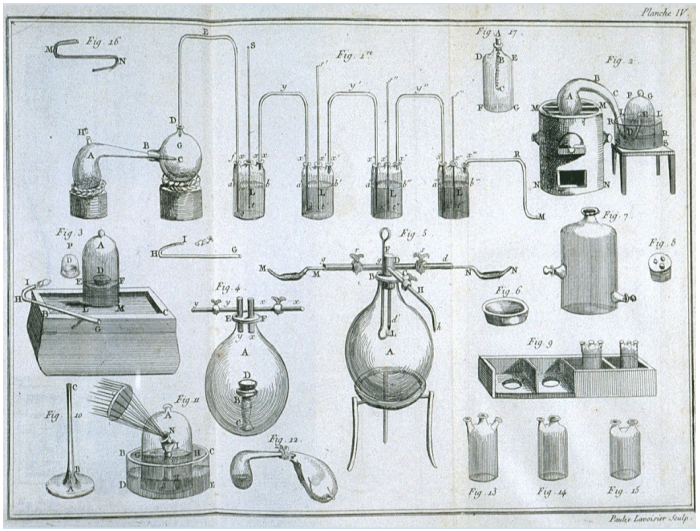
07. Kuhn: Anomalies and Crises

1. Anomaly and the Emergence of Scientific Discoveries

Ex. "Discovery" of Oxygen

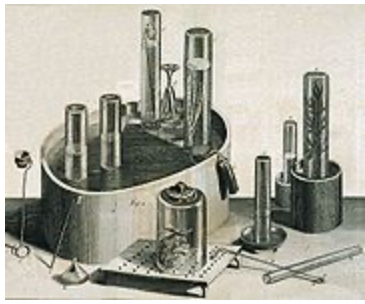
- *Phlogiston paradigm (~1600's)*
  - *Phlogiston* = substance contained in flammable bodies and released when they're burned.
  - *Ex*. Burning wood produces ash, lighter than wood.
  - "Dephlogisticated" air = air low in phlogiston and thus capable of supporting combustion.

- *"Anomalies" (~1770's)*
  - Some metals *gain* weight when burned (*ex*. magnesium).
    - *Does phlogiston have negative weight?*
  - In enclosed vessels, weight gained is equal to weight loss of air, and air volume decreases!
    - *Does combustion involve absorption?*



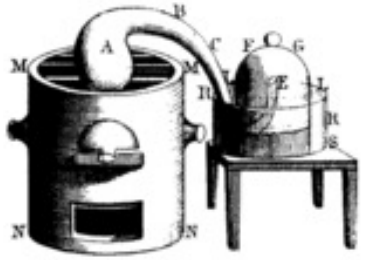
- *Priestley's experiments (1774-75)*
  - Burns mercury oxide.
  - Identifies product as dephlogisticated air.

Joseph Priestley
(1733-1804)



- *Lavoisier's experiments (1775-79)*
  - Determines that Priestley's dephlogisticated air has weight.
  - Identifies it as a new type of gas, "oxygen".
  - *Claim*: Oxygen is an atomic 'principle of acidity' and is formed only when that 'principle' unites with caloric.
  - Offers new account of combustion based on the absorption of oxygen.

Antoine Lavoisier
(1743-1794)



REVOLUTION!

- *Did Priestley "discover" oxygen?*
  - Had it in his hand.
  - *But*: Didn't have a pure sample, and didn't know it as what we take to be oxygen.

- *Did Lavoisier "discover" oxygen?*
  - Had it in his hand, and called it "oxygen".
  - *But*: Had it after Priestley and still didn't know it as what we take to be oxygen.

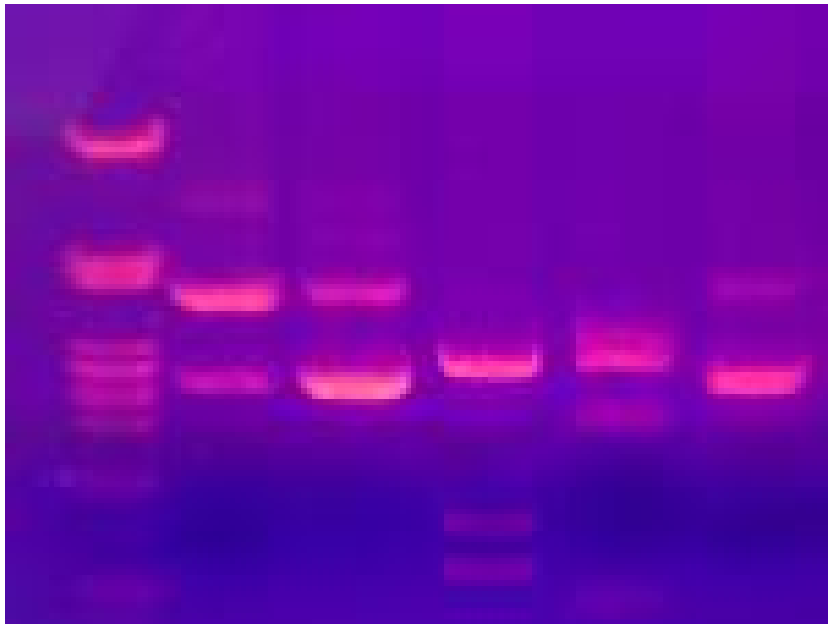
- *Claim*: Discovery is not a single act similar to "seeing":

"... discovering a new phenomenon is necessarily a complex event, one which involves recognizing both *that* something is and *what* it is." (Kuhn, pg. 55.)

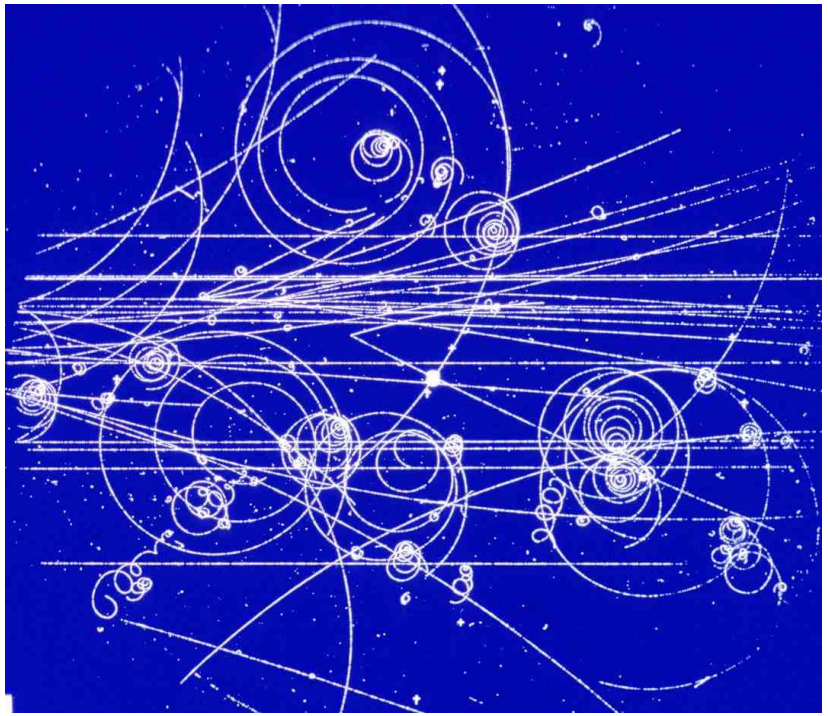
simple seeing

interpreting what is seen

Seeing *that* versus seeing *what*...



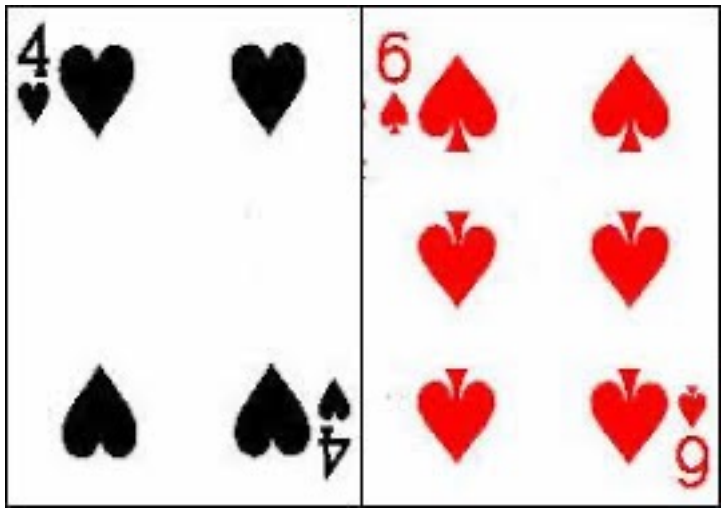
- *Me*: Pink blobs on a purple background.
- *Mona*: DNA molecules.
  - A photo of the outcome of a gel electrophoresis experiment. The pink bands are tracks left by DNA molecules of differing sizes as they migrate up the gel in the presence of an electric field.



- *Me*: Pretty blue spirals...
- *Maya*: Elementary particles.
  - A photo of a bubble-chamber during a scattering experiment. The spirals are the tracks left by particles of differing masses as they scatter in the presence of a potential field.

Characteristics of Discovery

- Previous awareness of anomaly.
- Emergence of both *observational* and *conceptual* recognition.
- Change of paradigm categories and procedures, often accompanied by resistance.
- *Role of normal science in discovery*: Provides "background of expectation" with respect to which novelties and anomalies are vivid and stand out.



Bruner, J. S. & L. Postman (1949) 'On the Perception of Incongruity: A Paradigm', *J. Personality 18*, 206.

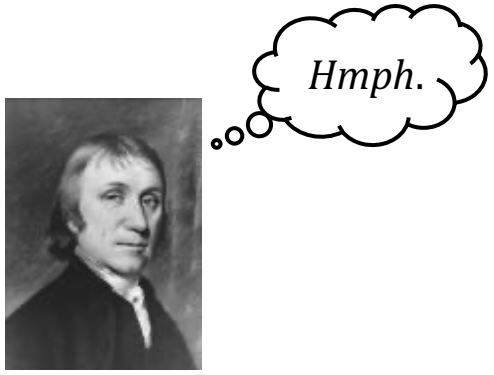
2. Crisis and the Emergence of Scientific Theories

> *Anomaly* = phenomenon for which a given paradigm has not readied the investigator.
>
> *Crisis* = build-up of anomalies.

Ex1. *Phlogiston theory*

- *Crisis*: Build-up of experiments that indicate:
  - Weight gain of some metals during combustion.
  - Weight gain = weight loss of surrounding air.
  - Volume of surrounding air decreases.

- In principle explainable:
  - *Phlogiston has negative weight for such metals.*
  - *Combustion is both a process of emission of phlogiston and absorption of something else.*



- *But*: As more qualifications of theory are made, alternatives may begin to look more attractive.

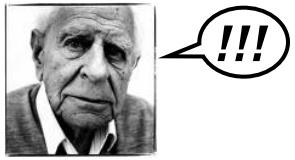
Ex2. Ether theories of light (1800's)

- *Claim*: Light consists of waves that propagate in a "luminiferous" ether.
- *Crisis*: Build-up of experiments that indicate motion through the ether cannot be detected.
- In principle explainable:
  - *Objects drag the ether as they move through it.*
  - *Objects physically contract as they move through it.*
- *But*: As more qualifications of theory are made, alternatives may begin to look more attractive.

Claim: Alternative theories can be anticipated during prior episodes of normal science, but only in the context of a crisis are they taken seriously.

"... retooling is an extravagance to be reserved for the occasion that admits it." (Kuhn, pg. 76.)

3. The Response to Crisis



- Anomalies are *not* treated as refutations.

- Crises are typically *tolerated* to a large extent:

> "Like artists, creative scientists must occasionally be able to live in a world out of joint—elsewhere I have described that necessity as 'the essential tension' implicit in scientific research." (Kuhn, pg. 79.)

- *Recall*: Paradigms do *not* completely resolve all their puzzles.
  - Those that do become "tools for engineering" (pg. 79) as opposed to scientific research programmes.

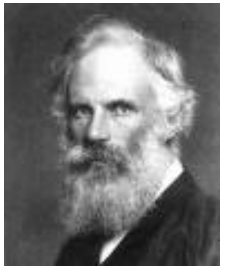
- Those puzzles that a paradigm has yet to solve can be viewed from other perspectives as sources of crisis!

<u>Ex</u>. Late 19th Cent. ether theories of light vs. special relativity

<u>Newtonian paradigm: Lorentz, Fitzgerald (~1890's-1900)</u>

- Retain ether.
- Retain Newtonian concepts of space and time.
- Claim that moving objects physically contract in the direction of motion through the ether.

Hendrik Lorentz
(1853-1928)



George Francis FitzGerald
(1851-1901)

<u>New Perspective: Einstein (1905)</u>

- Abandon ether.
- Abandon Newtonian concepts of space and time.

Albert Einstein
(1879-1955)

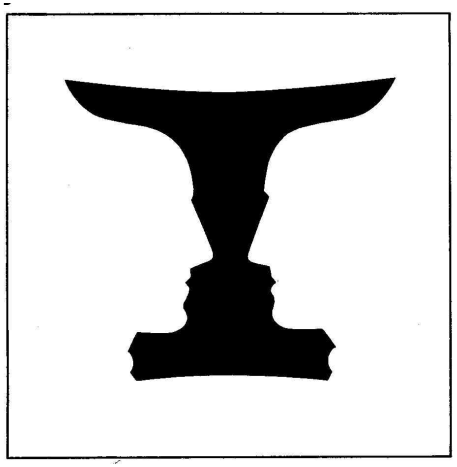
Three Ways Crises Can End

(a) Normal science overcomes anomalies.

(b) Anomalies are set aside for future research.

(c) ***Revolution!*** New candidate for paradigm arises and battle-lines are drawn.

- Transition to new paradigm is analogous to a gestalt switch:



Qualifications (pg. 85)

- Gestalt switches require interpretation.
- Initially, scientists just *see*.