The Experimental and Historical Foundations of Electricity

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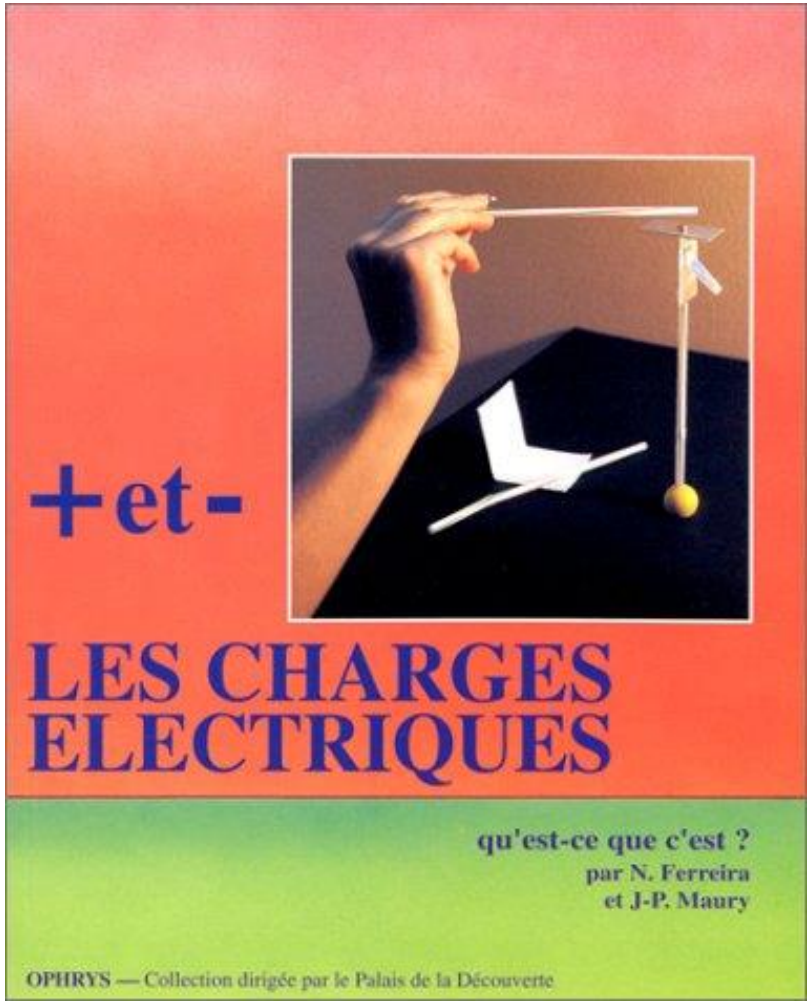
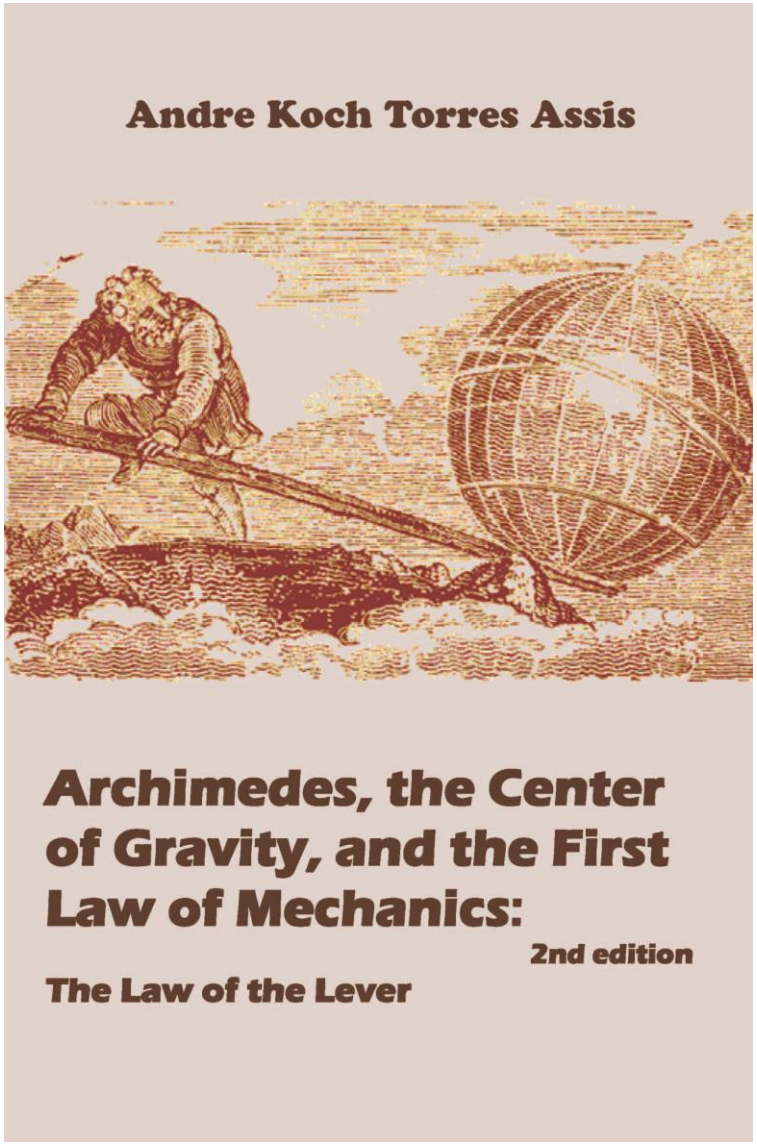


Norberto Ferreira and Jean-Pierre Maury (1991)

Norberto Ferreira



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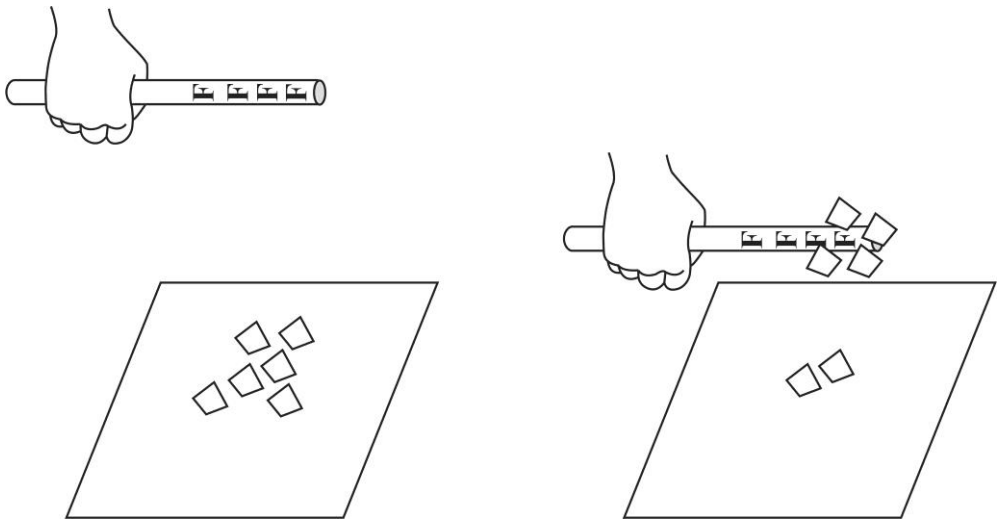
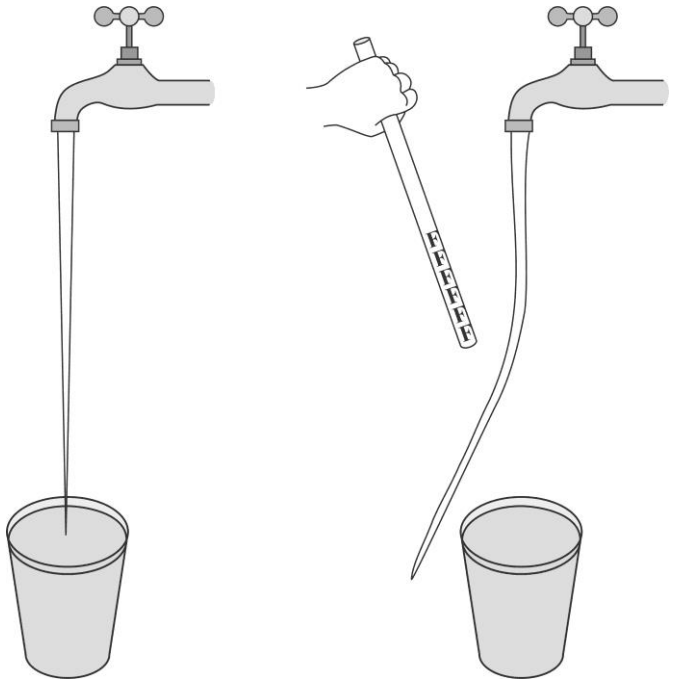
Rubbed amber attracts small objects

Plato (428-348 BC)

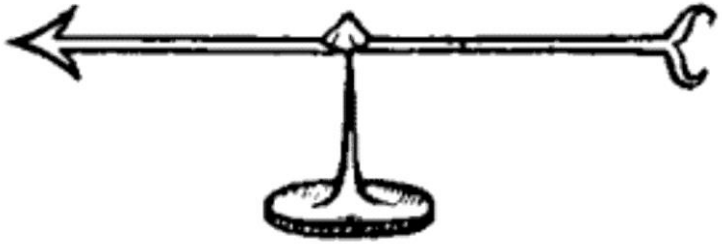


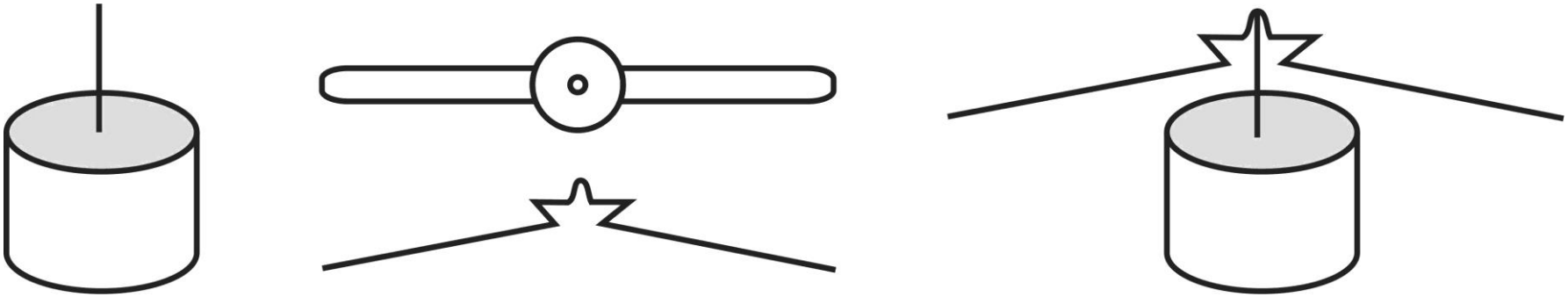
Deflection of a stream of water

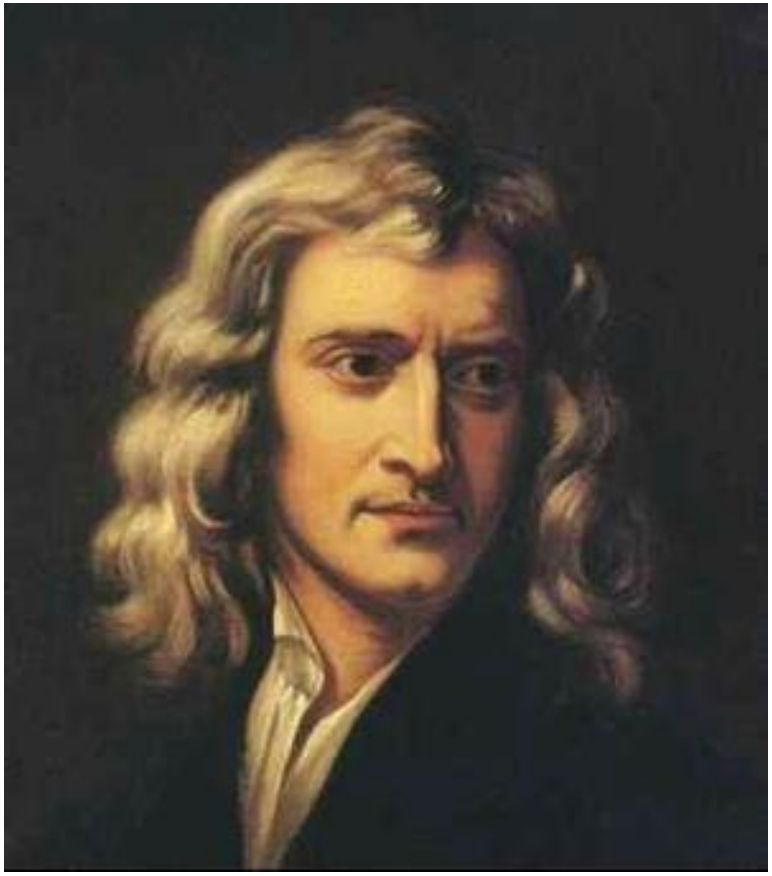
Desaguliers (1741)



Versorium of William Gilbert (1600)





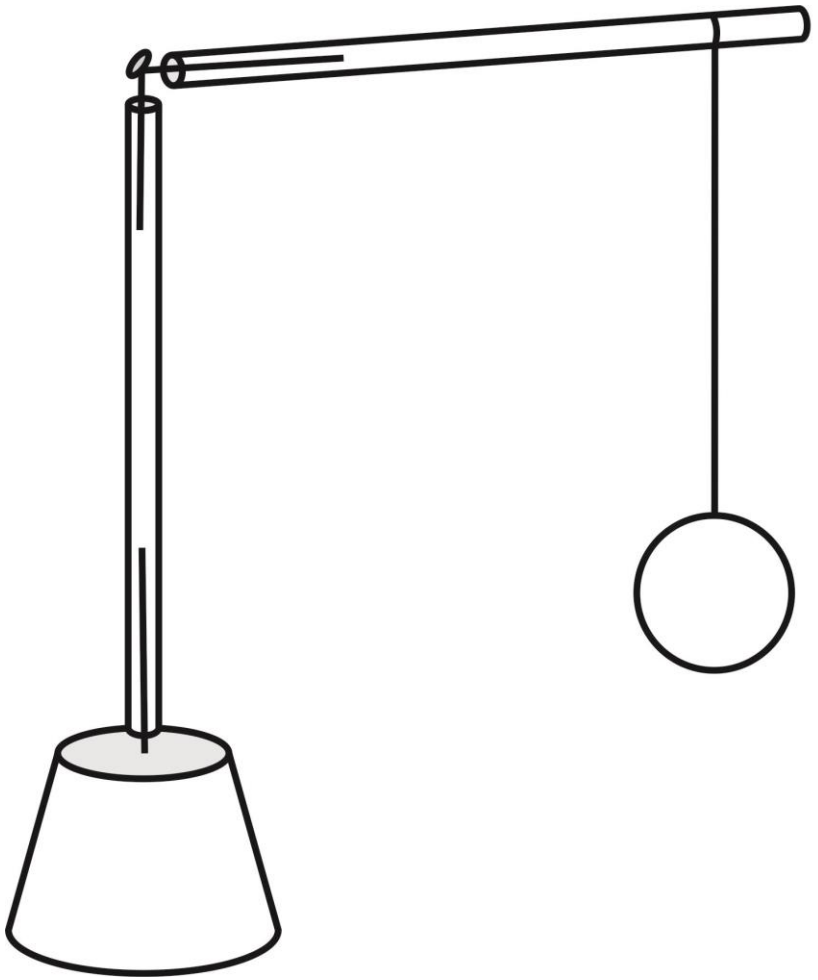


Isaac Newton
(1642–1727)

- Newton **was not aware** of the distinction between insulators and conductors of electricity!

- Newton **did not know** about the existence of positive and negative charges!

Electric Pendulum
Stephen Gray (1720 and 1736)



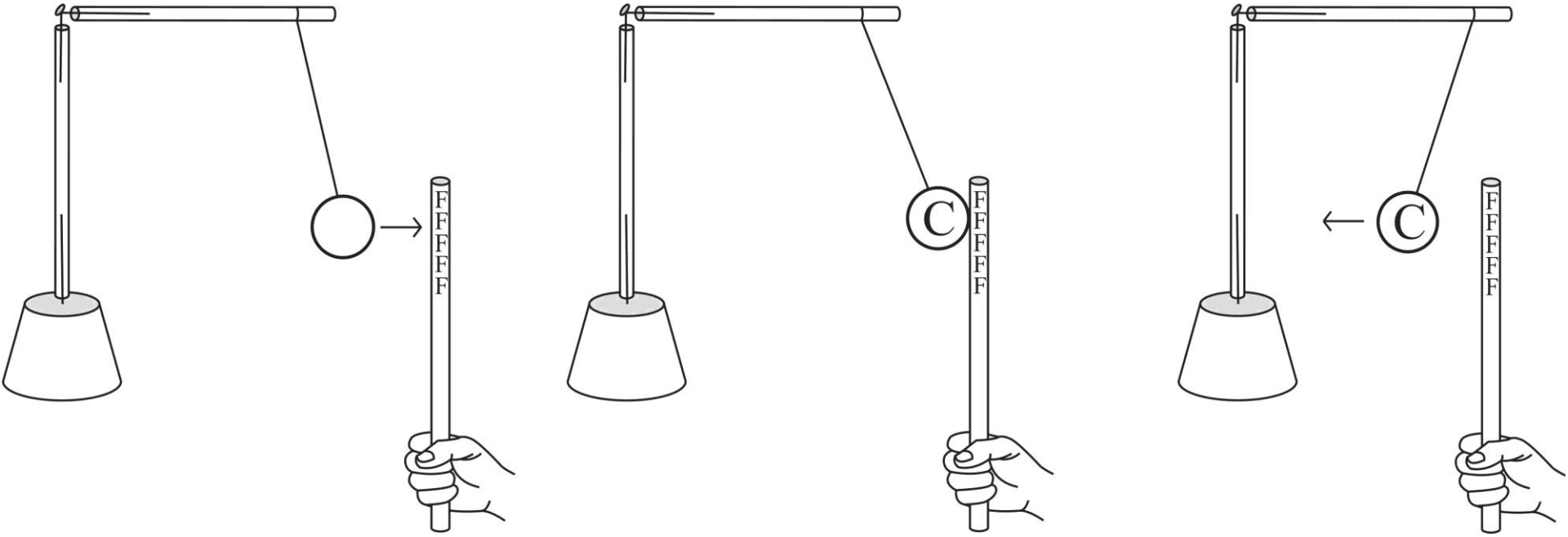
silk thread

paper disc

Attraction, Contact and Repulsion

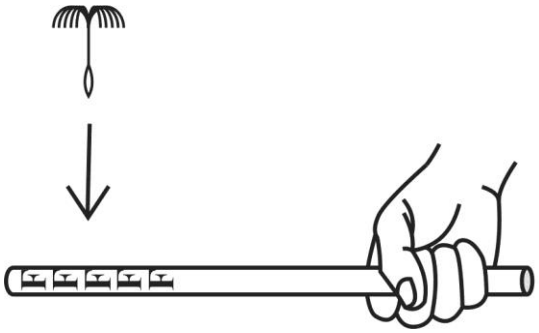
ACR mechanism

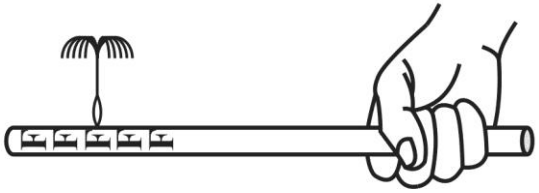
Charles Du Fay (1733)

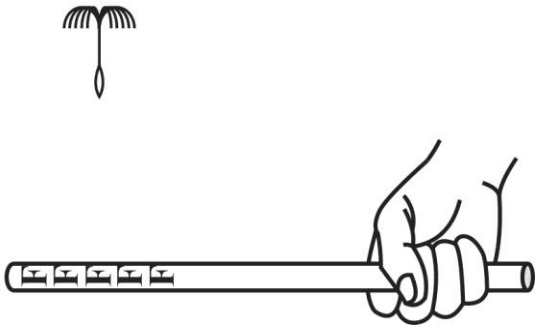


Floating feather

Otto von Guericke (1672), Stephen Gray (1708) and Charles Du Fay (1733)

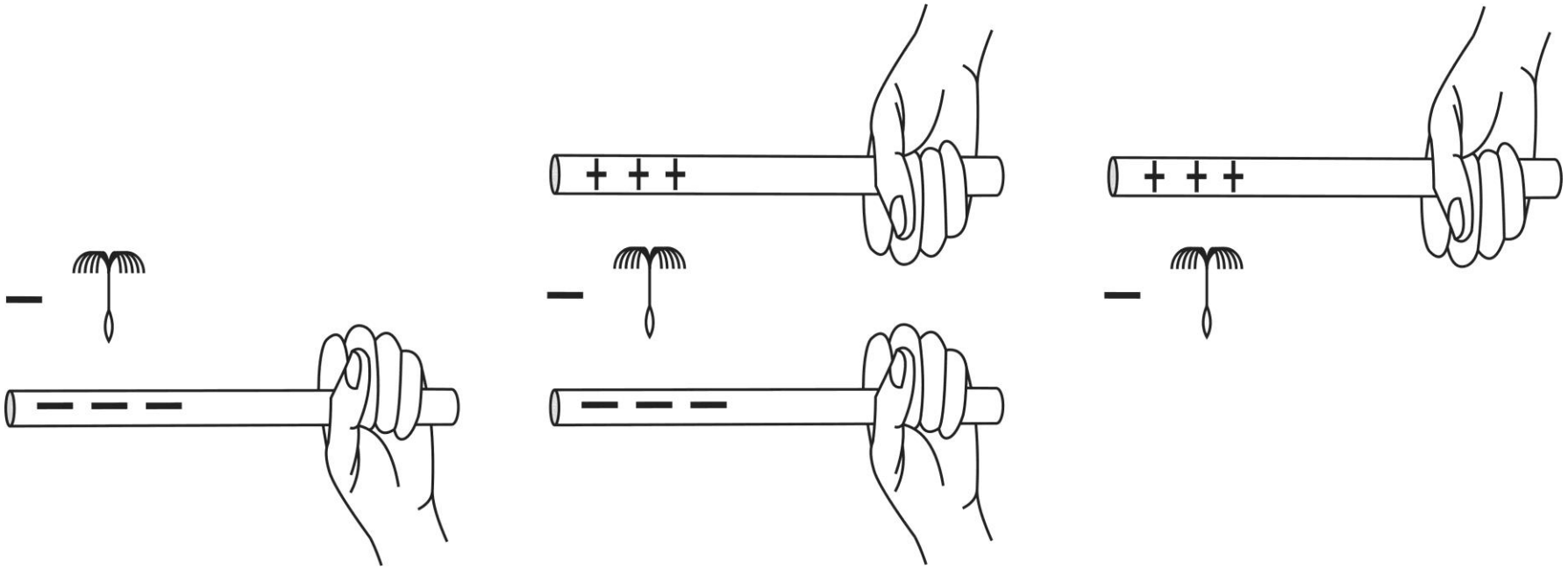




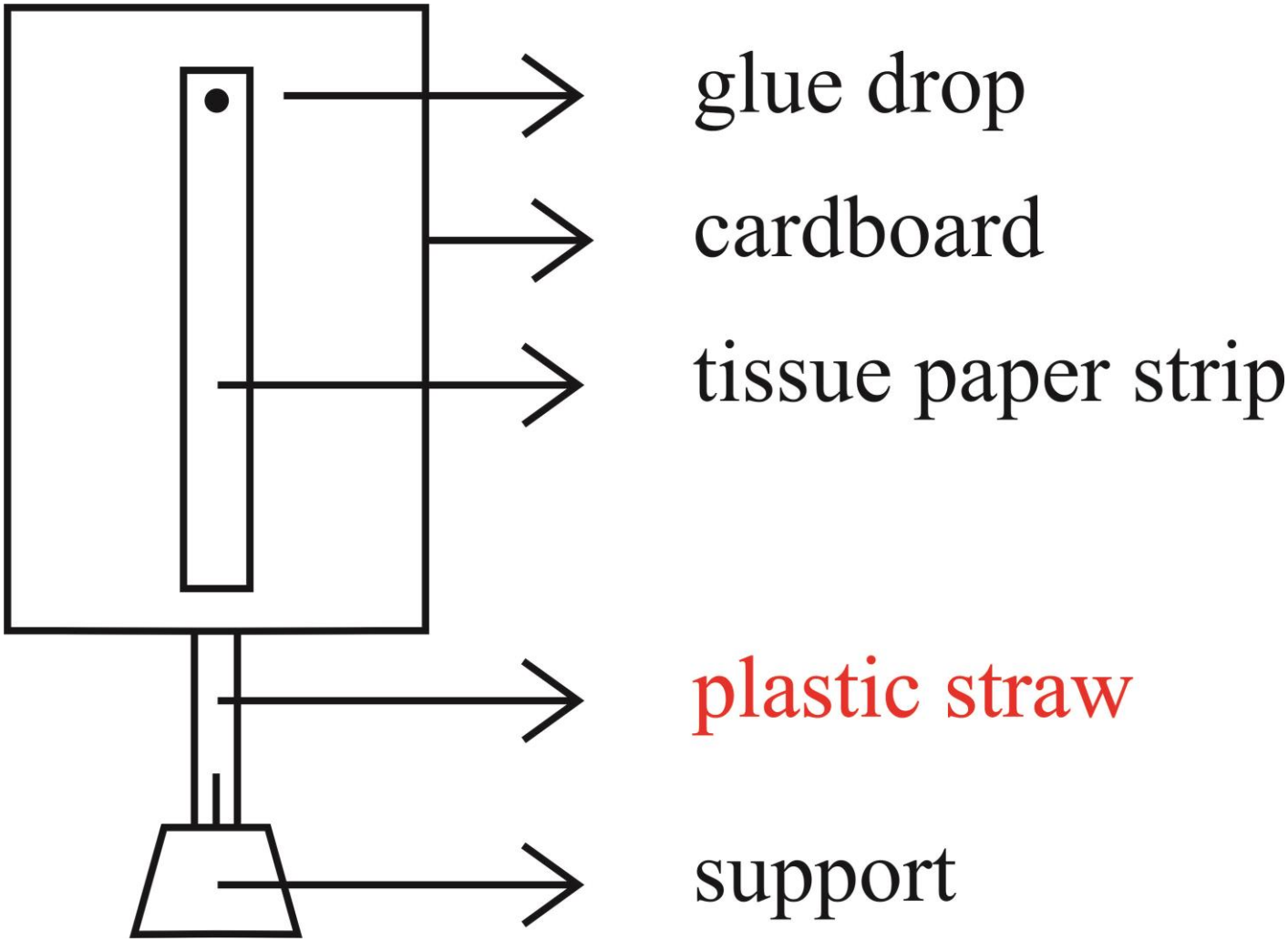


Du Fay and the Two Kinds of Electricity (1733)

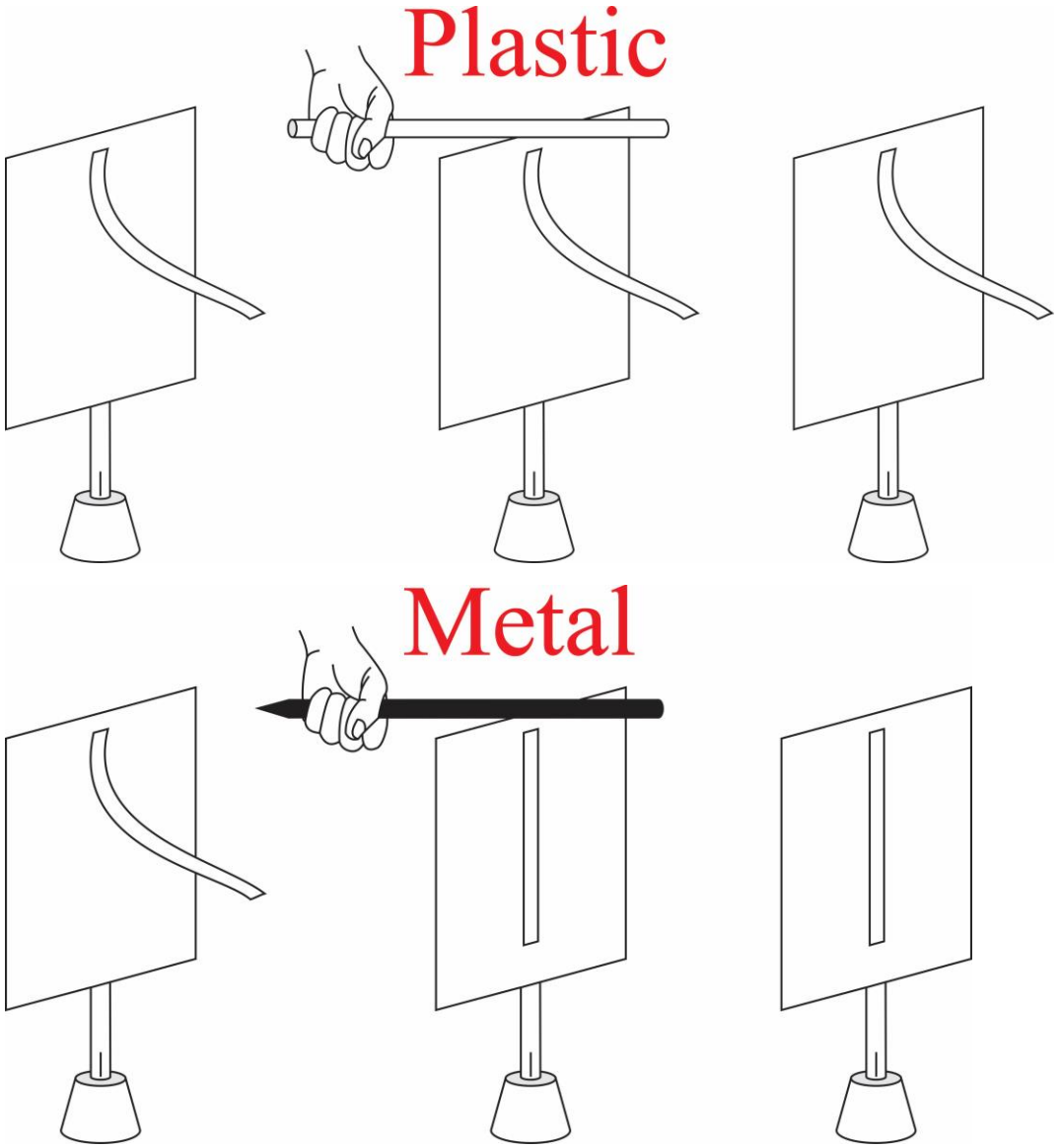
"I began by floating in air a thin gold leaf [by the ACR mechanism] ... But what disconcerted me prodigiously was the following experiment ... I confess I had expected quite the opposite effect ... This made me think that there were two diferent kinds of electricity ... I will call one of them vitreous electricity [+] and the other resinous electricity [-] ... Both kinds repel the bodies which acquired an electricity of the same nature as that of their own. On the contrary, they attract the bodies having an electricity of a different nature than their own..."



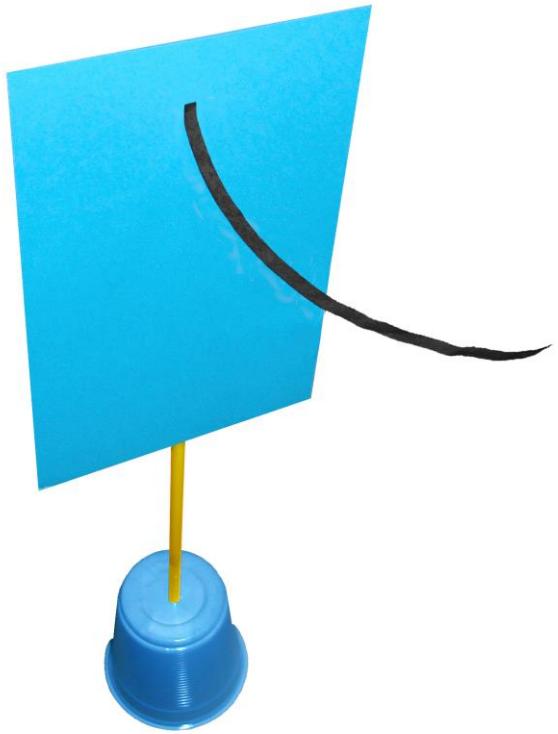
Electroscope – Du Fay (1737)



Insulators and Conductors discovered by Stephen Gray (1731)

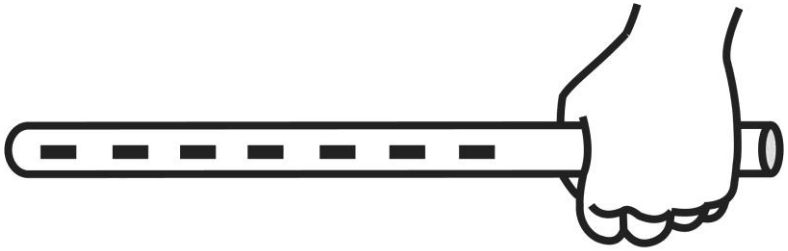


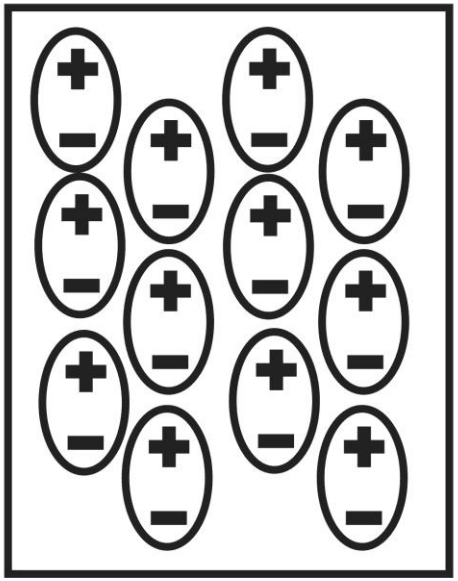
Low cost electroscope **versus** gold leaf electroscope



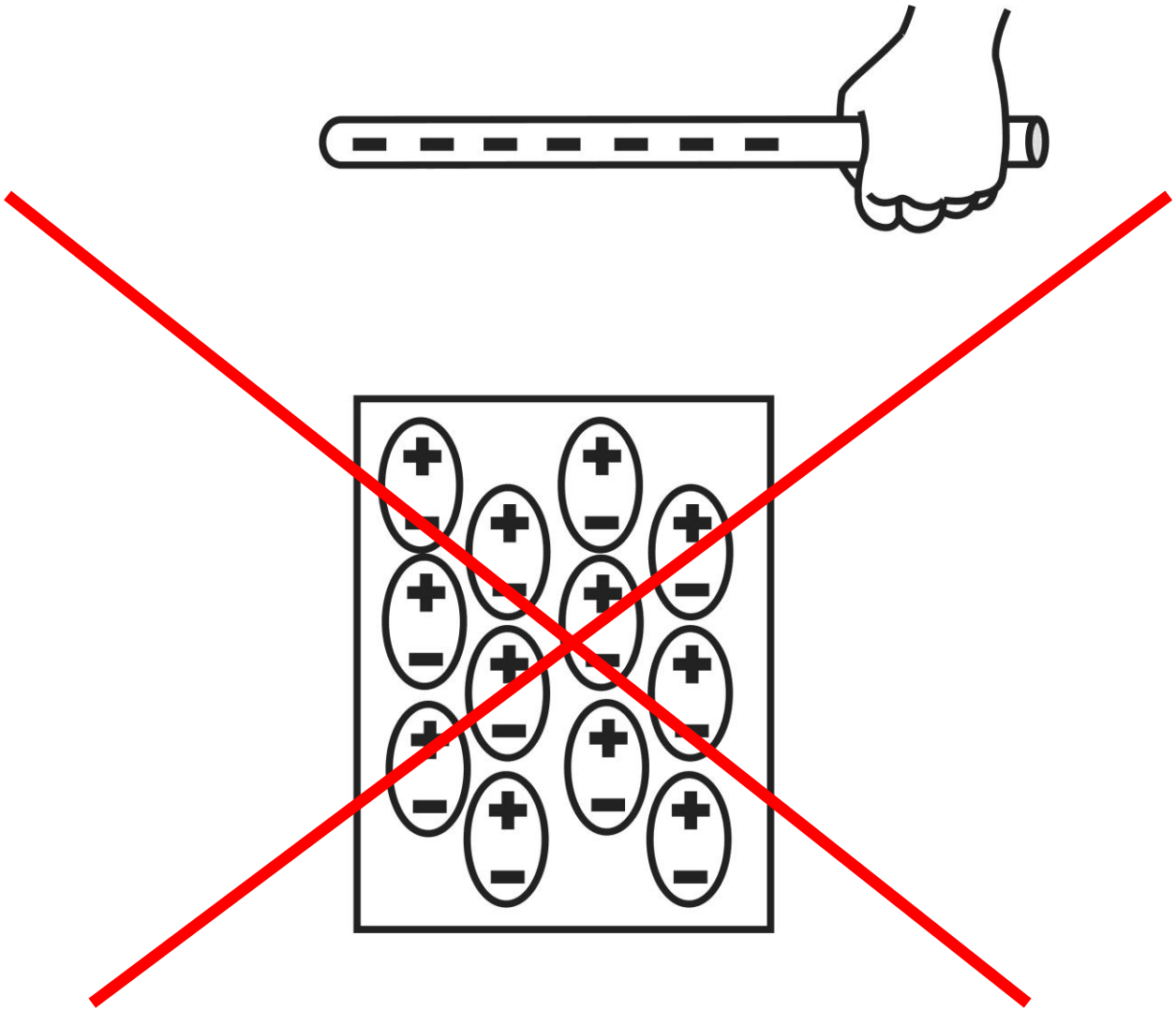
X

The explanation of the amber effect in the textbooks is based on the polarization of the paper molecules

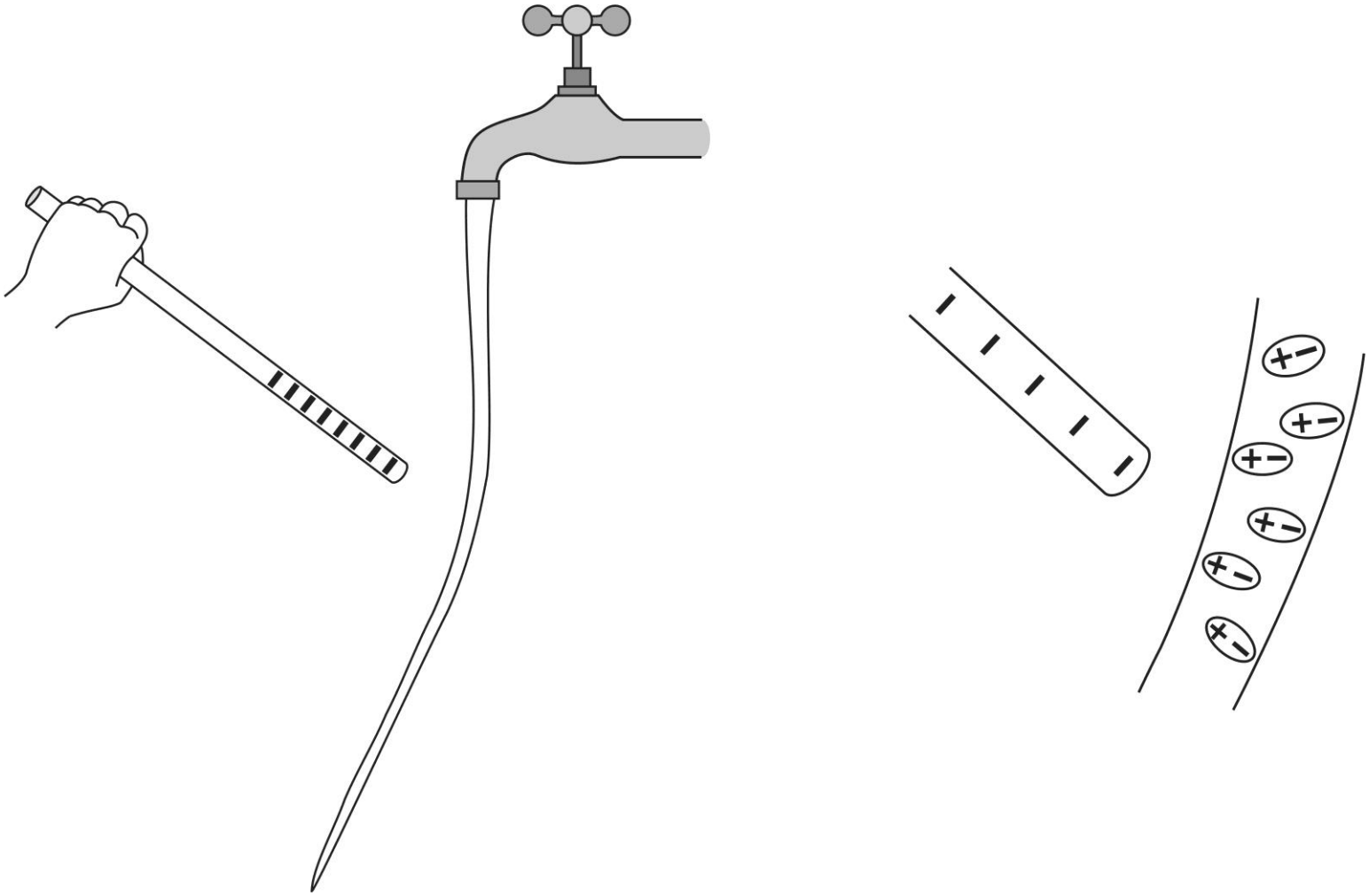




To me this explanation is wrong



The explanation of the deflection of a stream of water in the textbooks is based on the orientation of the previously polarized water molecules



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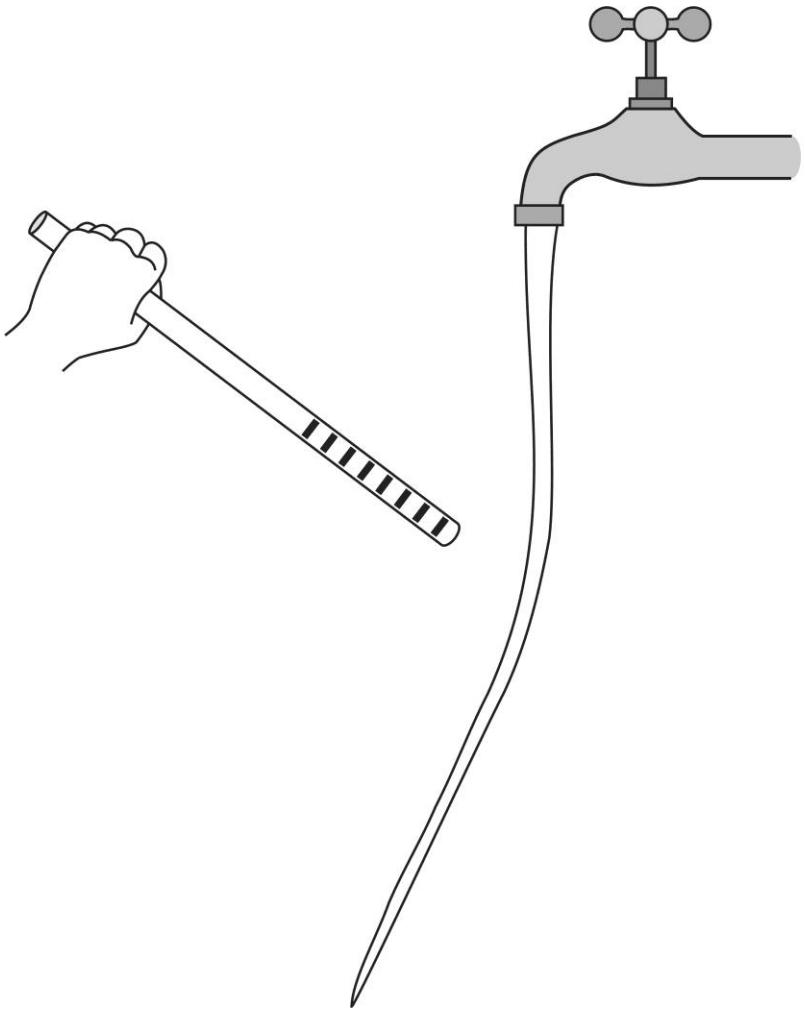
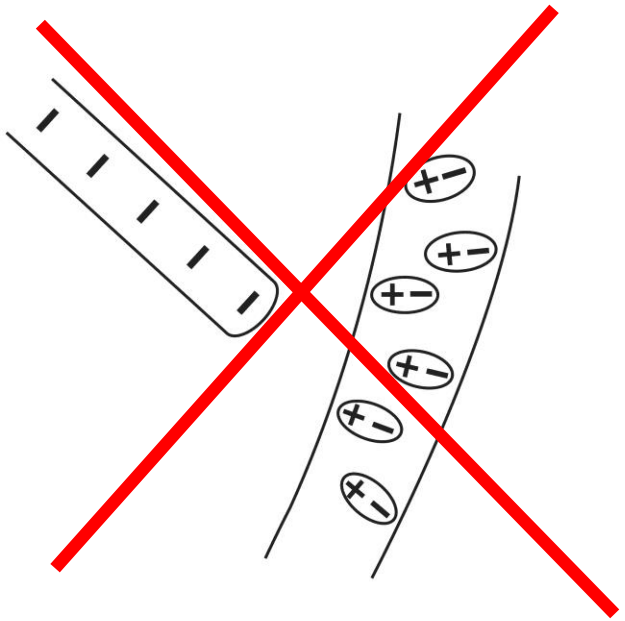
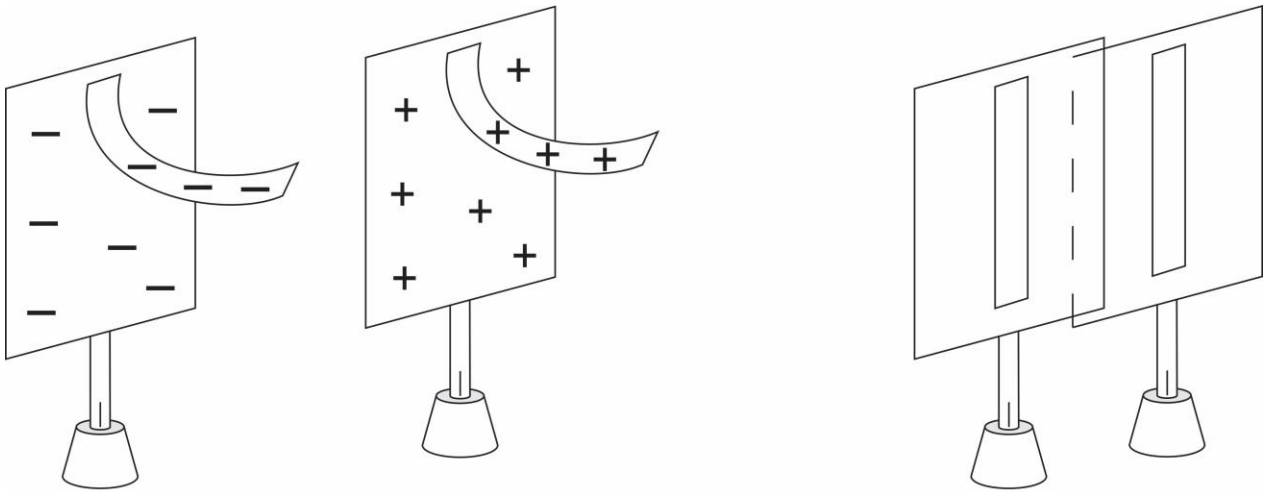




3 mysteries of the amber effect

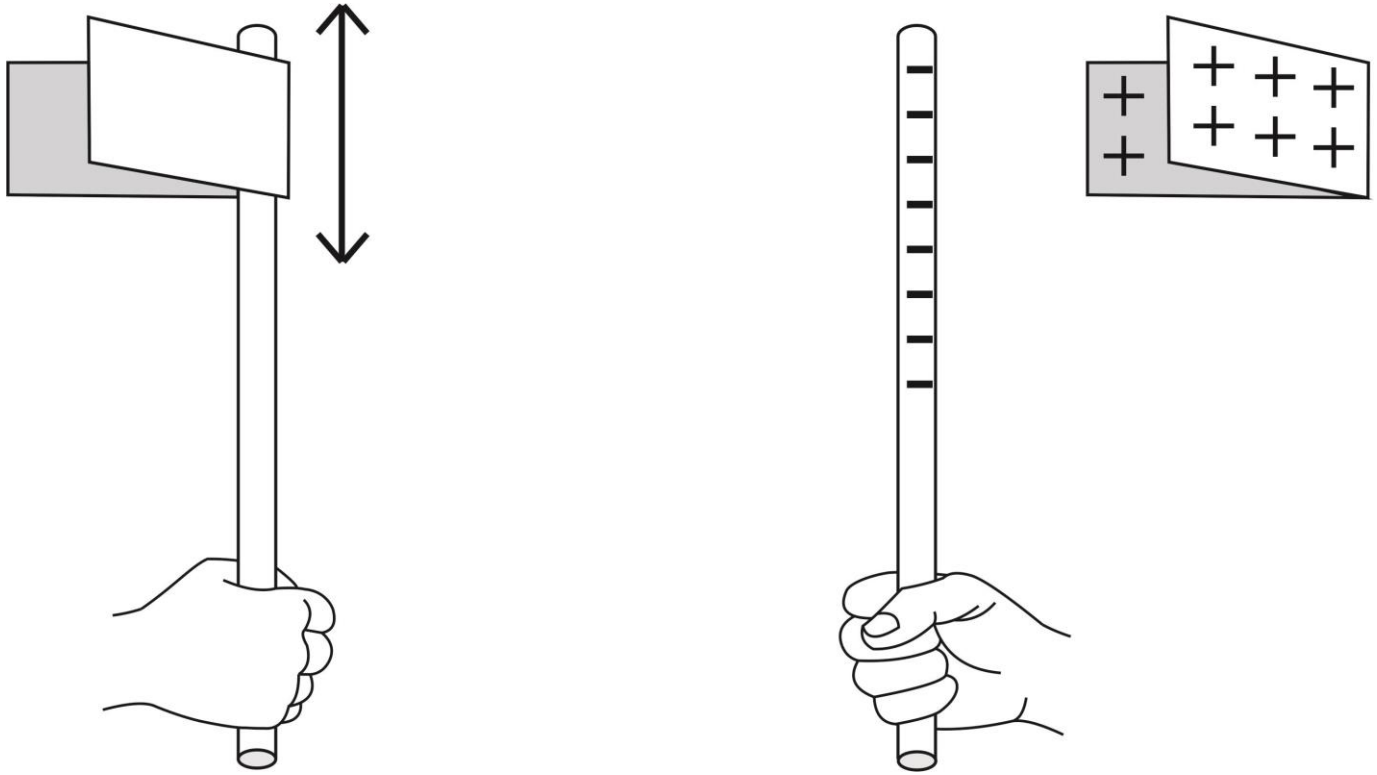
Neutralization of bodies electrified with opposite charges



(a) (b)

Explanation: attraction of positive and negative charges by Coulomb's force $F = \frac{q1q2}{r^2}$

However, in the amber effect:



First Mystery: What is the origin of the force which separates opposite charges during friction?

What is the law followed by this non-electrostatic force?

Textbooks mention that a plastic straw becomes negatively electrified when rubbed in hair due to a transfer of electrons.

Second Mystery:

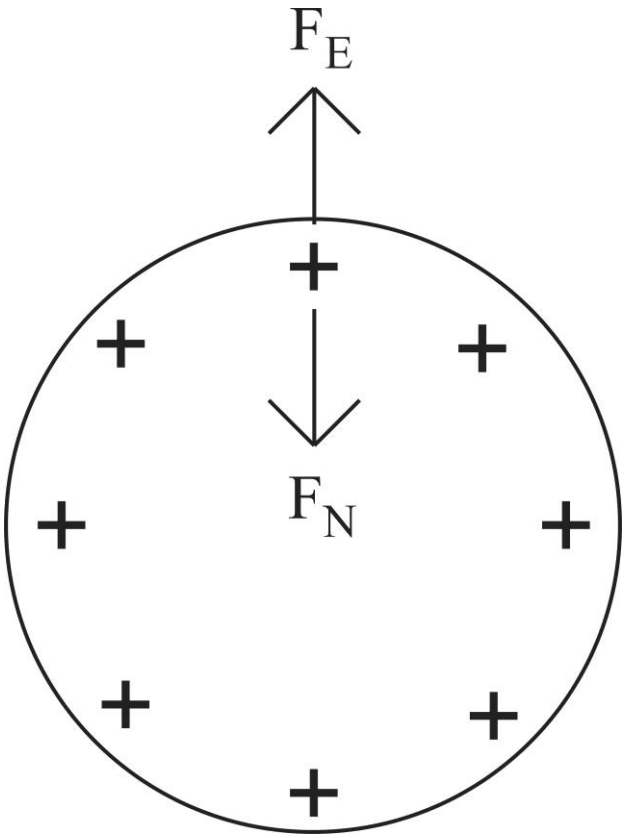
Is the electrification of two bodies during friction really due to a transfer of electrons?

Which experiments prove this supposition?

W. R. Harper, *Contact and Frictional Electrification* (Oxford University Press, 1967)

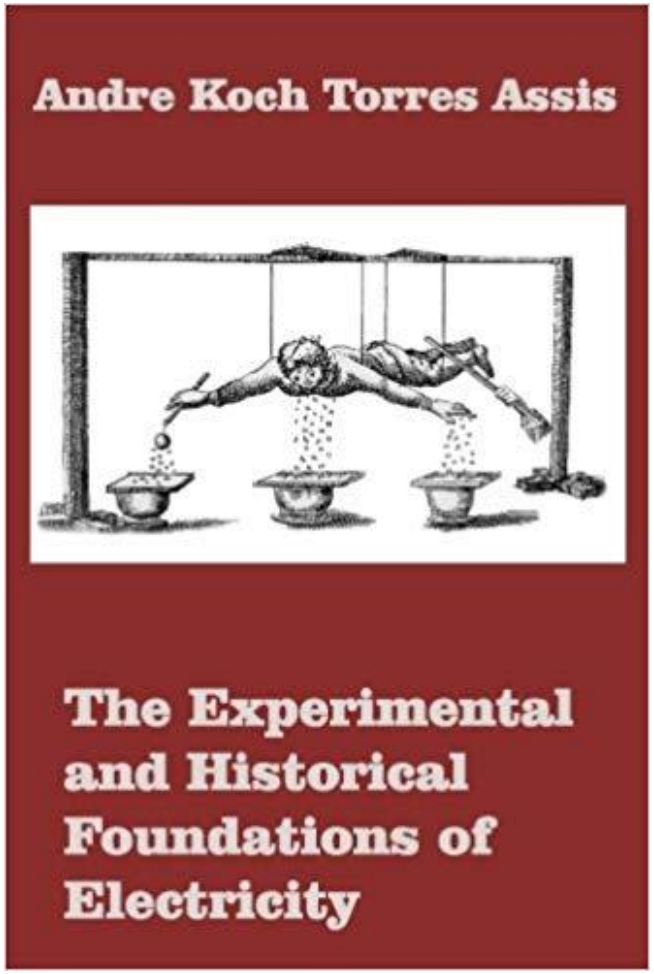
"A crucial question for the explanation of the production of static charge is whether the charging of insulators comes from a transfer of electrons, of ions, or of both. Montgomery would say that the carriers of charge **are always electrons** and Loeb that they **are generally electrons**. Henry feels that the question is still an open one. I am of the opinion that a definite answer can now be given which is that the carriers **are never electrons** when the material being charged is strictly an insulator."

A positively charged sphere:



Third Mystery:

What is the origin of the non-electrostatic force F_N which prevents the explosion of the charged sphere?



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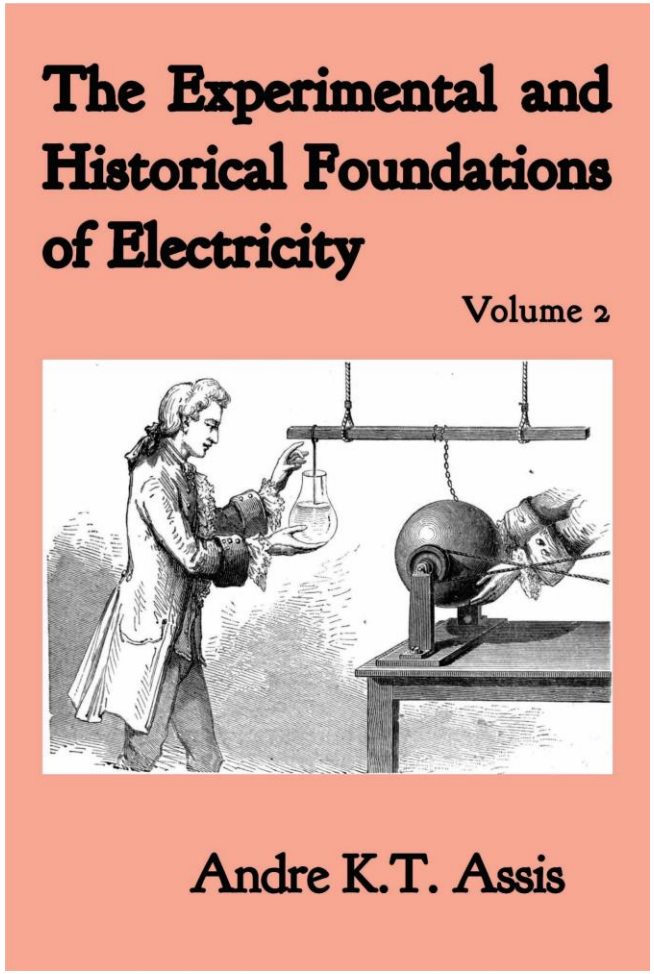

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Conclusion

- The main facts about electricity were discovered after the death of Newton.
- Electrostatics is an open area of research, full of deep mysteries which should be explored in physics teaching.
- The amber effect is a topic of modern research.
- Many basic phenomena and important instruments must be reproduced by teachers and students utilizing low cost materials.

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