

**Beyond the Scientific Method:  
Challenging the Myths that surround the  
Public Conception of Science**

**JONATHAN OSBORNE**

# ARGUMENTS ABOUT THE VALUE OF UNDERSTANDING SCIENCE

**OUR PREDILECTION FOR PREMATURE ACCEPTANCE AND ASSERTION, OUR AVERSION TO SUSPENDED JUDGEMENT, ARE SIGNS THAT WE TEND NATURALLY TO CUT SHORT THE PROCESS OF TESTING. WE ARE SATISFIED WITH SUPERFICIAL AND IMMEDIATE SHORT-VISIONED APPLICATION.....SCIENCE REPRESENTS THE SAFEGUARD OF THE RACE AGAINST THESE NATURAL PROPENSITIES AND THE EVILS WHICH FLOW FROM THEM.....IT IS ARTIFICIAL (AN ACQUIRED ART), NOT SPONTANEOUS; LEARNED, NOT NATIVE. TO THIS FACT IS DUE THE UNIQUE, THE INVALUABLE PART OF SCIENCE IN EDUCATION.**

Dewey, J. (1916). *Democracy and Education*. New York: The MacMillan Company.

# THE MISAPPREHENSIONS

- 1. THE FALLACY OF TRANSFER**
- 2. THE FALLACY OF SCIENTIFIC IDOLATRY**
- 3. THE FALLACY OF CRITICAL THINKING**
- 4. THE FALLACY OF SCIENTISM**
- 5. THE FALLACY OF THE SCIENTIFIC METHOD**
- 6. THE FALLACY OF MISCELLANEOUS INFORMATION**

Cohen, I. B. (1952). The education of the public in science. *Impact of Science on Society*, 3, 67-101.

# FUNCTIONAL SCIENTIFIC LITERACY

- 1. SUBJECT MATTER KNOWLEDGE**
- 2. COLLECTING AND EVALUATING DATA**
- 3. INTERPRETING DATA**
- 4. MODELING IN SCIENCE**
- 5. UNCERTAINTY IN SCIENCE**
- 6. SCIENCE COMMUNICATION IN THE PUBLIC DOMAIN**

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education*, 36, 1-44.

# THE RISE OF SCIENTIFIC VIGILANTES

**“TAKING SCIENTIFIC QUALITY CONTROL INTO ONE'S OWN HANDS AND ATTEMPTING TO EFFECT QUALITY CONTROL ACCORDING TO ONE'S OWN UNDERSTANDING OF RIGHT AND WRONG;**

**ACTION TAKEN BY A VOLUNTARY GROUP OF PERSONS, SCIENTISTS OR NOT, WHO ORGANIZE THEMSELVES FOR THE PURPOSE OF PROTECTING A COMMON INTEREST, NAMELY SCIENCE; ”**

da Silva, J. A. T. (2016). Vigilantism in science: The need and the risks. *Academic Journal of Interdisciplinary Studies*, 5(3), 9.

# MYTHS

- TODAY WE WILL EXAMINE *THE SCIENTIFIC METHOD* AS IT RELATES TO CLIMATE CHANGE
- FAR TOO OFTEN, ALARMIST THEORIES ON CLIMATE SCIENCE ORIGINATE WITH SCIENTISTS WHO OPERATE OUTSIDE OF THE PRINCIPLES OF *THE SCIENTIFIC METHOD*.
- *THE SCIENTIFIC METHOD* IS A SIMPLE PROCESS THAT HAS BEEN USED FOR CENTURIES
- AND IT AVOIDS SPECULATION ABOUT DISTANT EVENTS FOR WHICH THERE IS NO HARD PROOF.
- ALL TOO OFTEN, SCIENTISTS IGNORE THE BASIC TENANTS OF SCIENCE IN ORDER TO JUSTIFY THEIR CLAIMS.
- *THE SCIENTIFIC METHOD* IS REGARDED AS THE “FOUNDATION OF MODERN SCIENCE.” IT ENSURES THAT SCIENTIFIC EXPERIMENTATION IS NEITHER ARBITRARY NOR SUBJECTIVE, AND THAT RESULTS CAN BE REPLICATED.

[Opening Statement: Lamar Smith - Chair of the House Committee on Science, Space and Technology. March 29, 2017](#)

# A NARRATIVE FOR SCIENCE?

- 1. THERE ARE PLURAL METHODS AND TYPES OF REASONING WHICH REQUIRE A DIVERSE SET OF PROCEDURAL, EPISTEMIC AND ONTIC ENTITIES**
- 2. OBJECTIVITY IS MAINTAINED BY PEER REVIEW AND REPLICATION**
- 3. SCIENTISTS CAN MAKE MISTAKES BUT FRAUD IS RARE**
- 4. SCIENCE IS ABOUT CREATING MODELS OF REALITY. THEY ARE NOT INFALLIBLE.**
- 5. SCIENTIFIC BELIEFS ARE BASED ON A COMMITMENT TO EVIDENCE**
- 6. THE CROWNING GLORY OF SCIENCE IS SCIENTIFIC THEORIES.**



President's Science Advisory Committee, ca. 1958



and the abstract. It would seem to me better to begin with a rabbit sitting under a raspberry bush or something of that sort, and perhaps end with an excursus into the nature and philosophy of science. I wonder if the fellows who teach biology in our country really believe the crap about "scientific method" with which they uniformly start their textbooks.

I hope to hell to get my present book ("The Prevalence of People") off to Scribners by June 15th. I am spending most of the summer at the Hopkins Marine Station -- I believe Prosser is their visitor for the first half of the summer, me for the second -- and I hope to spend most of my time there writing up last summer's work in the Pacific. It might also be a good chance to collect ideas about the aspects of marine biology that should go in a text. The decks should thus be fairly clear by next fall. When I was in New York the other day, I warned Scribners that I might be ratting on them for long enough to write a textbook, which they took with good grace. So I seem to be clear there too. X

I do hope we can manage at least to explore the possibilities of this project of Joe's.

With all the best,

Sincerely,

Marston Bates

Marston Bates

Sincerely,

With all the best,

of this project of Joe's.

# Cognitive Historians of Science

**ALISTAIR CROMBIE**

**IAN HACKING**

**REVIEL NETZ**

**ARNOLD DAVIDSON**

**NANCY NERCESSIAN**

The history of science is the history of vision and **argument**

- Hypothetico-Deductive
- Inductive
- Abductive

Crombie, Alistair Cameron. (1994). *Styles of scientific thinking in the European tradition: The history of argument and explanation especially in the mathematical and biomedical sciences and arts (Vol. 1)*: Duckworth London.

# Styles of Reasoning

**1. MATHEMATICAL DEDUCTIVE LOGIC**

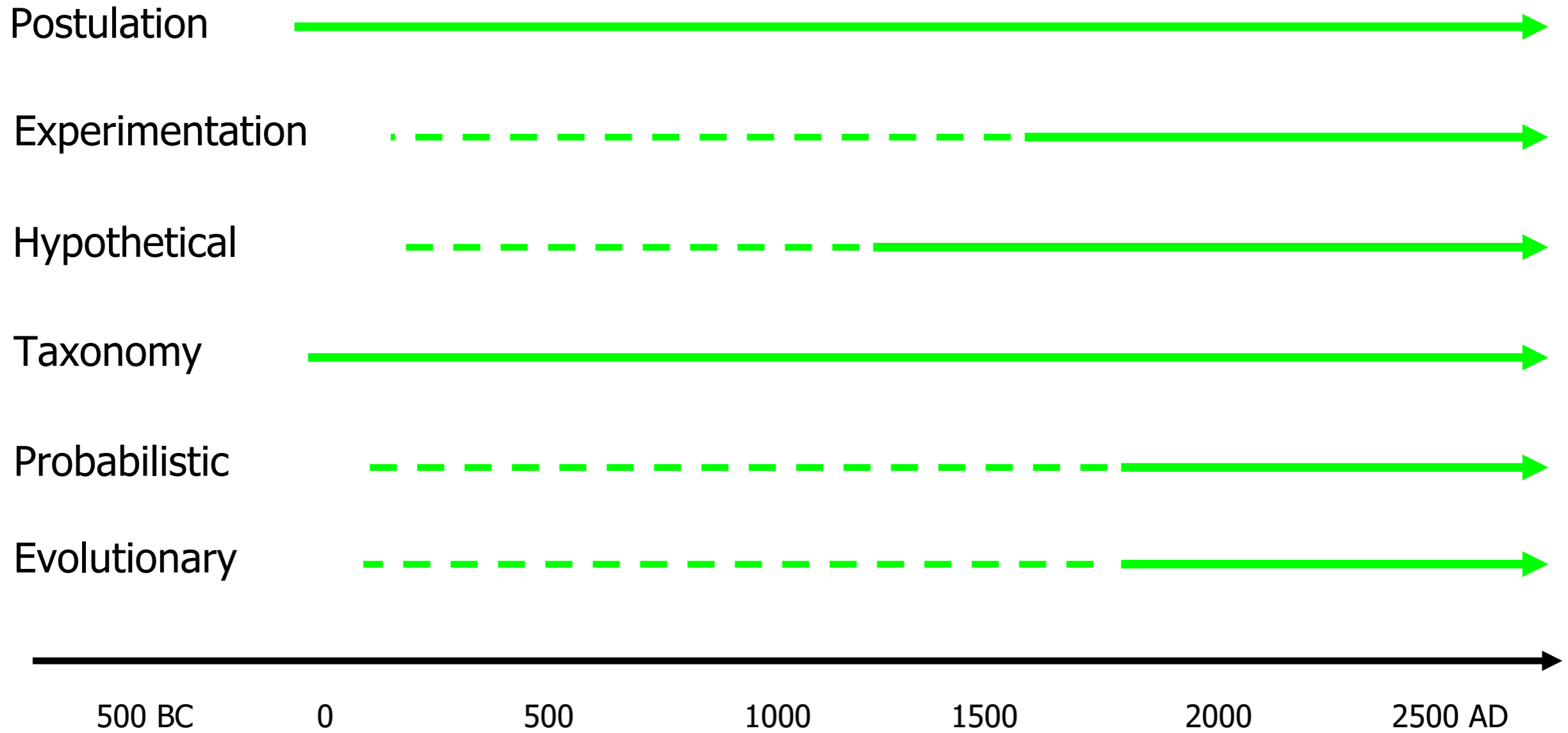
**2. EXPERIMENTAL EXPLORATION**

**3. HYPOTHETICAL MODELING**

**4. CATEGORIZATION AND CLASSIFICATION**

**5. PROBABILISTIC AND STATISTICAL THINKING**

**6. EVOLUTIONARY/GENETIC EXPLANATION**



<b>FEATURES</b>  <b>STYLE</b>	<b>Ontic Entities</b>	<b>Procedural Entities</b>	<b>Epistemic Constructs</b>	<b>Heroes</b>
<b>Mathematical Deduction</b>	Exponents Euclidian Lines Differentials Vectors Negative Numbers	Geometry, Limits Gradients Differentials	Deductive proof	Pythagoras, Euclid, Newton, Maxwell, Einstein
<b>Experimental Exploration</b>	Intrumentation Thermometers Ammeters Mass Spectrometers	Independent/Dependent Variables Control of Variables	Hypothesis Observations Experimental Tests Controls/RCT testing	Galileo Toricelli Marie Curie
<b>Hypothetical Modeling</b>	Idealized point masses Wave model of light Atoms as Mini-Solar Systems Chemical Models	Representational Models Thought Experiments	Explanatory coherence Parsimony Representations Theory	Galileo Einstein Bohr
<b>Categorization and Classification</b>	Species, Elements Periodic Table Differentiating Heat and Temperature	Criteria for Category Membership	The significance & role of classification	Linnaeus Mendeleev Rumford
<b>Probabalistic and Statistical Thinking</b>	Gaussian Distribution P-values Statistical Significance Chi-Square	Standard Statistical Tests Data Mining	Inference to Best Possible Explanation Role of uncertainty	Pascal, Gauss, Poisson, Cronbach
<b>On</b>	Gene Adaptation DNA Rock Types Planets Stars	Techniques for genetic determination Computer modeling	Role of Observation and Inference	Mendel, Darwin Wegener

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# OBJECTIVITY IN SCIENCE (WHAT ARE FACTS?)

**WHY SHOULD WE TRUST SCIENTISTS CLAIMS TO KNOW?**

**FACTS DO NOT STAND IN ISOLATION**

**INITIAL FINDINGS ARE TENTATIVE E.G THE ELECTRON**

**(BUT MOST SCHOOL SCIENCE IS BEYOND DOUBT)**

**OBJECTIVITY IS MAINTAINED BY PEER REVIEW**

**SCIENCE IS SOCIAL KNOWLEDGE**

## Why findings are likely not to be true

- 1. THE SAMPLE SIZES ARE SMALL**
- 2. THE EFFECT SIZES ARE SMALL**
- 3. THERE ARE TOO MANY DIVERSE HYPOTHESES BEING TESTED IN THE DOMAIN**
- 4. THERE IS TOO MUCH DIVERSITY IN THE DESIGNS IN THE AREA**
- 5. THERE ARE STRONG FINANCIAL INTERESTS OR PREJUDICES INVOLVED**
- 6. THE FIELD IS 'HOT' AND CONTESTED.**

Ioannidis, I. P. A. (2005). Why Most Published Research Findings Are False. *PLoS Medicine*, 2(8), e124.

## TO ERR IS NORMAL

Error	Method
Placebo Effect	Blind Clinical Trial
Observer Effect	Double Blind
Confounded Variables	Control of Variables
Biased Sampling	Randomization
Instrument Malfunction	Rigorous Calibration
Inappropriate Inferences	Peer Review
Gender/Cultural Bias	Communal Checks/Balances

# A History of Errors

**TRANSMUTATION**

**PHLOGISTON**

**N RAYS**

**COLD FUSION**

**LAMARKIANISM**

**PTOLEMY AND THE GEOCENTRIC THEORY OF EPICYCLES**

**PLUM PUDDING MODEL OF THE ATOM**

**SPONTANEOUS GENERATION**

**THE ETHER**

**REJECTION OF CONTINENTAL DRIFT HYPOTHESIS**

**CALORIC THEORY OF HEAT**

**BIOLOGICAL JUSTIFICATION FOR RACE**

**THE DEMISE OF PLUTO THE PLANET**

# SCIENCE AS THE CONSTRUCTION OF MODELS

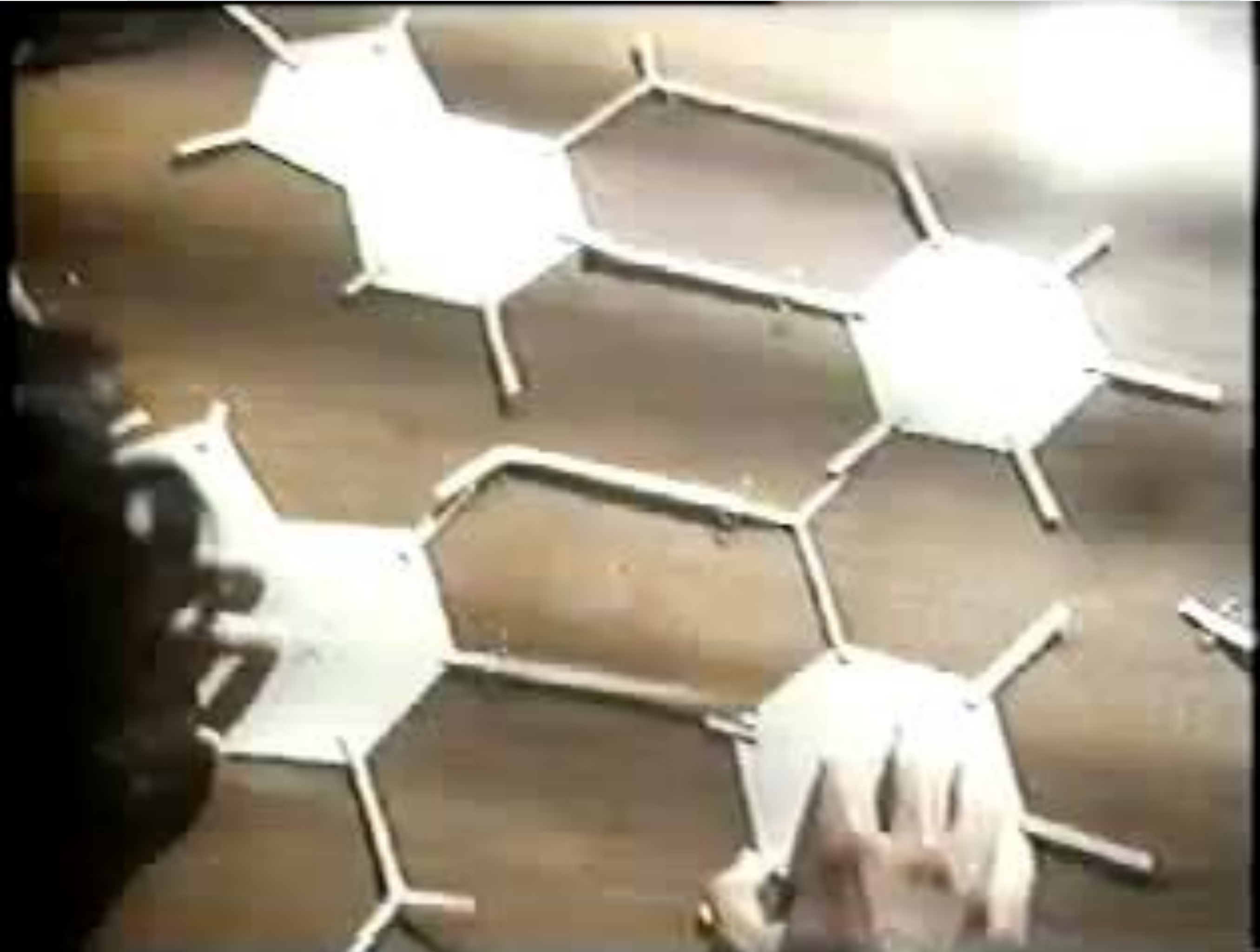
## PHYSICAL MODELS

### ANALOGICAL MODE

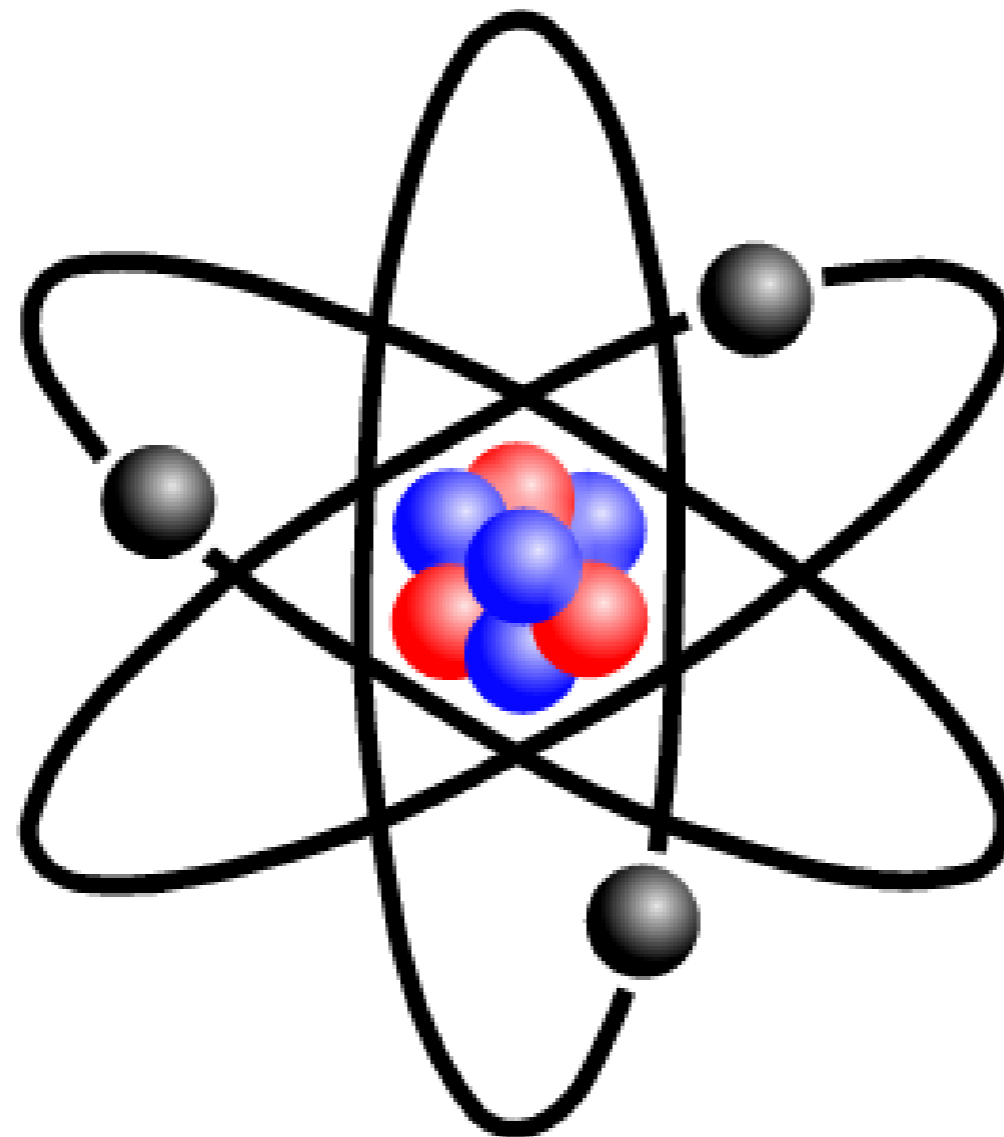
- ◆ WAVE/PARTICLE MODEL OF LIGHT
- ◆ MAGNETIC FIELDS
- ◆ BOHR MODEL OF THE ATOM
- ◆ PARTICLE MODEL OF MATTER
- ◆ CIRCULATORY MODEL OF BLOOD TRANSPORT

## MATHEMATICAL MODELS

Goal of science is the construction of Explanatory Models



# Bohr Model of the Atom



# THE DISTINCTIVE FEATURE OF SCIENCE

**COMMUNALISM**

**UNIVERSALISM**

**DISINTERESTEDNESS**

**ORIGINALITY**

**SCEPTICISM**

Rationality of Science is secured by its commitment to evidence



# Crazy Ideas in Science

**DAY AND NIGHT IS CAUSED BY A SPINNING EARTH**

**THE CONTINENTS HAVE MOVED**

**WE HAVE EVOLVED FROM OTHER ANIMALS**

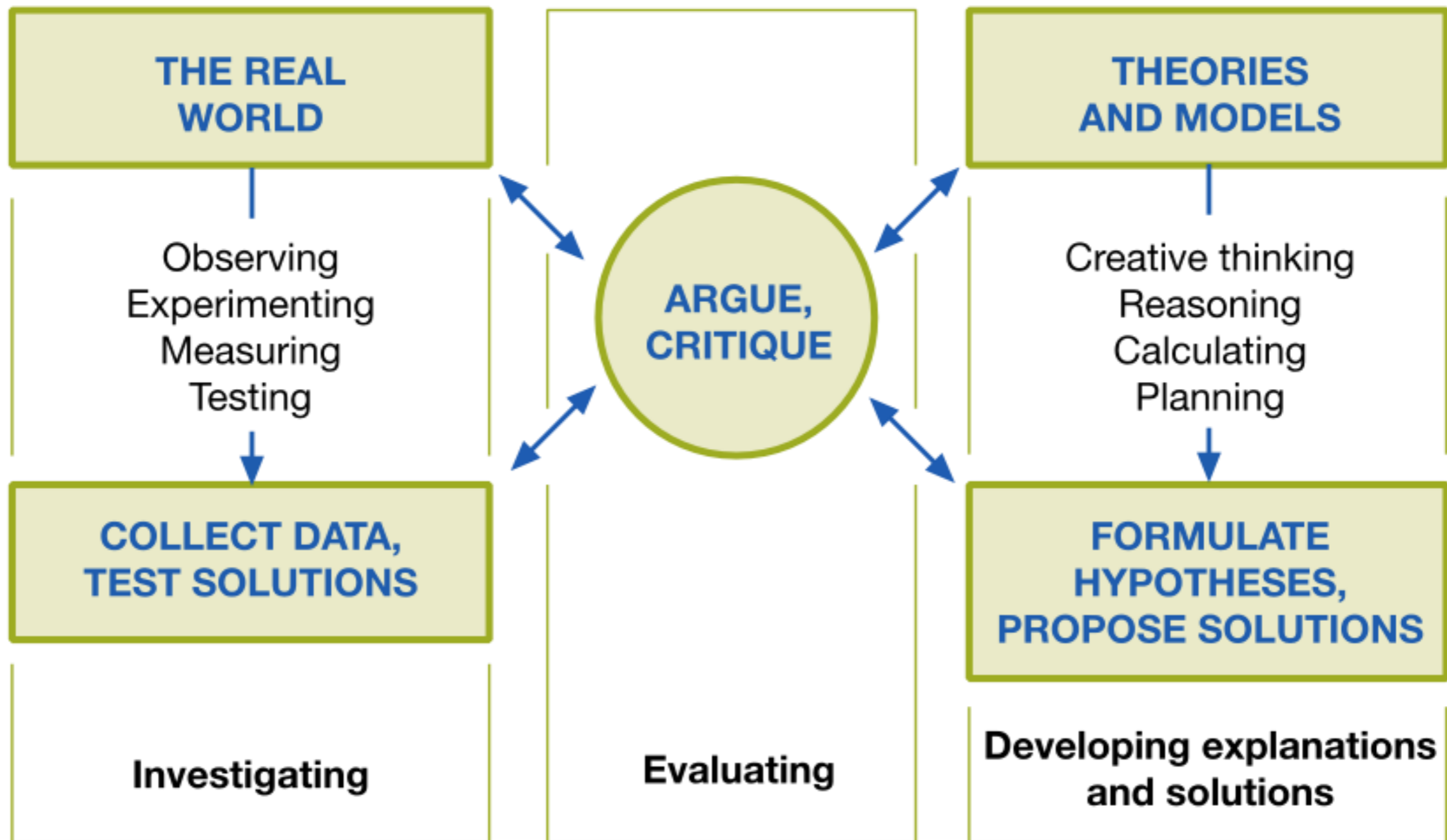
**THE EARTH IS 5 BILLION YEARS OLD**

**DISEASES ARE CAUSED BY TINY LIVING ORGANISMS**

**THE UNIVERSE STARTED WITH A BIG BANG**

**TIME SLOWS DOWN WHEN YOU TRAVEL AT THE SPEED OF LIGHT**

# The Role of Argument in Science



# A NARRATIVE FOR SCIENCE?

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Good Attempts

**JOHN OLIVER SCIENCE STUDIES**

**WHAT MAKES SCIENCE TRUE?**