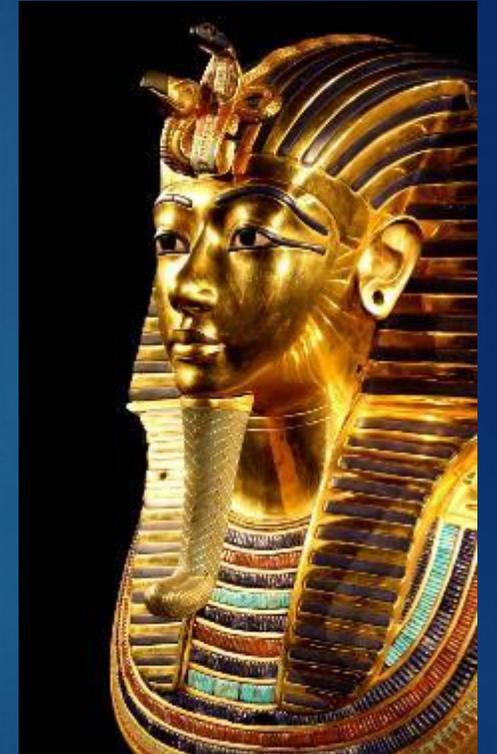
Water



- Alchemy began about 2000 years ago
- The first alchemist in the west was **Hermes Trismegistus**. He lived in Alexandria, Egypt. The Caduceus is his symbol. The hermetic seal is named after him.

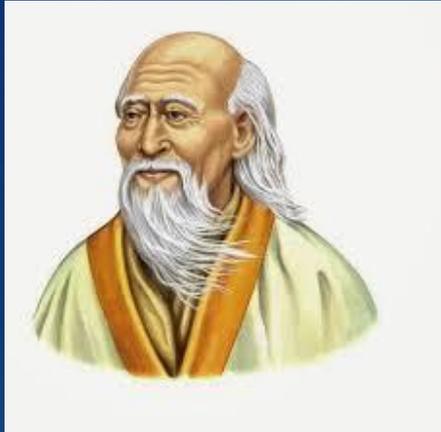


- Alchemy developed independently in Egypt, India, and China
- It was a spiritual discipline, not about getting rich
- Two fundamental beliefs:
 - Nature is constantly changing (including metals)
 - Death and disease are caused by impurity
- The purest metal was believed to be gold (it does not rust or tarnish, and it does not lose its luster)
- Gold is seen as a symbol of immortality



- “Khemia” was the Greek word for Egypt. After the Arabs occupied Egypt in the 700’s, they added the “al” to make it “al-Khemia” – The Black Land, for the black soil.
- In China, the focus of alchemy was on finding the “Elixir of Life”. Elixir comes from *al-'iksīr*, the Arabic term for “a powder that heals wounds”. It was hoped the Elixir of Life would bring immortality.
- A common idea was that the same techniques that purified metal would work to purify the soul. Since purifying metal often meant using mercury and arsenic, what could possibly go wrong?

What is the name of the first emperor of all China?



a) Lao Tzu

ExcellenceReporter.com



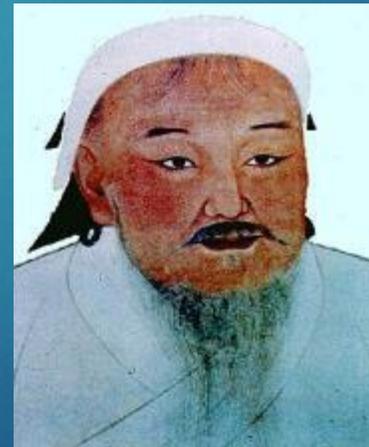
b) Kublai Khan

Wordpress.com



c) Qin Shi Huang

Thefamouspeople.com



d) Genghis Khan

NBCNews.com



Thefamouspeople.com

Qin Shi Huang – The First Emperor of China

(259 BCE - 210 BCE)



Istockphoto.com



TravelChinaGuide.com

Qin Shi Huang, king of Qin, took the other six kingdoms of China and unified the country.

He was extremely brutal, executing tens of thousands.

He began to fear the spirits of the dead, so he had 8000 terracotta warriors made to protect him after his death.

He also began the building of the Great Wall to protect the north.



- Qin Shi Huang began to fear death and ordered his alchemists to find the elixir of life.
- To buy time for the search, the alchemist Xu Fu provided the emperor with mercury pills to purify his soul.
- Eventually Xu Fu went on a sea journey to find the elixir and never returned. !!!!!!!!!!!!!
- Mercury poisoning caused paranoia, delusions, and finally death at the age of 49.
- At least 10 other Chinese emperors died because of “elixirs of life”.



Which of the following did alchemists NOT think was a “smallest thing”?



a) Gold

LiveScience.com



b) Salt

shutterstock.com • 566653357



c) Sulfur

Wikipedia.com



d) Mercury

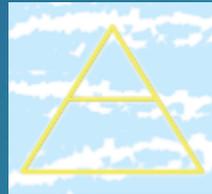
Indiamart.com

So, what did alchemists believe were the smallest things?

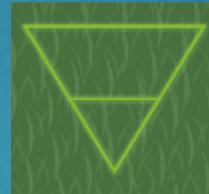
Well, they had SEVEN smallest things.



Fire



Air



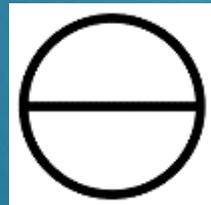
Earth



Water



Sulfur



Salt



Mercury -
Hydrargyrum

The alchemists believed that metals were composed of different amounts of these, so if you could adjust the mixture, you could transform one metal into another. Of course, this doesn't work.

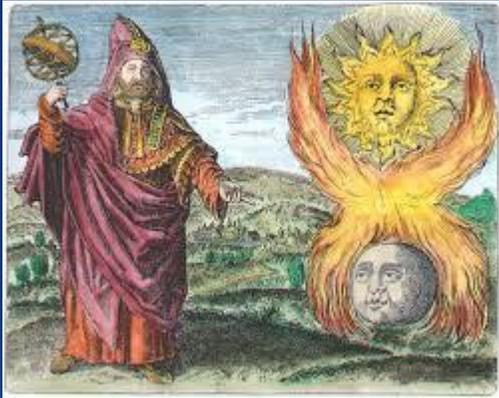
Discoveries made by the alchemists:

- The elements zinc, arsenic, and phosphorus
- Hermetic (air-tight) seals
- Distillation (thank Mary the Jewess, ca 200 CE)
- Basic techniques of metallurgy and metalworking
- Ways to tan leather
- New inks, dyes, paints, and cosmetics
- Porcelain! The English China industry started with alchemy.
- Many new compounds such as sulfuric and nitric acid, silver nitrate, carbon dioxide, laudanum, and ... gunpowder!
- The idea of using chemicals to cure disease
- The processes of experimentation and documenting results



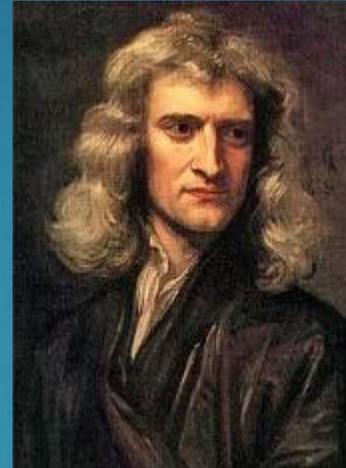
Wikipedia Commons

What famous alchemist appears in the Harry Potter series of books?



a) Hermes Trismegistus

Reddit.com



b) Isaac Newton

Wikipedia.com



c) Nicolas Flamel

Wikipedia.com

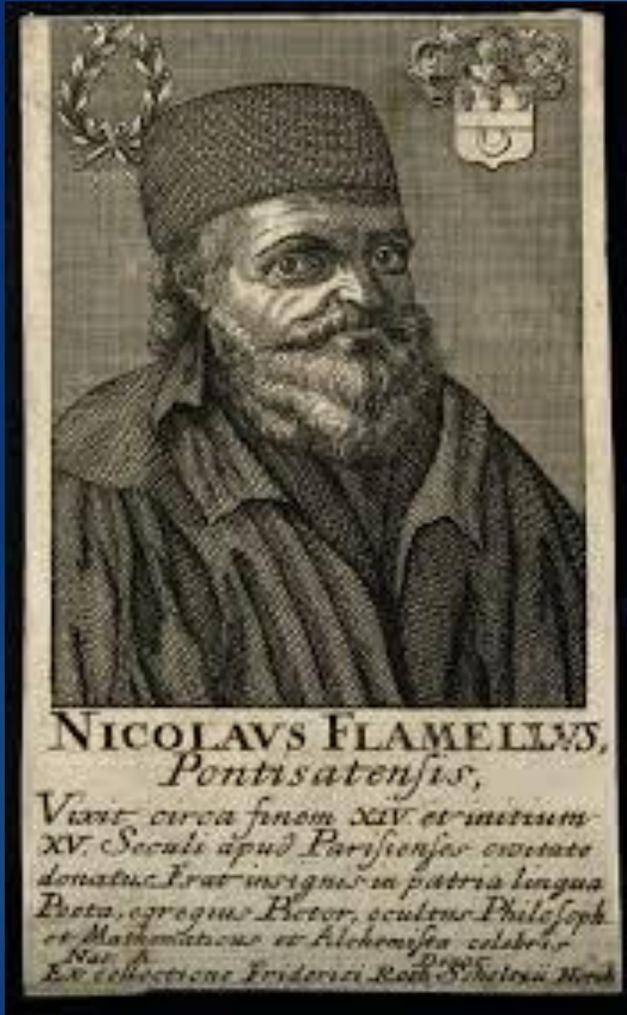


d) Mary the Jewess

Nli.org



- The life of Nicolas Flamel
- Born 1330 Died 1418, Lived in Paris
- Worked as a bookseller
- Married a wealthy widow
- Lived a pious and charitable life
- No evidence he practiced alchemy



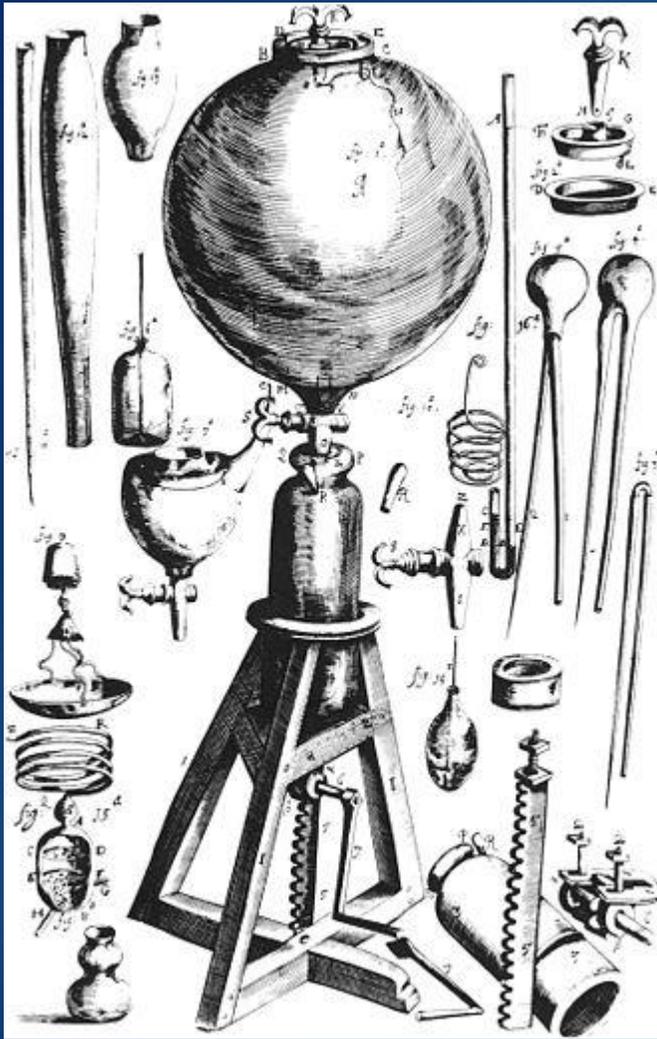
Discoverwalks.com

- The legend of Nicolas Flamel
- Began with a book called “Hieroglyphic Figures”, published in 1612 in Paris
- Supposedly written by Flamel, it described his success at creating the Philosopher’s Stone and subsequent immortality
- Isaac Newton noted the work
- Flamel appears in “The Hunchback of Notre Dame” and the Harry Potter Series, among others



Sciencehistory.org

- Robert Boyle (b 1627 CE, d 1691 CE)
- Son of an Irish Earl, one of 14 children
- Became an alchemist
- A thorough researcher and recorder of his experiments
- Became convinced it was impossible to break gold into sulfur, salt, and mercury (although he did claim to convert gold into mercury – wrong direction, Robert!)



Wikipedia.org

Boyle's Vacuum Pump

Boyle is best known for “Boyle’s Law”: If you reduce the volume of a gas its pressure increases. This was one of the very first laws of chemistry.

He became convinced that gold and other metals were not made of other things, but at the smallest level were made of “corpuscles” of the metal. Does this sound at all familiar?

Boyle is considered by many to be the first true chemist.



Wikipedia.org

Antoine Lavoisier 1743-1794

- French Nobleman and Chemist
- Called “the Father of Modern Chemistry”
- A tremendous experimenter
- Broke water into its components, thereby discovering oxygen (shared with Priestley)
- Discovered Conservation of Mass
- Helped create the metric system
- Made an early list of elements (which had many mistakes) – 55 in all
- Was guillotined

Antoine and Marie Ann Lavoisier



So, by the end of the 18th century,

- Alchemy was largely abandoned
- The atomic theory was being revived
- “The smallest thing” was a collection of things – each element had its own atom
- The law of conservation of mass had been discovered

But, how many atoms were there? And how big were they? This would have to wait for the 19th Century.

Meanwhile, work with electricity was getting interesting...



Wikipedia.com

Jean Antoine Nollet shocking 200 Monks simultaneously for the entertainment of King Louis XV in 1743.



TmAtlantic.com

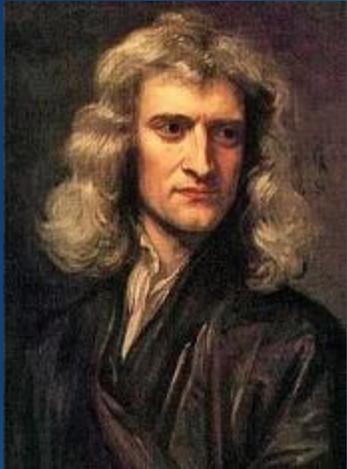


Nollet and his “Electric Boy” experiment, where a boy hung by silk ropes from the ceiling was electrified and showered sparks on people who got near him.

But who was the leading authority on electricity in the world in the 1740’s and 1750’s? You know his name!

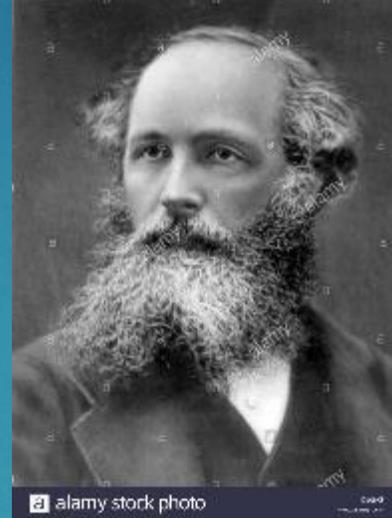
Wikipedia.com

Which of these is it?



a) Isaac Newton

[Wikipedia.com](https://en.wikipedia.org/wiki/Isaac_Newton)

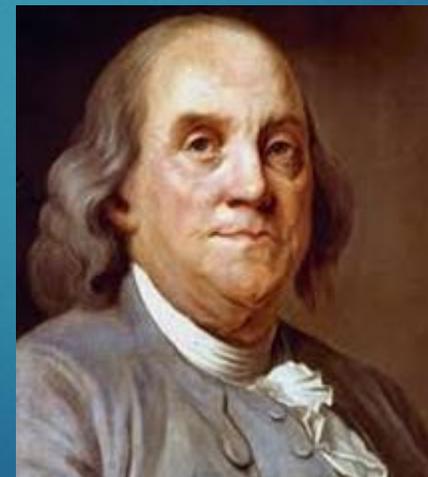


b) James Maxwell



c) Michael Faraday

[Sapaviva.com](https://www.sapaviva.com/)



d) Benjamin Franklin

[Commons.Wikipedia.com](https://commons.wikimedia.org/wiki/File:Benjamin_Franklin_1766.jpg)



Yes, that's right,
Benjamin Franklin!

- ▶ What discovery did Franklin make that was historic?
- ▶ Let's try a demonstration and see...

- Franklin discovered that like charges repel and unlike charges attract.
- This suggests there are two types of electric charge!
- Franklin called them “positive” and “negative”.
- Sadly, Franklin got them backwards, thus causing electricians grief ever since.



Commons.Wikipedia.com

What's a Leyden Jar?

What's the real story behind Franklin and the kite?

Who is Georg Wilhelm Richman?



Wikipedia.com

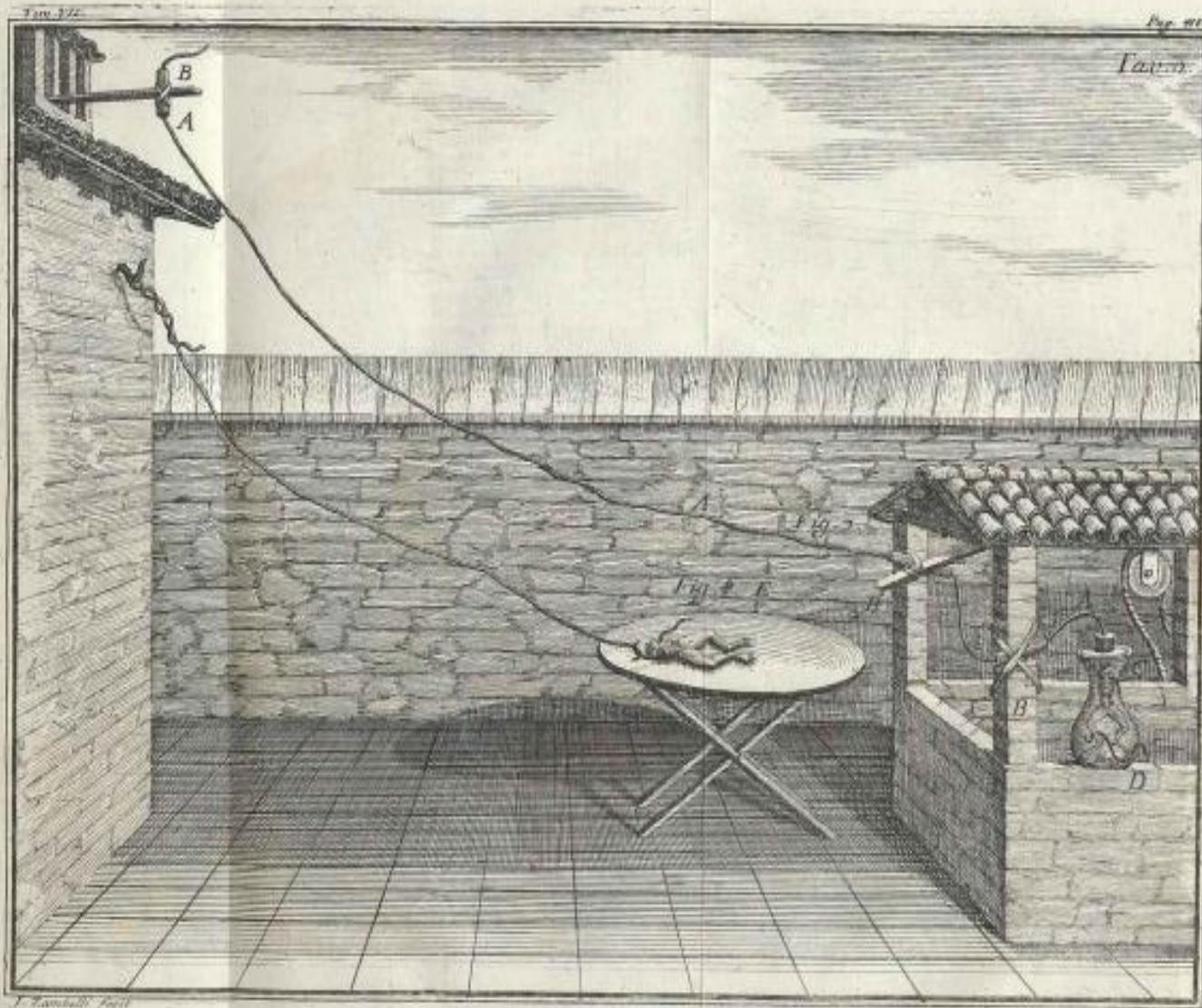


Franklin's work with electricity and lightning led him to develop lightning rods, which protect millions of buildings today.

Until Luigi Galvani came along, no one knew how to make electricity except by rubbing two things together.

Actually, credit for his discovery should go to his wife, but we all know about THAT sort of history...

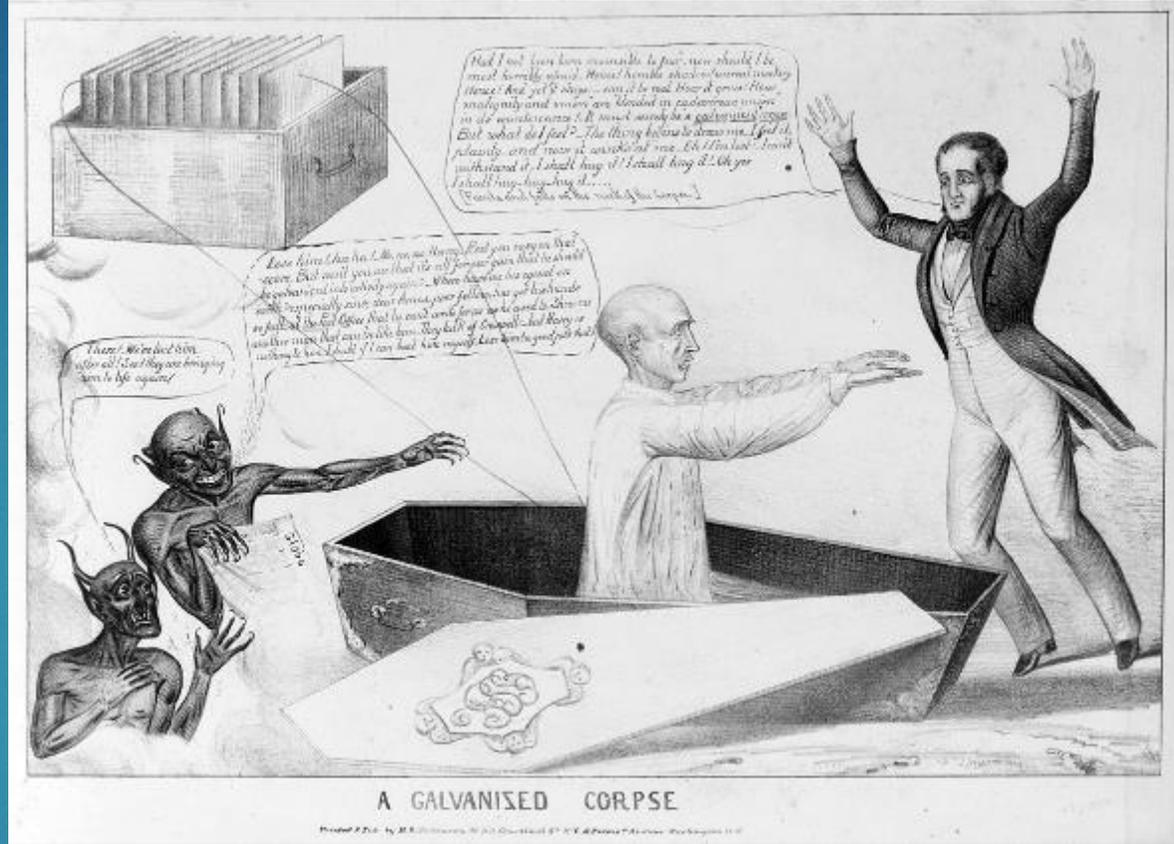




Luigi Galvani's
Dead Frog
Experiment on his
balcony between
1780 and 1791.



Brittanica.com



Smithsonian.com

It was this experiment that inspired Mary Shelley to write the story "Frankenstein"



So, by the end of the 18th century the atomic theory was being revived, but there were still many questions such as:

- How many types of atoms are there?
- How big is an atom (how much space does it take up)?
- How heavy is an atom?
- How do atoms attach themselves to each other?

These were the great searches of the 19th century, which we'll explore next week!