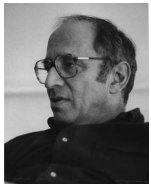


1. Anomaly and the Emergence of Scientific Discoveries

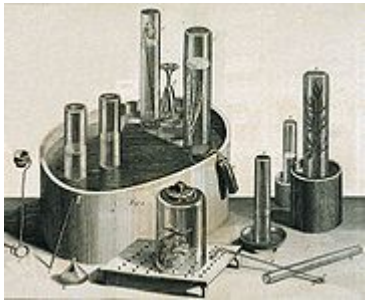
"Discovery" of Oxygen

- *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 is 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 surrounding air, and volume of air decreases!
    - Seems to indicate combustion involves absorption, not emission.

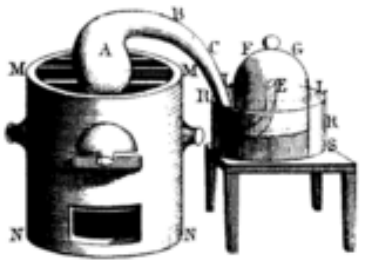
- Priestley's experiments (1774-75):
  - Burns mercury oxide.
  - Identifies product as dephlogisticated air.

Joseph Priestley
(1733-1804)



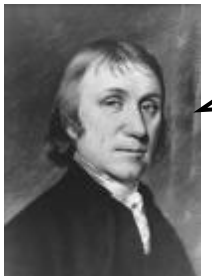
- Lavoisier's experiments (1775-79):
  - Determines that Priestley's dephlogisticated air has weight.
  - Identifies it as a new type of gas, "oxygen".
  - <u>*Claim*</u>: Oxygen is an atomic 'principle of acidity' and is formed only when that 'principle' unites with caloric.
  - Offers new account of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



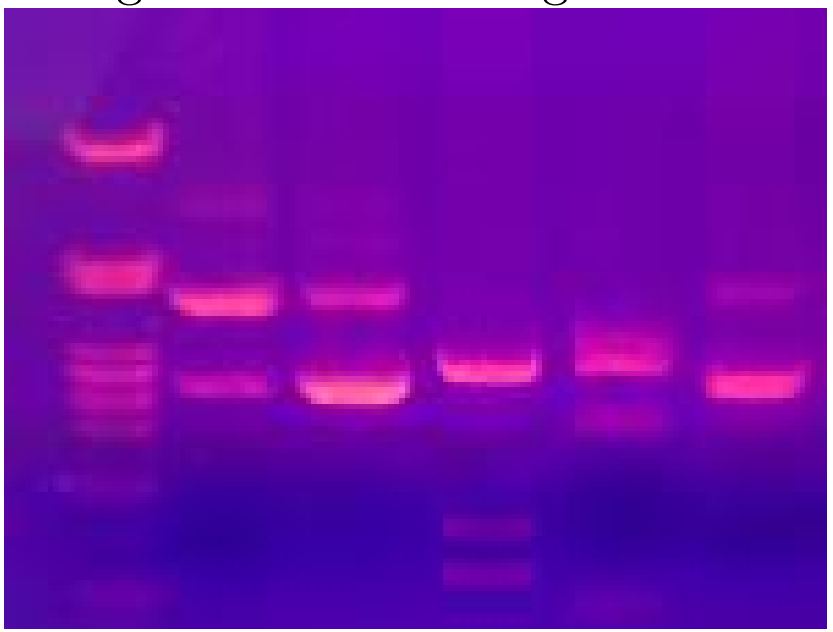
- Did Lavoisier "discover" oxygen?
  - Had it in his hand, and called it "oxygen".
  - *But*: Had it after Priestley and still didn't know it as what we take to be oxygen.

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

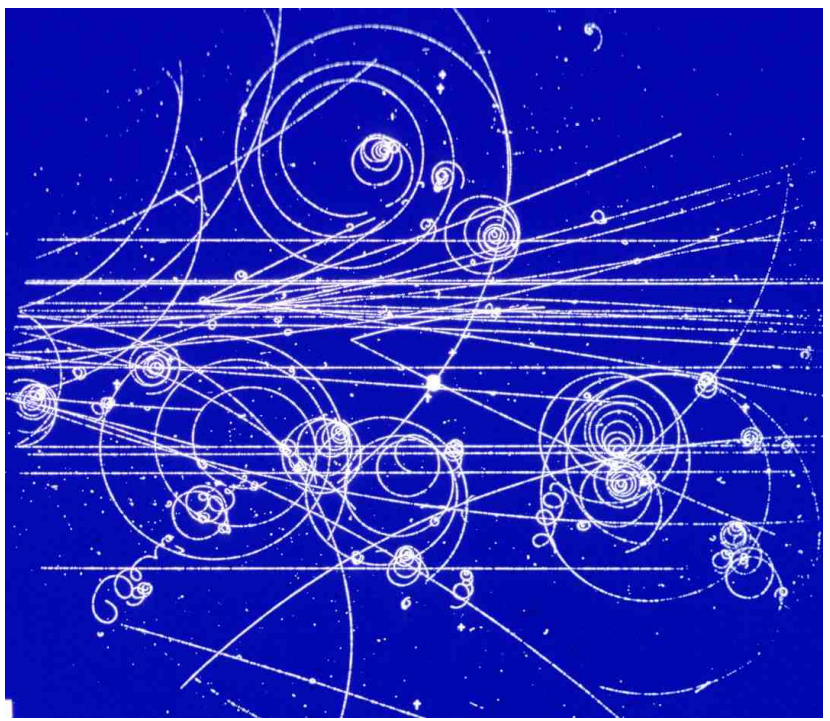
"... discovering a new phenomenon is necessarily a complex event, one which involves recognizing both *that* something is and *what* it is." (Kuhn, pg. 55.)

simple seeing — *interpreting what is seen*

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



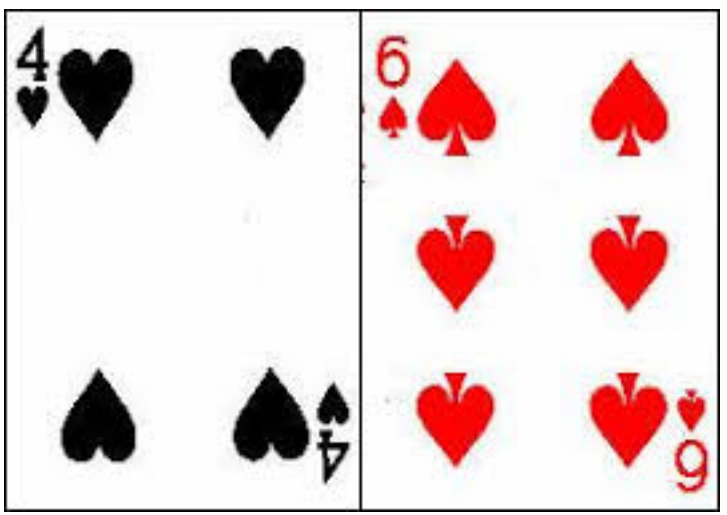
- *Me*: Pink blobs on a purple background.
- *Mona*: DNA molecules. (A photo of the outcome of a gel electrophoresis experiment. The pink bands are tracks left by DNA molecules of differing sizes as they migrate up the gel in the presence of an electric field.)



- *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. Crises 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.

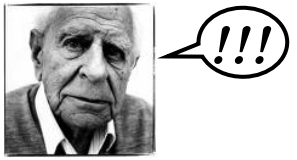
Ex2. Ether theories of light (1800's)

- *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.)

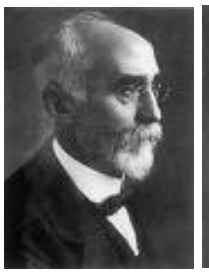
- *Recall*: Paradigms do *not* completely resolve all their puzzles.
  - Those that do become "tools for engineering" (pg. 79) as opposed to scientific research programmes.

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

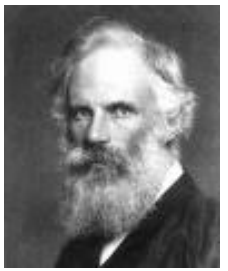
Ex. Late 19th Cent. Ether theories of light vs. Special Relativity

Newtonian paradigm: Lorentz, Fitzgerald (~1890's-1900)

- 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)

New Perspective: Einstein (1905)

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

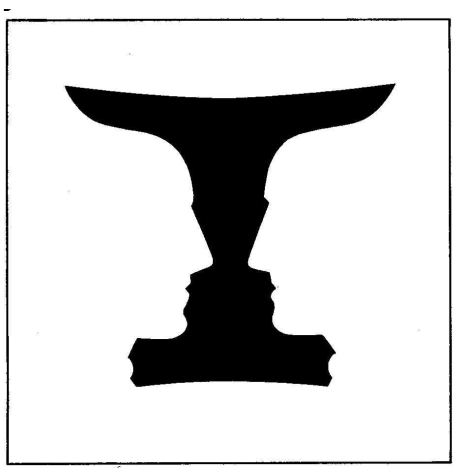
Albert Einstein (1879-1955)

How Crises End

- Normal science may overcome anomalies; or,
- Anomalies are set aside for future research; or,
- New candidate for paradigm arises and battle-lines are drawn.

REVOLUTION!

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



- Qualifications (pg. 85):
  - Gestalt switches require interpretation.
  - Initially, scientists just *see*.