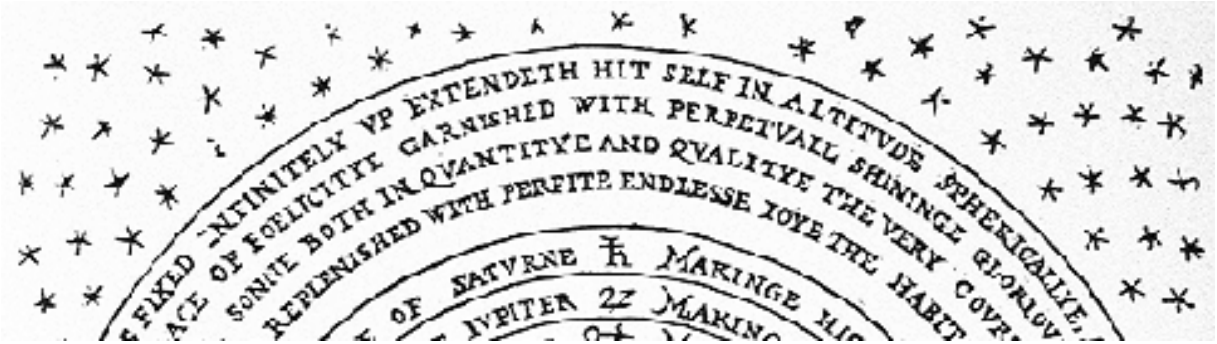


PHY1033C/HIS3931/IDH 3931 : Discovering Physics:

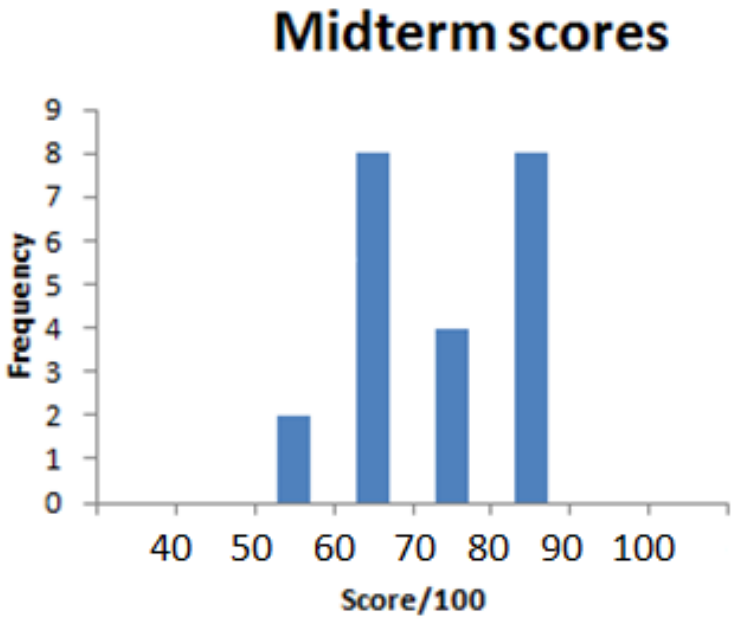
The Universe and Humanity's Place in It

Fall 2016

Prof. Peter Hirschfeld, Physics

Midterm remarks

- Mean 74.5 standard deviation 9



- Very very rough, estimated curve:
- >83 A >80 A- >77 B+ >74 B >72 B- >69 C+ >66 C >62 C- >58 D+ >54 D

Last time

18th cent. *vis viva* controversy: does the universe run down?

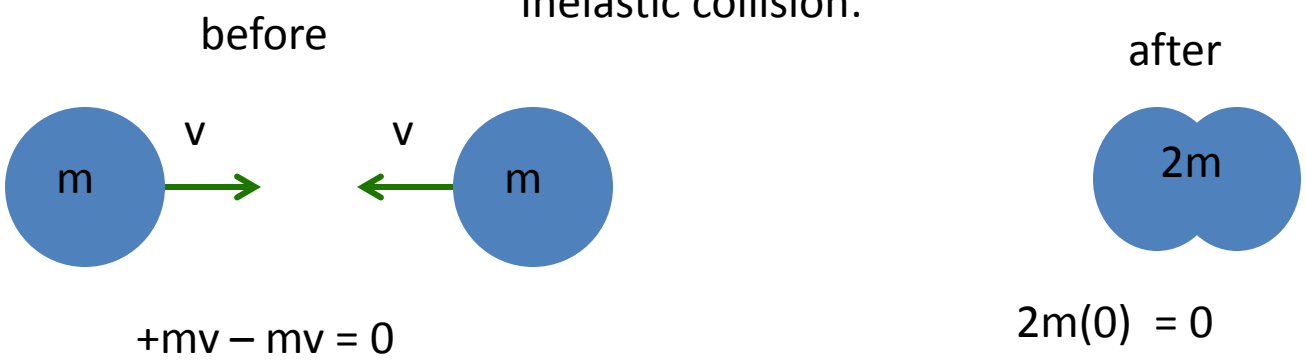
Descartes: universe consists of many parts colliding with each other, but in each collision God ensures that "no motion is lost"

His guess for what physical quantity stayed the same in a collision: "force of motion" mv

[today: mv=momentum]

Huygens: yes, but remember to include the sign of v!

Inelastic collision:



Last time

Leibniz: doesn't like Cartesian proposal, since *inelastic collisions* will still run universe down.

Proposed instead *vis viva*, mv^2

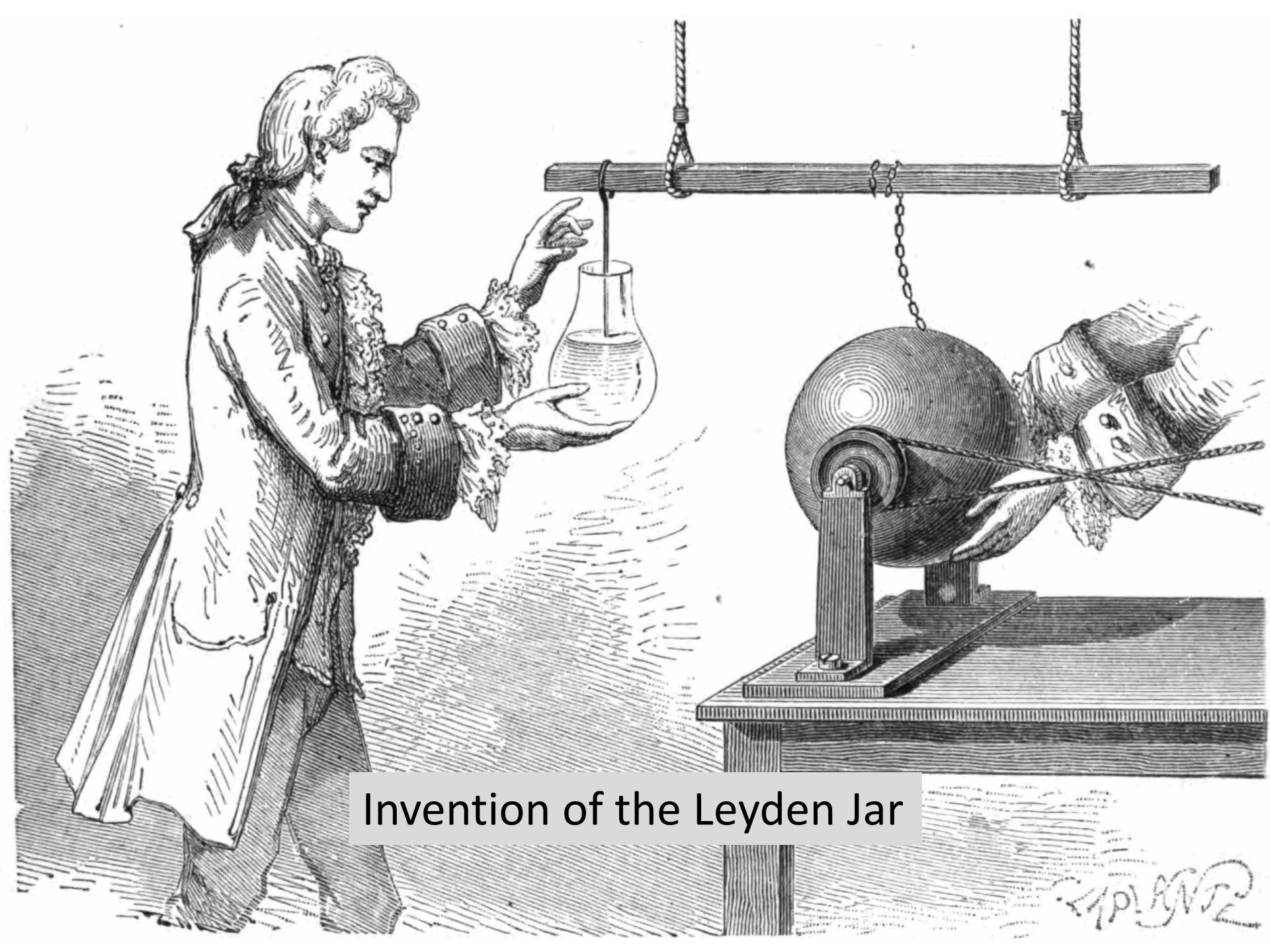
Vis viva survives inelastic collisions, since clay particles move afterwards (clay heats up)

'sGravesande corrected to ½ mv^2

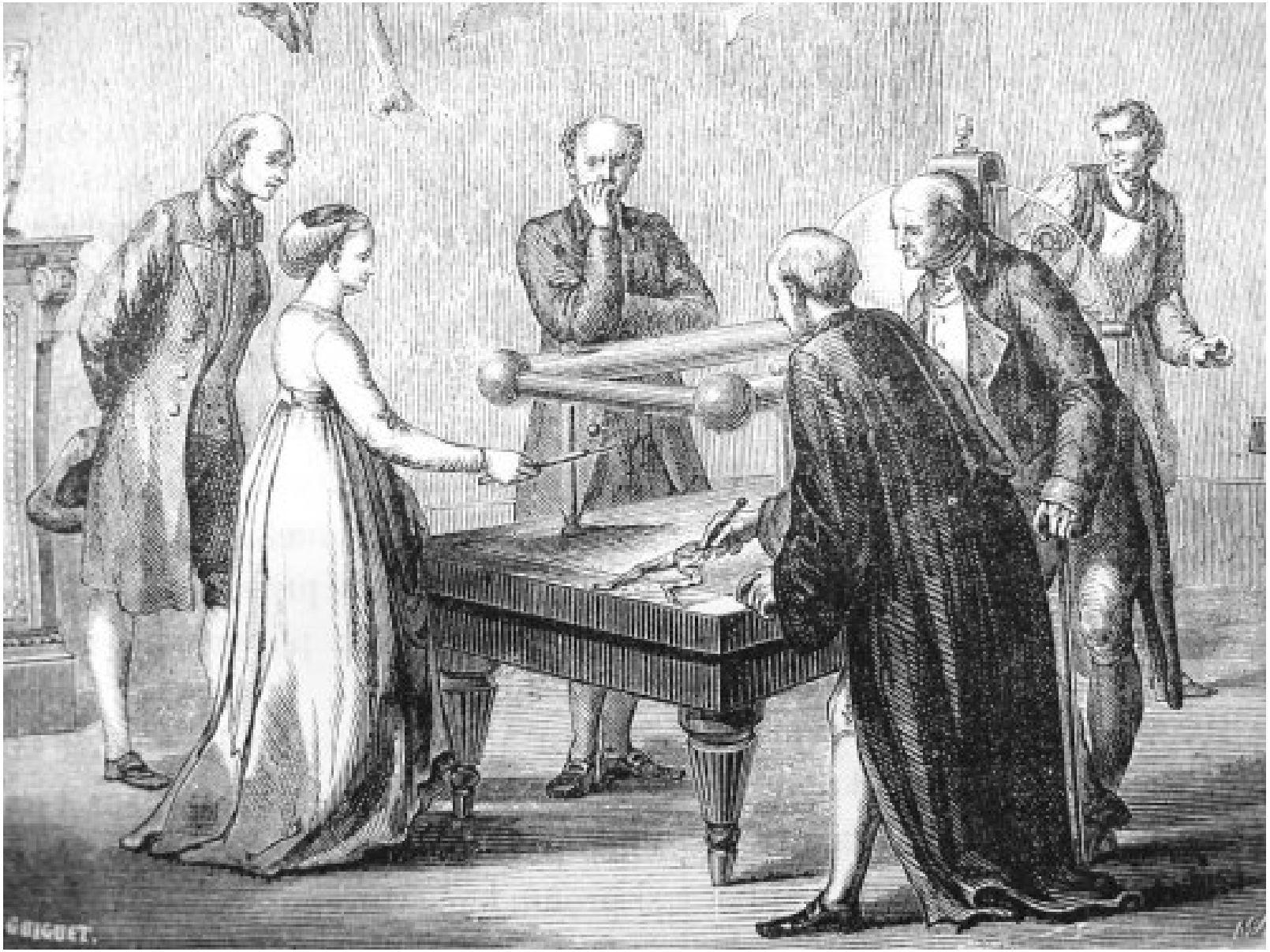
[today: ½ mv^2 =kinetic energy]

What was electricity?

Franklin thought of it as a weightless fluid that repelled itself but was attracted to normal matter

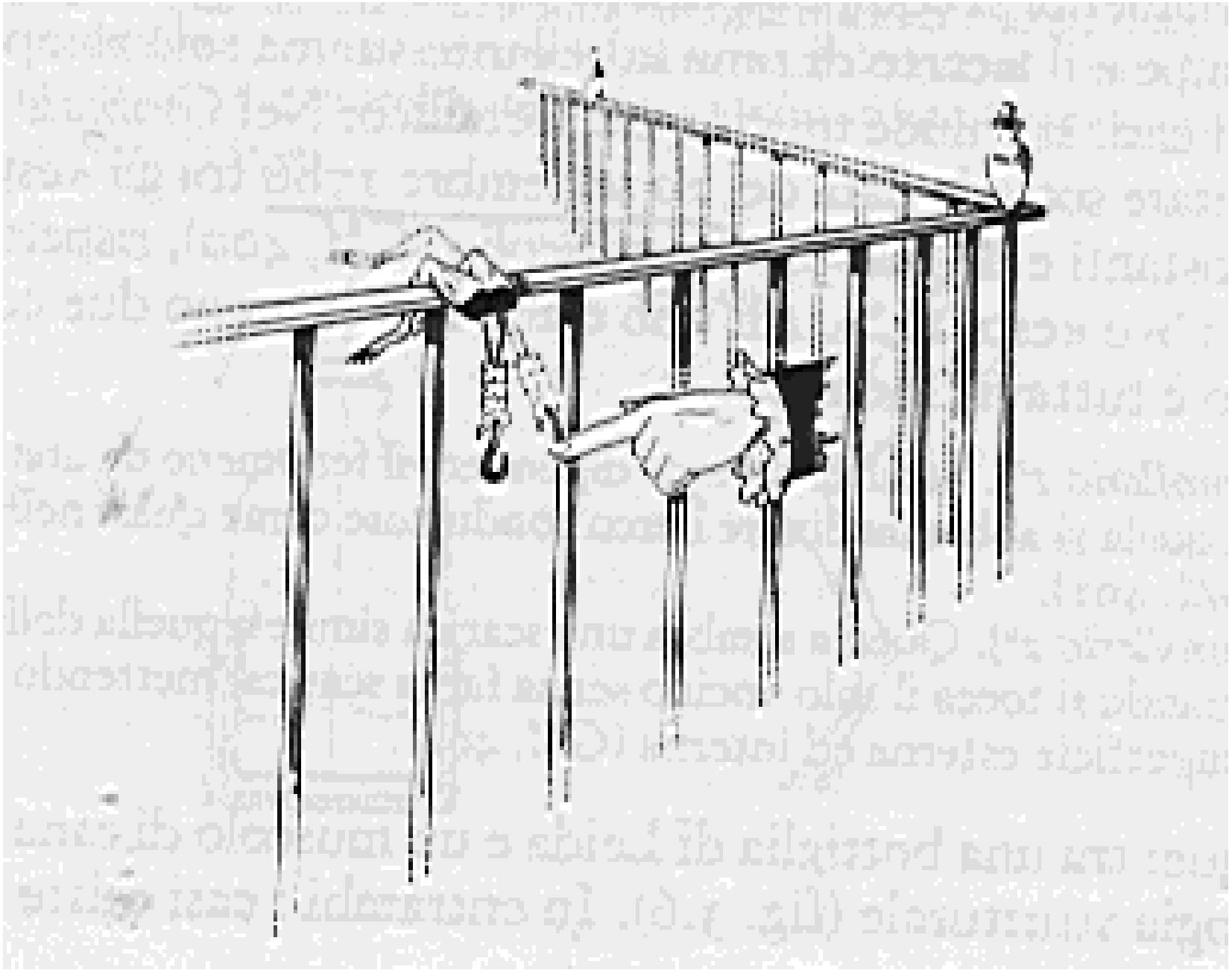


Invention of the Leyden Jar



Lucia Galeazzi and Luigi Galvani

Electricity ⇔ biology

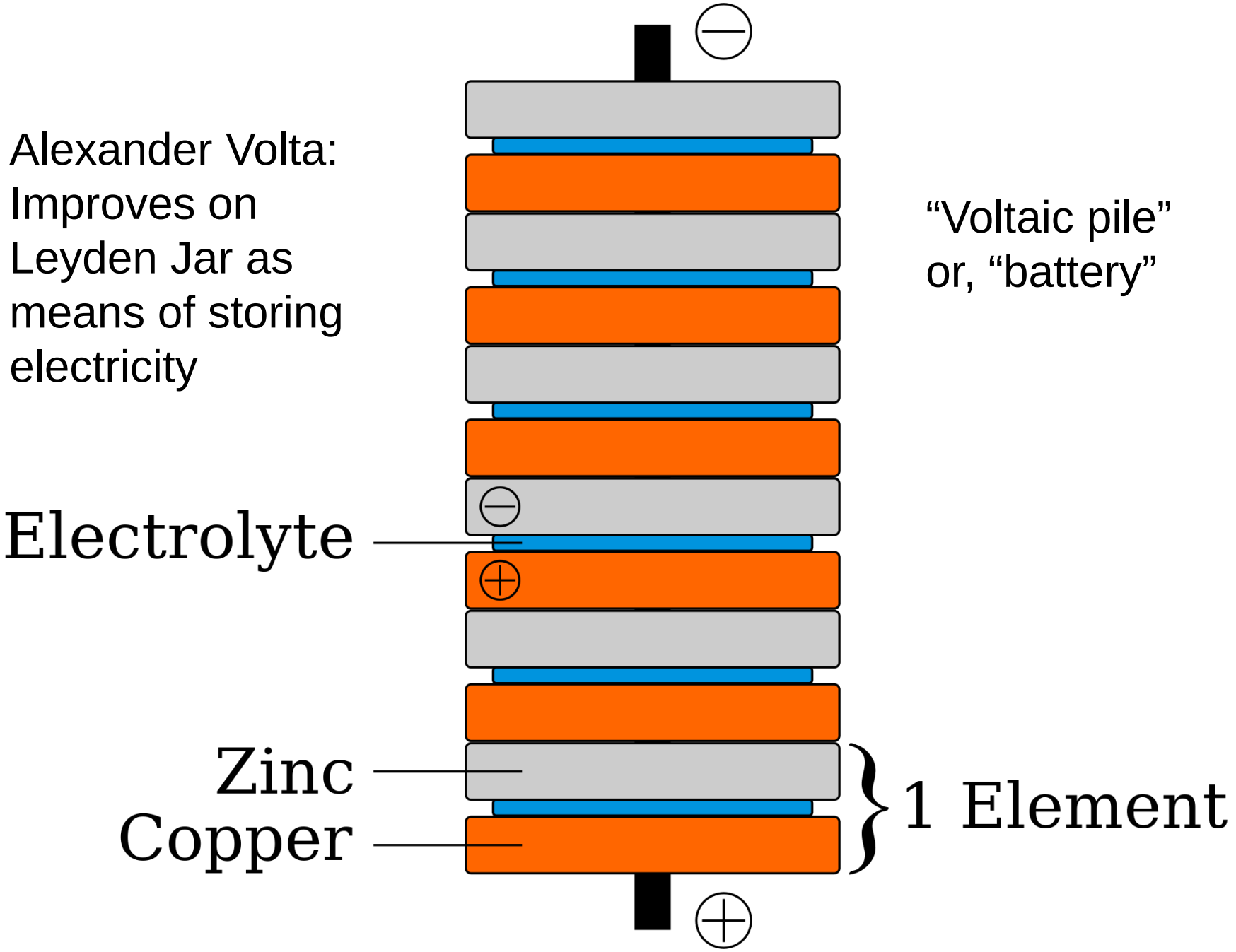


“Force” conversion??

18th-19th century fascinated by relation between life and electricity

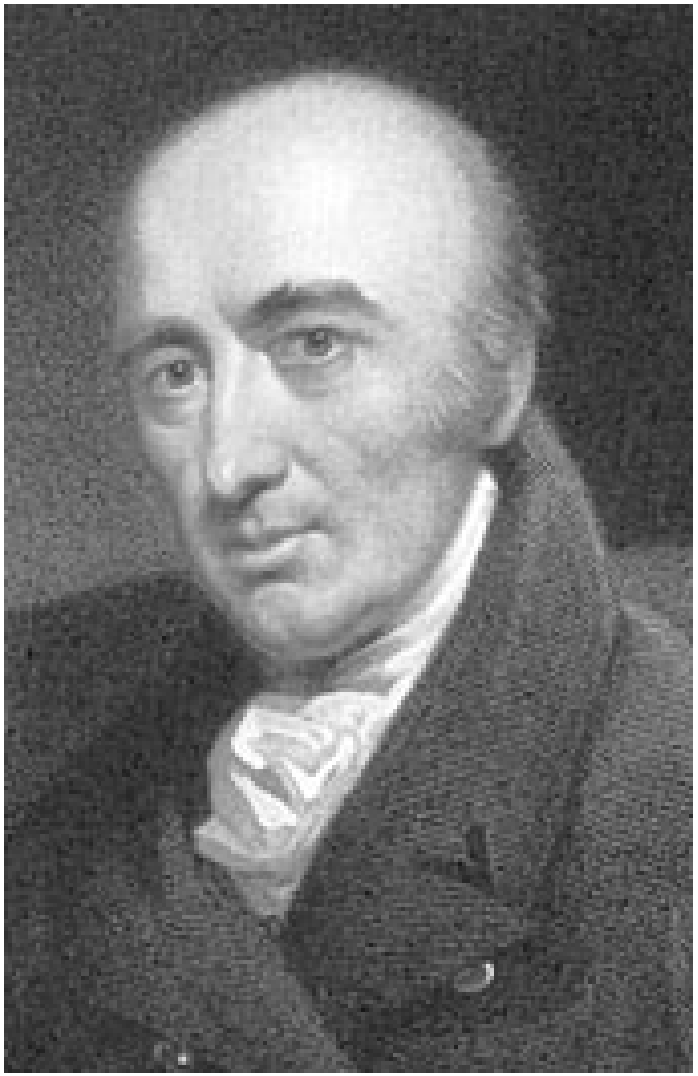
Frankenstein, Mary Shelley 1818

Alexander Volta:
Improves on
Leyden Jar as
means of storing
electricity



“Voltaic pile”
or, “battery”

Volta demonstrates his Voltaic pile



William Wollaston

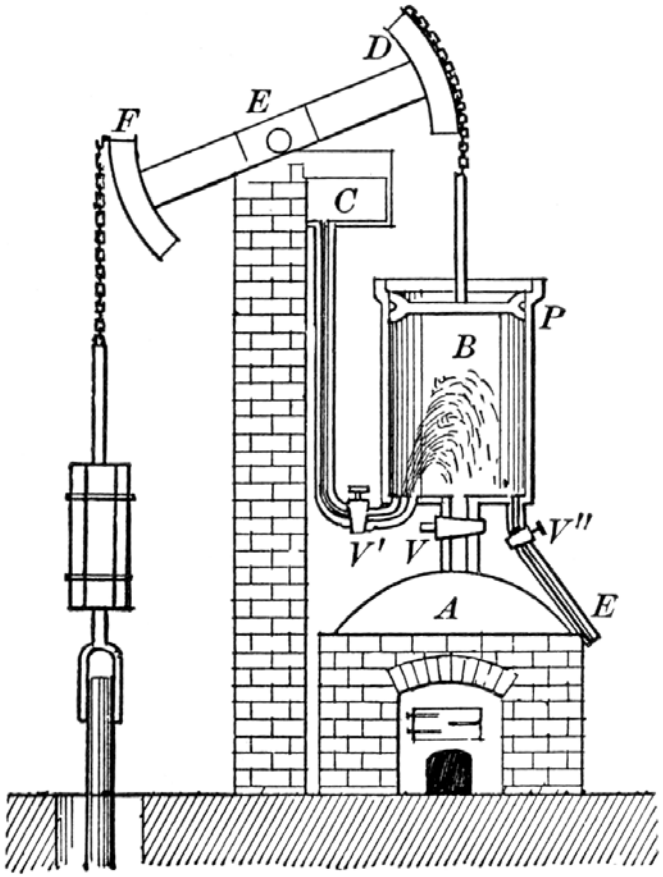
Dissociated water into two gases using current from a battery, 1800

Electricity $\Leftrightarrow$ chemistry

Heat

The transformation of heat into motive force was a major factor of the Industrial Revolution

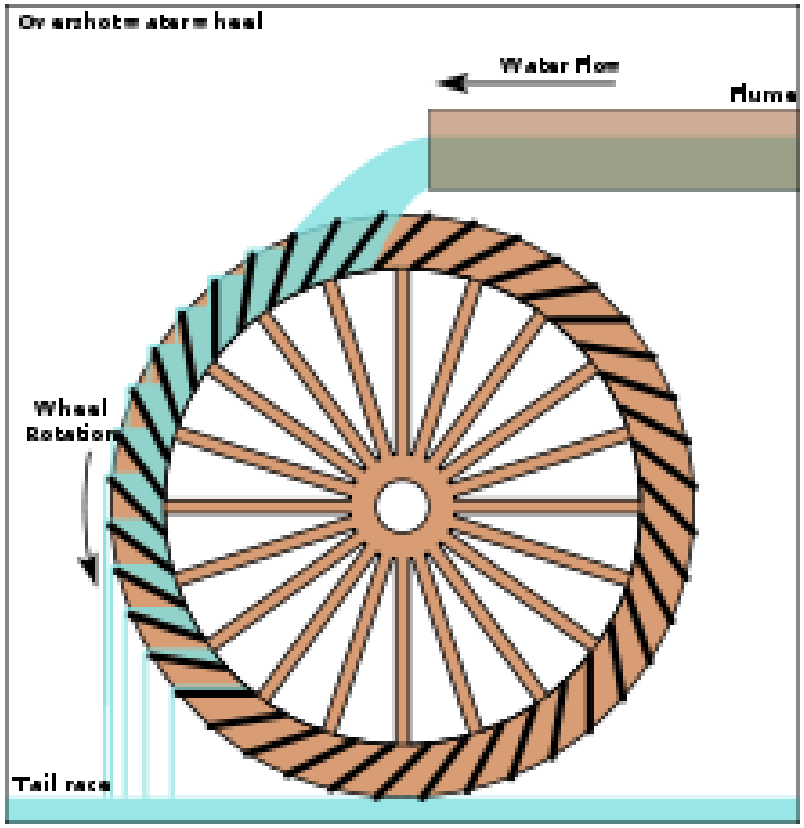
Sadi Carnot



Newcomen steam engine

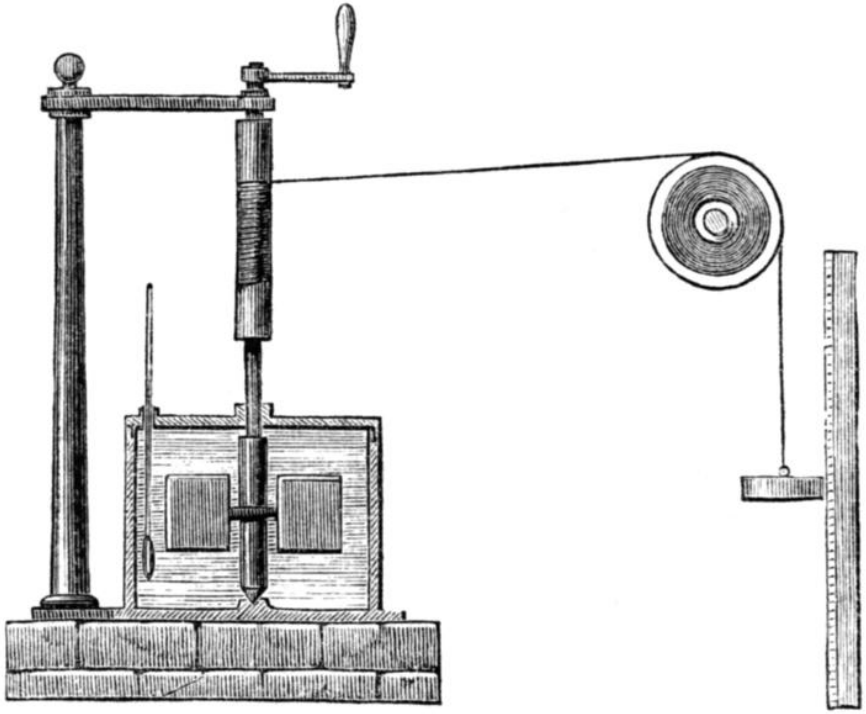
Carnot noted that to use heat to produce mechanical force required that something at a higher temperature fell to a lower temperature. Without a temperature difference the heat was “useless”

He also thought that heat was conserved



Carnot imagined that heat was merely used to create the motion of the pistonlike water is used in a water wheel (so the water is not used up but can be used again)

Others said Carnot was wrong -the heat actually *turned into* mechanical force



In England James Joule determined experimentallyhow much heat corresponded to how much mechanical force, settling the question of whether heat was conserved or not (it was not)

James Joule

In Germany Rudolf Clausius said Joule and Carnot were both right

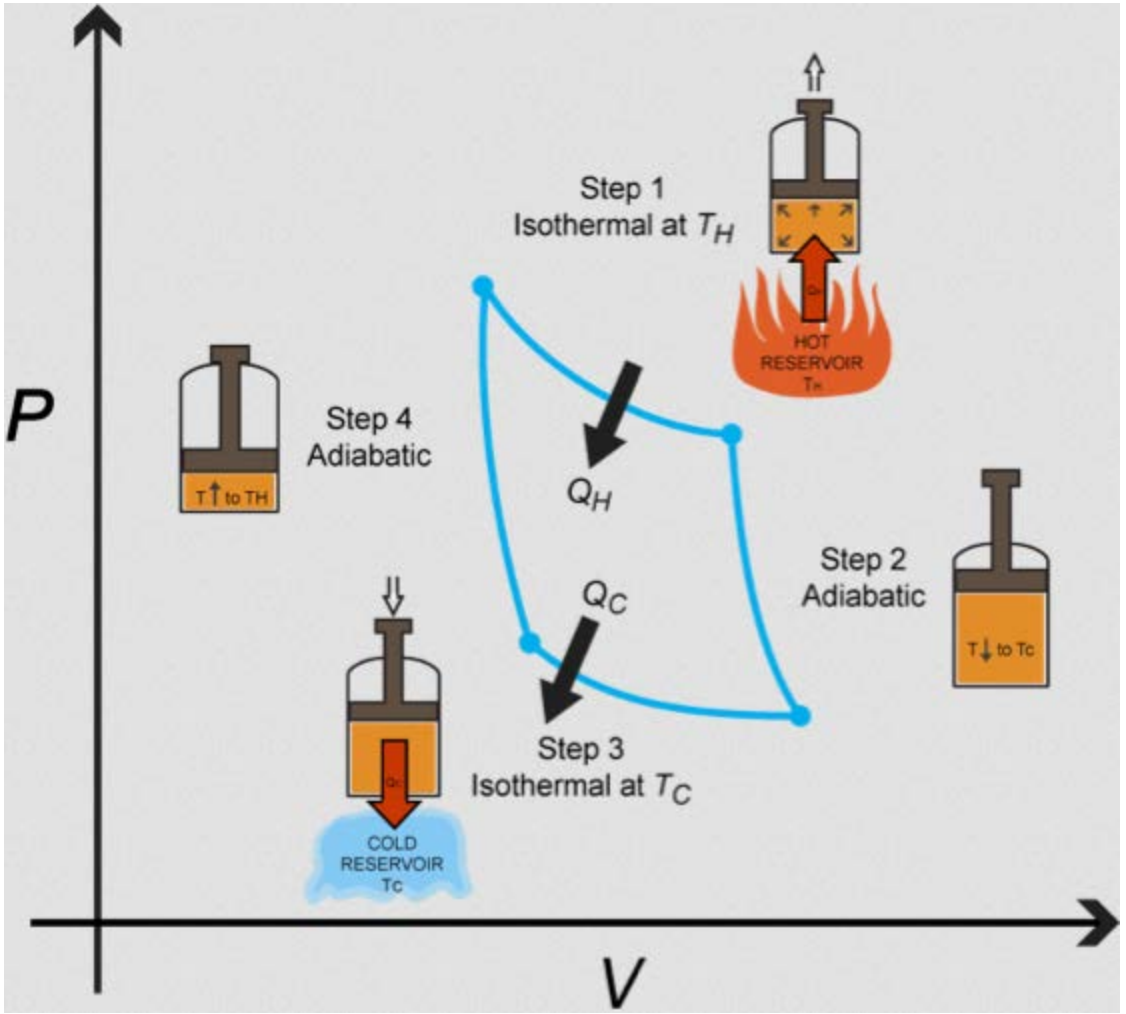
Joule was right that heat *became* mechanical force
(heat not conserved)

Carnot was right that there must be a temperature difference for heat to become mechanical force

Because of this *not all* of the heat became mechanical force. There was always some that was merely transferred from a warm body to a colder one.

Carnot engine: ideal thermodynamic cycle

Sets theoretical upper bound on how much mechanical work can be obtained from heat



Summary

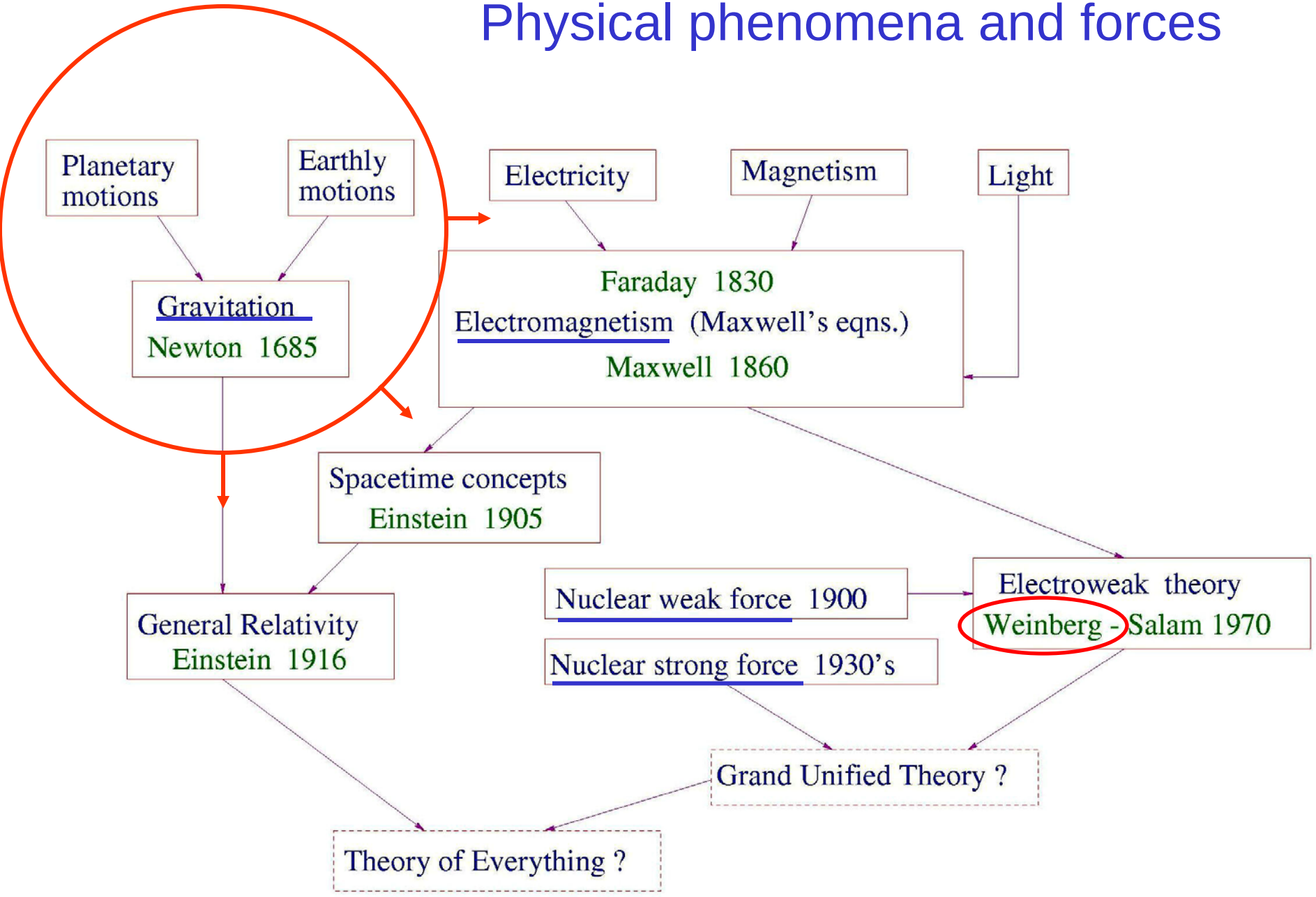
- Sadi Carnot: to run an engine you need reservoirs with two *different* temperatures. Heat is a fluid that is *conserved*: doesn't get created or destroyed, like water in water wheel (Carnot's view!!!)

- Hermann v. Helmholtz: heat not conserved, sum of "motive" and "tensive" "forces" conserved

- James Joule: there is a mechanical equivalent of heat

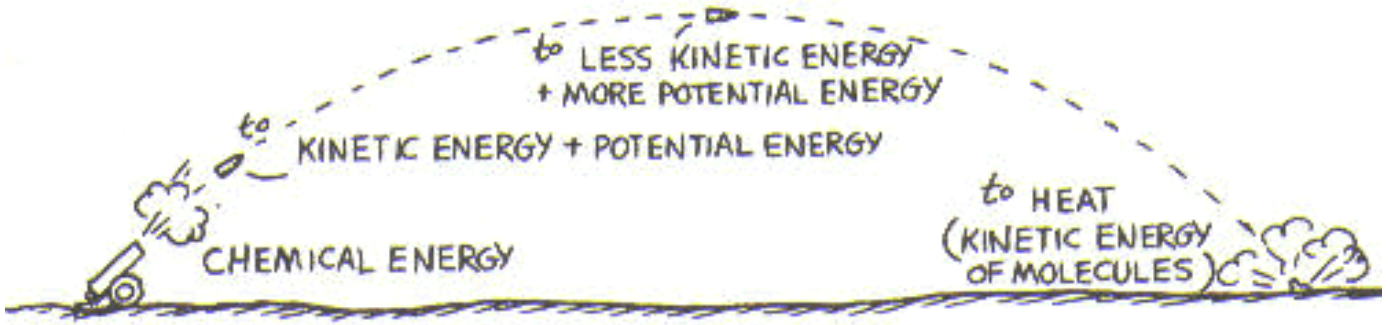
- Rudolph Clausius: Carnot was right about need for temperature differential to run an engine, *but* heat is *not* conserved separately, but can be transformed into "motive force". *Heat cannot be completely transformed into work! Some is always lost to the environment.*

Physical phenomena and forces



Energy conservation

- if you identify all the forms, energy is conserved!!!
- if there is no friction or other dissipation, mechanical energy is conserved!!!



Energy Cannot Be Created or Destroyed

(It just changes forms)

Momentum conservation

Q: What about Descarte's original "force of motion" mv?
(v = velocity, has a sign or direction)

A: It's conserved too!

Sir Isaac: $$F_{tot} = ma = m\frac{v_f - v_i}{t_f - t_i} = \frac{\Delta p}{\Delta t}$$

So if there is no total force applied to the system, the total momentum doesn't change!

PHY1033C
DISCOVERING PHYSICS

Mechanical energy

Def: *mechanical energy*: energy which is associated with the position or motion of macroscopic objects.

kinetic energy: energy of motion

$$KE = \tfrac{1}{2} m v^2$$

potential energy: energy of position, can take various forms.

The most common form is the gravitational potential energy an object has near the Earth's surface, when we can say

$$PE = m g h$$

where *h* is the object's height above the Earth's surface