Yale 耶鲁大学-南京信息工程大学大气环境中心
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# A discussion on book capter “Anomaly and the emergence of scientific discovery ” by Kuhn

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# Book Information

INTERNATIONAL ENCYCLOPEDIA of UNIFIED SCIENCE

## The Structure of Scientific Revolutions

Second Edition, Enlarged

*Thomas S. Kuhn*

VOLUMES I AND II • FOUNDATIONS OF THE UNITY OF SCIENCE
VOLUME II • NUMBER 2

International Encyclopedia of Unified Science
Volume 2 • Number 2

## The Structure of Scientific Revolutions

Thomas S. Kuhn

Contents:





**Thomas Kuhn**

| | |
|---|---|
| **Born** | Thomas Samuel Kuhn<br>July 18, 1922<br>Cincinnati, Ohio |
| **Died** | June 17, 1996 (aged 73)<br>Cambridge, Massachusetts |
| **Alma mater** | Harvard University |
| **Era** | 20th-century philosophy |
| **Region** | Western Philosophy |
| **School** | Analytic |
| **Main interests** | Philosophy of science |
| **Notable ideas** | Paradigm shift · Incommensurability · Normal science |
| **Influences** | [show] |
| **Influenced** | [show] |

# What is normal science?

- It is a puzzle-solving activity which is a highly cumulative enterprise, eminently successful in its aim, the steady extension of the scope and precision of scientific knowledge.
- It does not aim at novelties of fact or theory and, when successful, finds none.

novelty

However, new and unsuspected phenomena are repeatedly uncoverd, and radical new theories have again and again been invented !!!

**Scientific enperprise** has developed a uniquely powerful technique for producing surprises of this sort.

# What does fundamental novelties of fact and theory do?

- With combination of characteristics of science above, research under a paradigm must be a particularly effective way of inducing paradigm change.
- Paradigm change:  'Produced inadvertently by a game played under one set of rules, their assimilation requires the elaboration of another set.'

# How can paradigm changes come about?

- Discovery commences with the awareness of anomaly; then continues with a more or less extended exploration of the aera of anomaly; and it closes only when the paradigm theory has been adjusted so that the anomalous has become the expected.
- Assimilating a new sort of fact demanads a more than additive adjustment of theory, and until that adjustment is completed the new fact is not quite a scientific fact at all.

# What is the nature of scientific discovery?

- Discovery of oxygen

| Who | When | What |
|---|---|---|
| C. W. Scheele | 1771-1772 | prepared a relatively pure sample of the gas |
| Joseph Priestley | 1774 | collected the gas released by heated red oxide of mercury as one item of the 'airs' evolved by a large number of solid substances |
| | 1774 | identified the gas as nitrous oxide |
| | 1775 | identified the gas as common air with less than its usual quantity of phlogiston |
| Lavoisier | 1775 | reported the gas as 'air itslf entire without alteration ... it comes out more pure, more respirable' |
| | 1777 | concluded that the gas was a distinct species |
| | 1777-1794 | insisted that the gas was an atomic 'principle of acidity' and that the gas was formed only when that 'principle' united with caloric. |

Who first discovered oxygen ? When was oxygen discovered?

# What is the nature of scientific discovery?

➢Discovery of oxygen

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Phlogiston theory:

combustibles → ash + phlogiston

Who first discovered oxygen ? When was oxygen discovered?

# What is scientific discovery?

- 'Oxygen was discovered,' misleads by suggesting that discovering something is a single simple act assimilable to out usual concept of seeing.
- Discovering a new sort of phenomenon is necessarily a complex event, one which involves recognizing both *that* something is and *what* it is.
- If both observation and conceptualization, fact and assimilation to theory, are inseparably linked in discovery, then discovery is a process and must take time.
- Only when all the relevant conceptual categories are prepared in advance, in which case the phenomenon would not be of a new sort, can discovering *that* and discovering *what* occur effortlessly, together, and in an instant.

# Does discovery involves a change in paradigm ?

## Phlogiston theory:

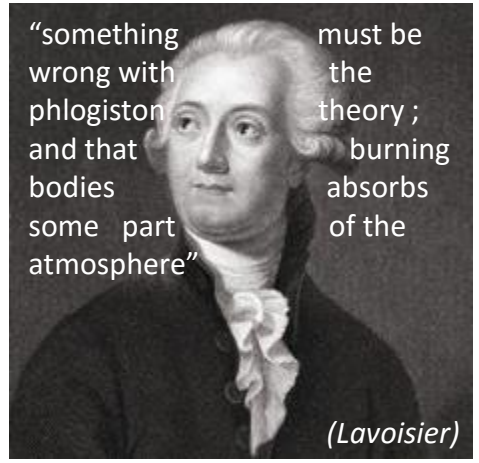
combustible → ash + phlogiston

## Oxygen theory of combustion:

combustible + oxygen in the atmosphere → compound

In 1772

1775 - 1777

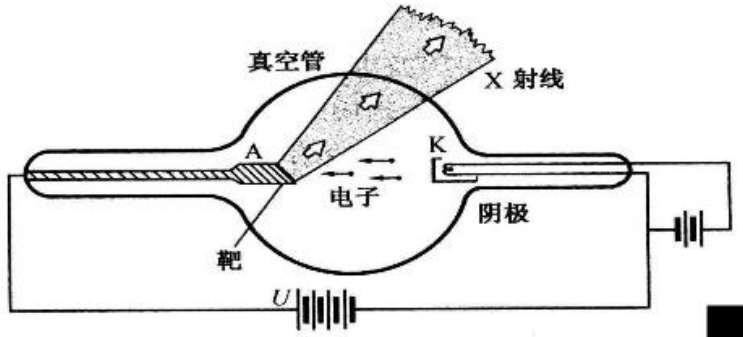



The work on oxgen gave much additional form and structure to Lavoisier's earlier sense.

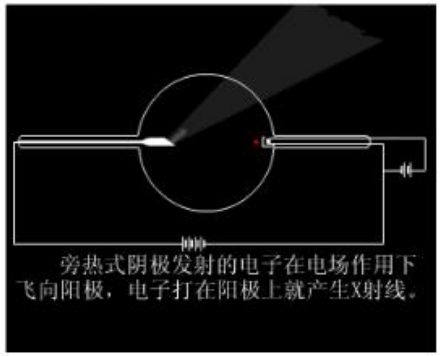
The fact that a major paradigm revision was needed to see what Lavoisier saw must be the principal reason why Priestley was unable to see it.

# Discoveries under different circumstances

- Discovery of X-rays through accident




X 射线管示意图




The discovery occurred during the investigation of cathode rays *（阴极射线）* by Roentgen in 1895.

# Resemblances between discoveries of oxygen and X-rays

| Resemblances | Subtle distinction |
| --- | --- |
| the anomaly played a prelude to the discovery | The discovery of X-rays takes more time to induce the paradigm change. |
| further process of experimentation and assimilation | Unlike oxygen, X-rays were not prohibited by established laboratory theory; but they violated deeply entrenched expectations. |
| lead to paradigm change | |

➢ When had X-rays been acturally discovered?

- Not at the first instant, nor during the last week of investigation, by which time Roentgen was exploring the properities of the new radiation he had already discovered.
- We can only say that X-rays emerged between November 8 and December 28, 1895.

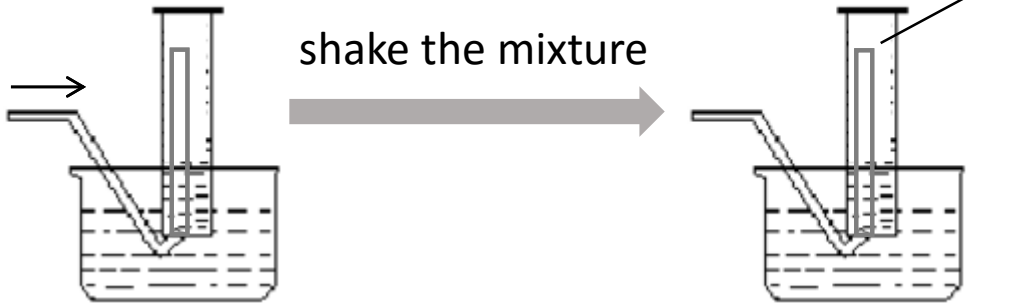
➢ How X-rays violated deeply entrenched expectations?

- If Roentgen's apparatus had produced X-rays, then a number of other experimentalists must have been producing those rays without knowing it.
- Previously completed work on normal projects would now have to be done again because earlier scientists had failed to recognize and control a relevant variable.

# Instrumental as well as theoretical expectations have often played a decisive role in scientific development

- a standard test for “the goodness of air”:

2 volumes of gas X
1 volume of gas NO

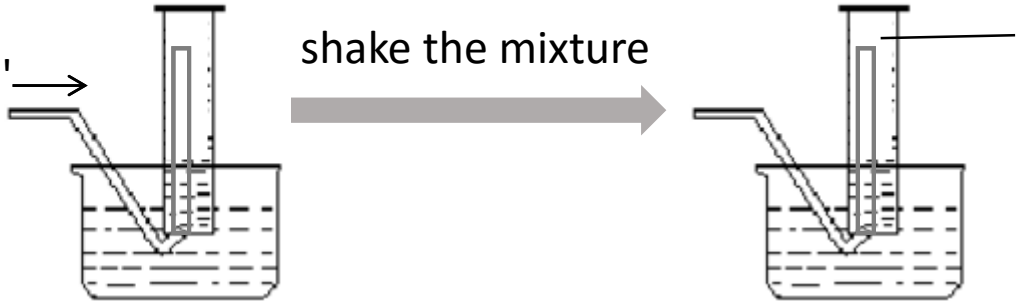



1 volume of residue, then atmospheric air
>1 volume of residue, then any other gas

Priestley's commitment to the original test procedure had been simultaneously a commitment to the non-existence of gases that could behave as oxygen did.

- Priestley's test for “the gas” :

2 volumes of 'the gas'
4 volumes of gas NO




almost no residue at all

# Necessity of paradigm procedures and applications

- Although such instrumental commitments prove misleading, we should not conclude that science should abandon standard tests and standard instuments.
- Paradigm procedures and applications are as necessary to science as paradigm laws and theories, and they have the same effects.
- We may see an essential sense in which a discovery necessitates paradigm change - and therefore change in both procedures and expectations - for a special segment of the scientific community.

# Discoveries under different circumstances

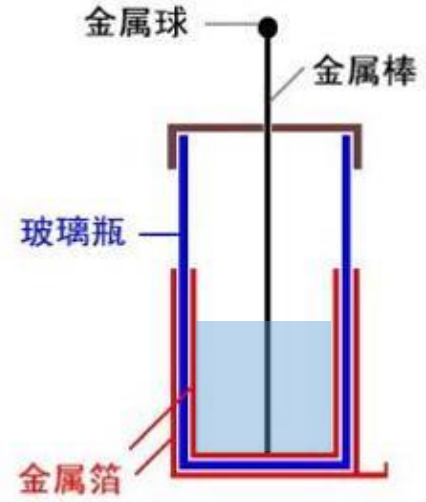
➢Discovery of Ldyden jar which belongs to theory-induced

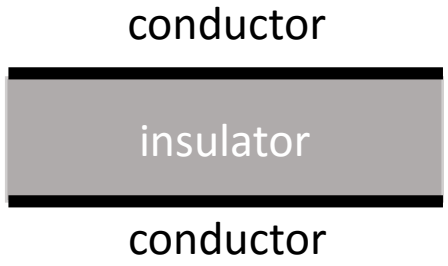
- Both during pre-paradigm periods and during the crises that lead to large-scale changes of paradigm, scientists usually develop many speculative and unarticulated theories that can themselves point the way to discovery.
- Only as experiment and tentative theory are together articulated to a match does the discovery emerge and the theory become a paradigm.

no single paradigm for electrical research

fluid theory

first full paradigm for electricity



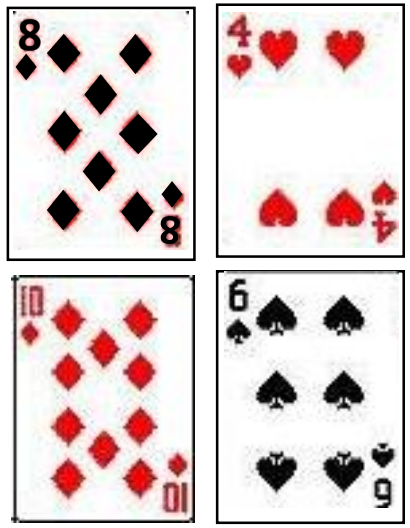



# Characterisic of all discoveries

- the previous awareness of anomaly
- the gradual and simultaneous emergence of both observational and conceptual recognition
- the consequent change of paradigm categories and procedures often accompanied by resistance

➢ These same characteristics built into the nature of the perceptual process itself.

# A psychological experiment



| | |
|---|---|
| shortest exposure | many subjects identified most of the cards |
| a small increase of exposure | all the subjects identified them all |
| a further increase of exposure | subjects begin to hesitate and to display awareness of anomaly |
| further increase.. | finally, most subjects produce the correct identification without hesitation |
| after exposured with two or three of the anomalous cards | subjects have little further difficulty with the others |
| at forty times the average exposure to recognize | A few subjects were never able to make the requisite adjustment of their categories. |

- The psychological experiment provides a simple and cogent schema for the process of scientific discovery

- Initially,only the anticipated and usual are experienced even under circumstances where anomaly is later to be observed.
- Further acquaintance does result in awareness of something wrong or does relate the effect to something that has gone wrong before.
- That awareness of anomaly opens a period in which conceptual categories are adjusted until the initially anomalous has become the anticipated.
- At this point the discovery has been completed.

**Scientific enperprise** has developed a uniquely powerful technique for producing surprises of this sort.

Recognizing the process,we can at last begin to see why normal science should be so effective in causing them to arise.

# Why normal science should be so effective in causing novelties?

- The first received paradigm is usually felt to account quite successfully .
- Further development  calls for professionalization which leads to an immense restriction of the scientist's vision and to a considerabole resistance to paradigm change; normal science leads to a detail of information and to a precision of the observation-theory match.
- Special apparatus constructed for anticipated functions is necessery for the occurance of novelty.
- Novelty emerges only for the man who, knowing *with precision* what he should expect, is able to recognize that something has gone wrong.

# Why normal science should be so effective in causing novelties?

- Anomaly appears only against the background provided by the paradigm.
- The more precise and far-reaching that paradigm is, the more sensitive an indicator it provides of anomaly and hence of an occasion for paradigm change.
- By ensuring that the paradigm will not be too easily surrendered, resistance guarantees that scientists will not be lightly distracted and that the anomalies that lead to paradigm change will penetrate existing knowledge to the core.
- The very fact that a significant scientific novelty so often emerges simultaneously from several laboratories is an index both to the strongly traditional nature of normal science and to the completeness with which that traditional pursuit prepares the way for its own change.

# Thank you

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