HSS
HS2113

Pushkar Sohini

Fall 2020

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1 Lectures

1.1 Lecture 1

HSS 102 | Spring 2019

Critical Reading and Communication

Sciences in/as Society

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Class Schedule

Lectures: Wednesdays	**10:50 – 11:50 a.m.**
	LHC 103
Pooja Sancheti & Pushkar Sohoni	
Tutorials: Fridays	**4:20 – 5:20 p.m.**
V. Abhinaya (B1)	*LHC 105*
Pallavee Gokhale (B2)	*LHC 106*
Prajakta Divekar (B3)	*LHC 107*
Vibhishan B. (B4)	*LHC 108*

Two objectives of the course

- Exploring links between science and society
- Developing communication skills

Exploring links between science and society

The class will explore…

- Science as part of wider society
  - Historical, political, economic contexts
- Ethics in scientific practice
- Scientists and their lives
- Science in literature and film
- Science and colonisation

Developing communication skills

Reading

Writing

Listening

Speaking

in the Academic Context

Reading

- Techniques like scanning, speed reading, and close reading
- Detecting shifts in vocabulary, tone, purpose
- Picking out information/ideas/logical flaws
- Differentiating between different kinds of writing (historical, logical, informative, argumentative, creative etc.)

Writing

- Organization/Structure of various types of writings for different purposes
- Editing
- Summarizing and Condensing
- Plagiarism, Citations, Sourcing

Listening and Speaking

- Attentive listening practices (picking out key words, ideas, segues)
- Making (PPT) Presentations
- Class presentations
- Group Discussions (Etiquette and Verbal Skills)

Do we have quizzes and exams?

Yes.

Are assessments/evaluations based on content discussed or skills acquired?

Both!

Lectures and tutorials are equally important.

Grading

- Mid term exam: 35%
- End term exam: 35%
- Quiz: 10%
- Project: 10%
- Participation/class exercises (tutorials): 10%

Quiz is on January 25th.
Based on content and skills
in lectures and tutorials.

There will be no re-quiz.

What is Science?

"Science is a systematic enterprise that creates, builds and organizes knowledge in the form of testable explanations and predictions about the universe."

Wikipedia

Science is…

- A set of methods
  - Primarily, evidence-based reasoning
- A type of <u>human</u> knowledge

and

- A social practice/institution

Are Social Sciences truly sciences?

Attributes of Scientific Research

- Systematic Enquiry
- Hypothesis
- Objective Search
- Reproducibility
- Modelling
- Theory/Framework of Theory
- Inductive and Deductive Reasoning

Systematic Enquiry: Research is a **systematic enquiry** or investigation aimed at acquiring new knowledge or solving a given problem. It involves certain approaches and methods for arriving at answers.

Hypothesis: A scientific hypothesis is the initial building block in the scientific method. It is an idea or explanation that can be tested (and proved correct or wrong) through study and experimentation. It is often coded as an “if…then” formulation.

Objective Search: Scientific objectivity expresses the idea that the claims, methods, and results of science are not, or should not be influenced by particular perspectives, value commitments, community bias or personal interests etc.

Reproducibility: A measurement is **reproducible** if the investigation is repeated by another person, or by using different equipment or techniques, and the same results (or close enough to be valid) are obtained.

- Modelling: A model is a mental-visual representation of an idea, an object, or a process or a system that is used to describe and explain phenomena that cannot be experienced directly. Models link theory with experiments.

- Theory: A scientific theory is an explanation of an aspect of the natural world that can be repeatedly tested and verified in accordance with the scientific method, using accepted protocols of observation, measurement, and evaluation of results.

Creating a Hypothesis

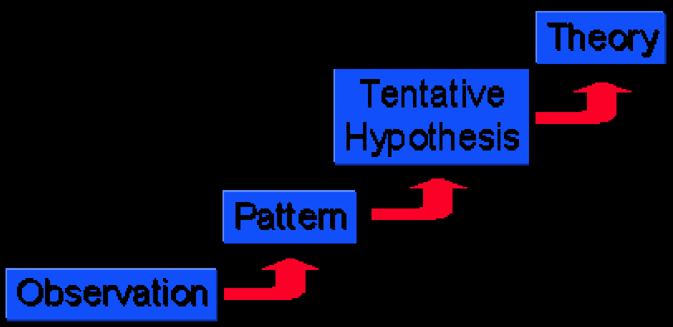
Testing of Hypothesis

(design of experimental apparatus)

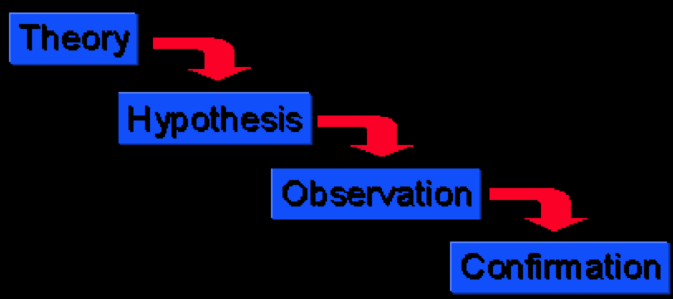
Reproducibility of Experiment

If the experiment fails, then the hypothesis is rejected, or eventually superseded by a hypothesis that is experimentally supported.

Inductive reasoning



Deductive reasoning

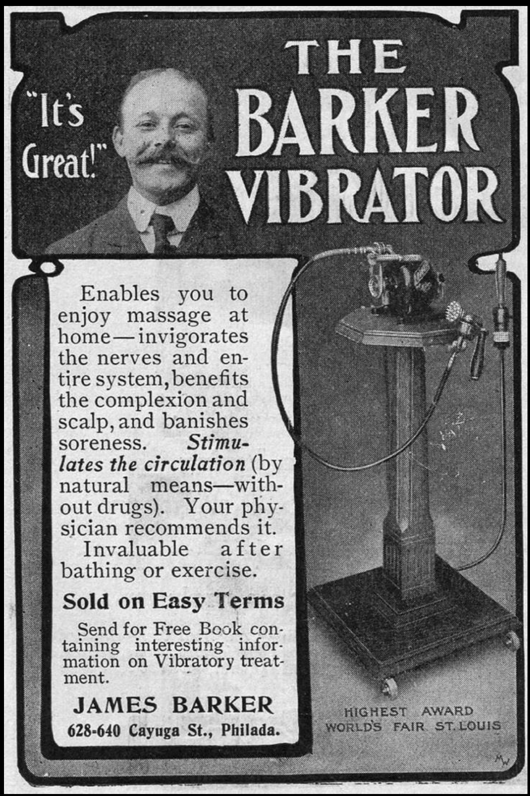


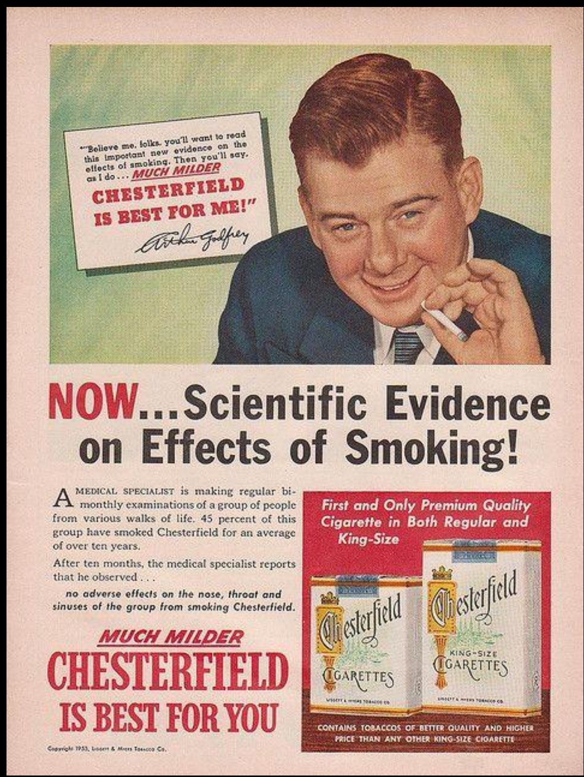
Summary

- Society and science are inextricably linked.
- Society and science shape each other.
- Science is only a sub-set of knowledge about the world around us.
- What constitutes scientific knowledge as opposed to other knowledge changes through time.
- The writing, reading, and listening (communication) of information constitutes knowledge.
- Science does not exist in a bubble isolated from language and other systems.

1.2 Lecture 2

What is modern science?





What is Pseudo-science?

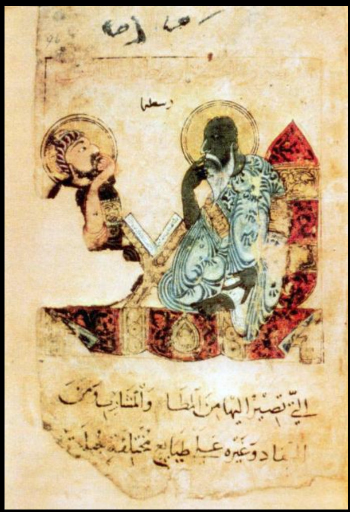
Ancient Science

Formal attempts to explain physical events based on the natural world

Aristotle (384 BCE – 322 BCE)

Speculative Philosopher, not an Experimentalist

Five Elements
Morphological Taxonomy of Living Creatures
Geological Timescales



'Aristotle teaching' c. 1220
British Library MS or. 2784, f. 96r
Kitāb naʿt al-hayawān by Jabril ibn Bukhtishu

Islamic Renaissance (800 – 1250 CE)

Alchemy, Astronomy, Algebra, Cartography,
Physics, Medicine, Optics, Botany

Ibn al-Haytham (Alhazen)
Ibn Rushd (Averroes)
Ibn Sina (Avicenna)

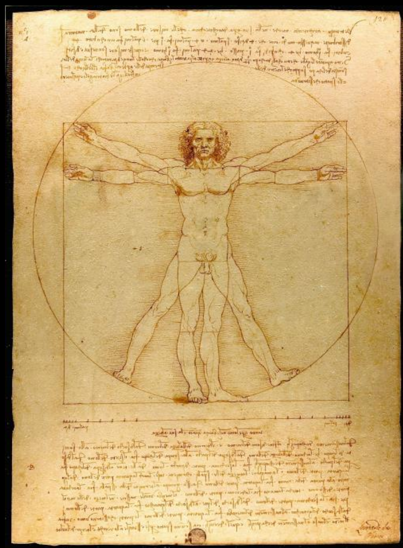
Renaissance (14th to 17th centuries)

Discovery of Classical Greek Philosophy

Anthropocentrism

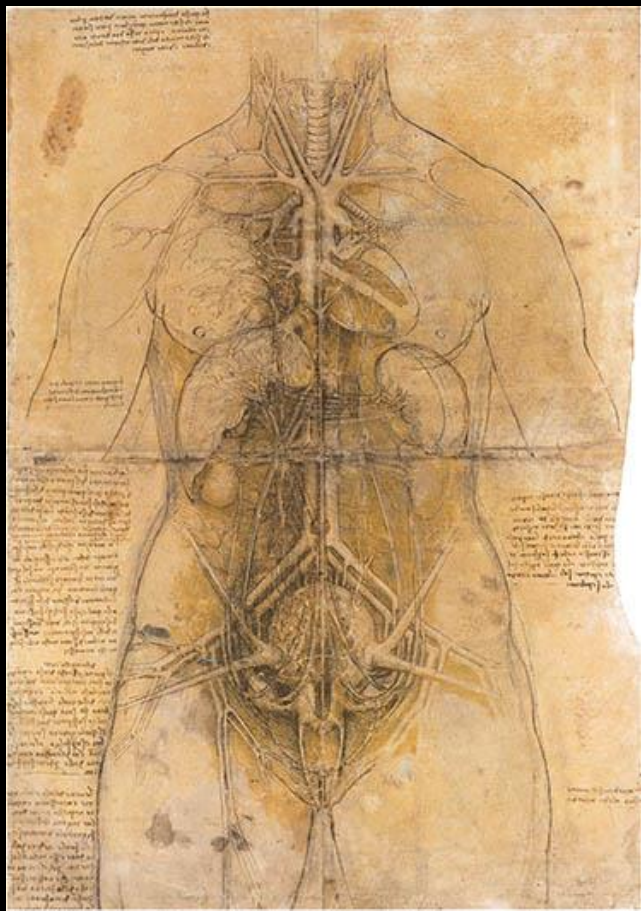
"Man is the Measure of All Things" – Protagoras

Increasing Observation and Inductive Reasoning



Vitruvian Man
Leonardo da Vinci
c. 1492

School of Athens
Raphael
c. 1509 – 1511
Apostolic Palace,
Vatican City



Leonardo da Vinci
c. 1510

Renaissance

Transition from Middle Ages to Modernity

Shifts in Knowledge

Change in Organisation of Knowledge

New Technologies of Knowledge Dissemination

ALSO

Continuities from the Middle Ages

Medieval Syllabus

Natural philosophy
Theology
Rhetoric
Logic
Grammar
Arithmetic

Laurentius de Voltolina
Liber ethicorum des Henricus de Alemannia
(university class in Bologna)
second half of 14th century

Scientific Revolution

The Scientific Revolution is a term commonly referring to the transformation of thought about nature through which the Aristotelian tradition was replaced by so-called "modern" science.

Most see it as a series of events focused in the period 16th and 17th century or, more precisely, from 1543 (De Revolutionibus of Copernicus) to 1687 (Principia of Newton). Others grant it some status from 1300 to 1800.

Still others, see revolutions all around, Glorious, American, French, Industrial, Chemical, Darwininan, Freudian, Russian, Quantum, and Plate Tectonics.

When did modern science begin?

Modern science traced to 16th century CE Europe – the beginning of scientific revolution

Shifts in knowledge as a result of the Renaissance

Shifts in philosophies/methods of science

– e.g. Aristotle vs. Galileo

Shifts ALSO in the social contexts of science:

– Academia, commerce, wars

Early times of modern science

Dichotomies of science
reason vs. religion/faith/dogma

Increasing validity of science
Increasing resources for scientific research. Where from?

Technological shifts
e.g. Gutenberg’s printing press (15^{th} century). Why?

Closely associated with ‘Enlightenment’ or the ‘Age of Reason’ in 18^{th} century Europe and America

Enlightenment

The **Enlightenment** (also known as the **Age of Enlightenment** or the **Age of Reason**) was an intellectual and philosophical movement that dominated the world of ideas in Europe during the 18th century, which is considered as the "Century of Philosophy". The Enlightenment and scholastic development changed the socio-political and literary scenario of Europe and its effects flourished during the French revolution and afterwards.

The Enlightenment

Joseph Wright 'of Derby’
1768
An Experiment on a Bird in the Air Pump

From Richard Savage's *The Wanderer* (1729)

So in some Engine, that denies a Vent,
If unrespiring is some Creature pent,
It sickens, droops, and pants, and gasps for Breath,
Sad o'er the Sight swim shad'wy Mists of Death;
If then kind Air pours pow'rful in again,
New Heats, new Pulses quicken ev'ry Vein,
From the clear'd, lifted, life-rekindled Eye,
Dispers'd, the dark and dampy Vapours fly.

Case Study: Heliocentrism

- An astronomical model developed by Nicolaus Copernicus in 1514, but published only in 1543
- Copernicus was a Renaissance mathematician, astronomer, and Catholic cleric
- The model positions the sun near the center of the Universe, motionless, and the Earth and other planets orbiting around it in circular paths
- Replaced the geocentric model of Ptolemy which had prevailed for centuries before
- Is often regarded as the launching point to modern astronomy and the Scientific Revolution
- The ancient Greek Aristarchus (in the 3rd Century BCE) had already proposed a heliocentric theory; Copernicus cited him as a proponent of it in a reference (that was, however, deleted before publication)

On the other side of the globe

- Several Islamic astronomers of the Maragha School, in the 12th and 13th centuries, had already questions the Earth's apparent immobility
- 12th century: Nur ad-Din al-Bitruji proposed an alternative to the Ptolemaic system (although not heliocentric); this system spread through most of Europe during the 13th century
- Mathematical techniques developed in this period by Arab and Persian astronomers such as Mo'avveduddin al-Urdi, Nasir-al-Din al-Tusi, and Ibn al-Shatir are referenced to obliquely by Copernicus in his *De revolutionibus orbium coelestium*

The Church and the theory

- Copernicus dedicated his publication to Pope Paul III
- 1615: Galileo defended heliocentrism, and claimed it did not oppose the Holy Scriptures [by arguing that the Bible should not be interpreted literally]
- 1616: Copernicanism was banned by the Church
- Galileo was forced to abstain from teaching or discussing his ideas on the matter and all books on Copernicanism were banned
- The ban continued until 1758! (though in the interim, astronomical observations were used by the Church for their calendars)

17th Century: Age of Reason

- Rene Descartes began (but never finished) his heliocentric treatise titled “The World”
- Around the same time, Kepler’s advocacy made heliocentrism popular around Europe
- By 1686, Copernicus’s book had been translated into English and other languages, making it into “one of the first great popularizations of science”
- 1687: Newton in his *Philosophiae Naturalis Principia Mathematica* (Mathematical Principles of Natural Philosophy) provided an explanation for Kelper’s laws in terms of universal gravitation

The scientific method

Scientists who were philosophers of science:

- Galileo Galilei, Francis Bacon (Empiricism)
- Rene Descartes (Mechanical view)
- Newton (Induction ←→deduction)

Galileo

- Galileo (1564-1642): father of observational astronomy, of the scientific method, of modern physics, and of modern science
- Innovation combination of experimentation and mathematical principles
- Stated that the laws of nature are mathematical
- One of the earliest figures to rely on observation and experimentation (i.e. empiricism and verifiability) to test hypotheses

Descartes

- Descartes (1596-1650): proponent of mechanical philosophy
- Argued that the physical world consists simply of inert particles of matter that collide and interact with each other

On Newton

Newton was a decidedly odd figure–brilliant beyond measure, but solitary, joyless, prickly to the point of paranoia, famously distracted (upon swinging his feet out of bed in the morning he would reportedly sometimes sit for hours, immobilized by the sudden rush of thoughts to his head), and capable of the most riveting strangeness. He built his own laboratory, the first at Cambridge, but then engaged in the most bizarre experiments. Once he inserted a bodkin—a long needle of the sort used for sewing leather—into his eye socket and rubbed it around "betwixt my eye and the bone as near to [the] backside of my eye as I could" just to see what would happen. What happened, miraculously, was nothing—at least, nothing lasting. On another occasion, he stared at the Sun for as long as he could bear, to determine what effect it would have upon his vision. Again he escaped lasting damage, though he had to spend some days in a darkened room before his eyes forgave him.

Set atop these odd beliefs and quirky traits, however, was the mind of a supreme genius—though even when working in conventional channels he often showed a tendency to peculiarity. As a student, frustrated by the limitations of conventional mathematics, he invented an entirely new form, the calculus, but then told no one about it for twenty-seven years. In like manner, he did work on optics that transformed our understanding of light and laid the foundation for the science of spectroscopy, and again chose not to share the results for three decades.

- (Excerpt from Bill Bryson's *A Short History of Nearly Everything*)

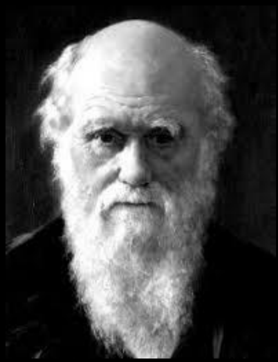
Industrial Revolution

Change in manufacturing processes in North America and England from the mid-18th to the mid-19th centuries

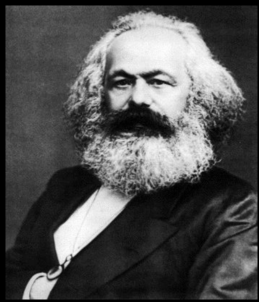
Iron Bridge, Shropshire, England, 1781

'Rain Steam and Speed'
J.M.W. Turner, circa 1840

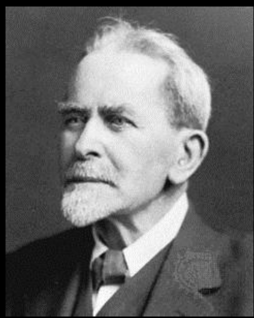
Universal Knowledge



- Charles Darwin (1809-1882) *On the Origin of Species by Means of Natural Selection*



- Karl Marx (1818-1883) *Das Kapital, Buch I: Der Produktionsprocess des Kapitals*



- James George Frazer (1854-1941) *The Golden Bough: A Study in Comparative Religion*

Around the same time as 1857

1.3 Lecture 3A

Quiz!

- Reminder: the Quiz is on Friday, 25th January
- Syllabus: Everything covered in the first 3 lectures (that includes today's lecture) and the first 2 tutorials

What is philosophy of science?

Philosophers of science seek answers to questions such as:

- How do/should scientists investigate nature?
- What methods of enquiry should be used?
- What are the limitations of these methods and of knowledge itself?
- What conditions must be satisfied for a scientific explanation to be accepted as correct?
- How is scientific inquiry distinct from other types of investigation?

Verifiability vs. Falsifiability

- Only those statements that can be verified through empirical observation (i.e. sensory experience) are meaningful and can be regarded as true.
- Also called logical positivism
- Empiricism: the theory that all knowledge is based on experience derived from the sense (for example, experimental sciences)

- A theory makes some definite predictions that are capable of being tested against experience. If the predictions turn out to be wrong, then the theory has been falsified or disproved.
- All scientific hypotheses must be inherently disprovable before they can have any credibility.
- Karl Popper, a proponent of falsifiability, claimed that any theory that could not satisfy this condition of falsifiability is pseudo-science.

Thomas Kuhn (1922-1996), physicist and science historian

- *The Structure of Scientific Revolutions* (1962)
- Phases of normal science vs. revolutionary science
- Concept of '**paradigm shift**': irreversible change in worldviews brought about by scientific revolutions (e.g. Copernican revolution, theory of evolution, etc.)
- Emphasis on the "community" of scientists clustered around a shared paradigm; also claimed that science is what scientists do!

How Kuhn changed the way we think Science

Before Kuhn, the primary beliefs about science were:

1. Science (and scientists) are constantly falsifying, constantly questioning their data and methods and theories
2. Scientists are purely objective, able to question everything, and keenly observe all phenomena
3. Knowledge builds up, accumulates, and evolves into a wider pool, and new blocks are added onto older ones, so we are constantly progressing towards the "truth"

Kuhn popularized the idea of a "paradigm", by which he means a disciplinary <u>matrix</u> (and not just a theory) or a <u>worldview</u> that underlies and encompasses the theories and methodologies of a particular scientific subject.

Kuhn’s Paradigm Shift

1. According to him, Science goes through phases of “Normal Science” and “Revolutionary Science”. Normal Science does not question the dominant ideas or theories or the paradigm of the time; not is it geared towards novelty or discovery. Discoveries are rare because we are not geared to look for them. When anomalies are detected, their numbers and complexity must increase to a point where they can no longer be fitted within the old paradigm, which then leads to a shift. With a paradigm shift, some problems are abandoned, others relegated to non-science (such as alchemy). The moment between normal science and a new paradigm is revolutionary science.

Paradigm shifts change the entire worldview of the scientific community.

2. Scientists see things in a certain way because they are conditioned to look at things in a certain way, forced so by their time, their lexicon, the methods and methodology and beliefs they have been taught by their teachers. All examples or fact must be fit to the theory they hold infallible – HUMANISING the scientific project.

3. Science is non-cumulative or discontinuous because terms change their meanings entirely. A paradigm shift will mean a change in the view of the field, its methods, its goals, and its philosophy. It also means the two paradigms are incompatible with each other. Therefore, there is no objective way of assessing their relative merits.

1.4 Lecture 3B

An Overview of Mathematics and Astronomy in India

Venketeswara Pai R.

- The word “**astronomy**” owes its etymology to the Middle English and the Old French term “**astronomie**” , which, in turn, was derived from the Latin form “**astronomia”** through the Greek word “**astronomos**” meaning 'star-law.'
- In Indian context, astronomy is known popularly by the term ज्योतिशास्त्र/Jyotiśāstra which means Science of illuminating objects.

- The earliest text on Astronomy is *Vedāṅga-jyotiṣa* (1400 BCE). It is a collection of two smaller texts having 35 and 43 verses respectively.

- Simple calculations pertaining to Calendars.

- Therefore, it is also known as *Kālavidhānaśāstra.*

- Astronomical computations enunciated in *Vedāṅgajyotiṣa* continued to be in use for a long time
- From the time of Āryabhaṭa (499 AD), there was emerging a new class of astronomical literature called the *Siddhāntas*.
- A huge corpus of literature available from the time of Āryabhaṭa to Sāmanta Chandraśekhara (18th Century CE).

Prof. David E Pingree (1933 - 2005), Brown University observers:

> At present there exist in India and outside of it some 100,000 manuscripts on the various aspects of *jyotiḥśāstra.* The great majority of these were copied within the seventeenth, eighteenth, and nineteenth centuries; for manuscripts cannot long survive in India except under exceptional circumstances. We have, therefore, essentially only those texts selected for study or composed by the scholars of the Mughal and British *rājyas.* Since the practice of copying manuscripts is virtually dead in modern India, many of these estimated 100,000 manuscripts will soon disappear, and the possibilities of our achieving a reasonably accurate assessment of the continuity, development, and transformation of the astral and mathematical sciences in India will be correspondingly diminished. But even without this appalling prospect, we must constantly be aware of the arbitrary way in which was made the selection of texts and commentaries preserved in today's libraries.

(REF: David E Pingree, A History of Indian Literature: *Jyotiśāstra:* Astral and Mathematical Literature, p. 118.)

Indian Tradition	West Asia	Europe
DARK PERIOD		
		Ptolemy (150 CE)
Vararuci (c.350)		Pappus (320), Theon (370)
Āryabhaṭa (499 CE))		Simplicius (530)
Varāhamihira (550)		
Brahmagupta (628)		
Bhāskara I (630)		
Current *Sūryasiddhānta*	Al Fazari (770)	
Lalla	Al Khwarizmi (830)	
Vaṭeśvara (906)	Thabit ibn Qurra (875)	
Muñjāla (930)	Al Battani (900)	
Śrīpati (1050)	Al Haytham (1000)	Gerard of Cremona (1175)
Bhāskara II (1150)	Al Biruni (1030)	
Mādhava (1380)	Al Urdi , Al Tusi (1250)	
Parameśvara (1430)	Al Shirazi (1300)	
Nīlakaṇṭha (1500)	Al Shatir (1375)	
Jyeṣṭhadeva (1530)	Al Kashi (1420)	Copernicus (1543)
Acyuta (1575)		Tycho Brahe (1587)
		Kepler (1609)

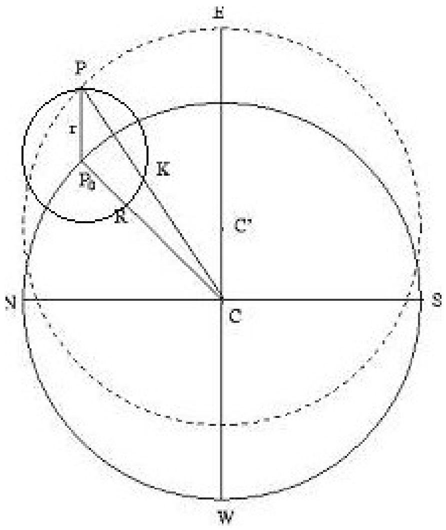
Planet	Revolutions in 43,20,000 years	Sidereal period in terms of days		
		Āryabhaṭa I	Ptolemy[1]	Moderns[2]
Sun	43,20,000	365·25868	365·24666	365·25636
Moon	5,77,53,336	27·32167	27·32167	27·32166
Moon's apogee	4,88,219	3231.98708	3231·61655	3232·37543
Moon's asc. node	2,32,226	6794·74951	6796·45587	6793·39108
Mars	22,96,824	686·99974	686·94462	686·9797
Śīghrocca of Mercury	1,79,37,020	87·96988	87·96935	87·9693
Jupiter	3,64,224	4332·27217	4330·96064	4332·5887
Śīghrocca of Venus	70,22,388	224·69814	224·69890	224·7008
Saturn	1,46,564	10766·06465	10749·94640	10759·201

- The procedure for calculating the geo-centric longitudes of the five planets, Mercury, Venus, Mars, Jupiter and Saturn involves essentially the following steps. First, the mean longitude (called the *madhyama-graha*) is calculated for the desired day.

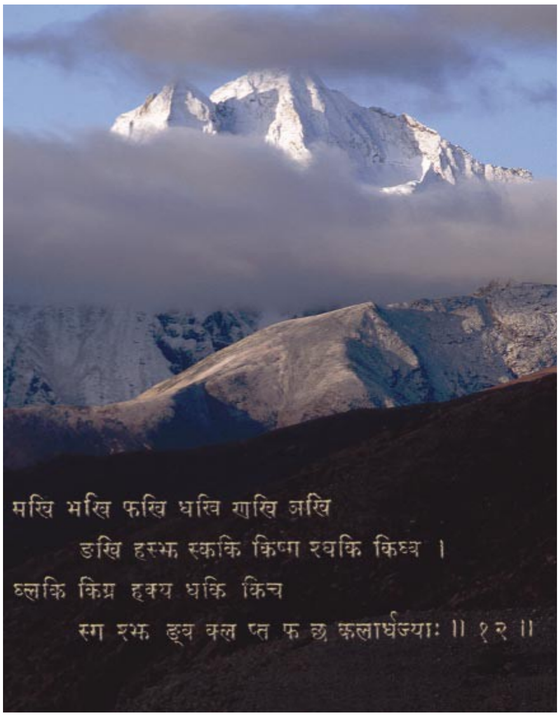
- Then two corrections namely the *manda-saṃskāra* and *śīghra-saṃskāra* are to be applied to the mean planet. The *madhyama-graha* corresponds to the mean-heliocentric planet. The *manda*-correction corresponds to the equation of centre giving the true heliocentric planet. The *śīghra-saṃskāra* corresponds to the process of conversion of the heliocentric longitude to the geocentric longitude.

- In the case of Mercury and Venus, the mean Sun is taken as the mean planet and the equation of centre is applied to it - a feature common to all the ancient planetary theories (Indian, Greco-European & Islamic).

The manda-correction is given by a variable epicycle model.

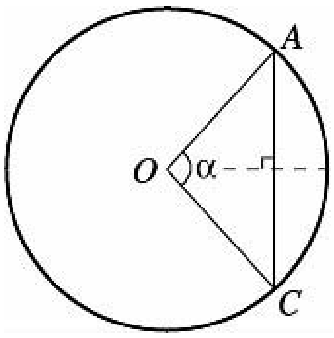


Rsin (P-M) = (r/K) Rsin (M-U) = (r_0/R) Rsin (M-U)



makhi bhakhi phakhi
dhakhi ṇakhi ñakhi
'nakhi hasjha skaki
ki.sga ghakhi kighva |
ghlaki kigra hakya
dhaki kica sga 'sjha
.nva kla pta pha cha
kala-ardha- jy–ah. ||

Indian Trignometric function = *Jyā* = *Rsine*,



Accuracy of the planetary longitudes depends on the accuracies of Rsine which depends on the accurate value of Radius, R and hence *pi.*

Hence, later astronomers started focussing on developing the Mathematical techniques for finding accurate trignometric functions and value *pi.*

Evolution to π

- Āryabhaṭa (499 AD) gives an approximation which is correct to four decimal places.
  caturadhikaṃ śatamaṣṭaguṇaṃ dvāṣaṣṭistathā sahasrāṇām |
  ayutadvayaviṣkambhasya 'āsanno' vṛttapariṇāhaḥ ||

$$\pi = \frac{(100+4)\times 8 + 62000}{20000} = \frac{62832}{20000} = 3.1416$$

- Then we have the verse 199 of *Līlāvatī* of Bhāskarācārya (12th centuary AD)
  vyāse bhanandāgnihate vibhakte khabāṇasūryaiḥ paridhiḥ susūkṣmaḥ |
  dvāviṃśatighne vihṛte'tha śailaiḥ sthūlo'thavā syād vyavahārayogyaḥ ||

$$\pi = \frac{3927}{1250} = 3.1416 \qquad \text{that's same as Āryabhaṭa's value.}$$

Evolution of π

Mādhava (14^{th} centuary)

mādhavācāryaḥ punaḥ atopyāsannatamāṃ paridhisaṅkyāmuktavān –
vibudhanetragajāhihutāśanatriguṇavedabhavāraṇabāhavaḥ |
navanikharvamite vṛtivistare paridhimānamidaṃ jagadurbudhāḥ ||[2]

The values of π given by the above verses are:

$$\pi = \frac{2827433388233}{9 \times 10^{11}} = 3.141592653592 \qquad \text{(correct to 11 places)}$$

~~The latter one is due to Mādhava~~.

[2] *Vibudha=33, Netra=2, Gaja=8, Ahi=8, Hutāśana=3, Triguṇa=3, Veda=4, Bha=27, Vāraṇa=8, Bāhu=2, Nava-nikharva*=9×10^{11}. (The word *nikharva* represents 10^{11}).

Infinite series for π

vyāse vāridhinihate ***rūpahṛte vyāsasāgarābhihate*** |
triśarādi ***viṣamasaṅkhyābhaktam*** ***ṛṇaṃ svaṃ*** ***pṛthak kramāt kuryāt*** ||

- *vyāse vāridhinihate* $4 \times$ Diameter (*vāridhi*)
- *viṣamasaṅkhyābhaktam* Divided by odd numbers
- *triśarādi* 3, 5, etc. (*bhūtasaṅkhyā* system)
- *ṛṇaṃ svaṃ* to be subtracted and added [successively]

$$Paridhi = 4 \times Vy\bar{a}sa \times \left(1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots\ldots\right)$$

Venketeswara Pai et al., The Discovery of Mādhava Series by Whish: An Episode in a Historiography of Science, *Gaṇita Bhārati*, Vol 32, No 1-2 (2010).

Venketeswara Pai et al., K. Mahesh and K. Ramasubramanian, 'Turning an algebraic identity into an infinite series', in *History of Mathematical Science II*, eds. B. S. Yadav and S. L. Singh, Cambridge Scientific Publishers, UK 2010, pp. 61.

End-correction in the infinite series for π

yatsaṅkhyayātra haraṇe kṛte nivṛttā hṛtistu jāmitayā |
tasyā ūrdhvagatā yā samasaṅkhyā taddalaṃ guṇo'nte syāt ||
tadvargo rūpayuto hāro vyāsābdhighātataḥ prāgvat |
tābhyāmāptaṃ svamṛṇe kṛte ghane kṣepa eva karaṇīyaḥ ||
labdhaḥ paridhiḥ sūkṣmaḥ bahukṛtvo haraṇato'tisūkṣmaḥ syāt ||

$$\text{Remainder term} = \frac{4 \times \left(\frac{p+1}{2}\right)}{(p+1)^2 + 1}$$

R. Venketeswara Pai et al., 'Kriyākalāpa: A Commentary of *Tantrasaṅgraha* in Keralabhāṣā', *Indian Journal of History of Science*, pp. T1–T47, **45**, No. 2, June 2010.

K. Ramasubramanian and **R. Venketeswara Pai**, *Infinite Series Inlaid in Verses*, ICRTGC-2010, A Satellite Conference of the International Congress of Mathematicians (ICM) 2010.

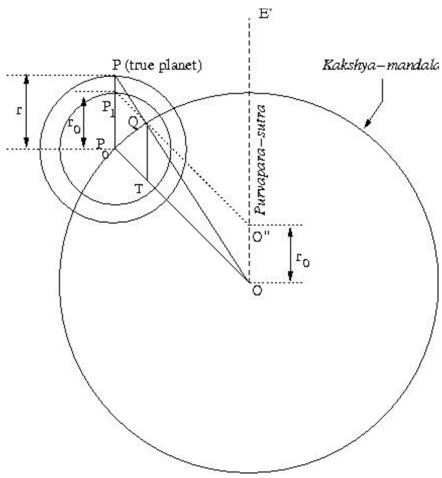
R. Venketeswara Pai et al., *Mādhava series for π and its fast convergent approximations*, Astronomy and Mathematics in Ancient India, ed. J M Delire, Peeters Publishers, Leuven 2012, pp. 175.

Bhāskara explains that the epicycle radius in the *Manda*-process is not constant. The radius (r) and the hypotenuse (K) both vary in such a way that their ratio is constant and equal to the ratio of the mean epicycle radius (r_0) and the radius of the concentric circle (R).

This entails that the actual orbit of the planet may be seen to be an oval − the first non-circular orbit in the history of astronomy.

Bhāskara gives a process of iteration (*asakṛt-karma*) to calculate r and K.

could easily derive the following formula for the *viparīta-karṇa*



E'
P (true planet)
Kakshya−mandala
r
r_0
P_1
Q
P_0
T
Purvapara−sutra
O"
r_0
O

Other Contributions

Rotation of the Earth

Till the time of Aryabhata, it was believed that Earth was stationary and all the planets including celestial sphere was revolving around the Earth.
Aryabhata's theory of Earth's rotation.

अनुलोमगतिर्नौस्थः पश्यत्यचलं विलोमगं यद्वत् ।
अचलानि भानि तद्वत् समपश्चिमगानि लङ्कायाम् ॥

'Just as a man in a boat moving forward sees the stationary objects (on either side of the river) as moving backward, just so are the 'stationary stars' (*acalāni bhāni*) seen (by people) at Laṅkā (the hypothetical city at the equator), as moving exactly towards the west.

Objections to Aryabhata's theory of Earth's Rotation: Lalla (720 - 790 AD)

यदि च भ्रमति क्षमा तदा स्वकुलायं कथमाप्नुयुः खगाः ।

If the Earth rotates how could birds in flight return to their nests. (By the time they return, trees on which the nests were would have sped away)

Lalla's Objection continues ......

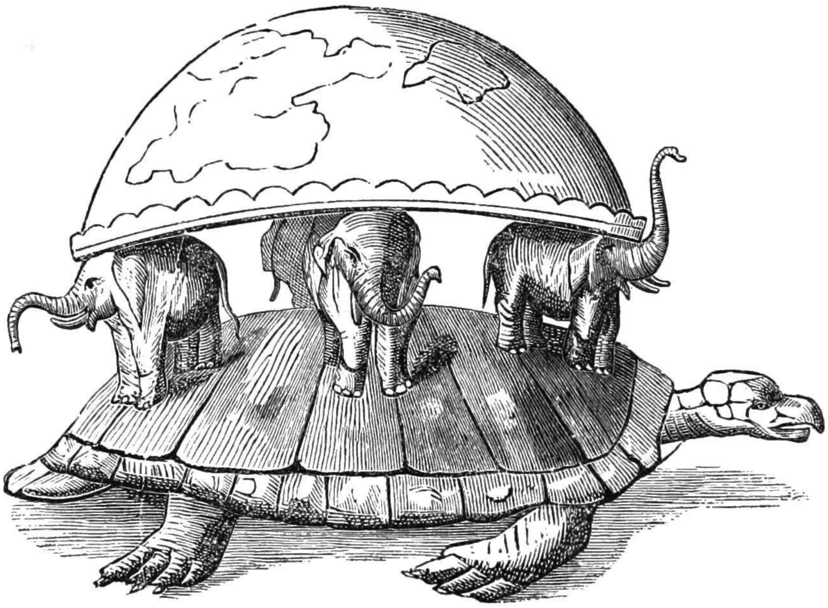
इषवोऽभिनभः समुज्झिता निपतन्तः स्युरपांपतेर्दिशि ॥
पूर्वाभिमुखे भ्रमे भुवो वरुणाशाभिमुखो व्रजेद् घनः ।

Arrows thrown vertically upwards would fall towards the west and the clouds would always be moving to the west.

Lalla's Objection continues ......

अथ मन्दगमात् तदा भवेत् कथमेकेन दिवा परिभ्रमः ॥

If it is argued that the earth is moving at a slow speed, how could it then go around the universe in a day.



● The Earth is supported by a tortoise, a serpent, a boar, elephants or by mountain ranges, etc.

● All these views are based upon the premise – heavy objects cannot stand in space without a support

Lalla on Situation of Earth

कमठादिभिरुद्धृता मही यदि ते केन धृता नभःस्थिताः ।
अत एषां वियति स्थितिर्यदि क्षितिगोलस्य तु केन वार्यते ॥

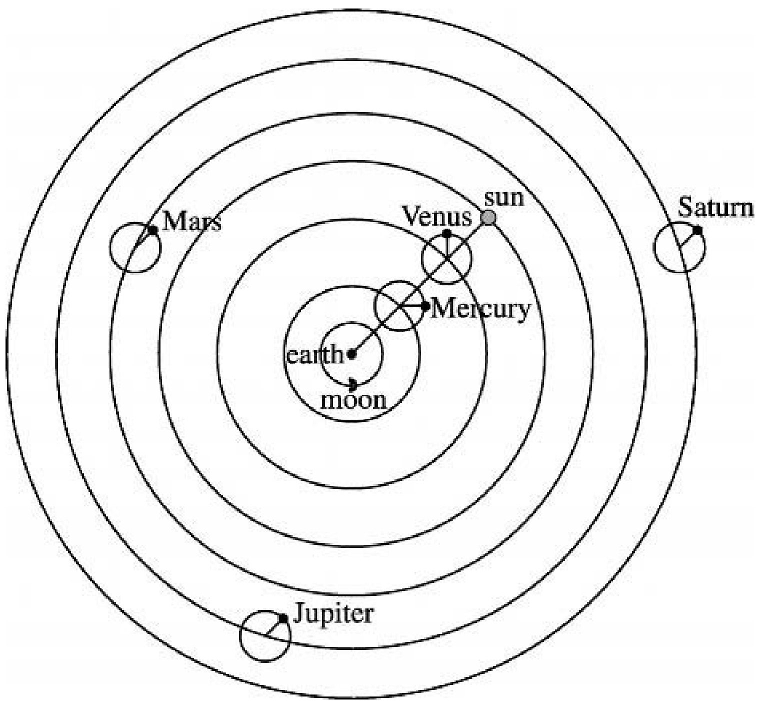
If the Earth is supported by tortoise and other things, by whom are they supported in space? If these can remain in space unsupported what prevents the Earth from remaining thus (unsupported)?

View of Bhaskara II (1114 CE)

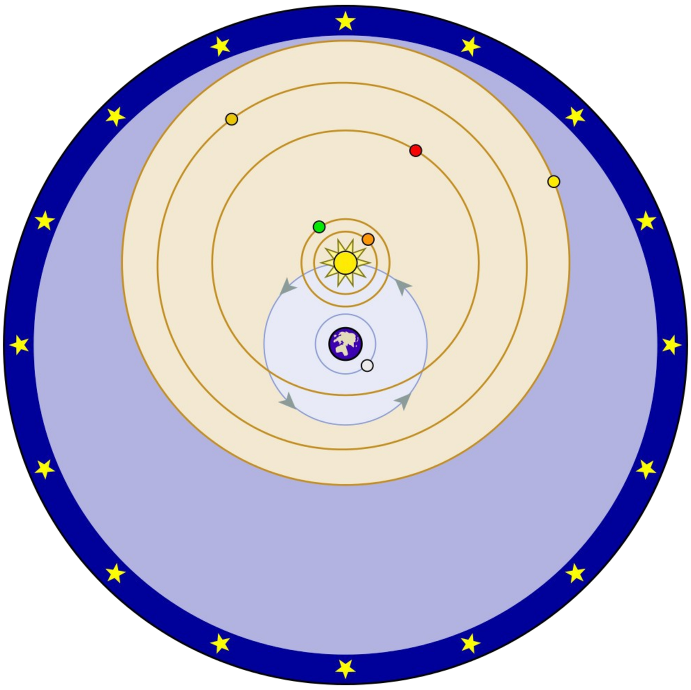
- आकृष्टशक्तिश्च मही तया यत् खस्थं गुरु स्वाभिमुखं स्वशक्त्या ।
  आकृष्यते तत्पततीव भाति समे समन्तात् क्व पतत्वियं खे ॥
- The Earth is known to be possessing the power of attraction (*ākṛṣṭa-śaktiḥ*). All the heavy objects in the sky are attracted towards it by this power. That is why, the objects are indeed found to be falling. This phenomenon is uniform (*samaṃ*) all around (*samantāt*) the Earth; [This being the case,] if this (the Earth) itself were to fall [being unsupported] where would it fall (go and settle) in the space?

- Thus clearly according to the Indian astronomers, the Earth stands in the space self-supported.

<u>Traditional Planetary Model</u>



Nilakaṇṭha's revised planetary model



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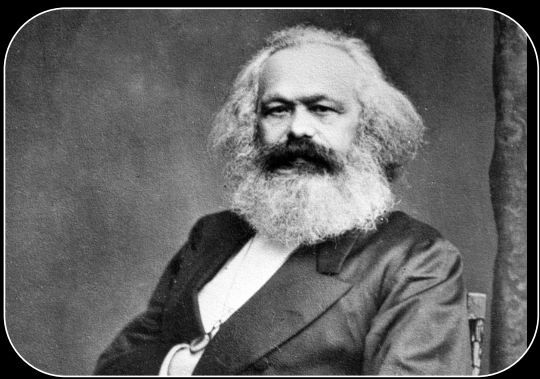
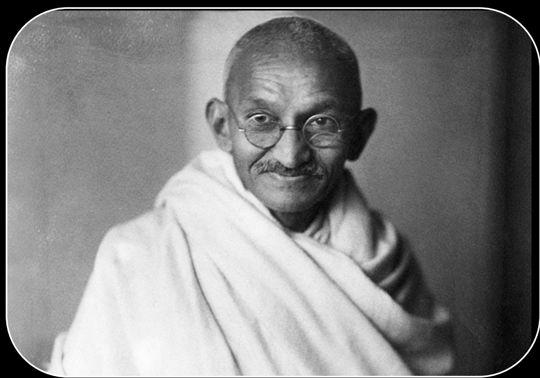
1.5 Lecture 4A

Science & Society
in
Marx & Gandhi

How did scientific revolution affect human society?



Karl Marx



M. K. Gandhi

Karl Marx

Materialistic Interpretation of History

Mode of Production

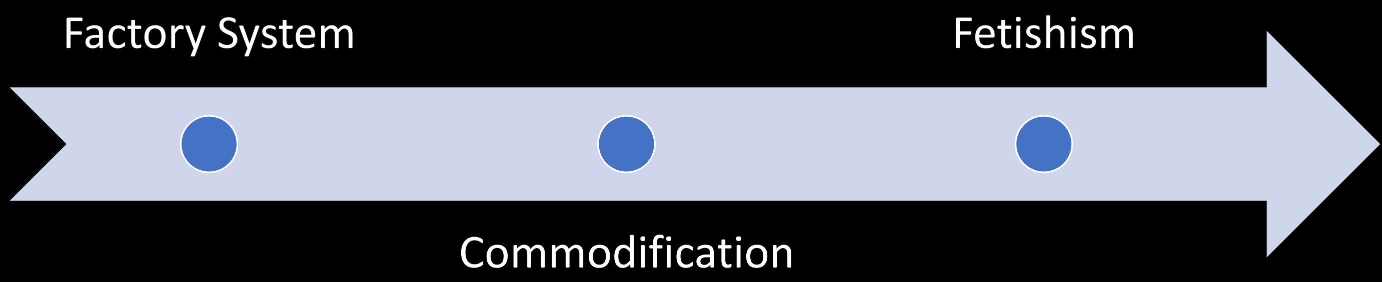
- Means of Production
- Production Relations

Capitalist System

Alienation

Term used to describe the central experience of the capitalists subjects

Capitalist Production Relations



What causes alienation?

- Related to the product as an alien subject. No control over the production process or productive activity itself.
- Performing the job to satisfy other needs.
- Activity directed against himself,
- Man is alienated from his fellow men.

Marxist Utopia of Liberation from Alienation

- Socialization of means of production
- Control over the production process
- End to Commodification of labour
- End of commodity fetishism

Marxist approach

- Critique of technological and cultural dimension of modern science but adheres to the normative framework
- ‘Scientific’ socialism versus ‘utopian’ socialism
- ‘Universal’ theory of revolution

M. K. Gandhi

- Gandhi is critical of the technological dimension as well as the meta-narrative of science

Critique of machine

- Replacement of human labour
- Philosophy of industrialism

Critique of Modern Medicine

- Doesn’t require changing life-style
- Vivisection – extreme anthropocentrism

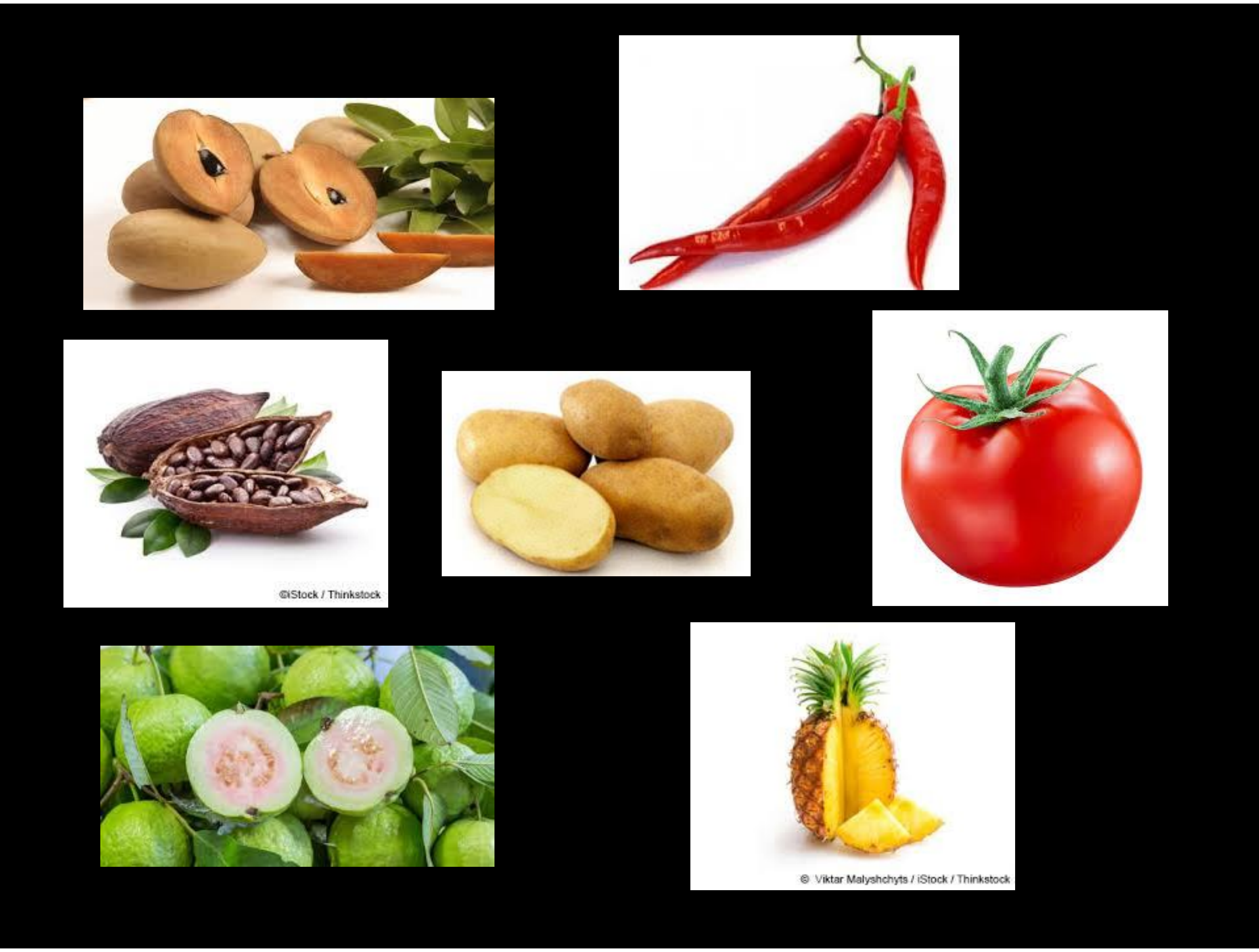
Science as spirit of enquiry

- Wants all the culturally diverse medicinal and technological practices should incorporate the spirit of enquiry and experimentation
- Highly critical of indigenous medical practitioners
- Idea of *Satyagrahi Scientist*

1.6 Lecture 4B

Botanic Gardens and Economic Botany

HSS 102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WORLD MAP
W 0° E
Prime Meridian
A R C T I C O C E A N
Greenland (Denmark)
Baffin Bay
Beaufort Sea
Arctic Circle
Alaska (USA)
Canada
Hudson Bay
Gulf of Alaska
Labrador Sea
Jan Mayen (Norway)
Svalbard (Norway)
Zemlya Frantsa-Iosifa
Oktyabr'skoy Revolyutsil
Novaya Zemlya
Kara Sea
Laptev Sea
Kotelny Island
East Siberian Sea
Norwegian Sea
Barents Sea
Iceland
Faroe Islands (Denmark)
Finland
Sweden
Norway
Russia
Estonia
Latvia
Lithuania
Belarus
Black Sea
Aral Sea
Caspian Sea
United Kingdom
North Sea
Denmark
Ireland
Poland
Germany
Ukraine
France
San Marino
Monaco
Andorra
Vatican City
Spain
Portugal
Italy
Romania
Bulgaria
Greece
Malta
Turkey
Georgia
Azerbaijan
Armenia
Turkmenistan
Uzbekistan
Kazakhstan
Kyrgyzstan
Tajikistan
Mongolia
North Korea
South Korea
Sea of Japan (East Sea)
Sea of Okhotsk
Japan
China
Afghanistan
Pakistan
Iran
Iraq
Kuwait
Bahrain
Qatar
U.A.E.
Saudi Arabia
Oman
Yemen
Jordan
Israel
Syria
Egypt
Libya
Tunisia
Algeria
Morocco
Mediterranean Sea
Red Sea
NORTH ATLANTIC OCEAN
NORTH PACIFIC OCEAN
PACIFIC OCEAN
United States of America
Bermuda (U.K.)
Bahamas
Haiti
Dominican Rep.
Puerto Rico(U.S.)
St. Kitts And Nevis
Antigua and Barbuda
Dominica
St. Lucia
Barbados
Grenada
Trinidadn& Tobago
Mexico
Gulf of Mexico
Cuba
Belize
Jamaica
Guatemala
Honduras
El. Salvador
Nicaragua
Costa Rica
Caribbean Sea
Tropic of Cancer
Hawaii Islands (U.S.)
Venezuela
Colombia
Suriname
French Guiana (FR)
Guyana
Ecuador
Galapagos (Ecuador)
Equator
Peru
Brazil
Bolivia
Paraguay
Chile
Uruguay
Argentina
Kiribati
French Polynesia
Cook Island(N.Z.)
Tropic of Capricorn
Easter I. (Chile)
Canary Islands (Spain)
Western Sahara
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Djibouti
Ethiopia
Somalia
Cape Verde
Senegal
Gambia
Sierra Leone
Liberia
Ivory Coast
Burkina Faso
Nigeria
Central African Rep.
South Sudan
Uganda
Kenya
Gabon
Congo
Dem. Rep. Congo
Burundi
Tanzania
Seychelles
Comoros
Mayotte(France)
Angola
Zambia
Zimbabwe
Mozambique
Madagascar
Mauritius
Reunion(France)
Namibia
Botswana
Swaziland
Lesotho
South Africa
São Tomé and Príncipe
Ascension (U.K.)
St Helena (U.K.)
Trindade (Brazil)
Arabian Sea
India
Nepal
Bhutan
Bangladesh
Myanmar (Burma)
Laos
Thailand
Vietnam
Cambodia
Bay of Bengal
Sri Lanka
Maldives
Andaman Is.(India)
Malaysia
Singapore
Sumatra
Indonesia
Java
Brunei
Philippines
Philippine Sea
Taiwan
East China Sea
Northern Mariana Islands (U.S.)
Guam (U.S.)
Palau
Federated States of Micronesia
Marshall Islands
Papua New Guinea
Nauru
East Timor
Soloman Islands
Tuvalu
Walis & Fatuna(France)
Vanuatu
Fiji
Coral Sea
New Caledonia (France)
Cocos Is. (Aus.)
Christmas Is. (Aus.)
INDIAN OCEAN
Australia
Great Australian Bight
Tasmania
Tasman Sea
New Zealand
North Island
South Island
SOUTH ATLANTIC OCEAN
SOUTH PACIFIC OCEAN
Falkland Islands (U.K.)
South Georgia (U.K.)
South Sandwich (U.K.)
S O U T H E R N O C E A N
Antarctic Circle
1. Netherlands
2. Belgium
3. Luxembourg
4. Switzerland
5. Slovenia
6. Croatia
7. Bosnia and Herzegovina
8. Czech Republic
9. Slovakia
10. Austria
11. Hungary
12. Serbia
13. Moldova
14. Macedonia
15. Albania
16. Cyprus
17. Lebanon
18. Guinea-Bissau
19. Guinea
20. Ghana
21. Togo
22. Benin
23. Cameroon
24. Equatorial Guinea
25. Rwanda
26. Cambodia
27. Panama
28. Malawi
29. Liechtenstein
30. Montenegro
31. Kosovo
32. Palestinian Territories
33. St. Vincent and the Grenadines
1260Km 0 1260 2520 3780 5040Km
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John Rose, the royal gardener, presenting Charles II with the first pineapple grown in England. Backdrop: Kew Gardens. Painter: Hendrick Danckerts. Year: 1766 approximately.

Where do pineapples come from?

- Indigenous fruit of Brazil and Paraguay
- Discovered by Europeans (Columbus, to be precise) in 1493 in Guadeloupe (the Caribbean islands) and brought to Europe
- Did not succeed in growing it commercially because the plant needs a tropical climate
- By the 16th century, the Portuguese and Spanish colonies introduced pineapples into their Asian, African, and South Pacific colonies, such as the Philippines and Guam.
- The Portuguese brought it to India in 1550
- Effects are evident even now: Philippines is the world's third largest producer of pineapples and accounts for 17% of the global pineapple export

Arabic	أناناس ('ananās)
Armenian	անանաս (ananas)
Danish	ananas
Dutch	ananas
English	**pineapple**
Esperanto	ananaso
Finnish	ananas
French	ananas
German	Ananas
Georgian	ანანასი (ananasi)
Greek	ανανάς (ananás)
Hebrew	אננס (ananás)
Hindi	अनानास (anānās)
Hungarian	ananász
Icelandic	ananas
Italian	ananas
Latin	ananas
Macedonian	ананас (ánanas)
Norwegian	ananas
Persian	آناناس (ânânâs)
Polish	ananas
Portuguese (eu)	ananás
Romanian	Ananas
Russian	ананас (ananás)
Spanish	ananás
Swedish	ananas
Turkish	ananas

Plants take root

- Thomas Jefferson: "*The greatest service which can be rendered to any country is to add a useful plant to its culture*."

– New World maize and sweet potato introduced to China in the 16th century prevented famine

– White potato from the Andes spread in northern Europe and supported population explosion and increasing labour force in the 18th and 19th centuries

–'Turkey red' strain of hard winter wheat traveled from Russian Crimea to the US through immigrants in the early 20th century

(So, not natural selection but human intervention!)

BUT…

Economic Botany

- "Economic botany" was the planting of seeds and introduction of plants which had commercial value for the (European) empire (rubber, tobacco, spices, breadfruit etc.)
- Part of the impetus to collect and learn more about plants (developing botanical sciences and techniques like hybridization, species selection) was also to learn how they could be useful for various purposes, usually with an economic benefit
- Central to this enterprise was the "***botanic garden**, a historic institution with worldwide connections whose nineteenth-century expansion resulted in a greatly accelerated process of plant transfers with consequent ecological, economic, social, and political changes*" - Brockway
- Botany has aided **imperialistic** projects

Imperialism

- *“State policy, practice, or advocacy of extending power and dominion, especially by direct territorial acquisition or by gaining political and economic control of other areas”*

- Encyclopedia Britannica

About botanic(al) gardens

- Can be understood as "*a 'living museum',*" playing roles varying with time and circumstances— as "… *academic collections, displays of curiosities, displays of beauty, and educational institutions*" - Fagg
- Earliest botanic gardens were physic gardens for medicinal herbs, and attached to universities or apothecaries
- World's first botanic garden – in Padua (Italy) – 1545

- 18th Century: economic potential of plant introduction
- First botanic garden in a colony – St Vincent (West Indies) – 1765
- Britain's East India Company founded one at Calcutta in 1787 to break the Dutch monopoly on spices

- 19th Century: gardening as a leisure activity in Europe – scientific, economic, and aesthetic pursuits blend
- The aim of colonial botanic gardens? "*Eventually, there would be a network of gardens that spanned the globe, which would prove vital to the British Empire, allowing vital crops like rubber and cinchona … to be collected outside the empire and moved to colonies where they could be grown profitably*" - Endersby

Sydney's Botanic Garden

- New South Wales (NSW) was a penal colony that faced repeated droughts and near famines
- Everything from writing paper to seeds for the colony's farms had to be brought over from Britain (both dangerous and expensive)
- 1812: the NSW government issued a proclamation that "*the whole of the Government Domain*" was being "*completely enclosed by stone walls*" and no animals would be allowed inside
- 1812-1818: Sydney's Botanical Garden is established
- All such colonial botanic gardens were projected to become financially self-sufficient while providing increasing yields and profit to the empire
- Initial trade at Sydney was for crucial food grain seeds in exchange for exotic flora


© Alamy

The Kew Garden in England

- The Royal Botanic Gardens at Kew were founded by Princess Augusta (1713-1772) in the 1760s; by 1789, it had close to 5500 plant species
- In the 1820s, it went into a decline
- In 1838, a Royal Commission was set up to inquire into the future of the gardens under the chairpersonship of Dr John Lindley. Lindley declared that Kew must have an **imperial as well as a domestic** role and proposed that the government, rather than the royalty, run the garden
- He argued that if run properly and <u>in conjunction with the botanic gardens in British colonies</u>, Kew was "*capable of conferring very important benefits upon commerce and . . . colonial prosperity*" (Endersby)
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- Kew became a center of knowledge and trade, and colonial botanic gardens depended on it for advice, books, and plants

Sir Joseph Banks (1743-1820)

- In 1770, Captain **James Cook** arrived in the then almost unknown land of Australia
- His ship had a botanist named Joseph Banks
- Banks, enamored of the flora, called the east coast “Botany Bay”
- He envisaged an Australian colony where settlers would grow provisions and make masts, spars, and sails
- Returned with an astonishing variety of plants to England, became a celebrity, a friend to King George III, and president of London’s Royal Society
- First, though unofficial, director of the Kew Botanic Gardens
- Suggested Australia as dumping ground for British convicts in 1779
- Was instrumental in establishing key botanic gardens in the British colonies (including Sydney), promoting both their scientific role and their economic benefits in transferring and acclimatising plants.
- Following Banks’s death in 1820, the Kew Gardens and some gardens in the colonies went into decline

Banks, Food, Economics

- 1787: in a bid to provide cheap nutritious food to the cotton plantation slaves in the West Indies, Banks decided to cultivate breadfruit from the central Pacific islands
- Breadfruit arrived from Tahiti in 1793, and was planted at the botanic garden in St Vincent
- Banks saw great potential in botanical wealth and furthering of the empire

Kew and Imperialism

- 1840s onwards - Kew gardens received substantial government grants because science (in conjunct with imperial expansion) was high priority for the Victorian government. One of the aims of Kew was to coordinate *"'the efforts of the many gardens in the British colonies and dependencies, such as Calcutta, Bombay, Saharanpur, the Mauritius, Sidney, and Trinidad, whose utility [was] wasted for want of unity and central direction'"* (Basdeo)
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Kew’s functions in the 1840s-1900s

- **Display and public education**: it drew thousands of visitors every year to see its acres of plantings and labeled specimens, its greenhouses and museums
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Kew Today

- 1945 onwards: Kew has shifted its focus from economic botany, and the imperialist activities of the past to conservation ethics
- 1970s - 1990s: forged links with global plant conservation movements and the IUCN (World Conservation Union)
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- Kew and the Millennium Seed Bank Partnership: managed to ‘bank’ ten per cent of the world’s wild flowers

Then and Now

- Earlier, seeds and saplings were often smuggled (such as rubber) or won through war (such as tea)
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Take away

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- **Economic botany** is closely tied with the imperialist project
- The **Royal Gardens at Kew** and **botanic gardens in colonies** worked in tandem to profit the Empire
- Botanic gardens were sites of **scientific knowledge production** but this knowledge was tied to other projects like **imperialism**, **medicine**, and **economics**
- Plants that have traveled: rubber, cinchona, breadfruit, grapes, pineapple, sugarcane, cotton, tea etc.
- People that traveled: botanists, ship captains and crew, colonial administrators, slaves, slave traders, indentured labour, adventurers

Case Study: Cinchona

- **Malaria** – fatal for many British soldiers serving in tropical climates in the 19th century
- **Quinine** – extracted from the cinchona bark
- **Cinchona** *(quina)* – native to South America, one of its most valuable exports (especially Bolivia and Ecuador)
- The British government was spending £53,000 per year to purchase quinine for its troops in India in the 1840s.
- Cinchona plants were **semi-smuggled** out of South America and brought to Kew (competition between Dutch and English botanists)
- Initially, The East India Company refused to let cinchona be cultivated in India because India was already being employed for tea plantation (which contributed to 10% of England's profits from exports)
- However, with the 1857 Sepoy Mutiny, things changed: the government decided to increase the British military presence in the region and needed fit and healthy soldiers
- Plants and seeds taken out of South America were taken to Kew in 1860-61, and from there to botanic gardens in Ooty, Calcutta, and Darjeeling
- Additionally, cinchona grown on Indian (and therefore British) soil was substantially cheaper than importing it from South America

Cinchona – who lost out?

- The newly independent South American countries whose trade commodity was no longer in demand
- The Indian public: cheap quinine available in India rarely filtered down to the common Indian. British-made quinine and quinidine were reserved for the representatives of the British Raj, and Britain's grip on India was made more secure by an influx of soldiers and civil servants who no longer feared “the deadly climate”
- Quinine was also essential to the British, French, and Germans in their colonization of Africa, where high death rates had confined Europeans to the coast until quinine prophylaxis was adopted
- Kew’s reputation as a great contributor to the Empire was sealed with this transfer

1.7 Lecture 5A

Economic Zoology and the Human Price

Animals are used in peace and war

Animals come with handlers and trainers

Animals are often associated with specific plants


46.


Afghan camel train on the Wanaaring Road, north west NSW.
Camel trains varied from 20 to 80 camels,1890-1917.
Museum of Applied Arts and Science Collection, 85/1284-765, Powerhouse Museum, Sydney.

Australia's Muslim Cameleers: Pioneers of the Inland, 1860s-1930s (Kent Town, Southern Australia: Wakefield Press, 2010), p. 28.

Tom L. McKnight, *The Camel in Australia* (Melbourne: Melbourne University Press, 1969), p. 74

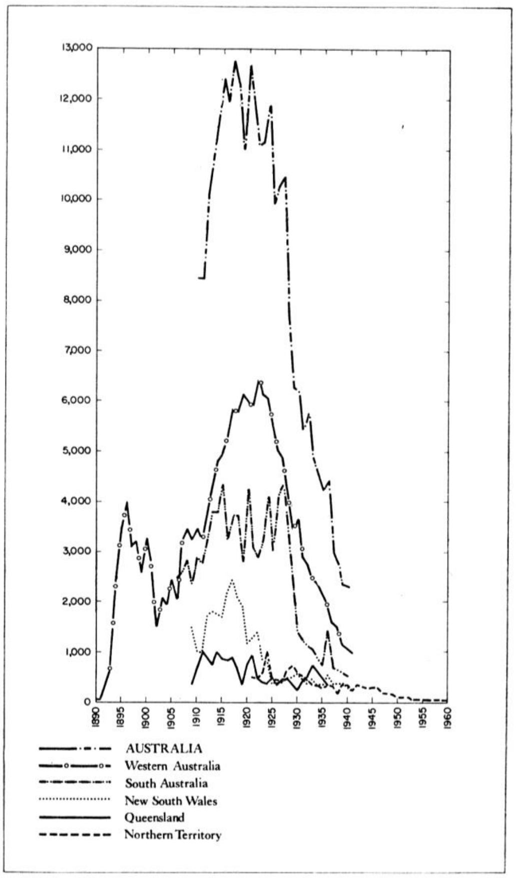


Fig. 1 Numbers of domesticated camels in Australia and various colonies and States
Source: As for Table 1

11 films, 40 Photos & 4 used sent to Mrs Pat Tremlett (25/3/35)

TAMING THE AFRICAN ELEPHANT

A SUCCESSFUL EXPERIMENT IN THE BELGIAN CONGO

CONGO ELEPHANTS BATHING UNDER SUPERVISION, WITH THEIR PERSONAL ATTENDANTS

IT is very largely the wonderful fauna of Africa that have attracted many adventurous spirits into the heart of her bush country, the depths of her jungles, and to the shores of her big rivers. Sportsmen who have taken their lives in their hands, penetrating the fastnesses and seeking out the haunts of African big-game will, however, only agree according to individual experience in such matters as to which animal is most to be feared and respected.

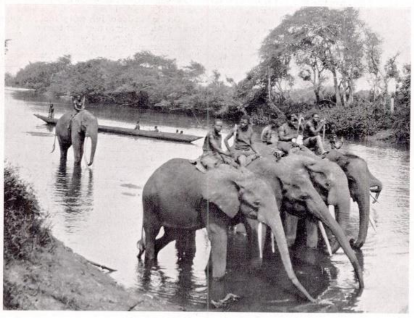
"The Lion is the King of Beasts," someone will say. "Buffalo the most savage and dangerous," replies another, who has had a narrow shave in long grass during an attempt to "bag" a record head out of a herd of a hundred odd. "What animal more formidable than a charging rhino?" say others whose whole *safari* has been caught unawares on the march, and charged, right, left and centre, by a ton and a half of bad temper.

But ask a genuine big-game hunter, or the game rangers whose job it is to protect the native crops, and there is little doubt that it is of elephant you will hear them talk, with the greatest mixture of admiration, fear, respect, excitement and even annoyance. For are not thousands of square miles in Africa to-day given over to the wild as sanctuaries? Yet these great pachyderms, with their marauding instincts, destructive natures, and their love of certain cultivated crops, still continue to ramble far and wide from their reserves, causing havoc and subsequent famine in the native villages they happen to visit at certain seasons of the year. No other animal is capable of leading you such a dance, giving you a greater thrill, and often testing your endurance to the utmost limit when in pursuit with either gun or camera. The African elephant, so different mentally and in his appearance from the Indian variety, has hitherto been considered untamable — unapproachable. Nevertheless, wild African elephant *are* now being tamed and trained for agriculture and forestry on special farms for the purpose in the Belgian Congo.

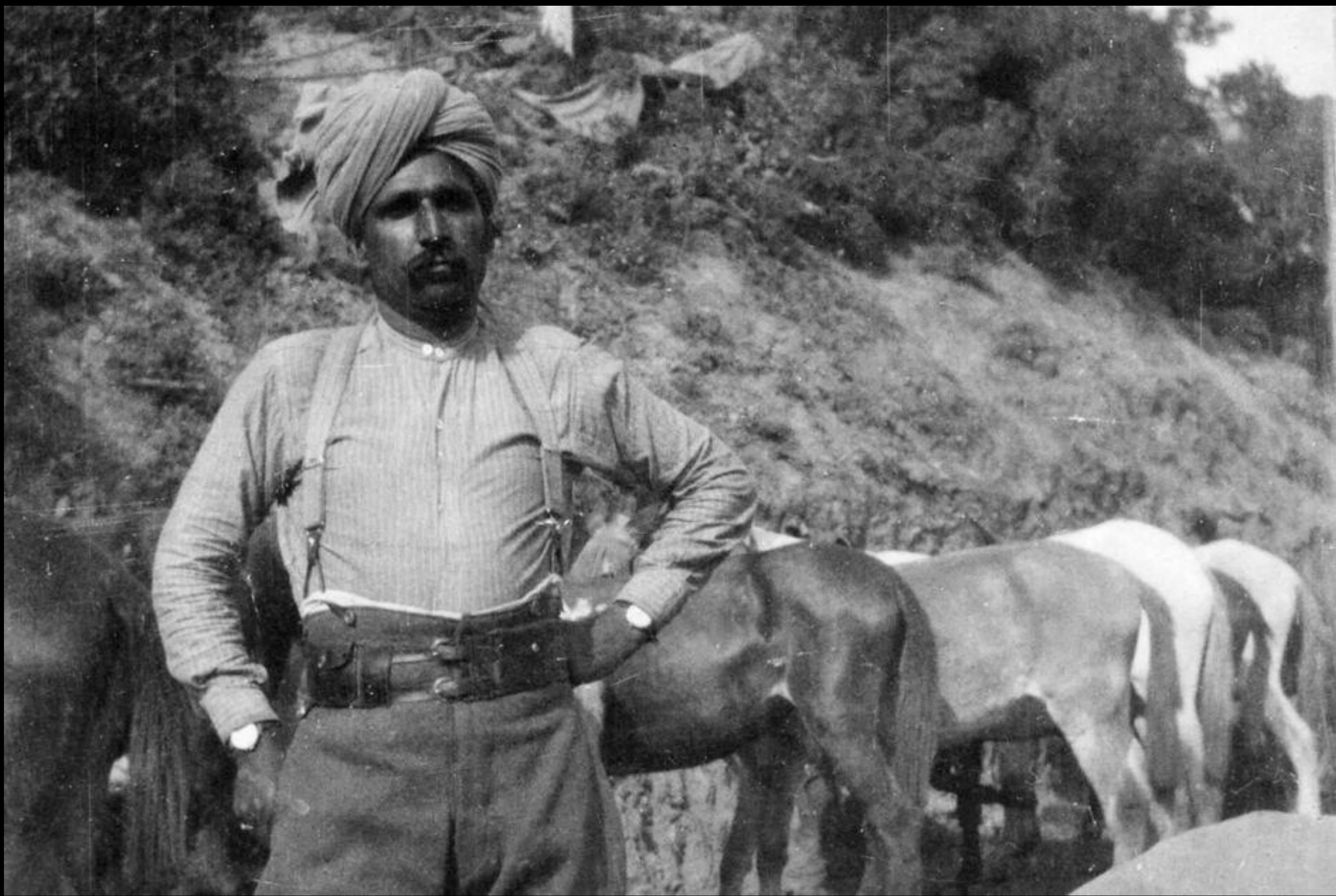
The Belgians are the only colonists to attempt to bring the African elephant into line with his Indian relative. It is a grand enterprise and a huge task, requiring endless patience and considerable courage in dealing with what have always been considered the most dangerous and cunning creatures to be met with in a day's march, particularly if it happens to be in their favourite "thick bush" and the cow elephants are aware of your presence. It is nearly always the ladies who start a packet of trouble.

Although the work has only been begun in very recent years, there is every hope already of the results being permanently successful. The Belgians run the farms in typical elephant country so that the animals feel that they are living in their natural surroundings, and scarcely realise that they are in any way prisoners. The proof of this is that already there have been baby elephants born on the farm, despite the fact, well known to naturalists and zoologists, that elephants will not breed in captivity. While so much freedom is allowed during the taming of these animals, it is of the utmost importance that no strangers should be introduced or allowed on the farm during the early training, as the presence of strangers and unaccustomed human scent may tend to upset the elephants.

Each elephant has his own personal native boy in attendance. (If



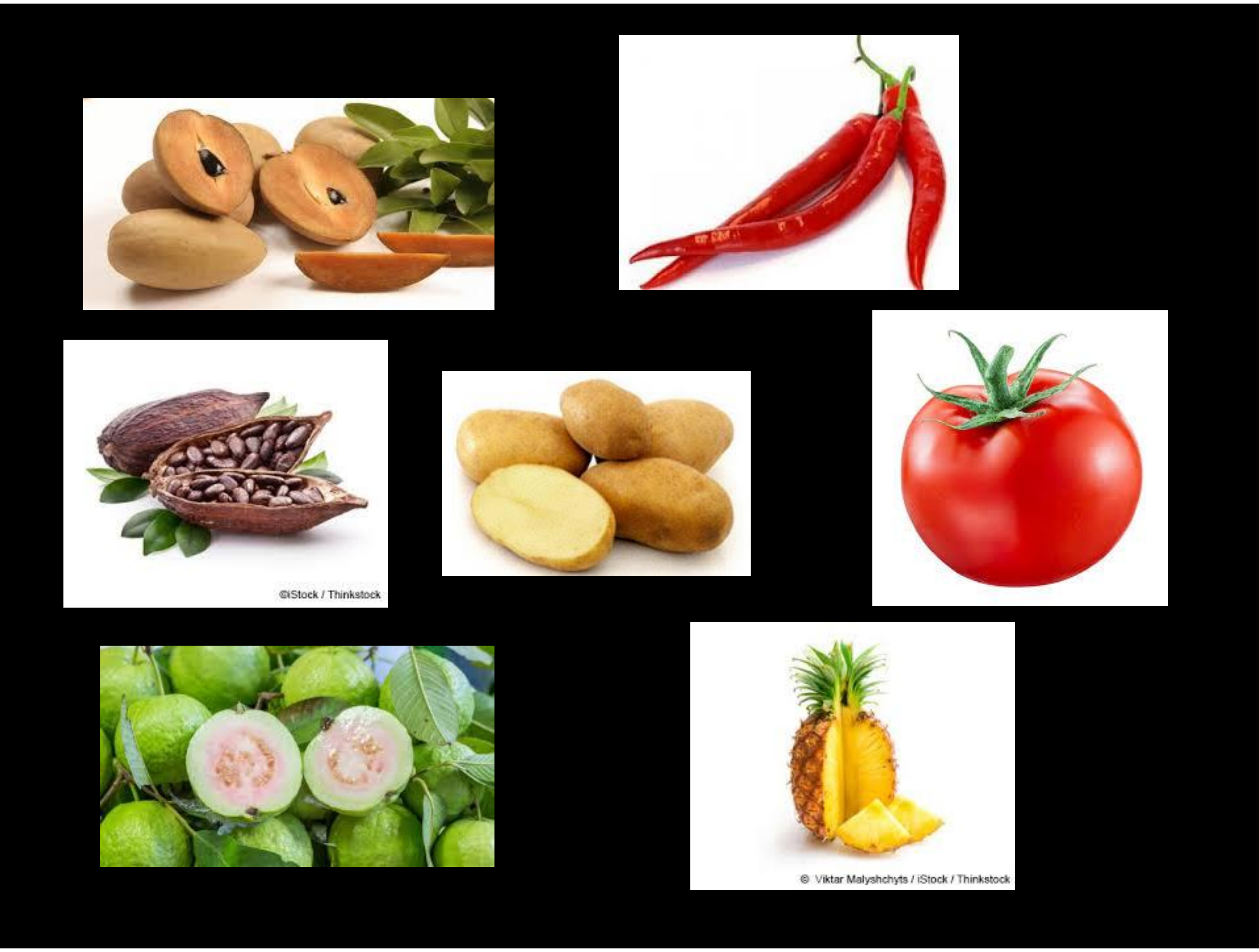
BY THE RIGHT, FORM FOURS!
African elephants in training in the Belgian Congo



1.8 Lecture 5B

Botanic Gardens and Economic Botany

HSS 102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WORLD MAP
W 0° E
Prime Meridian
ARCTIC OCEAN
Greenland (Denmark)
Zemlya Frantsa-Iosifa
Oktyabr'skoy Revolyutsil
Svalbard (Norway)
Novaya Zemlya
Kara Sea
Laptev Sea
Kotelny Island
East Siberian Sea
Beaufort Sea
Baffin Bay
Jan Mayen (Norway)
Norwegian Sea
Barents Sea
Arctic Circle
Alaska (USA)
Canada
Hudson Bay
Gulf of Alaska
Labrador Sea
Iceland
Faroe Islands (Denmark)
Finland
Sweden
Norway
Russia
Estonia
Latvia
Lithuania
Belarus
Black Sea
Aral Sea
Caspian Sea
Sea of Okhotsk
United Kingdom
North Sea
Denmark
Ireland
Poland
Germany
Ukraine
France
Kazakhstan
Mongolia
NORTH PACIFIC OCEAN
NORTH ATLANTIC OCEAN
United States of America
San Marino
Monaco
Andorra
Romania
Georgia
Uzbekistan
Kyrgyzstan
North Korea
Sea of Japan (East Sea)
Vatican City
Spain
Portugal
Italy
Bulgaria
Azerbaijan
Turkey
Armenia
Turkmenistan
Tajikistan
Greece
Mediterranean Sea
China
South Korea
Japan
PACIFIC OCEAN
Bermuda (U.K.)
Haiti
Bahamas
Dominican Rep.
Puerto Rico(U.S.)
Canary Islands (Spain)
Morocco
Tunisia
Malta
Syria
Lebanon
Iraq
Iran
Afghanistan
Israel
Jordan
Kuwait
Bahrain
Qatar
Pakistan
Nepal
Bhutan
East China Sea
Tropic of Cancer
Mexico
Gulf of Mexico
Cuba
St. Kitts And Nevis
Antigua and Barbuda
Dominica
St. Lucia
Barbados
Trinidadn& Tobago
Western Sahara
Algeria
Libya
Egypt
Red Sea
Saudi Arabia
U.A.E.
Oman
India
Myanmar (Burma)
Taiwan
Hawaii Islands (U.S.)
Belize
Jamaica
Guatemala
Honduras
Caribbean Sea
Grenada
El. Salvador
Nicaragua
Costa Rica
Cape Verde
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Yemen
Arabian Sea
Bangladesh
Bay of Bengal
Laos
Thailand
Philippine Sea
Philippines
Northern Mariana Islands (U.S.)
Guam (U.S.)
Marshall Islands
Senegal
Gambia
Burkina Faso
Sierra Leone
Liberia
Ivory Coast
Nigeria
Central African Rep.
South Sudan
Ethiopia
Djibouti
Somalia
Vietnam
Cambodia
Venezuela
Suriname
French Guiana (FR)
Colombia
Guyana
Galapagos (Ecuador)
Equator
Kiribati
Ecuador
Gabon
Congo
Uganda
Kenya
Burundi
Maldives
Sri Lanka
Andaman Is.(India)
Sumatra
Malaysia
Brunei
Palau
Federated States of Micronesia
Indonesia
Nauru
Papua New Guinea
Singapore
Java
East Timor
Solomon Islands
Tuvalu
Wallis & Futuna
Brazil
Peru
Bolivia
Paraguay
Ascension (U.K.)
São Tomé and Principe
Dem. Rep. Congo
Tanzania
Seychelles
Comoros
Mayotte(France)
Angola
Zambia
Malawi
Madagascar
Mauritius
Reunion(France)
Cocos Is. (Aus.)
Christmas Is. (Aus.)
Coral Sea
Vanuatu
Fiji
French Polynesia
Cook Island(N.Z.)
St Helena (U.K.)
Trindade (Brazil)
Namibia
Zimbabwe
Botswana
Mozambique
Swaziland
Lesotho
South Africa
INDIAN OCEAN
Australia
New Caledonia (France)
Tropic of Capricorn
Easter I. (Chile)
Chile
Uruguay
Argentina
Great Australian Bight
Tasman Sea
New Zealand
North Island
South Island
Tasmania
SOUTH PACIFIC OCEAN
SOUTH ATLANTIC OCEAN
Falkland Islands (U.K.)
South Georgia (U.K.)
South Sandwich (U.K.)
1. Netherlands
2. Belgium
3. Luxembourg
4. Switzerland
5. Slovenia
6. Croatia
7. Bosnia and Herzegovina
8. Czech Republic
9. Slovakia
10. Austria
11. Hungary
12. Serbia
13. Moldova
14. Macedonia
15. Albania
16. Cyprus
17. Lebanon
18. Guinea-Bissau
19. Guinea
20. Ghana
21. Togo
22. Benin
23. Cameroon
24. Equatorial Guinea
25. Rwanda
26. Cambodia
27. Panama
28. Malawi
29. Liechtenstein
30. Montenegro
31. Kosovo
32. Palestinian Territories
33. St. Vincent and the Grenadines
1260Km 0 1260 2520 3780 5040Km
SOUTHERN OCEAN
Antarctic Circle
Copyright © 2013 www.mapsofworld.com


John Rose, the royal gardener, presenting Charles II with the first pineapple grown in England. Backdrop: Kew Gardens. Painter: Hendrick Danckerts. Year: 1766 approximately.

Where do pineapples come from?

- Indigenous fruit of Brazil and Paraguay
- Discovered by Europeans (Columbus, to be precise) in 1493 in Guadeloupe (the Caribbean islands) and brought to Europe
- Did not succeed in growing it commercially because the plant needs a tropical climate
- By the 16th century, the Portuguese and Spanish colonies introduced pineapples into their Asian, African, and South Pacific colonies, such as the Philippines and Guam.
- The Portuguese brought it to India in 1550
- Effects are evident even now: Philippines is the world's third largest producer of pineapples and accounts for 17% of the global pineapple export

	Arabic	أناناس ('ananās)
	Armenian	անանաս (ananas)
	Danish	ananas
	Dutch	ananas
o_O	**English**	**pineapple**
	Esperanto	ananaso
	Finnish	ananas
	French	ananas
	German	Ananas
	Georgian	ანანასი (ananasi)
	Greek	ανανάς (ananás)
	Hebrew	אננס (ananás)
	Hindi	अनानास (anânâs)
	Hungarian	ananász
	Icelandic	ananas
	Italian	ananas
	Latin	ananas
	Macedonian	ананас (ánanas)
	Norwegian	ananas
	Persian	آناناس (ânânâs)
	Polish	ananas
	Portuguese (eu)	ananás
	Romanian	Ananas
	Russian	ананас (ananás)
	Spanish	ananás
	Swedish	ananas
	Turkish	ananas

Plants take root

- Thomas Jefferson: "*The greatest service which can be rendered to any country is to add a useful plant to its culture*."

– New World maize and sweet potato introduced to China in the 16th century prevented famine

– White potato from the Andes spread in northern Europe and supported population explosion and increasing labour force in the 18th and 19th centuries

–'Turkey red' strain of hard winter wheat traveled from Russian Crimea to the US through immigrants in the early 20th century

(So, not natural selection but human intervention!)

BUT…

Economic Botany

- "Economic botany" was the planting of seeds and introduction of plants which had commercial value for the (European) empire (rubber, tobacco, spices, breadfruit etc.)
- Part of the impetus to collect and learn more about plants (developing botanical sciences and techniques like hybridization, species selection) was also to learn how they could be useful for various purposes, usually with an economic benefit
- Central to this enterprise was the "***botanic garden**, a historic institution with worldwide connections whose nineteenth-century expansion resulted in a greatly accelerated process of plant transfers with consequent ecological, economic, social, and political changes*" - Brockway
- Botany has aided **imperialistic** projects

Imperialism

- *“State policy, practice, or advocacy of extending power and dominion, especially by direct territorial acquisition or by gaining political and economic control of other areas”*

- Encyclopedia Britannica

About botanic(al) gardens

- Can be understood as "*a 'living museum',*" playing roles varying with time and circumstances— as "… *academic collections, displays of curiosities, displays of beauty, and educational institutions*" - Fagg
- Earliest botanic gardens were physic gardens for medicinal herbs, and attached to universities or apothecaries
- World's first botanic garden – in Padua (Italy) – 1545

- 18th Century: economic potential of plant introduction
- First botanic garden in a colony – St Vincent (West Indies) – 1765
- Britain's East India Company founded one at Calcutta in 1787 to break the Dutch monopoly on spices

- 19th Century: gardening as a leisure activity in Europe – scientific, economic, and aesthetic pursuits blend
- The aim of colonial botanic gardens? "*Eventually, there would be a network of gardens that spanned the globe, which would prove vital to the British Empire, allowing vital crops like rubber and cinchona … to be collected outside the empire and moved to colonies where they could be grown profitably*" - Endersby

Sydney’s Botanic Garden

- New South Wales (NSW) was a penal colony that faced repeated droughts and near famines
- Everything from writing paper to seeds for the colony’s farms had to be brought over from Britain (both dangerous and expensive)
- 1812: the NSW government issued a proclamation that “*the whole of the Government Domain*” was being “*completely enclosed by stone walls*” and no animals would be allowed inside
- 1812-1818: Sydney’s Botanical Garden is established
- All such colonial botanic gardens were projected to become financially self-sufficient while providing increasing yields and profit to the empire
- Initial trade at Sydney was for crucial food grain seeds in exchange for exotic flora


© Alamy

The Kew Garden in England

- The Royal Botanic Gardens at Kew were founded by Princess Augusta (1713-1772) in the 1760s; by 1789, it had close to 5500 plant species
- In the 1820s, it went into a decline
- In 1838, a Royal Commission was set up to inquire into the future of the gardens under the chairpersonship of Dr John Lindley. Lindley declared that Kew must have an **imperial as well as a domestic** role and proposed that the government, rather than the royalty, run the garden
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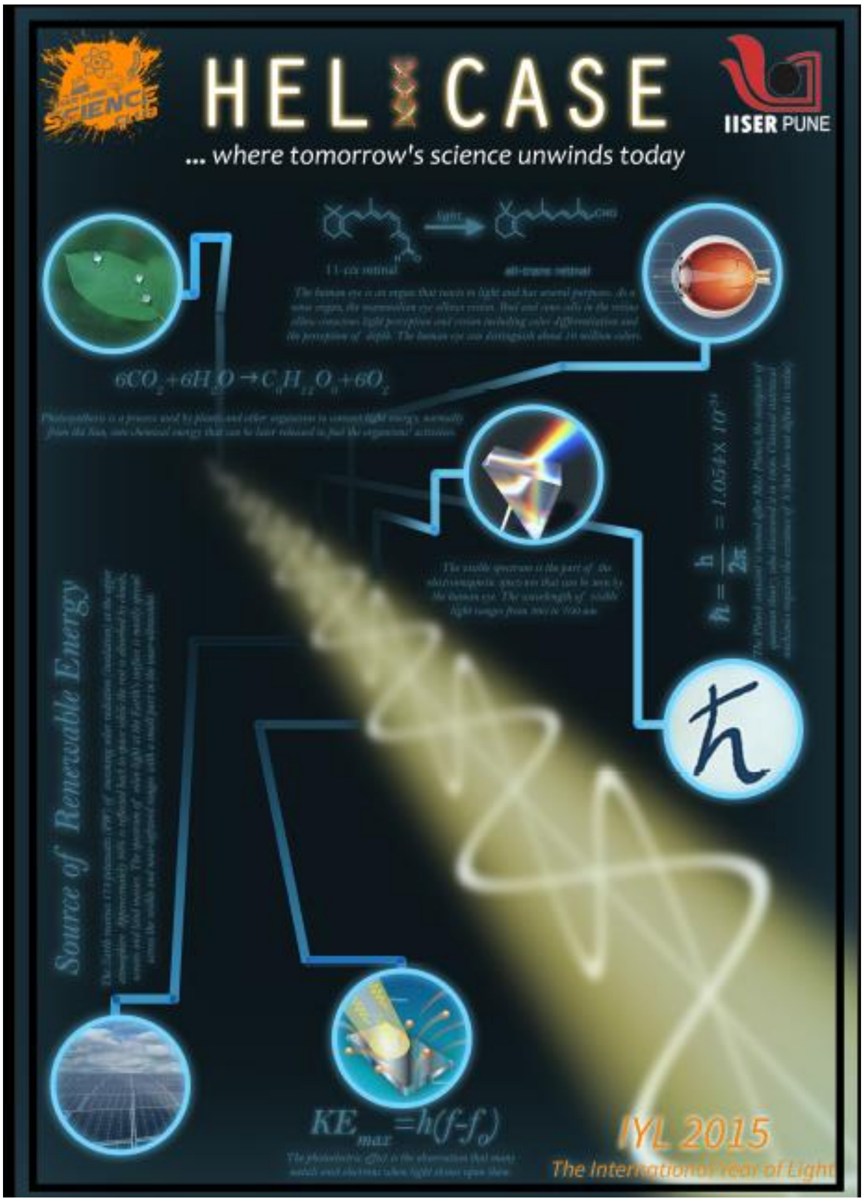
1.9 Lecture 5C

Glass Models and Natural History

John Mathew



HELICASE
IISER PUNE
... where tomorrow's science unwinds today
11-cis retinal
all-trans retinal
$6CO_2+6H_2O \rightarrow C_6H_{12}O_6+6O_2$
Source of Renewable Energy
$\hbar = \frac{h}{2\pi} = 1.054 \times 10^{-34}$
$KE_{max}=h(f-f_o)$
IYL 2015
The International Year of Light

Blaschkas in the East and the Story of Glass Models for Zoology

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People approach museums differently. Some are coerced, others take to them like fish to water, while still others go to museums out of convivial social obligations. What is often lost for all these groups, however, is the mystery that fuels discovery – the less discussed, the overlooked, sequestered in some corner or otherwise occupying pride of place in a room that itself only serves as a viaduct between other chambers of greater interest.

Such indeed is the invertebrate room in the Trivandrum Museum of Natural History, to which I have repaired often since I was an aging adolescent in college. Tucked away between the bird room, the mammal room and the anthropology room, lies the invertebrate and lower vertebrate section, the place through which I dashed through years with seldom more than a cursory glance. The same would have been true last September, except for a friend.

Melis van den Berg is an artist, Dutch, a former flat mate in London. Now he paused by a series of glass topped and sided cabinets in the middle of the room to which I was giving such short shrift, then steadied a camera. I asked him desultorily what he was examining; he pointed and all of a sudden, there was an epiphany.

His objects were glass models of marine invertebrates.

"Hey, don't you think these remind of the glass flowers at Harvard?" I asked him.

"That's why I'm photographing them," he replied equably.

The content was important. When Melis had visited me in Cambridge, Massachusetts, I had with great pride showed him the climate-controlled room in which a magnificent plenitude of glass models of flowering plants, resided and which were the pride and joy of the Harvard Natural History Museum, having received international acclaim ever since their creators, the father and son Leopold and Rudolf Blaschka of Bohemian descent with their professional base in Dresden, had entered into an exclusive contract with Harvard to fashion a botanical teaching collection for them. The exquisite workmanship evident there seemed in many instances to be true for the objects now in front of us. I approached one of the gallery guides.

"Where are these from?"

"I don't know," he responded. "But the superintendent returns next week."

Days later, the superintendent didn't know either. But he told me that his predecessor had mentioned to him that the objects had been placed in the museum from Dresden.

Dresden!

In the intervening months, I have been in touch with the Corning Museum in upstate New York, which house the Blaschka archives. It turns out that before the flower contract, the duo were about the business of making glass invertebrate models for museums in Europe and North America, first from illustrations, then live animals, with attention paid also to development forms as a consequence of meeting Ernst Haeckal, originator of the aphorism, "Ontogeny recapitulates Phylogeny". Some glass models, however, made their way to the East as well – Tokyo, Shanghai and proximate to us, Jeypore, Bombay, Calcutta and Lahore (as written in their colonial names, seeing as the years in question were the 1880s and 1890s). Melis has long since returned to London, where he is studying the Blaschka models in London. Another friend at Harvard is doing the same for objects of the kind in North America. I relentlessly visit natural history museums in India to piece the story together from this end. Trivandrum (or then, Travancore) does not appear in the Corning Archives, but comparisons with pieces in other museums suggest that the makers are the same, coupled with the fact that the Dresden connection has been confirmed via mention in the State records for 1890-91. The work is tantalising, frustrating and always compelling. Furthermore, it casts light on the manner in which zoology in different princely Indian states was being prosecuted in the late nineteenth century, through objects, made not by the ruling British, but two obscure Czech glassworkers in eastern Germany.

Thus it is that I, for one, shall always be grateful for museums.

About the Image:Glass model of the Portuguese Man O' War at the Trivandrum Natural History Museum. Photograph by Mr. Sajeev Ramakrishnan

Definitions

- Representation
- Museum
- Natural History

Representation

- A call up in the mind by description or portrayal or imagination…. an effort to serve as a likeness of.

(Concise Oxford Dictionary, paraphrased)

Loxodonta africana

Elephas maximus

Two Questions

- Did the painter, Nicolas Poussin (1594 AD-1665 AD) know that there were different kinds of elephants?

- What might Hannibal (247 BC-183 BC) actually have used?

Albrecht Durer's Rhinoceros (1515)

Great Indian Rhinoceros
(*Rhinoceros unicornis*)

Albrecht Dürer (1471-1528)

Museum

- Building used for storing and exhibition of objects illustrating antiquities, natural history, arts, etc.

(Concise Oxford Dictionary)

Cabinets of Curiosity

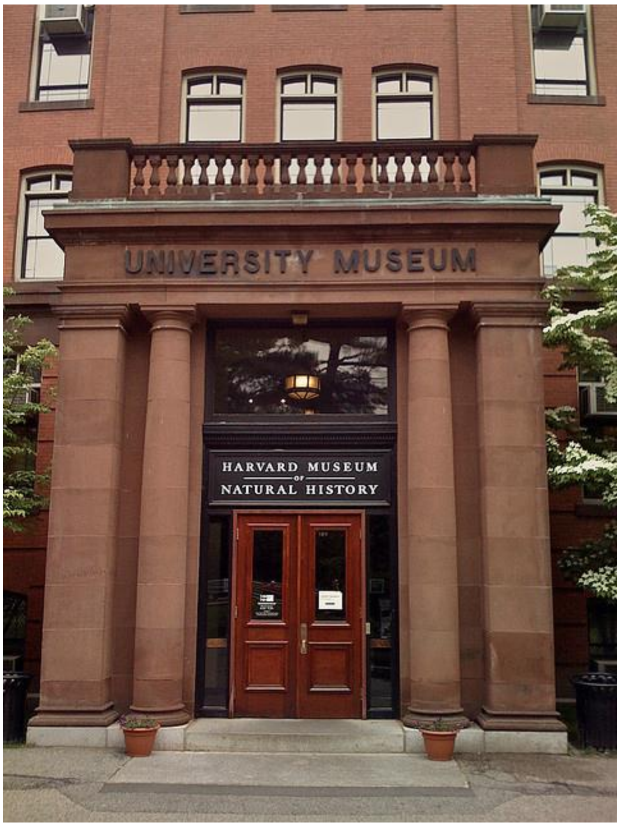
Natural History

1) The study of natural objects, especially of animal or vegetable life and especially as set forth for popular use.

2) An aggregate of facts about the natural objects or the characteristics of a place or class.

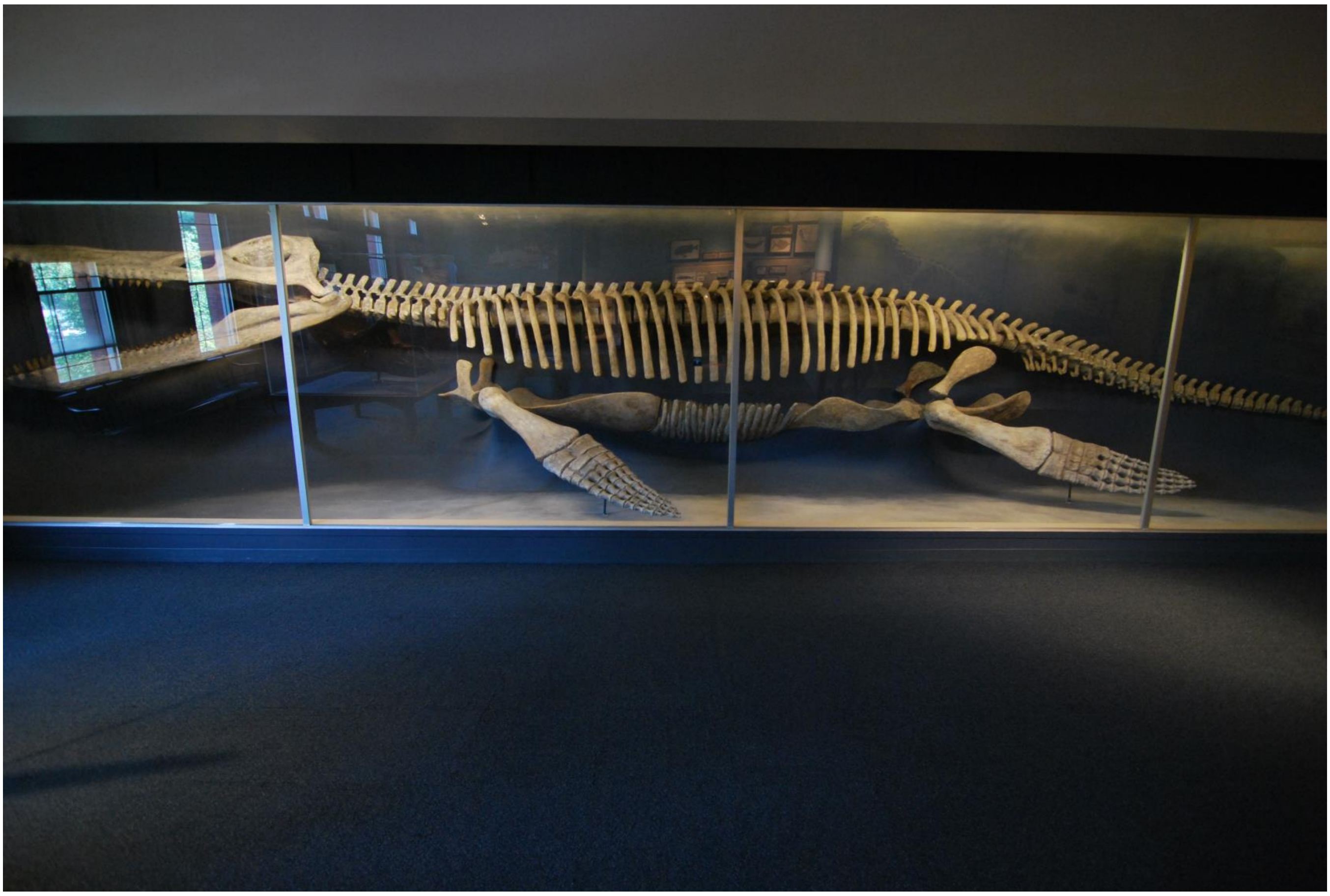
(Concise Oxford Dictionary)

Harvard Museum of Natural History



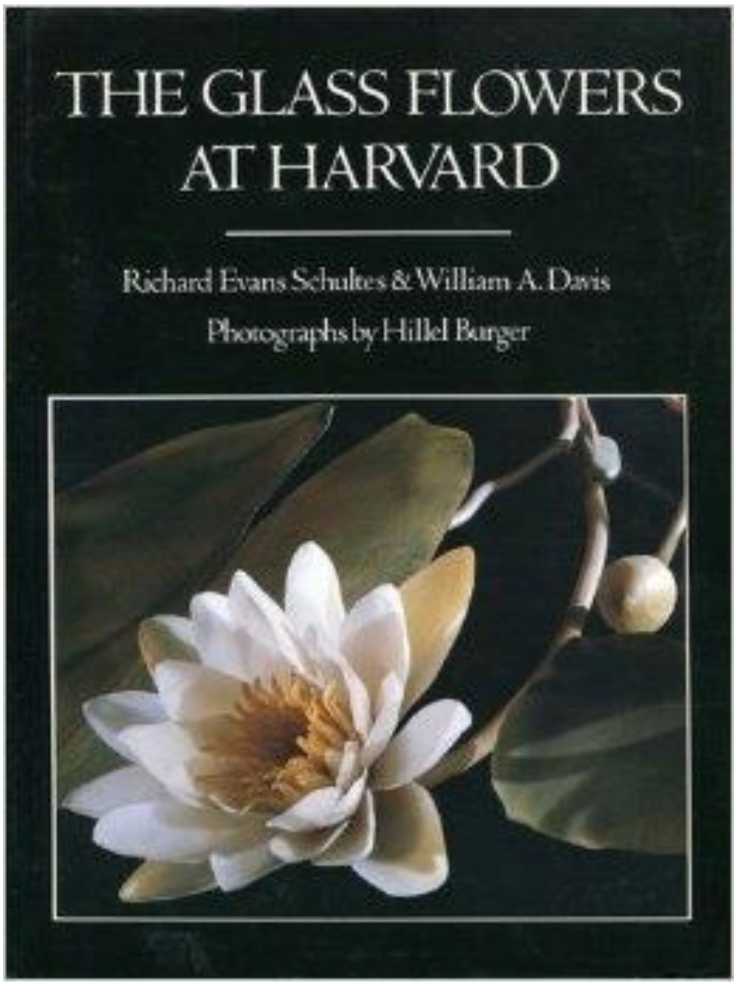
Great Hall of Mammals

Romer Hall of Vertebrate Palaeontology



The Glass Flowers at the Harvard Museum of Natural History

Red Maple (*Acer rubrum*)


THE GLASS FLOWERS
AT HARVARD
Richard Evans Schultes & William A. Davis
Photographs by Hillel Burger

Leopold Blaschka (1822-1895) and Rudolf Blaschka (1857-1939)

Technique

At least two accounts of the Blaschkas' working methods survive: one, in a letter from Goodale to Mary Lee Ware, describes Leopold and Rudolph at work in 1889; the other, in a letter from Mary Lee Ware to Prof. Oakes Ames (then the director of the Botanical Museum at Harvard), describes Rudolph in 1928. Neither reporter was a glassworker, and some of the terms they use are incorrect, but the descriptions are easy enough to follow.

Here is Goodale's description in 1889: "The worktables are covered with rods and tubes of glass, and blocks of colored glass, and spools of wire of different sorts. The bellows under the tables are of the ordinary sort used by glassworkers and the blast-tube is a very simple one of glass. The lamp is made of a tin cup containing a wick, and solid paraffin which melts at a pretty low temperature is used as the fuel. In making the Phlox which they asked me to bring to you and your mother, they drew first of all a rough sketch of the relations of all the flowers to each other and to the leaves, and then began to mix some glass with colors to get the right tints. The corolla is drawn and formed from a tube of glass. Then the petals are formed and melted to the tube of the corolla. The stamens are melted in next, and then the whole thing is placed in an annealing oven to remain for a few hours. It took Mr. B. just an hour and a half to make the tubes and petals of the three flowers. It required about an hour to put in the stamens and add the calyx. Next, the buds with their twists are made and all are fastened to wires covered with glass. All of these are next fastened to a stem with leaves and the product is then ready for a little paint which is added with great skill where it is required. The molding of the shapes is effected by means of ordinary pincers and tweezers. With these clumsy tools they fashion the flat plates and turn them in any way they please. With little needles fastened in handles, they make the grooves and lines and figurings of the edges. But although you may see him touch a flat piece of glass with his little metallic tools, you know that it is no ordinary touch which suddenly shapes it into a living form."

In a letter to Goodale, written on August 7, 1900, Rudolph noted that his father had been a skilled painter, "but I got so established and versed in working very rapidly with the brush that, since more than twenty years, all and every painting of models, of the invertebrate animals as well as later of all plants came exclusively on my part." It appears, therefore, that from some time before about 1880 Blaschka senior ("Mr. B.") formed the models, and that Blaschka junior painted them.

In the second account, we learn something of the innovations made by Blaschka junior. Mary Lee Ware visited the

Rudolph Blaschka, "Winter Aster," c. 1930. Photo courtesy The Corning Museum of Glass.

71 year-old Rudolph Blaschka at Hosterwitz in September and October 1928. On October 3, she wrote to Ames, describing one of her visits. "I sat and watched his movements as he worked. The table is covered not only with implements but with trays of leaves, formed but not colored, bottles in which he can stand the glass stems with leaves while drying or cooling, specimens of fungus-covered fruits or dried leaves for use as guides (for the most part he studies them without glasses), bottles with powdered glass for use as needed, and saucers for the enamel

The Natural History Museum, London

Natural History Museum, Trivandrum

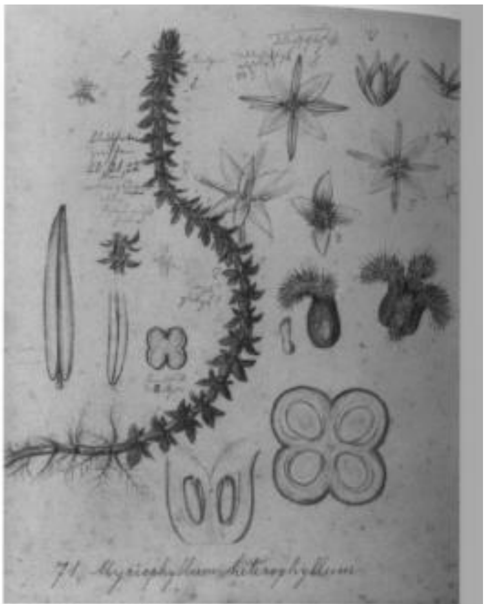
ture, and color are concerned, the species of larger dimensions being full length pictures, whereas the smaller ones have been adequately magnified. The representations, which have, in many instances, been drawn from the very life, are the outshoot of a series of close observances and researches instituted by me and my son, during a succession of years, both on the seashore and in our own aquarium, subsequently, in general, to judiciously consulting the various monographies [*sic*] extant ...

"[The models] have been purchased by numbers of museums and scholastic establishments in all the quarters of the globe. I now respectfully beg to mention the following institutions, to wit, in New Zealand, by the Canterbury Museum at Christchurch; by the Otago Museum in Dunedin; in Asia, for the Educational Museum in Tokio [*sic*], Japan, and by the Educational Department of Japan for a hundred Japanese schools; for the Indian Museum in Calcutta, too. In the United States of America by Professor Ward's Natural Science Establishment in Rochester, New York; for the Museum of Comparative Zoology in Cambridge, Massachusetts; for the Boston Society of Natural History; the University of Cornell; the Wellesley Female College ... In Great Britain, Scotland, and Ireland, copies have been conveyed to London, Edinburgh and Dublin ... In Austria orders have not only been made for the imperial royal Court Collection, but also for the Universities in Innsbruck, Graz, Czernowitz [now Chernovtsy in the Soviet Union], and so forth. In Germany purchases have been made for the Universities of Berlin, Bonn, Koenigsberg [now Kaliningrad in the Soviet Union], Jena, Leipsic [*sic*], Rostock and many other museums ...

"With this catalogue many new kinds of models are introduced ... The models appertaining [*sic*] to anatomy and the history of development (or formation) have so rapidly risen into favor, that I have been induced to increase these departments considerably...

"The models do very well ... in dry places; they are not, however, ... intended for aquariums ..."

Blaschka's claim to supply "all the quarters of the globe" was scarcely an exaggeration. In addition to the places just mentioned, his order book for the years between 1883 and 1890 (when he signed an exclusive contract with the Botanical Museum at Harvard) documents sales to customers in Perth, Aberdeen, and Dundee in Scotland; Utrecht and Maastricht in the Netherlands; Weymouth, Marlborough, Burton on Trent, Nottingham, and Liverpool in England; Prague in Czechoslovakia; Bolzano in Italy; Wroclaw and Warsaw in Poland; Galway in Ireland; Cardiff in Wales; Marburg, Hamburg, Tubingen, Cologne, and Munich in the Federal Republic of Germany; Liège in Belgium; Leningrad and Moscow in the Soviet Union; Genevà in Switzerland; Melbourne in Australia; Lahore in India; and Strasbourg in France. The list of customers in the United States would



Rudolph Blaschka, "Myriophyllum heterophyllum," drawing. Photo courtesy The Corning Museum of Glass.

probably have been longer were it not for the fact that Ward's Natural Science Establishment in Rochester was a commercial supplier; he supplied some (possibly all) of Cornell's models, for example.

Although most of these customers were universities or museums, they also included individuals, and Blaschka's third German catalogue (the only one I have seen) advertises the models not only as teaching aids and exhibits but also as "decoration for elegant rooms." The catalogue also describes two other Blaschka specialties: glass eyes for stuffed animals—they came in five different sizes—and for humans.

To the best of my knowledge, only one other glassworker has produced models of invertebrates: Herman Mueller, whose enlarged models of micro-organisms, made in the early part of this century, are in the American Museum of Natural History, New York. Unlike Leopold Blaschka, Mueller concentrated on models of protozoa, which are so small they cannot be seen with the naked eye. Mueller worked from drawings, wax models, and his own observations. Some of his models, for example, were based on drawings by the German biologist Ernst Hackel

The Indian Museum (1866), Calcutta

12. Decbr. 1886

Mr. Handley Hon. Secretary Jeypore India

I have duly received your postcard of Octbr. 19th as
well as your Favor of Novbr. 8th the latter with an
annexed ~~note~~ list of glass-models of Invertebrates, which
you ordered for the Jeypore-Museum. ~~These~~ as ~~in conformity~~ according
to your ~~desire~~ wish I have ~~all~~ ~~together~~ with Mr. Damon
all perfectly arranged; I will begin next time to
make the models (as I have nothing in stock) and
send them, as soon as they ~~will~~ are ready, ~~in the~~ ~~succession~~ exactly
~~to your~~ in conformity to your appointments.

As to your inquiry where ~~here or~~ in our vicinity
preparations of papier-maché and other museum-
requisites are to be sold I know and can recommend you especially the
commercial establishment of the naturalist Mr. W. Fric, Wladislaus-
g. 21. A. of Prague (Austria) who has I believe his own fabric of
such articles and stock of all Museum-requisites.

In the course of the next year I also ~~shall~~ will make
some studies in Botanical objects; The directors
in Cambridge Mass. (U. S. of America) are intending to
found a national Botanical Museum, and I was
requested to try to make ~~in~~ glass models of American
plants also with scientific details etc. In former
years I already have made from nature glass-models of tropical
plants, especially of the beautiful forms of the
Orchideae in their living state with great success. Of the Indian Orchideae
I had f. i. the following ~~plants~~ species: Vanda insignis,
Cypripedium venustum & insigne, Saccolabium, Sarcanthus
Dendrobium sanguinolentum, several Aërides, Chysis

albiflora, Calanthe masuca, Pleione maculata,
Cymbidium, Coelogyne a. others; also from
other plants the Hoya imperialis, Enkianthus etc.
As these preparations had been more partly in remembrance
of my own voyages and the preliminary of my models
of invertebrate animals, which occupied my interest ~~?~~ exceedingly,
I never offered them ~~to the~~
to Museums. But by the by as we speak of, if
you ~~like to have some~~ are fond of these ~~?~~ plants, ~~I will~~ ~~you~~ ~~kindly~~ ~~let~~ ~~me~~ ~~know~~ ~~it~~ so
and like to have some, I am ready
to make you later some of ~~them~~ ~~later~~ ~~on~~.

Mr. Damon 26th Decbr.

At first you receive my best thanks for the two
addresses for which I am much obliged to you.
As to other models of botanic and the anatomy of fishes
if you guess it advantageous enough to undertake
a mediation, I think it best to induce those
museums or persons who are inquiring after such
models, to send me drawings of the required objects.
In this case I ~~will~~ will also prepare such models to please you.
On the next week I will begin with ~~Mr. Handley's~~ the
models for Jeypore.
I wish you a happy and prosperous new-
year and remain

12th Decbr. 1886

Mr. Handley Hon. Secretary Jeypore India

I have duly perceived your postcard of Octbr 19th as well as your Favor of Novbr 8th the latter with an annexed list of glass-models of Invertebrates, which you ordered for the Jeypore Museum. According to your wish I have with Mr. Damon all perfectly arranged; I will begin next time to make the models (as I have nothing in stock) and send them, as soon as they are ready, exactly in conformity to your appointments. As to your inquiry where in our vicinity preparations of papier-mâché (sic) [NOTE: should be papier-mâche] and other museum requisites are to be sold I know and can recommend (to) you especially the commercial establishment of the naturalist Mr. V. Fric, Wladislaw g.21.A. of Prague (Austria) who has I believe has his own fabric of such articles in stock of all Museum requisites. In the course of the next year I also will make some studies in Botanical objects. The directors in Cambridge, Mass. (U. S. of America) are intending to found a national Botanical Museum, and I was requested to try to make glass models of American plants, especially of the beautiful forms of the Orchideae (sic)in their live state with great success. Of the Indian Orchideae (sic) I had fini (finished (?)) the following species: *Vanda insignis, Cypripedium venustum & insigne*, *Saccolabium*, *Sarcanthus, Dendrobium sanguinolentum*, several *Aorides, Chaysis albiflora, Calanthemsassica, Pleione maculata, Cymbidium, Coelogyne* a. others; also from other plants the *Hoya imperialis, Enkianthus* etc. As these preparations had been more partly in remembrance of my own voyages and the preliminary of my models of invertebrate animals which occupied my interest. Actually I never offered them to Museums. But by the by (sic) as we speak of, if you are fond of them and like to have some, I am ready to make you later some of them.

26th Decbr

Mr. Damon

At first you receive my best thanks for the two addresses for which I am much obliged to you. As to other models of botanic and the anatomy of fishes if you guess it advantageous enough to undertake a mediation, I think it best to induce those museums of persons who are inquiring after such models, to send me drawings of the required objects. In this case I will also prepare such models, to send me drawings of the required objects. In this case I will also prepare such models to please you on the next week I will begin with the models for Jeypore.

I wish you a happy and prosperous new year and season.

The Albert Industrial Museum (1887), Jaipur

MUSEUM
CATALOGUE
PART II.

CATALOGUE OF THE COLLECTIONS

IN THE

JEYPORE MUSEUM

COMPILED BY

T. HOLBEIN HENDLEY, C.I.E.,

BRIGADE-SURGEON LIEUTENANT-COLONEL, I.M.D.: HONORARY SECRETARY OF THE JEYPORE MUSEUM AND OF THE EXHIBITION OF INDIAN ART METAL WORK, IMPERIAL INSTITUTE, 1891: PRESIDENT OF THE ART CONFERENCE, LAHORE, 1894: GOVERNOR AND MEMBER OF COUNCIL OF THE IMPERIAL INSTITUTE, 1891-2, &c., AUTHOR OF SEVERAL WORKS ON INDIAN ART.

PART II.—EDUCATIONAL AND INDUSTRIAL SECTIONS.

Delhi:
IMPERIAL MEDICAL HALL PRESS.
1896.

3498

THE UPPER FLOOR OF THE MUSEUM.

EDUCATIONAL SECTION.

CATALOGUE
PART II.

ANIMAL KINGDOM No. II.

WALL FRAMES Nos. I. to IX.

PATERSON'S ZOOLOGICAL DIAGRAMS, illustrating the classification of the Animal Kingdom, beginning with the lowest forms of Animal life.

WALL FRAME No. I.

SHEET I.

INVERTEBRATE ANIMALS.

Sub-kingdoms—Radiata and Protozoa.

(Vincent Brooks, Day & Son, Lithographers, London, W. C.)

Class—ECHINODERMATA.

Fig. 1. Star-fish. Asteria aurantiaca.

Fig. 2. Purple Sea Urchin. Echinus lividus, with the spines.

Fig. 3. Sea Urchin (the Piper), with the spines removed. Cidaris papillata.

Fig. 4. Spine of Cidaris.

Fig. 5. Sea Cucumber. Cucumaria Drummondii.

ANIMAL KINGDOM No. II.

Desk Cases attached to the Gallery Rails, Nos. X to XXVI.

Glass and Enamelled Models made by Herr Blaschka of Dresden to illustrate the great division of the Animal Kingdom known as the Invertebrata. (Nos. 10 to 213).

The Animal Kingdom includes eight sub-kingdoms, each of which is generally more complex than the one which precedes it.

INVERTEBRATA.

Sub-kingdom I.

Protozoa, the simplest animals, which have neither cavity nor nervous system, and thereby differ from other sub-kingdoms which possess at some time in their life-history a body cavity, and which are collectively called Metazoa.

Class I.—RHIZOPODA.

Amœba proteus. Pallas. $\frac{250}{1}$. Two forms. Proteus animalcule. See Plate A., Pillar No. 10.

13

Difflugia pyriformis. Perty. $\frac{200}{1}$. See Plate D., Pillar 10.

12

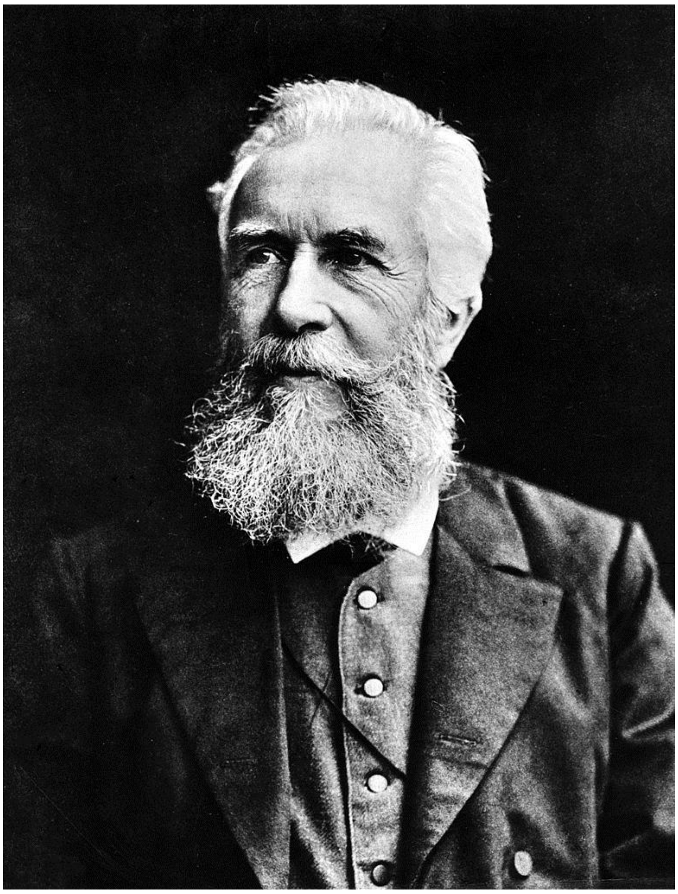
Order Monera represented in plates B. and C., Pillar Frames No. 10.

Order Foramnifera represented in plate E., Pillar Frames No. 10.

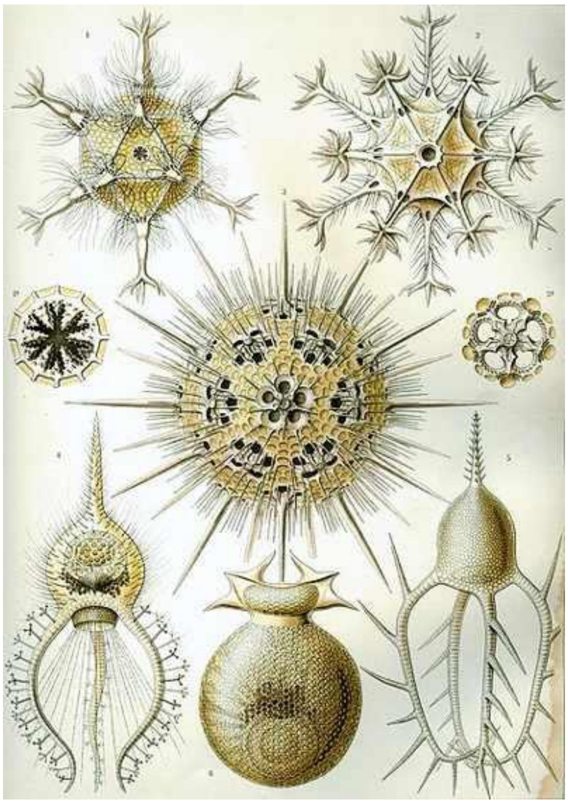
Ernst Haeckel (1834-1919)

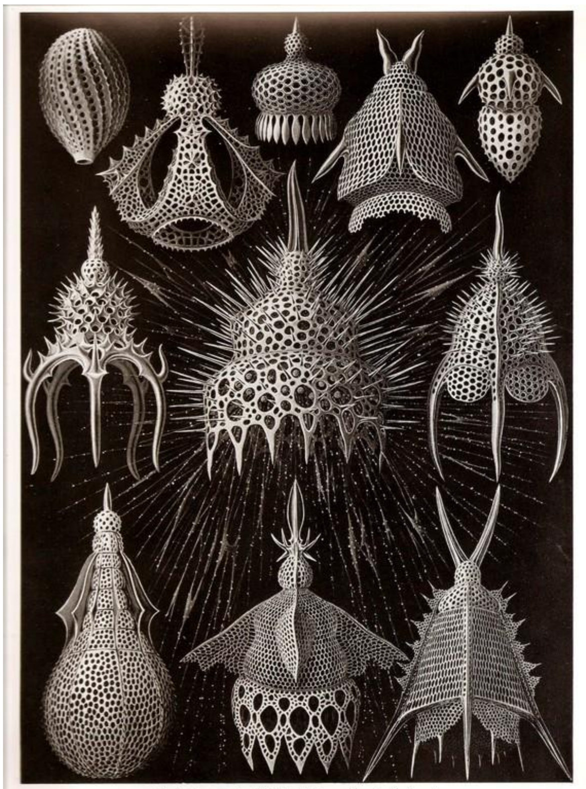
Ontogeny recapitulates phylogeny.

Originator of the term ‘Ecology’ from the Greek ‘Oikos’ which means house.

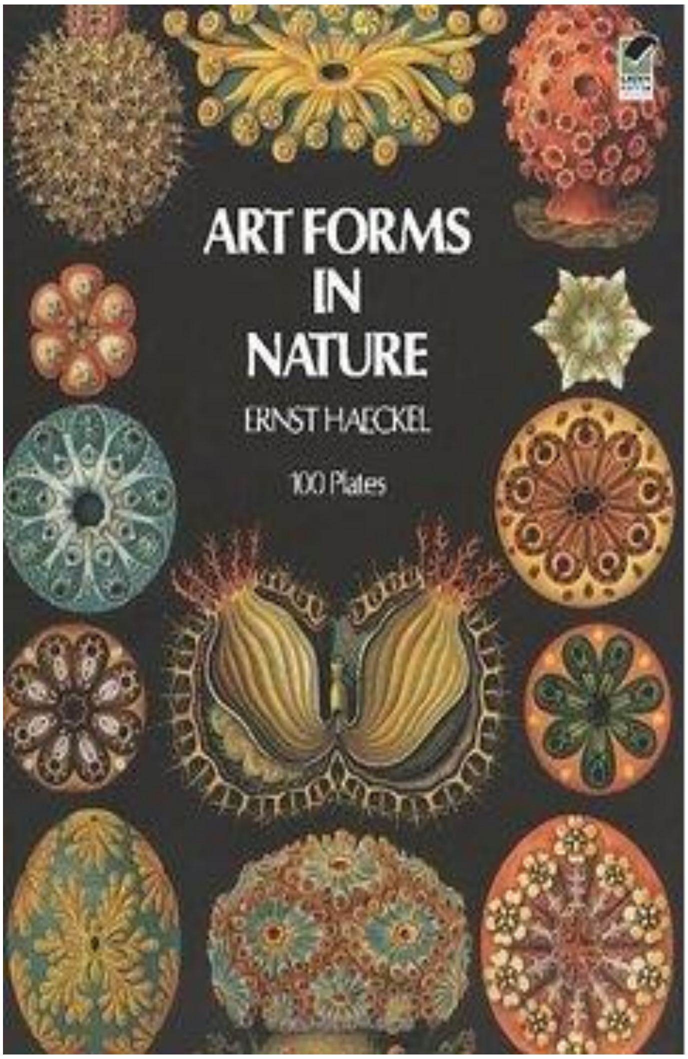
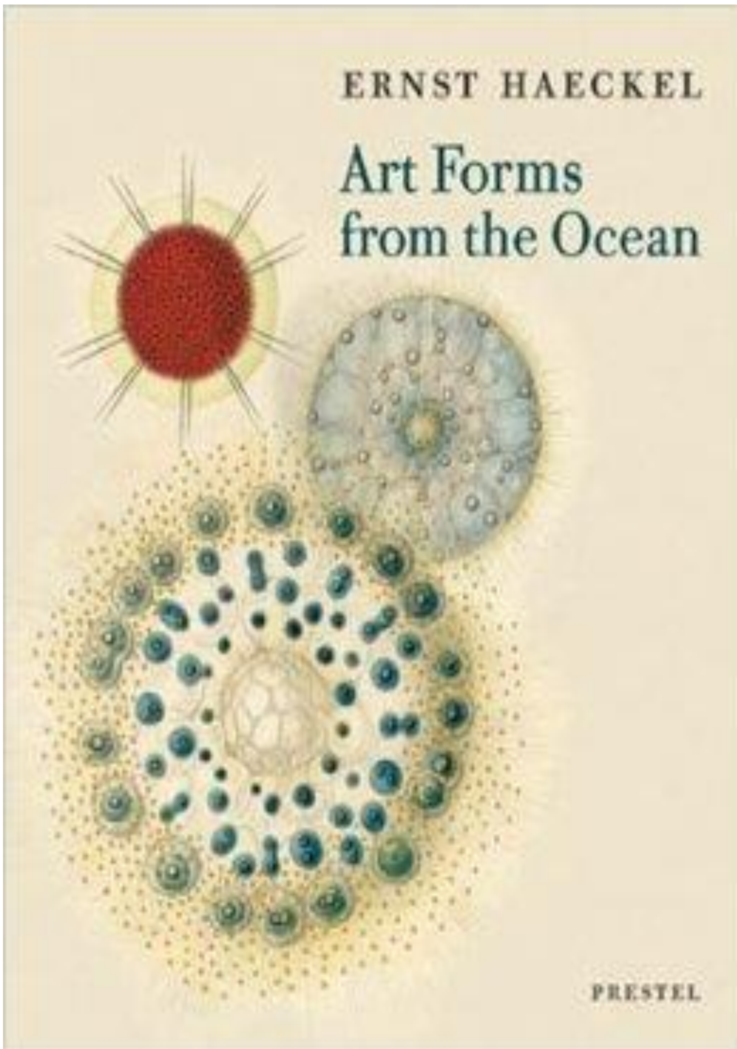


Haeckel’s Radiolarians





31. Various species of Radiolaria (a type of marine Protozoa).


ART FORMS
IN
NATURE
ERNST HAECKEL
100 Plates

ERNST HAECKEL
Art Forms
from the Ocean
PRESTEL

THE BLASCHKAS' GLASS ANIMAL MODELS: ORIGINS OF DESIGN

HENRI REILING

IN THE SECOND HALF of the 19th century, glass models of invertebrate animals were introduced in natural history collections. They originated in the studio of two glassworkers based in Dresden: Leopold Blaschka (1822–1895) and his son, Rudolf (1857–1939). These models, produced between 1863 and 1890, were meant to function as educational aids, and they were preferred to alcohol-preserved specimens, which soon lost shape and color. Today, the survival of these models is based more on their esthetic and historical value than on their continuing use as exhibits.

The earliest of these animal models were sold to museums, local schools and residents, and buyers in England. Soon, however, the business expanded. The Blaschkas' order book documents sales between 1883 and 1890 to customers in England, Scotland, Wales, Ireland, the Netherlands, Czechoslovakia, Italy, and Poland. In addition, models were sent to Belgium, Switzerland, Russia, and Australia. Many sales to German customers were recorded.[1] Purchases of glass models by buyers in Japan and India are noted in the preface to a German catalog printed in 1885.

How could the Blaschkas, living far from the sea, familiarize themselves with the body shapes of the hundreds of marine species they represented in glass? Why did specific body shapes change? These questions surfaced while I was studying collections in Europe and North America, as well as documents pertaining to the Blaschkas.[2] This article surveys the twin

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Acknowledgments. I wish to thank David Whitehouse, Susan Rossi-Wilcox, Chris Meechan, and the board and staff of the Utrecht University Museum for supporting, encouraging, and sharing my passion for glass animals. For providing me with access to their Blaschka animal models, I thank Profs. Kenneth Boss and Ardis Baker-Johnston of the Museum of Comparative Zoology at Harvard University, Prof. C. Drew Harvell of Cornell University, William Kochanczyk of the Boston Museum of Science, and curators at many other museums and institutes.

Kind help in the preparation of this article was supplied by the staff of the Rakow Library of The Corning Museum of Glass, the old prints and special collections staff at the Utrecht University Library, the library of the Institute of the History of Natural and Medical Sciences (Utrecht University), the Ernst Mayr Library of Harvard University (special collections), the library of the National Natural History Museum in Leyden, the Artis Library in Amsterdam, and Hugo Vandendries and Prof. K. Wouters of the National Natural History Institute in Brussels.

I also thank Barbara Keller in Paris and Susan and Richard Diez in Corning, New York, for providing me with a home during my research; the biologist Rob van Apeldoorn and the art historian Loek Reyers for their support; the Board of Trustees of The Corning Museum of Glass for awarding me the Rakow Grant for Glass Research in 1995, which supported this study; and Peter Vanderputte for his assistance.

1. David Whitehouse, "The Amazing Blaschkas," *The Glass Art Society Journal*, 1990, p. 80 (list of destinations).

2. These manuscripts and drawings are housed in the Rakow Library of The Corning Museum of Glass and the Botanical Museum of Harvard University.

ed the resemblance between ontogenesis and phylogenesis: developing forms of individual animals reflect stages in the evolution of the species. The assumed link between these processes, which Haeckel termed the "biogenetic law" or recapitulation theory, fostered an interest in embryology. When fossil records were not available, the study of embryonic stages could show scientists what animals' ancestors looked like.[13]

In his book on general anatomy, Haeckel defined and classified elementary shapes ("Grundformen") of animal bodies.[14] He also connected these shapes to Darwin's theory of evolution. Haeckel believed that a group of related animal forms can be viewed as steps in an evolutionary series,[15] and that, by studying a succession of shapes in embryonic development, the laws that define the form of the adult organism could be clarified.[16] Indeed, he perceived organisms as products of evolution rather than as entities interacting with their environment.[17]

Haeckel produced illustrations to accompany his zoological descriptions. A specific feature of his style was sinuous shapes. Representing linear body parts as curved or folded was helpful in making economical use of the space on a page.

Haeckel and the Blaschkas

The influence of Haeckel on the Blaschkas is best summarized by Rudolf Blaschka, who reported that he and his father particularly appreciated Haeckel's friendship.[18] This friendship was probably a professional one nurtured by shared interests in invertebrates. Drafts of letters reveal that the Blaschkas borrowed books from the professor's library in order to copy the zoological illustrations, and they strongly suggest that the Blaschkas met with Haeckel. The Blaschkas planned to visit Haeckel in 1877, and Haeckel was invited to visit them when he traveled to Dresden in the summer of 1881. A notebook entry demonstrates that one of the Blaschkas was in Jena, where Haeckel resided, because it records an observation made in a museum there.[19] The draft of a letter to Haeckel of May 28, 1877, mentions the Blaschkas' safe homecoming, perhaps from a visit to Jena. At that time, they may have borrowed books in order to copy the plates, as is suggested in a letter of June 11, 1877.[20] As Leopold Blaschka stressed in that letter, these zoological works resulted in the production of "a catalog, restricted to scientific models."

When it comes to determining the influence of Haeckel on the Blaschkas' modelmaking, the difference with the impact made by Gosse is evident. Gosse had—in one book—supplied illustrations that served at the time as the sole source for the models that the Blaschkas offered for sale. On the contrary, Haeckel's scientific drawings provided preparatory material for a relatively small part of the Blaschkas' models, which were by then based on a wide

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13. Eli C. Minkoff, *Evolutionary Biology*, rev. ed., Reading, Menlo Park, London, Amsterdam, Don Mills, and Sydney: Addison-Wesley Publishing Company, 1984 (first published in 1983), pp. 93–94.

14. Haeckel [note 12], v. 1, pp. 60–62, 377–399, and 559–574, pls. 1 and 2, figs. 1–30.

15. Ernst Haeckel, "Das Challengerwerk," *Deutsche Rundschau*, v. 86, no. 5, 1896, pp. 232–248, esp. p. 243.

16. Haeckel [note 12], v. 1, p. 391.

17. Lynn K. Nyhart, "Natural History and the 'New' Biology," in *Cultures of Natural History*, ed. Nick Jardine, Jim A. Secord, and Emma C. Spray, Cambridge: Cambridge University Press, 1996, pp. 428 and 430.

18. Rudolf Blaschka [note 3]. The Botanical Museum of Harvard University houses a copy of Haeckel's lecture on the division of labor in nature and in human life ("Über Arbeitstheilung in Natur und Menschenleben"), which was a gift from Haeckel to Blaschka. On the cover is a handwritten note: "Herr Blaschka zur freundl. Ering. an den Verf." (for friendly remembrance of the author).

19. Leopold and Rudolf Blaschka, "Renilla reniformis [sketch] Das in Jenaer Museum ist Renilla violacea," small brown notebook in Botanical Museum of Harvard University (no date or page numbers).

20. Leopold Blaschka, letter to Haeckel, June 11, 1877; draft in Rakow Library, original in Ernst Haeckel Haus, Jena.

FIG. 5. *Glass model of* Sarsia siphonophora *Haeckel, almost identical to plate I, figure 5, in Haeckel's* Das System der Medusen *(1879) [note 22]. H. 28 cm. Museum of Natural History, Geneva, acquired in 1888. (Photo: C. Ratton, Museum of Natural History, Geneva)*

variety of zoological sources. These models had to present contemporary zoology, as can be understood in what Leopold Blaschka wrote to Haeckel (translated): "Your kind attitude enables me, indeed, to execute my catalog more perfectly, and [it is] restricted only to scientific models."[21]

Haeckel's scientific description of animal species can be identified in the glass models that the Blaschkas offered for sale. As an example, three models of jellyfish, based on Haeckel's depictions, were included in sales catalogs of about 1871 and about 1874. Additional models of jellyfish and siphonophores, again derived from Haeckel's work (Fig. 5), were added in later catalogs, and models of radiolarians, first included in the 1885 catalog, were based on Haeckel's famous monograph of 1862.[22]

Haeckel's contribution to zoological thought was another mark of his influence on the Blaschkas. According to Minkoff, Haeckel's "biogenetic law" or recapitulation theory triggered a German aspect of Darwinism: interest in embryology as a clue to evolution.[23] This may have prompted the addition of a series of 13 "stages of development" models to the Blaschkas' catalog of about 1878 (the catalog that was, in Leopold's words, "restricted to scientific models"). Four more expensive embryology models of complex design were added to the 1885 catalog. Several of Haeckel's observations on embryonic development were also interpreted by the Blaschkas in glass models.

21. *Ibid.*

22. Ernst Haeckel, *Die Radiolarien (Rhizopoda Radiaria): Eine Monographie*, Berlin: Georg Reimer, 1862. See also *idem*, *Beiträge zur Naturgerchichte der Hydromedusen. Erstes Heft: Die Familie der Rüsselquallen & 6 Kupfertafeln*, Leipzig: Wilhelm Engelmann, 1865; and *idem*, *Das System der Medusen. Erster Theil einer Monographie der Medusen*, Jena: Gustav Fischer Verlag, 1879.

23. Minkoff [note 13], p. 93.

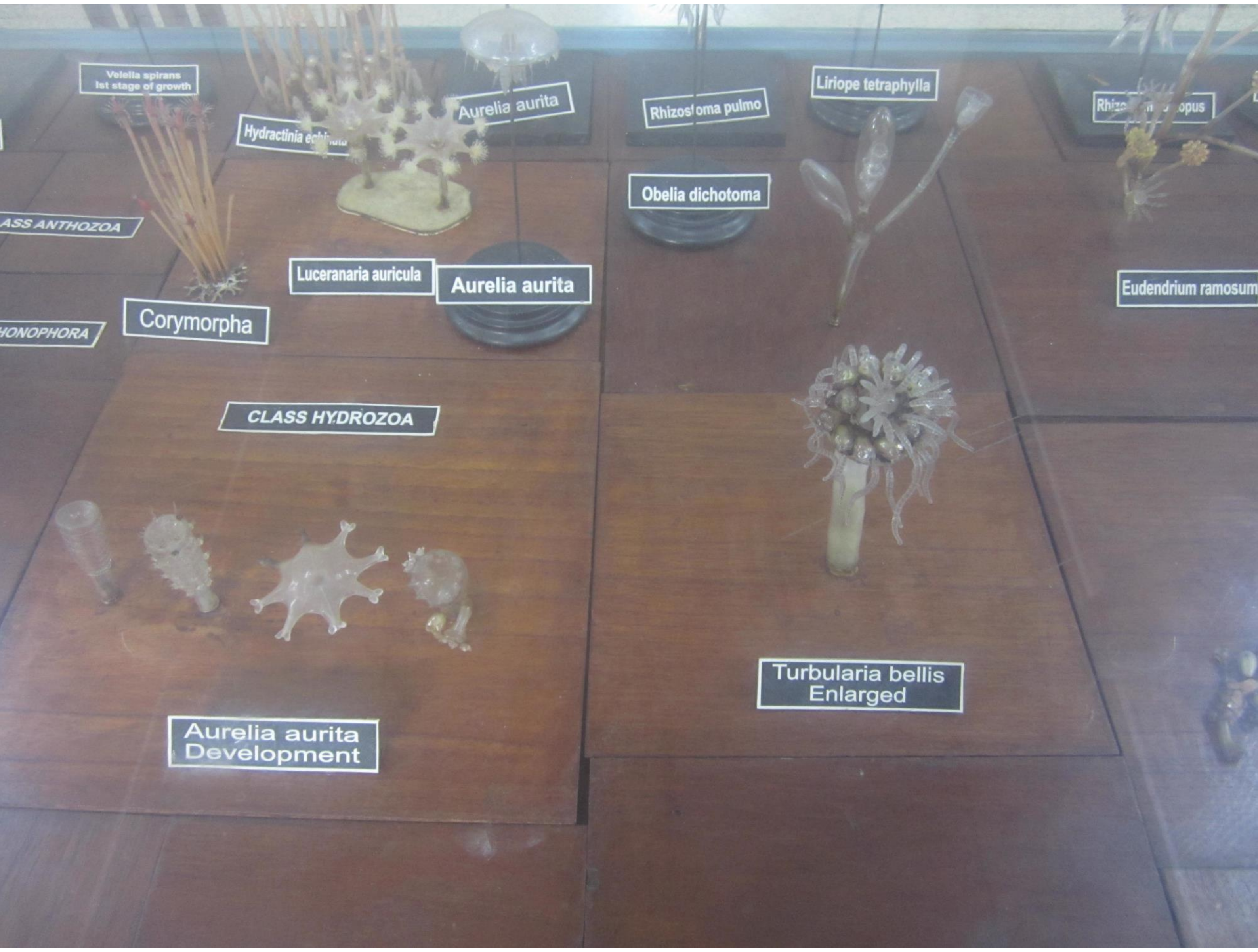
FIG. 6. *Stages of development in the common jellyfish. Incomplete series of glass models based on Sars's "Über die Entwicklung der Medusa aurita und Cyanea capillata" (1841) [note 26]. H. (tallest) 6 cm. Utrecht University Museum, inv. nos. UZ 3503–3505, acquired in 1883. (Photo: Jac. P. Stolp, Universiteitsmuseum, Utrecht)*

Illustrations of the developmental stages of the jellyfish *Carmarina hastata*, which Haeckel published in 1865, were executed in glass and offered in the Blaschkas' 1878 catalog.[24] Models of adult jellyfish from the same publication had appeared in earlier catalogs, but the embryology series apparently had to wait until that subject was in demand in a collection that was restricted to scientific models.

1878 catalog. It is obviously based on Haeckel's illustrated publication on the development of siphonophores.[25] A set of glass models representing the development of the common jellyfish (*Aurelia aurita* L.) was originally derived from a publication by Michael Sars, from which

24. Haeckel, *Beiträge* [note 22].

25. Ernst Haeckel, *Zur Entwicklungsgeschichte der Sipho-*



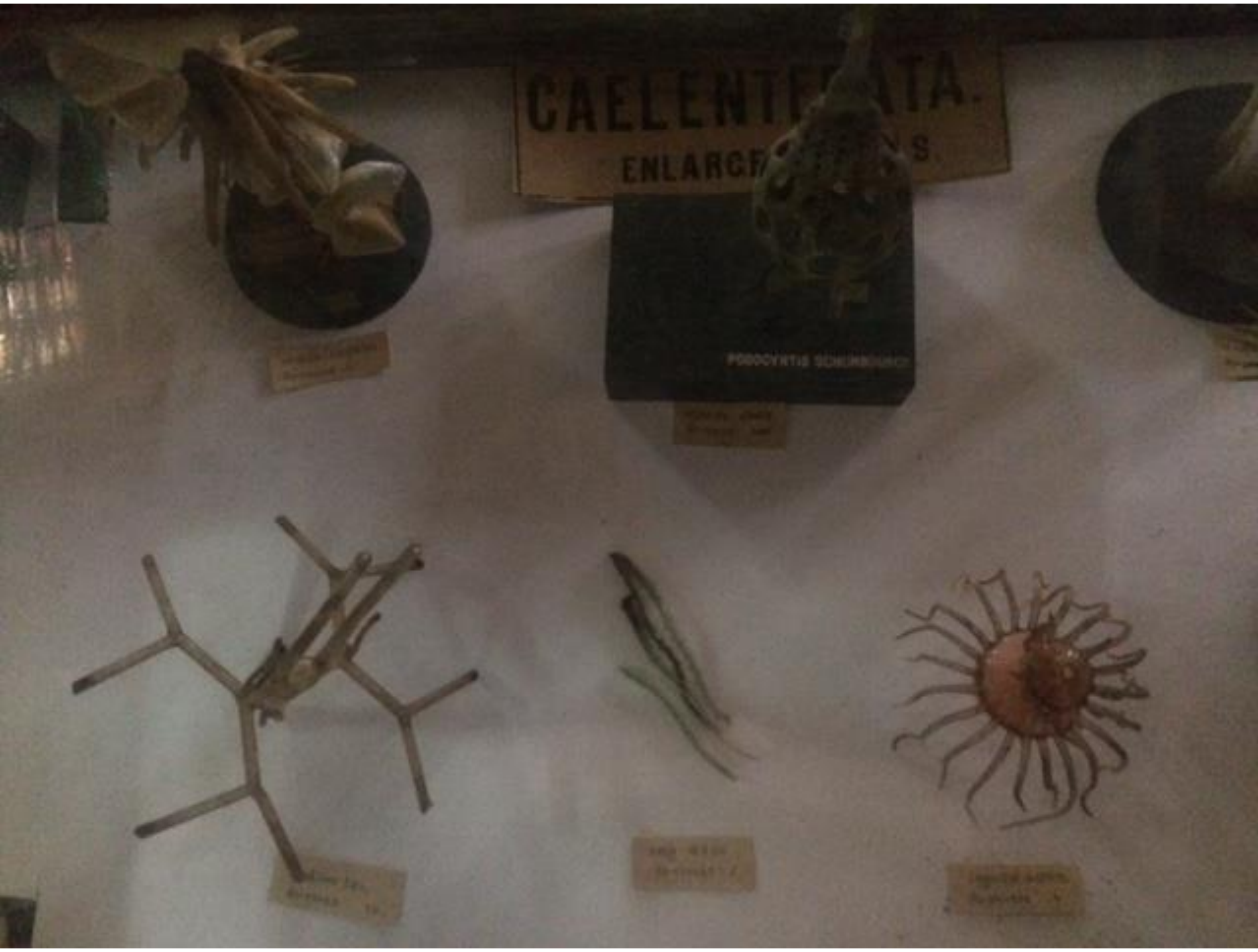
Velella spirans
Ist stage of growth
Aurelia aurita
Rhizostoma pulmo
Liriope tetraphylla
Obelia dichotoma
ASS ANTHOZOA
Luceranaria auricula
Aurelia aurita
Eudendrium ramosum
Corymorpha
HONOPHORA
CLASS HYDROZOA
Turbularia bellis
Enlarged
Aurelia aurita
Development


INDEX GALLERY
COELENTERATA
Cestum veneris


BARODA MUSEUM & PICTURE GALLERY


RADIOLARIA


RADIOLARIA.
ENLARGED MODELS.

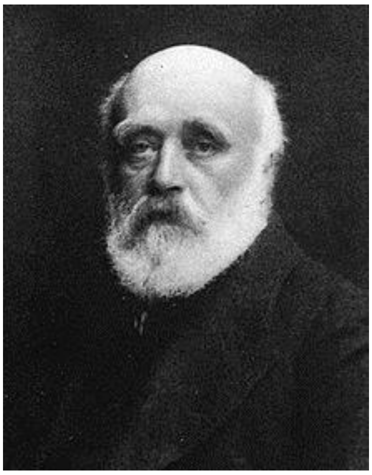



PODOCYRTIS SCHOMBOURGII

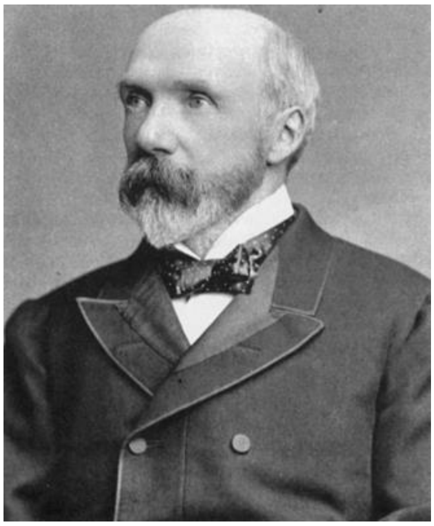
Zoology - [illegible]rates

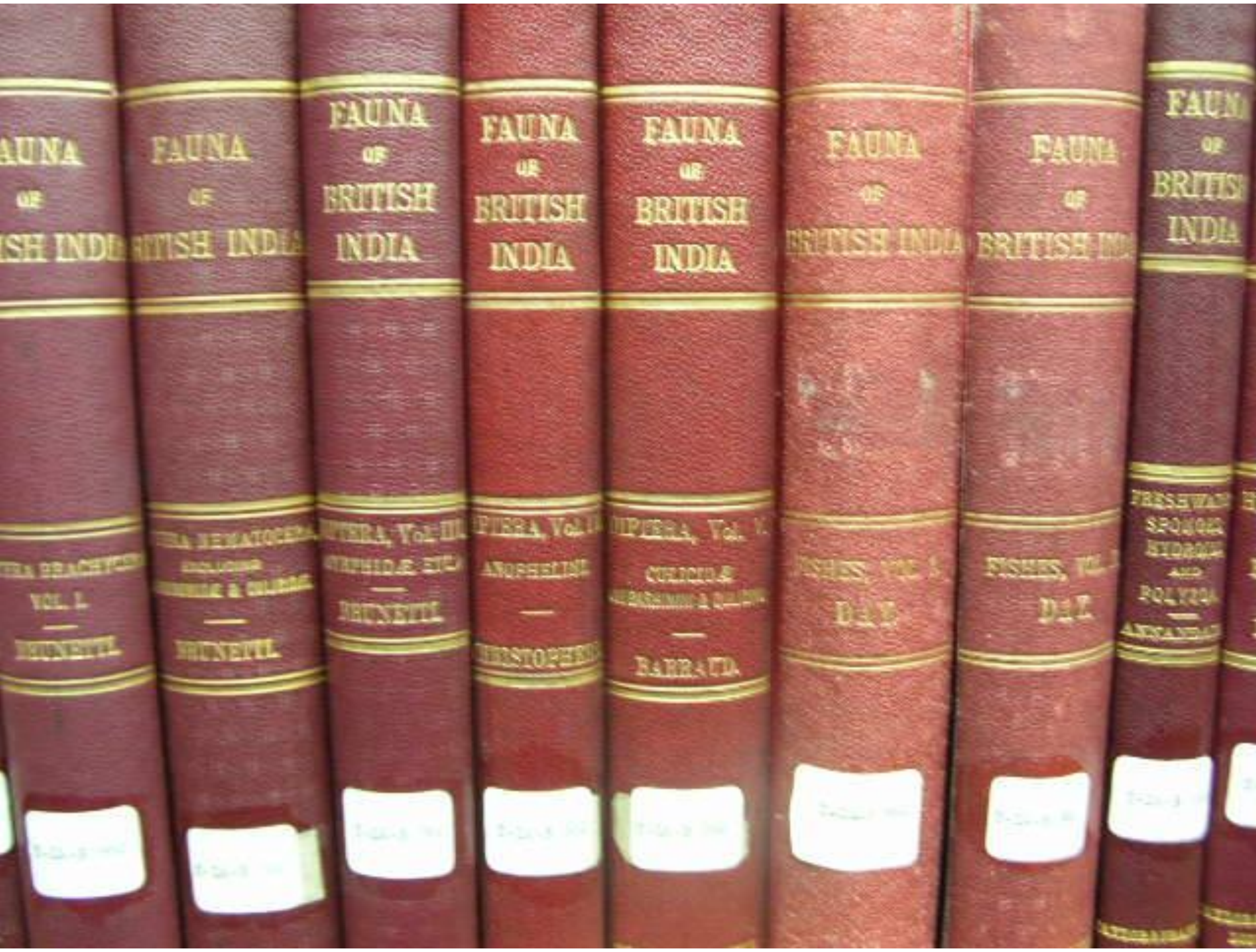
Sectional Register No.	Date of acquisition	Old Register Number	Showcase Number	Description of the Object	Source of manufacture occurrence or find	Source of Acquisition	Purchase Price	Present market value	Remarks
				Enlarged Models of Invertebrates					
1	15-5-96	Z.10.98	Gallery showcase	Podocyrtis schombourcii	Barbados	V. Fric, Prague, Bohemia.	Price paid Fl.15-00 for the set of six.	Rs. 30/- R.V. 70/-	Received the Exhibit [illegible] 2-10-94 [illegible]
2	12-6-96	99	"	Cladonema radiatum	Leipzig	P. Osterloch, Leipzig.	Mks. 8.00	Rs. 25/- R.V. 35/-	Broken. [illegible] Broken condition.
3	"	105	"	Aurelia aurita(medusa)	"	"	" 12-00	" 35/- RV. 70/-	Received the exhibit no-Z 10-105 [illegible]
4	"	104	"	Aurelia aurita	"	"	"26-50	" 35/- RV. 70/-	
5	"	100	"	Clava squamata	"	"	" 20-00	" 35/- RV. 70/-	
6	"	103	"	Physophora hydrostatica	"	"	" 25-00	" 20/- RV 35/-	Broken.

1



Dr. Edgar Thurston, C.I.E., F.R.C.S., Superintendent (1885–1908)

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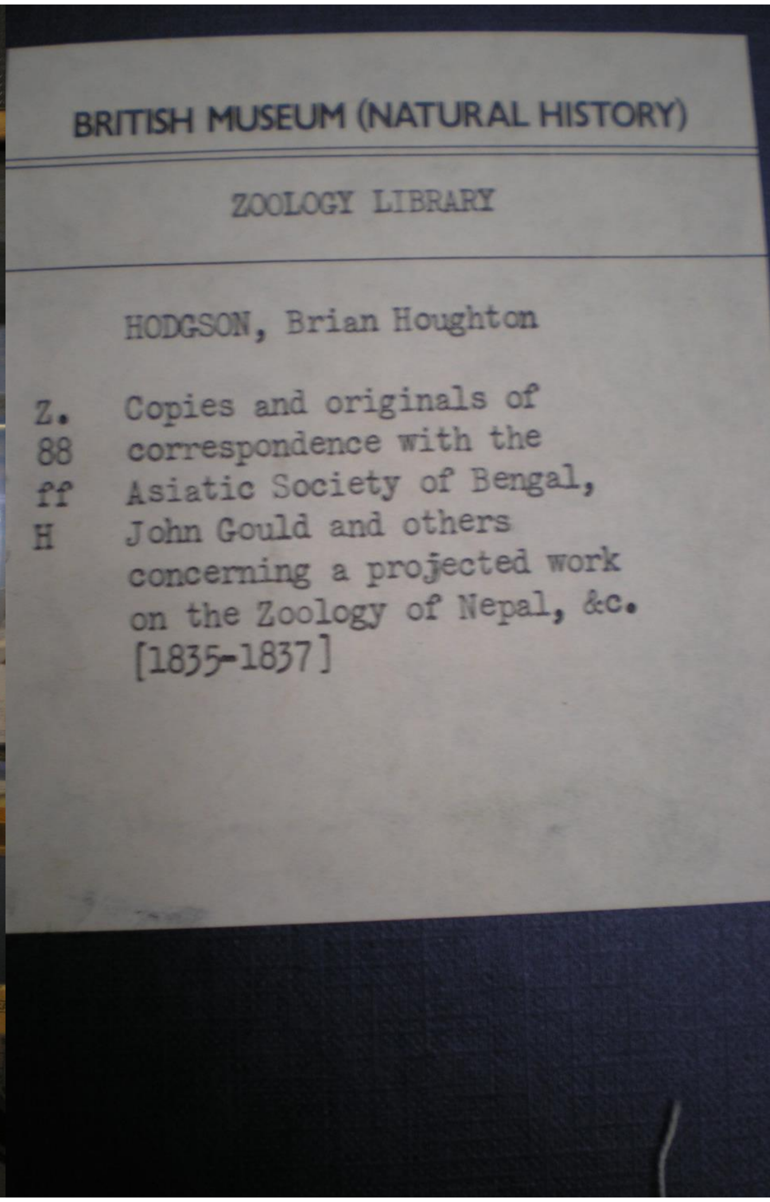

BRITISH MUSEUM (NATURAL HISTORY)

ZOOLOGY LIBRARY

HODGSON, Brian Houghton

Z. Copies and originals of
88 correspondence with the
ff Asiatic Society of Bengal,
H John Gould and others
concerning a projected work
on the Zoology of Nepal, &c.
[1835-1837]


IN LOVING MEMORY
EDWARD BLYTH,
THE EMINENT ZOOLOGIST,
BORN DEC 23 1810, DIED DEC 27
S. CLARA BLYTH
BESSIE,



Leopold Blaschka (1822-1895) and Rudolf Blaschka (1857-1939)

Thank You

1.10 Lecture 6A

Scientific Knowledge
&
Scientific Method

- What was the source of legitimacy for the magic man chanting mantras to heal the ailing?
- <u>The belief was in the act itself</u>
- It didn't have any external source of legitimacy

- What is the source of legitimacy for the modern scientific empirical methods of verification / falsification
- <u>Philosophy of positivism & logical positivism</u>
- An external source acknowledges it as the only scientific method superior to all others

Philosophy of positivism – logical positivism rests on certain assumptions associated with European Enlightenment

- Humans are essentially rational
- Progression of human society = manifestation of reason
- Scientific Knowledge is observable, quantifiable, testifiable (falsifiable), reproduceable, verifiable, predictable

René Descartes

August Comte

Emile Durkheim

Karl Popper

Crisis of Positivism

- 'Scientific Method' was conceived for the consolidation and institutionalisation of Social Sciences and not for Natural Sciences
- What is applicable in the domain of nature is not necessarily applicable in the domain of human society. Positivism, undermines the creativity, reflexivity and agency of social actors
- The positivist science is nothing but a form of instrumental rationality leading to domination and manipulation of human and natural resources.

- Structures of Scientific Revolution by Thomas Kuhn
- Scientific discoveries take place in the realm of a dominant paradigm
- Science is not outside society's consensus on what is science

- Now what is the source of legitimacy for the scientific method and scientific knowledge?
- <u>The belief was in the act itself</u>
- It doesn't have any external source of legitimacy

- Jean Francois Lyotard, *Post Modern Conditions: A Report on Knowledge* (1974)
- When science encounters paradox such as electron that goes opposite direction simultaneously, it abandons its search for decidable truths and seeks to legitimize itself through performativity.

<u>What is performativity</u>?

To stop asking ”What kind of research will unfold the laws of nature?”

To focus on, “What kind of research will work best? that is, “What kind of research can generate more of the same kind of research? Can it perform? Can it produce more of the same kind of research?”

Satyagrahi Scientist

- A Scientist concerned with truth rather than with performativity
- To acknowledge that the methods we are using are products of a particular historical framework and not the only or the ultimate methods
- Our commitment is to truth rather than its current version shaped by the dominant paradigm
- To democratize the methods and be more creative about what we consider as ‘scientific research’

1.11 Lecture 6B

Biographies of Scientists

HSS 102

- **Biography**: from medieval Greek words '*bios*' meaning **life** + '*graphia*' meaning **writing**
- a usually written history of a person
- an account of the life of something (such as an animal, a coin, or a building)

- **Hagiography**: from Greek '*hagio-*' meaning **saintly** or **holy** + '*graphia*' meaning **writing**
- a biography of saints or venerated persons
- idealizing or idolizing biography

- **Memoir**: a book or other piece of writing based on the writer's personal knowledge of famous people, places, or events
- focuses on certain memories, experiences or particular aspects of someone's life.
- a written record of a usually famous person's own life and experiences

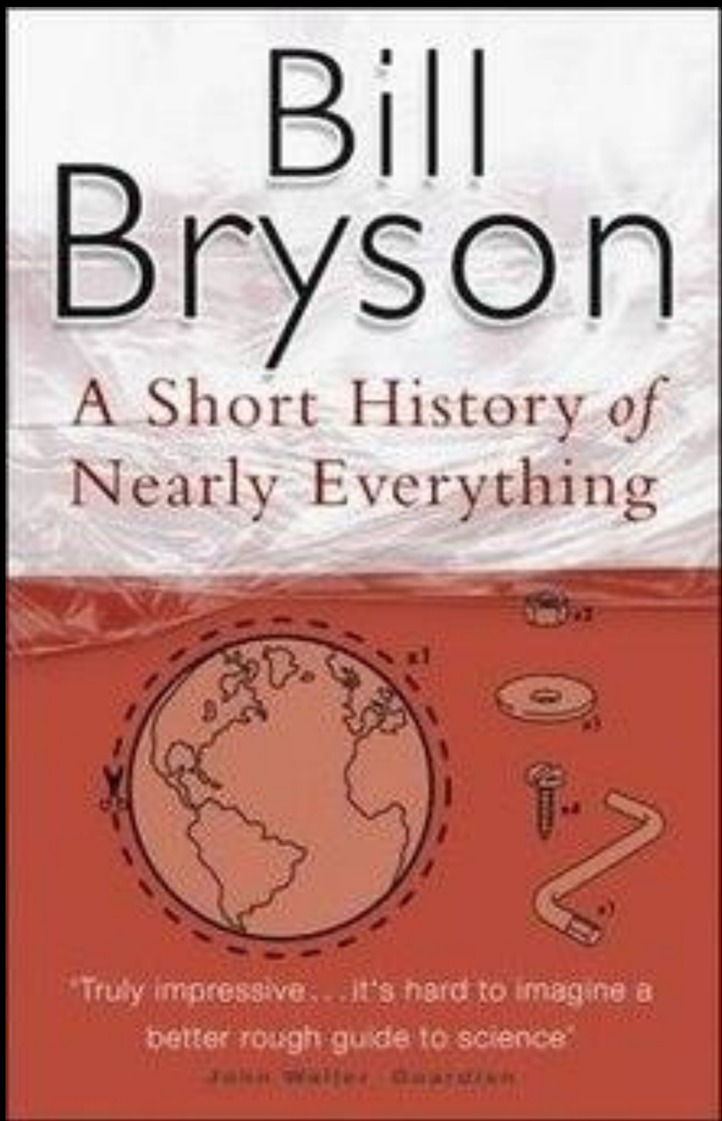
"No species of writing seems more worthy of cultivation than biography, since none can be more delightful or more useful, none can more certainly enchain the heart by irresistible interest, or more widely diffuse instruction to every diversity of condition."

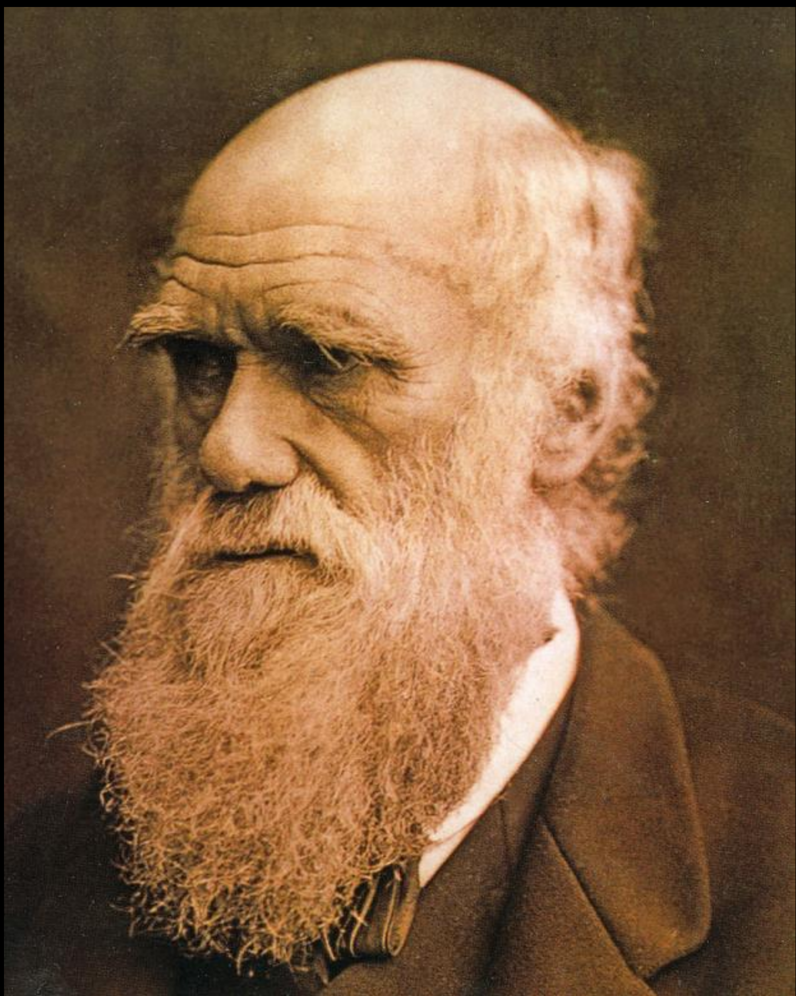
– Samuel Johnson, 1750

"As biographers some of us don't just look into the door, we open it…get into wardrobes…look into papers…get under the bed…under the linen and then tell the person look this is who you are. Whoever you might be this is what we think you are and you are good enough for the world" – Sankarshan Thakur (biographer of Indian politicians such as Nitish Kumar and Laloo Prasad Yadav)

Why are biographies of scientists important?

- A different story of science
- Presents scientists as people, with emotions and personalities, and personal relationships that go beyond (but influence) their scientific careers
- Shows scientists in their social, cultural, historical, racial, national, gendered contexts
- Provides insight into the complex creation of scientific knowledge and its dissemination crisscrossed with other contexts


Bill
Bryson
A Short History *of*
Nearly Everything
'Truly impressive...it's hard to imagine a
better rough guide to science'



Different intents and effects

"In the late summer or early autumn of 1859, Whitwell Elwin, editor of the respected British journal the *Quarterly Review*, was sent an advance copy of a new book by the naturalist Charles Darwin. Elwin read the book with interest and agreed that it had merit, but feared that the subject matter was too narrow to attract a wide audience. He urged Darwin to write a book about pigeons instead. "Everyone is interested in pigeons," he observed helpfully." - Bryson

"Charles Robert Darwin (February 12, 1809 to April 19, 1882) was a naturalist and biologist known for his theory of evolution and the process of natural selection. Born in Shrewsbury, England, in 1831 he embarked on a five-year survey voyage around the world on the HMS Beagle; his studies of specimens led him to formulate his theories. In 1859, he published *On the Origin of Species*."

– biography.com

Darwin as a student

Darwin enjoyed every advantage of upbringing, but continually pained his widowed father with his lackluster academic performance. “You care for nothing but shooting, dogs, and rat-catching, and you will be a disgrace to yourself and all your family,” his father wrote in a line that nearly always appears just about here in any review of Darwin’s early life. Although his inclination was to natural history, for his father’s sake he tried to study medicine at Edinburgh University but couldn’t bear the blood and suffering. The experience of witnessing an operation on an understandably distressed child—this was in the days before anesthetics, of course—left him permanently traumatized. He tried law instead, but found that insupportably dull and finally managed, more or less by default, to acquire a degree in divinity from Cambridge.

- Bryson

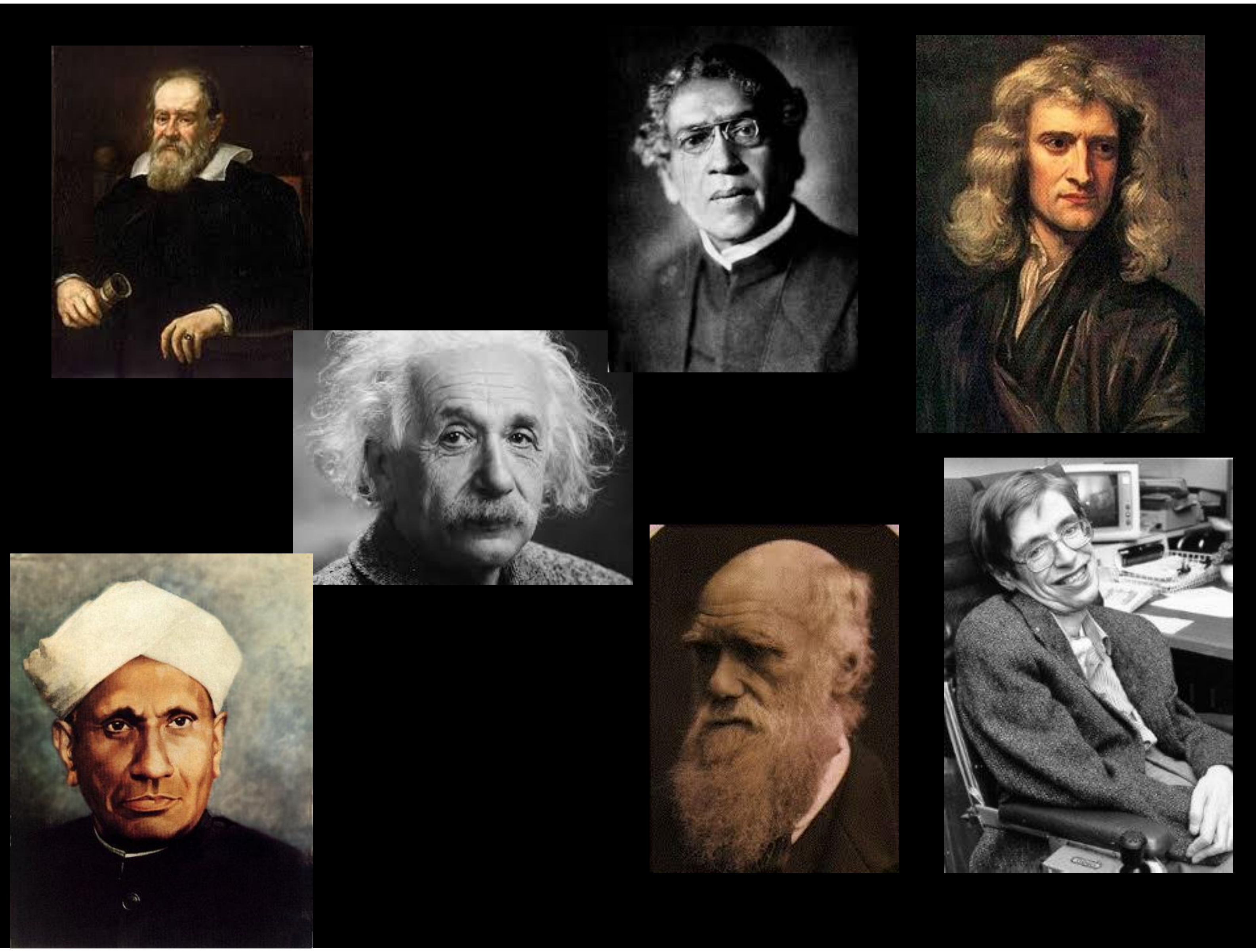
His father, considering the 16-year-old a wastrel interested only in game shooting, sent him to study medicine at Edinburgh University in 1825. Later in life, Darwin gave the impression that he had learned little during his two years at Edinburgh. In fact, it was a formative experience. There was no better science education in a British university. He was taught to understand the chemistry of cooling rocks on the primitive Earth and how to classify plants by the modern “natural system.” At the Edinburgh Museum he was taught to stuff birds by John Edmonstone, a freed South American slave, and to identify the rock strata and colonial flora and fauna.

- Britannica.com

From Bryson

"The most enigmatic character of all was Franklin. In a severely unflattering portrait, Watson in *The Double Helix* depicted Franklin as a woman who was unreasonable, secretive, chronically uncooperative, and—this seemed especially to irritate him—almost willfully unsexy. He allowed that she "was not unattractive and might have been quite stunning had she taken even a mild interest in clothes," but in this she disappointed all expectations. She didn't even use lipstick, he noted in wonder, while her dress sense "showed all the imagination of English blue-stocking adolescents."[1]"

Why are obscure scientists obscure?



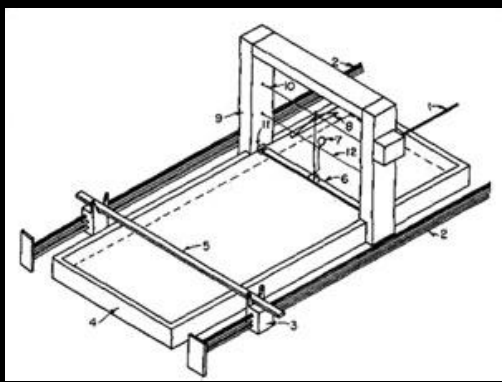
Out of the 51 “famous scientists” that a preliminary Google search throws up,
only 3 are women

Emilie du Chatelet

- 1706-1749, Paris
- Educated at home, but learned from prominent mathematicians and physicists
- Did her own experiments at home
- Had a flair for gambling, used her math skills to win and used the money to buy books and equipment!
- 1737: wrote on a paper on the nature of light, heat, and fire, suggested that different colours of light carry different heating powers, anticipated infrared radiation
- Greatly interested in Newton's work; co-authored *Elements of Newton's Philosophy* (not credited)
- Did experiments and corrected Newton's statement that energy is proportional to mv to mv^2
- Translated and commented on Newton's *Principia*, adding clarifications, explanations, and experimental data—her translation remains definitive even today
- Is responsible for having encouraged Newtonian science (over Descartian science) in France

Agnes Pockels

- 1862- 1935, Venice
- Pioneer in surface tension studies
- No formal training in the sciences; carried out experiments in the kitchen using buttons and trays with soaps and oils while taking care of her parents
- Was not allowed to study science in college; her brother helped her out by sending his books
- Experimented to study the effects of impurities on surface tensions of liquids
- Invented Pockels trough (eventually developed by Nobel Laureate Irving Langmuir) to measure surface tension
- Had her research published in *Nature*
- 1932: honorary doctorate from the Technical University of Braunschweig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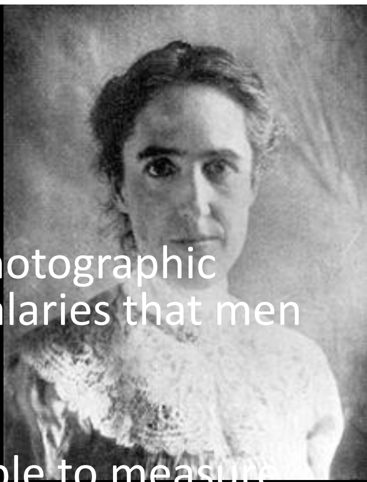
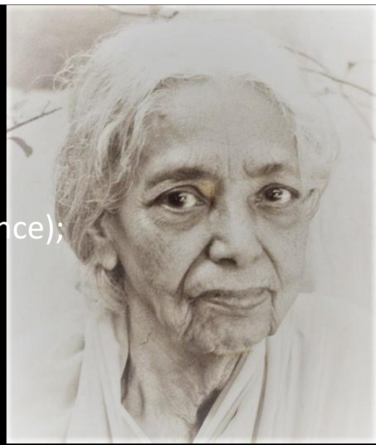
Henrietta Swan Leavitt



- 1868 – 1921, Massachusetts
- One of Harvard’s “Computers”- their job was to study photographic plates for fundamental properties of stars (worked for salaries that men would not accept for the amount of work done)
- Discovered close to 2400 variable stars
- Her discovery about Cepheid stars enabled Edward Hubble to measure galaxy distances in the 1920s
- Considered now to be “the woman who discovered how to measure the Universe”
- Her research was published by her boss Edward Charles Pickering under his name
- Her research helped Harlow Shapley find out distances around the Milky Way but he did not credit her
- 1924: Gosta Mittag-Leffler of the Swedish Academy of Sciences tried to nominate her for the Nobel Prize, not knowing that she had already died
- 2011: Nobel Laureate (Physics) Adam Reiss credited Leavitt’s work as the best tool to study the universe
- Her discovery of luminosity and position is now called Leavitt’s Law


β Aurigae Dec 1888

Janaki Ammal



1897-1984, Tellichery (Kerala)

- A pioneering botanist and cytogeneticist (study of chromosomes and inheritance); also researched ecology, biodiversity, medicinal plants, and sustainable agricultural practices in higher altitudes in India
- One of the first women to win the Padma Shri (1977)
- Got her PhD from Michigan University in 1931 (possibly the first woman to get a PhD in botany in the US)
- Honored with a honorary DSc from the U of Michigan
- Created newer varieties of sugarcane through selective crossbreeding of hybrids at the Sugarcane Breeding Station, Coimbatore; discovered the S. Spontaneum variety is native to India
- Studied chromosomes of thousands of species of flowering plants
- Colleagues at Coimbatore did not like her because she was an unmarried woman and from a caste lower than theirs; facing discrimination, she joined the John Innes Horticultural Institute, London
- 1935: CV Raman invited her to be a research fellow at IAS
- Invited to be a cytologist at Wisley (near Kew Gardens) by the Royal Horticulture Society, England
- Co-authored *The Chromosome Atlas of Cultivated Plants*
- 1951: Jawaharlal Nehru invited her back to India to head the Botanical Survey of India
- An ardent environmentalist, she opposed the building of a hydro-power plant in Kerala's Silent Valley
- 1955: Only woman to be invited to the International Symposium on Environmental History at Princeton
- 2000: the Ministry of Environment and Forestry created the National Award of Taxonomy in her name
- A herbarium with 25,000 species in Jammu Tawi is named after her


Magnolia Kobus Janaki Ammal
© WWW.HORTUSCONCLUSUS.BE

Take Away

- The lives of scientists teach us a lot about societies, histories, and human worlds
- A biography is only one of several ways of knowing about a larger picture; and no narrative can ever tell us everything
- Biographies are written differently for different purposes, audiences, and carry different types of information
- Most obscure scientists are obscure because history and institutions tend not to remember them or given them due importance due to inherent biases
- The women scientists we have looked at are case studies that show the struggle against gender based prejudices from society, family, colleagues, teachers, and institutions; their lives show us our own social, historical, and personal contexts and changes!

1.12 Lecture 7

What can biographies tell us?

- Scientists as people
– Not just milestones in scientific progress
– What their lives say about society (gender, religion, nationality)

- The social side of scientific knowledge
– Scientific cultures, personal relationships
– Who can practice science? Who gets recognition?
– Contexts and reasons for scientific imperatives

Royal society honour for father of Indian chemistry P C Ray

PTI | Updated: Sep 30, 2011, 16:15 IST

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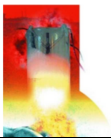

KOLKATA: The Royal Society of Chemistry, UK has honoured the life and work of Acharya Prafulla Chandra Ray, father of Indian chemistry, with the first-ever Chemical Landmark Plaque outside Europe.

RSC's newly-appointed chief executive Robert Parker made the announcement here yesterday at the launch of a report

Bengal Chemicals & Pharmaceuticals Ltd.
(A Government of India Enterprise)

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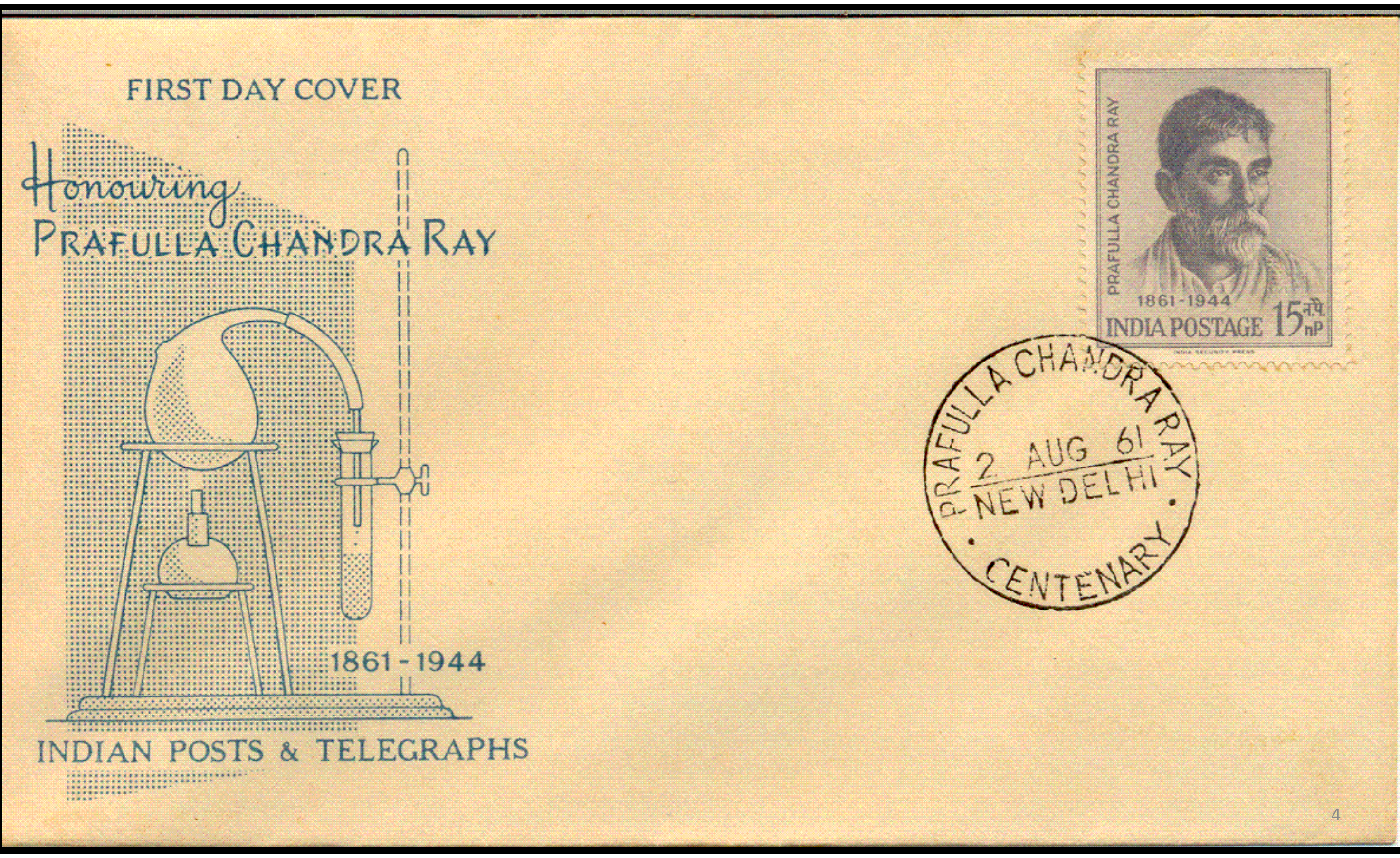
BCPL, the first Pharmaceutical Company of India

Bengal Chemicals is the **first Pharmaceutical Company of India**, founded by Acharya Prafulla Chandra Ray, the Father of Indian Chemistry

P.C. Ray : A Biography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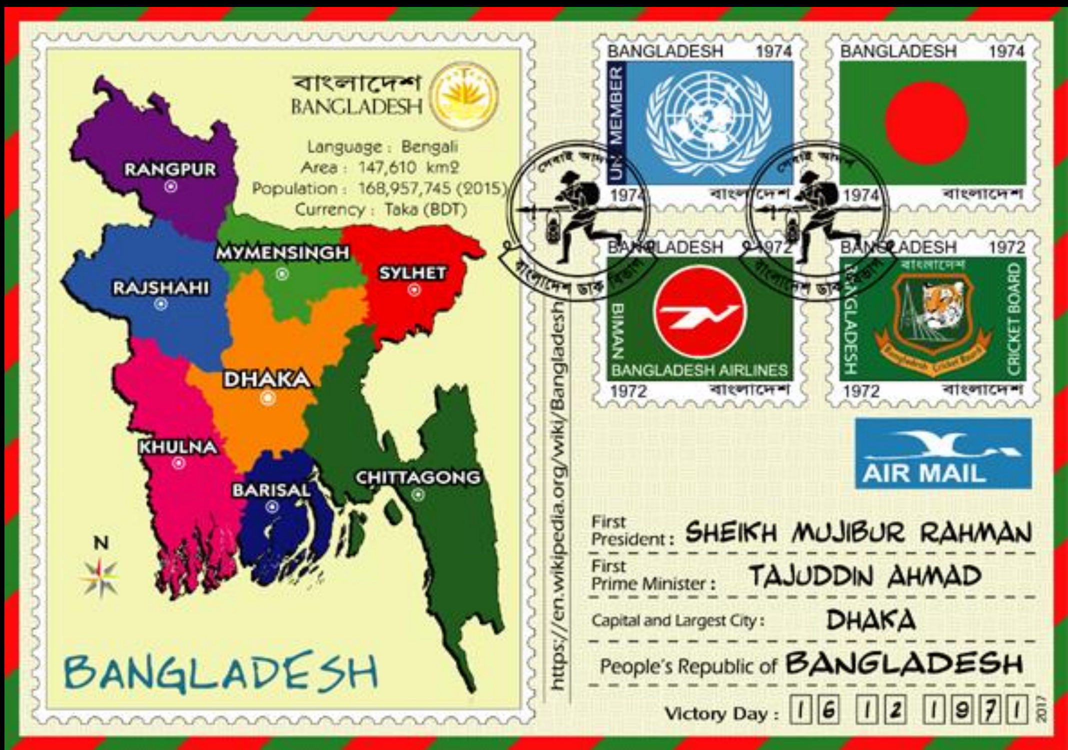

বাংলাদেশ
BANGLADESH
Language : Bengali
Area : 147,610 km2
Population : 168,957,745 (2015)
Currency : Taka (BDT)
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RAJSHAHI
MYMENSINGH
SYLHET
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https://en.wikipedia.org/wiki/Bangladesh
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BANGLADESH AIRLINES
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BANGLADESH 1972
BANGLADESH
CRICKET BOARD
1972 বাংলাদেশ
AIR MAIL
First President : SHEIKH MUJIBUR RAHMAN
First Prime Minister : TAJUDDIN AHMAD
Capital and Largest City : DHAKA
People's Republic of BANGLADESH
Victory Day : 16 12 1971
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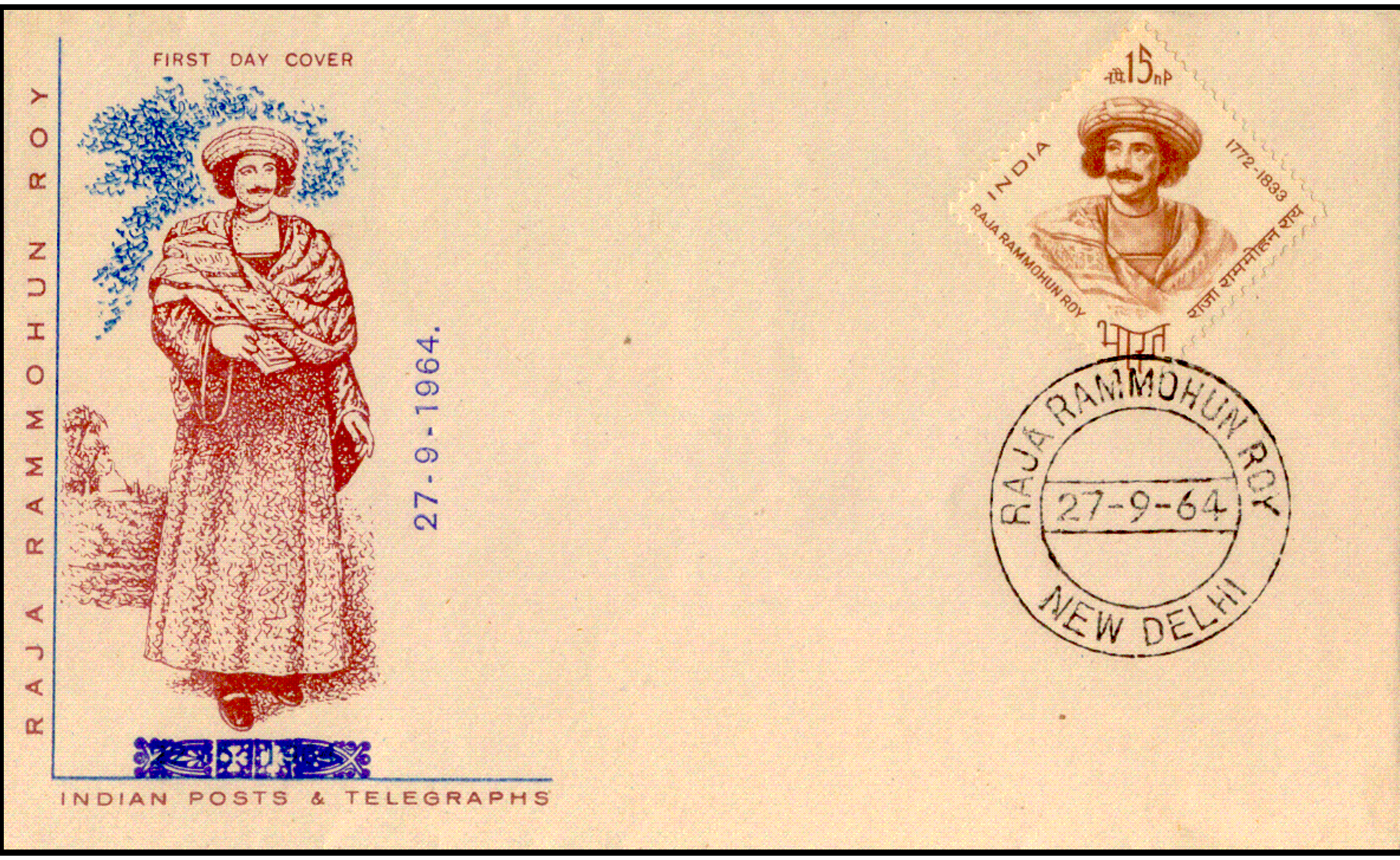
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प्रथम दिवस आवरण
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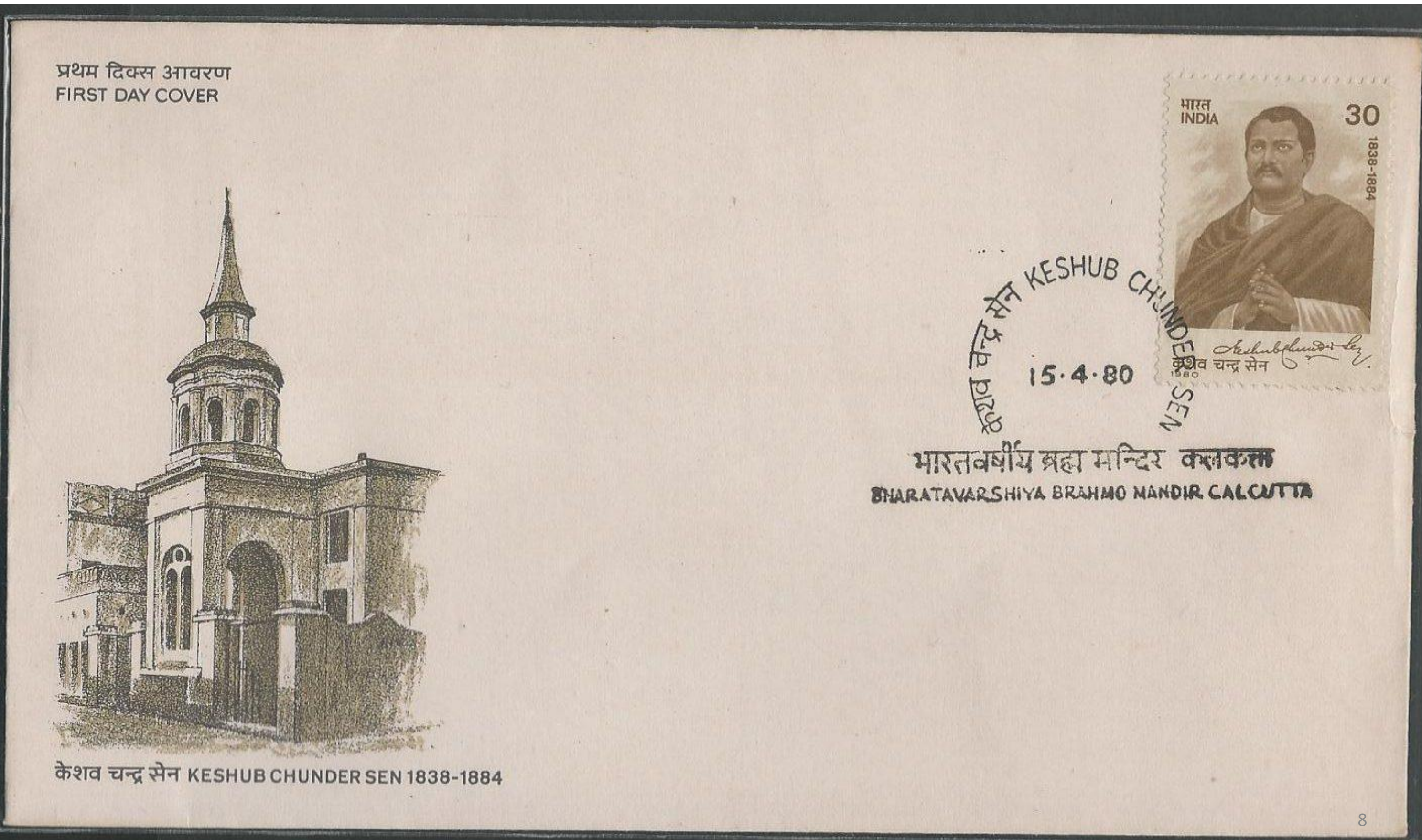

प्रथम दिवस आवरण
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1980
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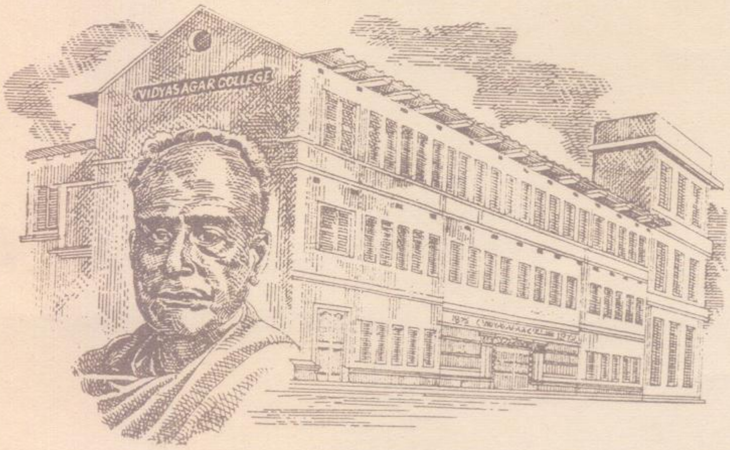
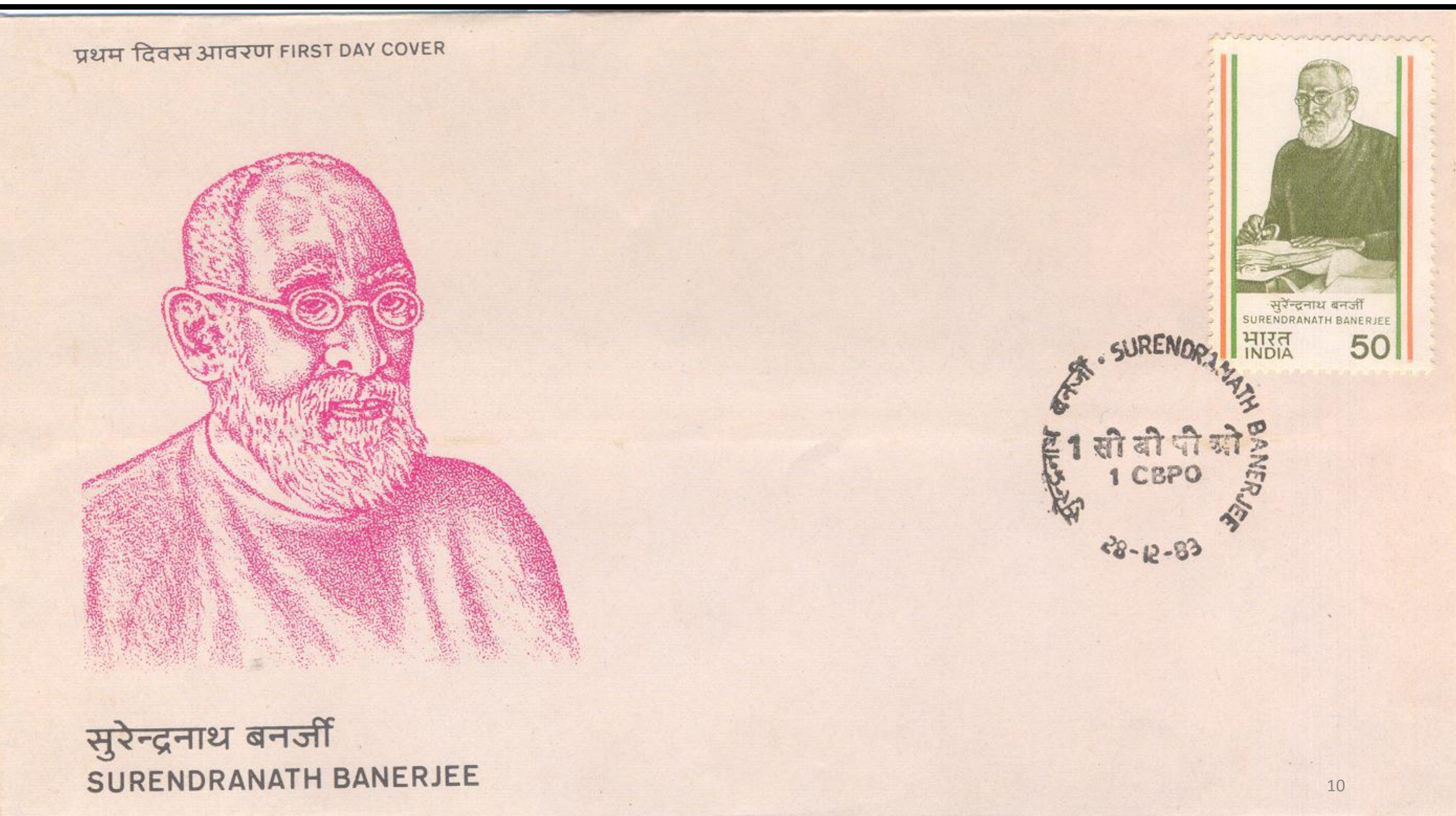
BHARATAVARSHIYA BRAHMO MANDIR CALCUTTA
केशव चन्द्र सेन KESHUB CHUNDER SEN 1838-1884

प्रथम दिवस आवरण FIRST DAY COVER



विद्यासागर कॉलेज के 125 वर्ष
125 YEARS OF VIDYASAGAR COLLEGE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SURENDRANATH BANERJEE


FIRST DAY COVER
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1857 1957
10 nP INDIA POSTAGE
बम्बई विश्वविद्यालय
1857 1957
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5/14-B, Roop Nagar,
Subzi Mundi,
DELHI-6.
बम्बई, कलकत्ता,
विश्वविद्यालय की शताब्दी
1957
INDIAN POSTS & TELEGRAPHS

PRESENTED TO
BUREAU CUSTOMERS
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Bureau
EDINBURGH
6 MARCH 1990
British Philatelic Bureau, 20 Brandon Street, Edinburgh, EH3 5TT


FIRST DAY COVER
प्रथम भारतीय स्वतंत्रता संग्राम
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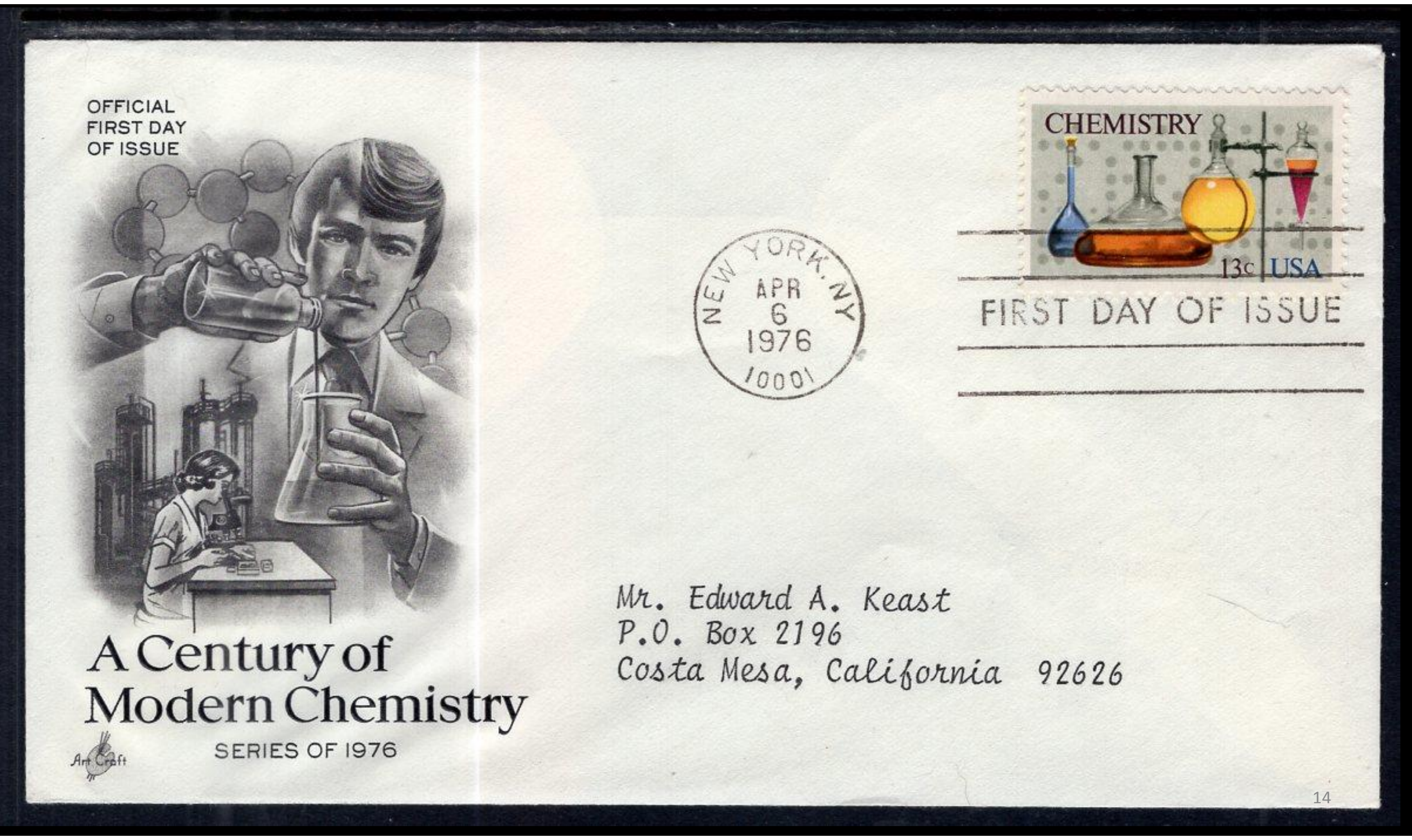
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FIRST DAY OF ISSUE
Mr. Edward A. Keast
P.O. Box 2196
Costa Mesa, California 92626


FIRST DAY COVER
JAGDISH CHANDRA BOSE
Birth Centenary
30-11-58
J. C. Bose's Microwave Apparatus
INDIAN POSTS & TELEGRAPHS
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30·11·1858 - 23·11·1937
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JAGADISH CHANDRA BOSE
BIRTHDAY CENTENARY
30-11-58
BOMBAY
Mr. Homi J. Mistry.
C/O. Messrs.B.J.Mistry,
491,Kalbadevi Road,
B O M B A Y 2.


प्रथम दिवस आवरण
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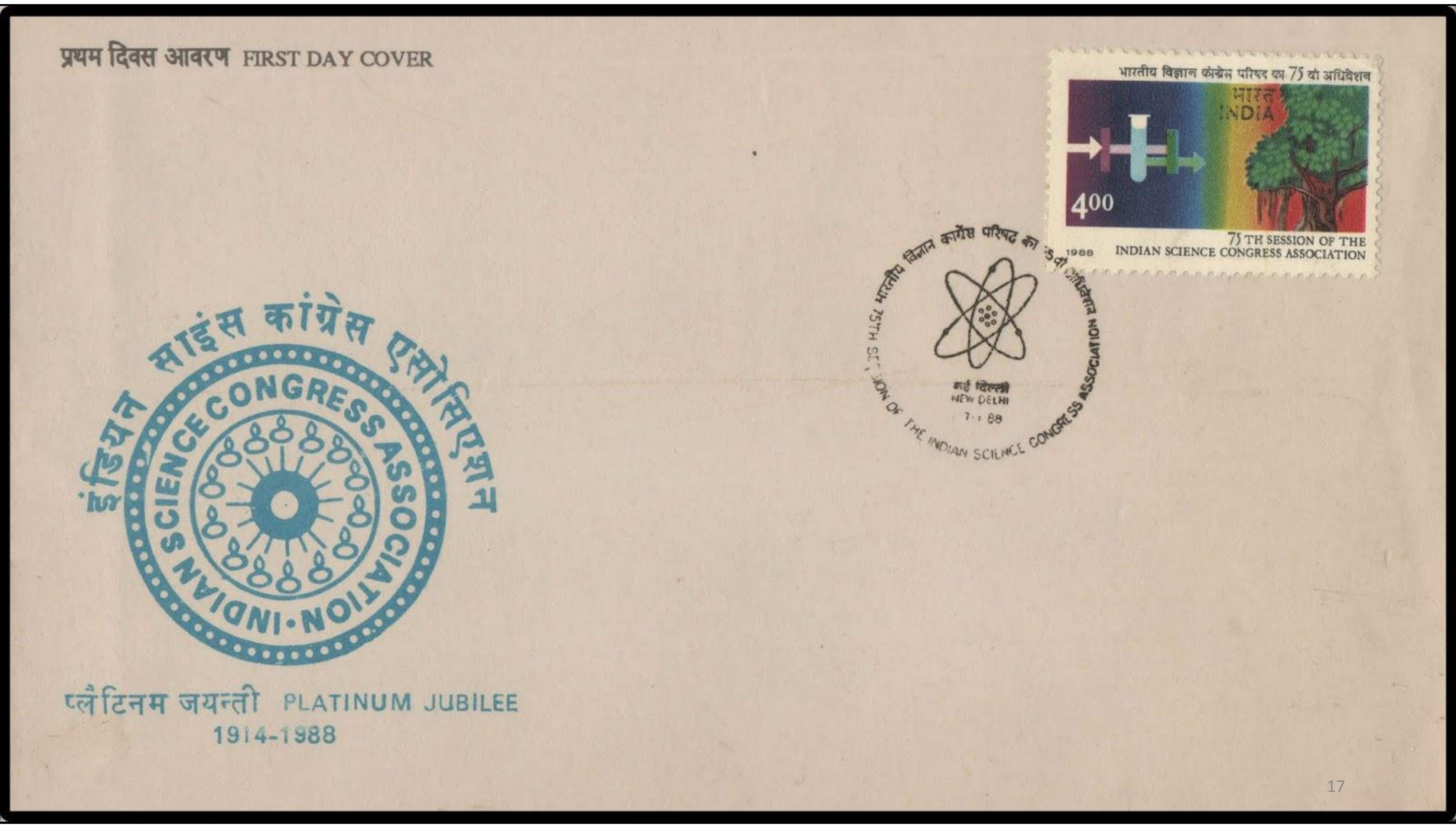
BOMBAY G.P.O.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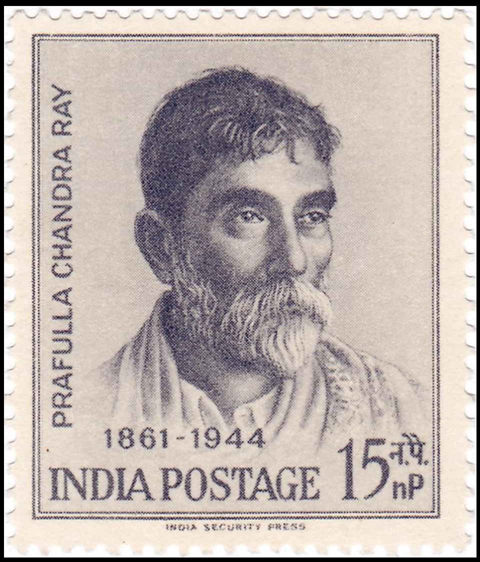
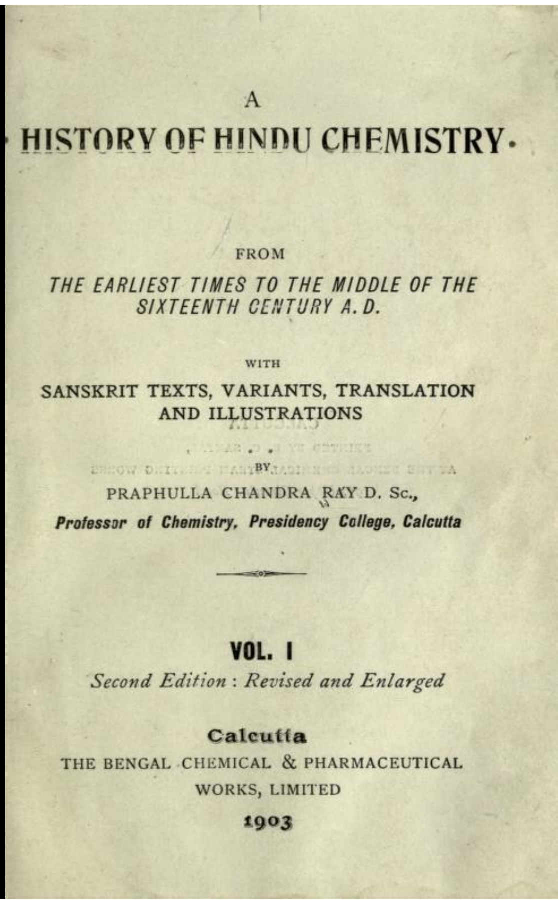
1914-1988


PRAFULLA CHANDRA RAY
1861-1944
INDIA POSTAGE
15 न.पै. nP
INDIA SECURITY PRESS



A

HISTORY OF HINDU CHEMISTRY

FROM

THE EARLIEST TIMES TO THE MIDDLE OF THE SIXTEENTH CENTURY A. D.

WITH

SANSKRIT TEXTS, VARIANTS, TRANSLATION AND ILLUSTRATIONS

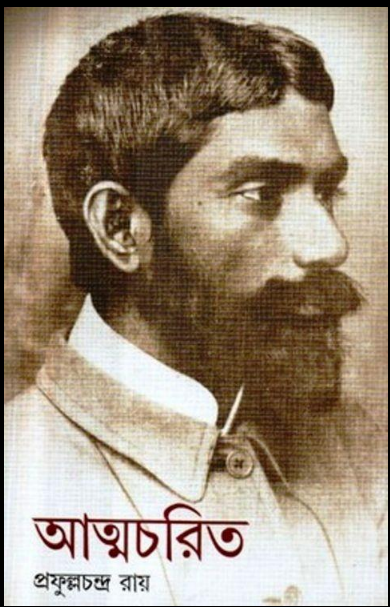
BY

PRAPHULLA CHANDRA RAY D. Sc.,
Professor of Chemistry, Presidency College, Calcutta

VOL. I

Second Edition : Revised and Enlarged

Calcutta
THE BENGAL CHEMICAL & PHARMACEUTICAL WORKS, LIMITED
1903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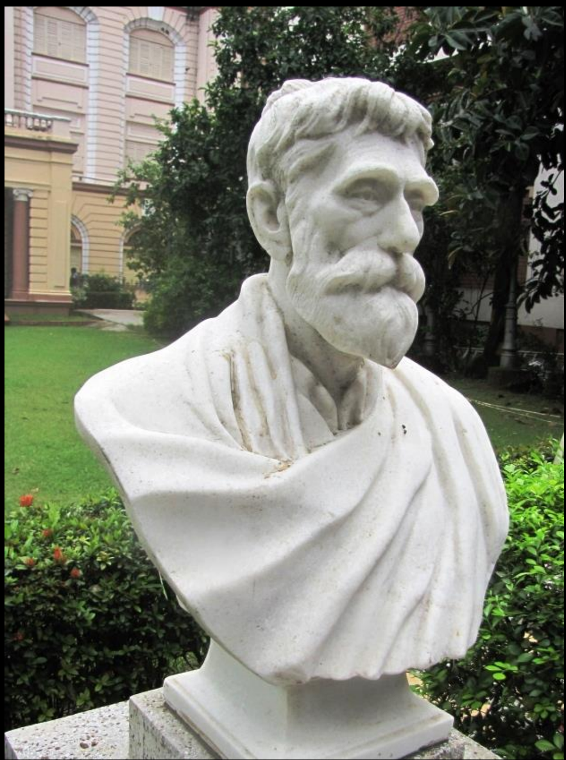
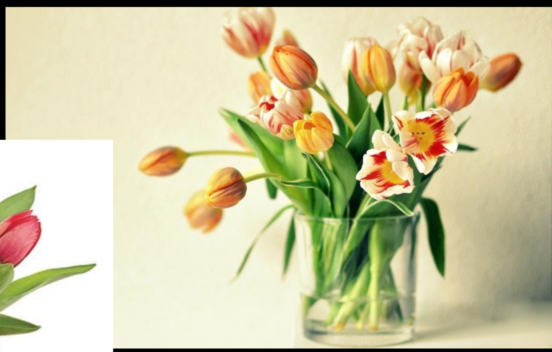
প্রফুল্লচন্দ্র রায়



Reality and Representation

e.g. botanical illustration


Narcißus alter Turcicus triphyllus
colore purpureo, ad obscurum tendente.
maculis luteis in extremo florum ad=
herescentium caudiculo n.° 1.
Narcissus alter Turcicus flore purpu=
rante n.° 2.
Narcissus alter Turcicus flore luteo cum
maculis purpurascentibus n.° 3.




Definition
The history of botanic gardens
Botanical illustration
Living collections
Role of botanic gardens
Commercial activity
Seedbanks
Botanic gardens and conservation
Herbaria
Information management systems
Starting a botanic garden

Resource centre > Botanical Illustration

Botanical Illustration

The main goal of botanical illustration is not art, but scientific accuracy. It must portray a plant with the precision and level of detail for it to be recognized and distinguished from another species.

The need for exactness differentiates botanical illustration from more general flower painting. Many great artists, from the seventeenth-century Dutch masters to the French Impressionists, such as Monet and Renoir, to modernists like Georgia O'Keeffe, portrayed flowers; but since their goal was aesthetic, accuracy was not always necessary or intended. In the hands of a talented botanical artist, however, the illustration goes beyond its scientific requirements

So why can't this job be done using photography?

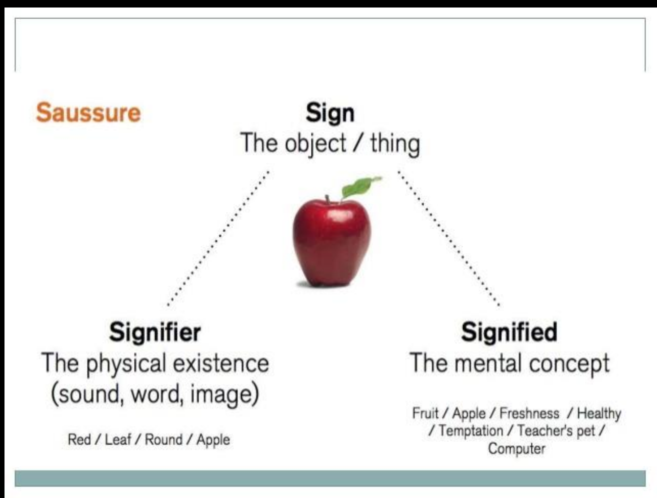
Although photography and perhaps particularly microscopic photography, may help inform botanical work, there is certainly still a need for botanical illustration because it can represent clearly what may not easily be seen in a photograph. Outline drawings for example, distinguish elements that cannot easily be made out using reflected light alone. Also, the composition of the image can be manipulated more fully in illustration, and features displayed together which may not easily be shown simultaneously in nature.

Kitāb-i ḥashā’ish [manuscript] Dioscorides Pedanius, of Anazarbos
https://franklin.library.upenn.edu/catalog/FRANKLIN_9949183233503681

Visual representations and conventions used
to generate and present data

These conventions are based on subjective choices

SEMIOTICS
Ferdinand de Saussure

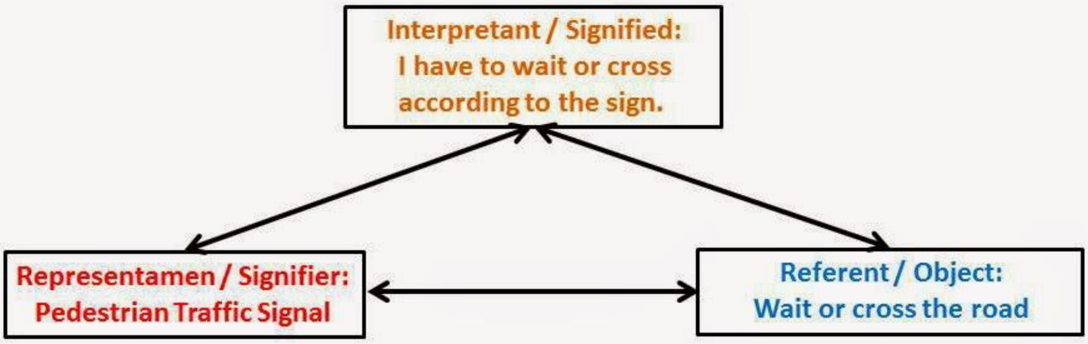


Symbol

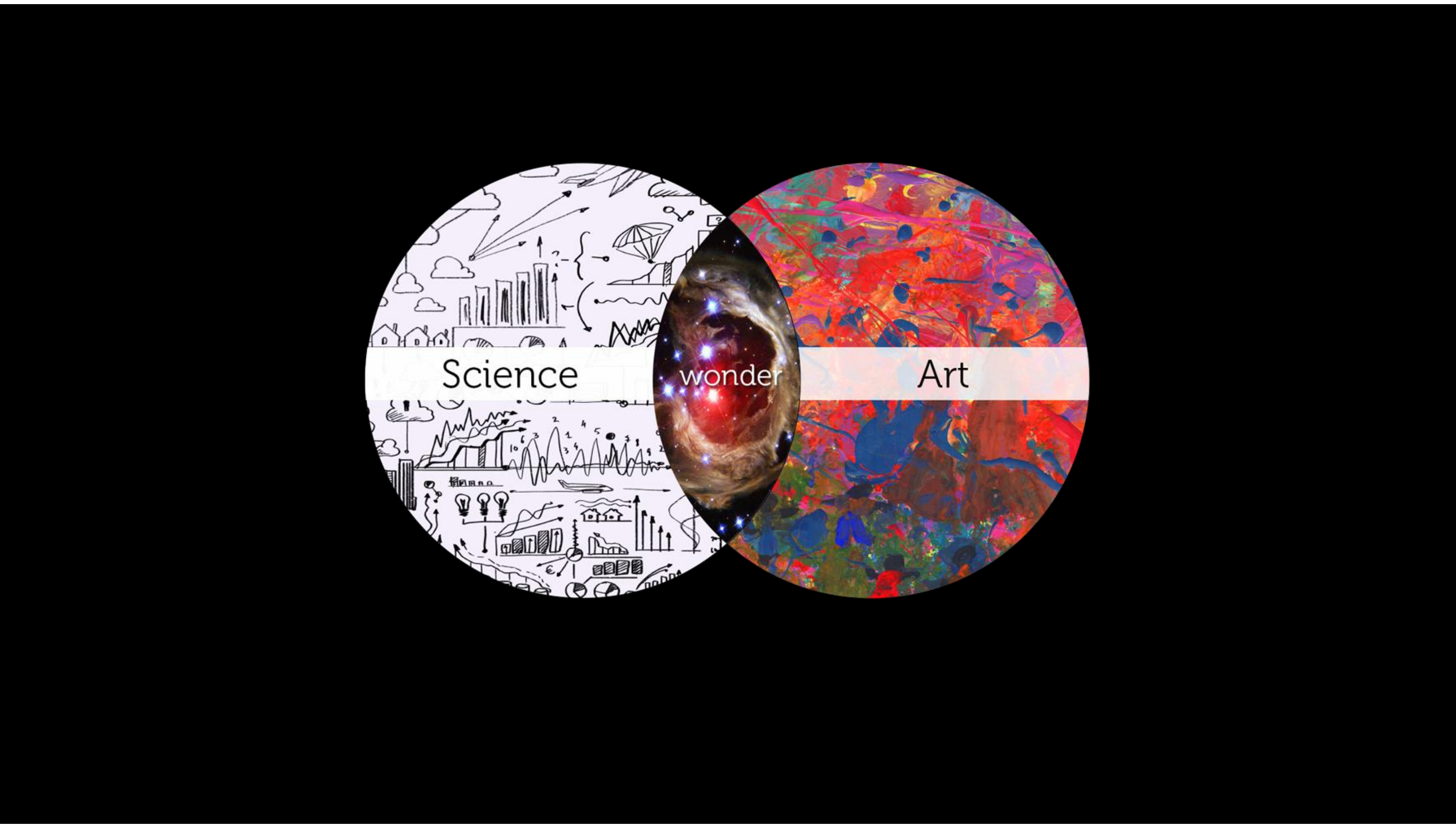
Icon

Index

The Semiotics of Charles Sanders Peirce – Symbols




Priority road
End of priority road
Traffic signals ahead
Roundabout ahead
Two-way traffic ahead
Traffic queues likely ahead
Give way to oncoming traffic
Priority over oncoming
Road narrows on both sides
Road narrows on right
10%
Steep descent
10%
Steep ascent
Road closed
No entry for vehicular traffic
Road bump ahead
Uneven road ahead
Curve
Double curve
30
Maximum speed limit
3 m 50
Maximum height
3 m 50
Maximum width
No right turn
No left turn
No U-turns
No parking
No stopping
Proceed straight
Turn right
Turn right ahead
Proceed straight or turn right


Science
wonder
Art

Applied Mechanics and Materials
ISSN: 1662-7482, Vols. 713-715, pp 664-667
doi:10.4028/www.scientific.net/AMM.713-715.664

Submitted: 2014-11-08
Accepted: 2014-11-08
Online: 2015-01-13

Research on Ocean Wave Spectra Predicting Based on X-band Radar System

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Keywords: X-band Radar; Wave spectrum; Wavelet neural network; Prediction

Abstract.A new method to predict ocean wave spectra based on X-band radar is proposed. X-band wave-measuring radar is a new powerful tool to monitor ocean wave, and is the only method that can be used to measure wave spectra onboard and in real-time. This makes wave spectra prediction possible. The real ocean wave is a non-linear process. Through screening time series prediction method based on wavelet neural network is chosen looking at its strong ability on dealing with non-linear problems. The experimental result indicates that this method is of high precision.

Introduction

Relative to wave parameters like significant wave height, wave spectra can portray the internal structure information of wave field. Now some offshore operations have very high requirements on the accuracy. Therefore, it has great practical significance to realize wave spectra prediction and obtain information of ocean wave fields.

X-band wave-measuring radar is a new powerful tool to monitor ocean wave information. Relative to traditional ocean wave spectrum measurement, X-band radar has some advantages, such as low cost, convenient and reliable. It can provide the data needed in real time[1,2]. Data used in this paper is collected from onboard WaMoS II system.

Figure 1 and figure 2 show the comparison between significant wave height data measured by BSH Buoy and WaMoS II in Helgoland, Germany.

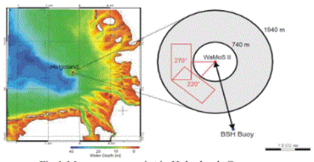


Fig 1 Measurement point in Helgoland, Germany

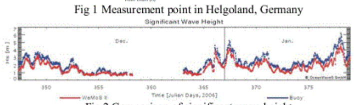
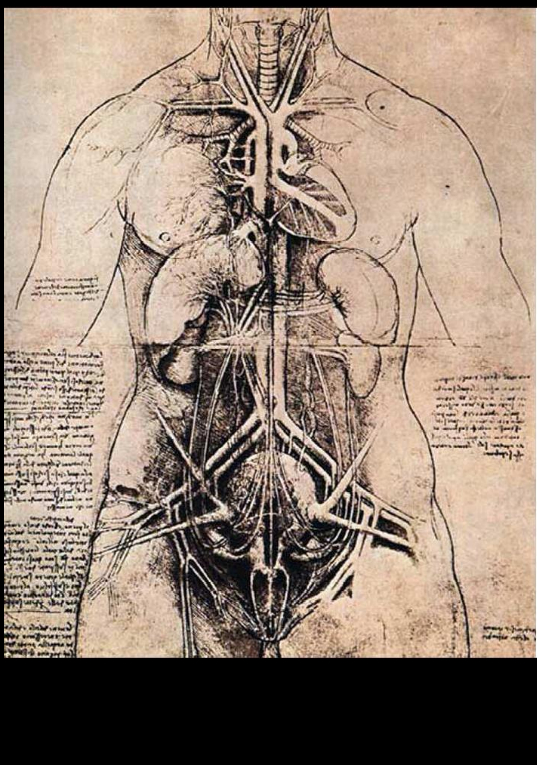
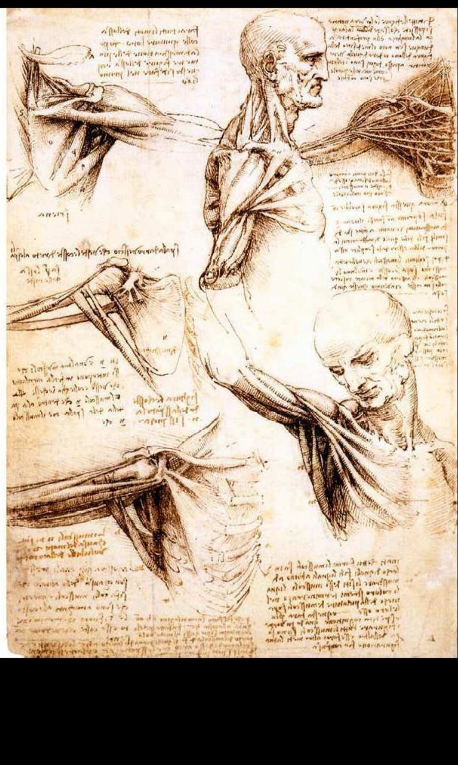


Fig 2 Comparison of significant wave height

After lots of verification, WAVEX and WaMoS II have gotten certificates of approval from DNV and GL Register of shipping because of high precision and high reliability.


冨嶽三十六景 神奈川沖浪裏

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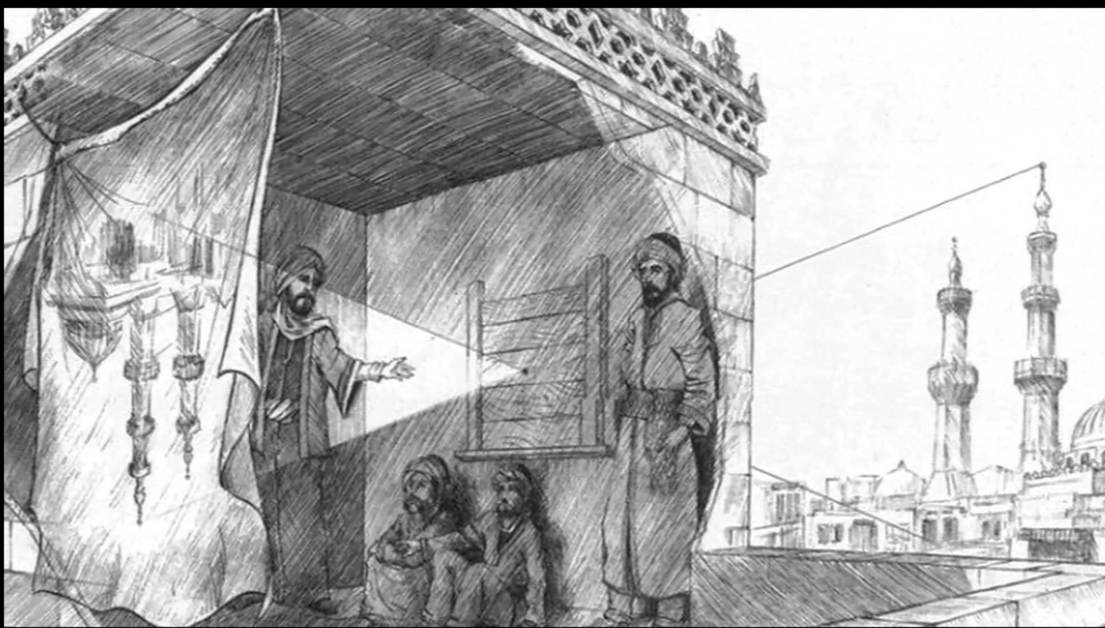

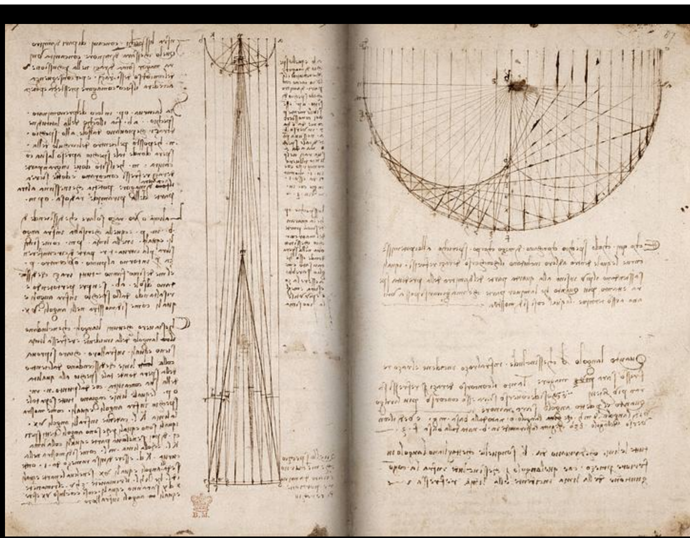

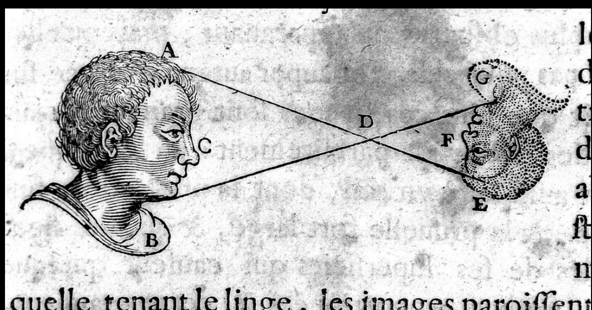
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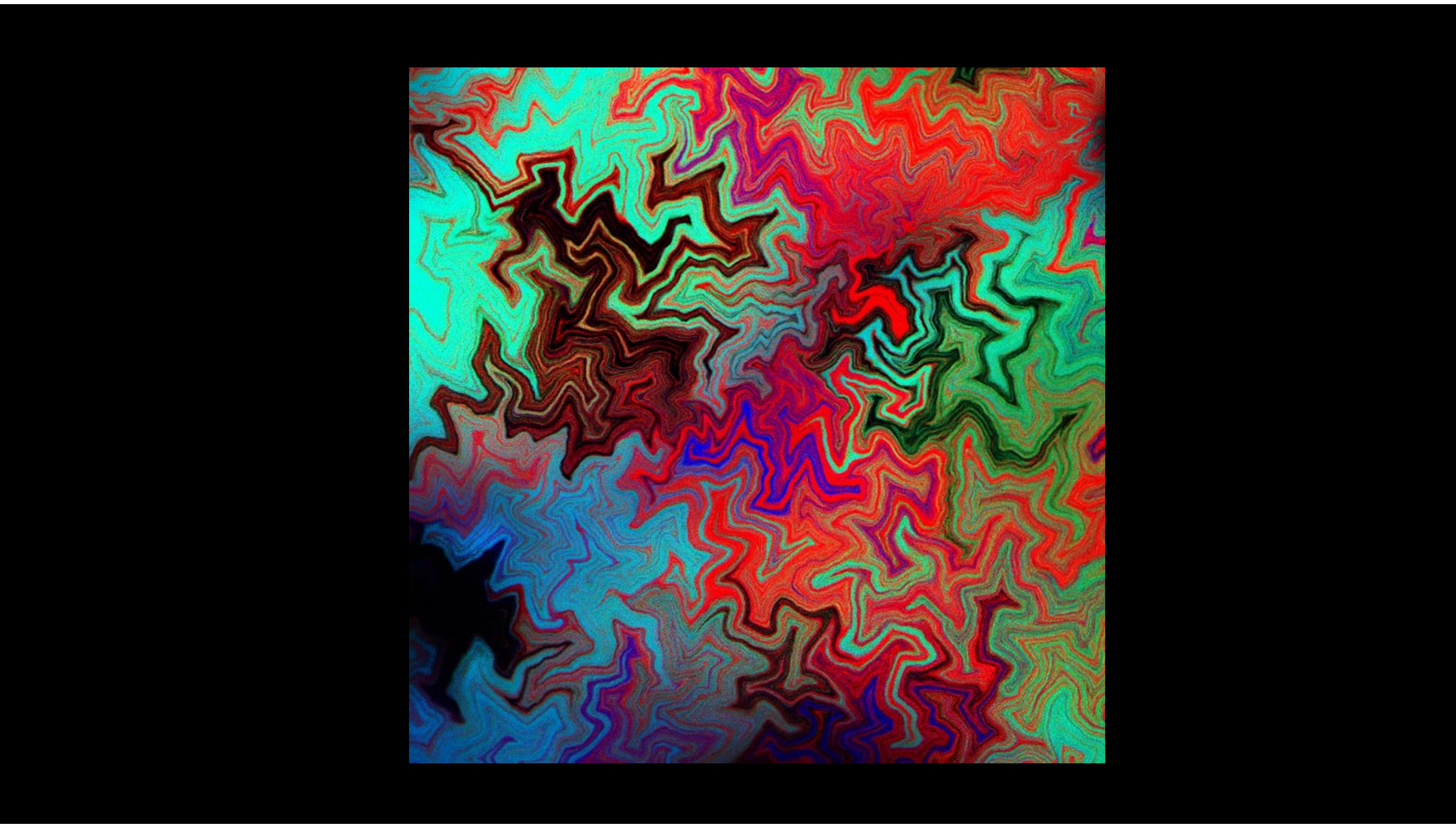
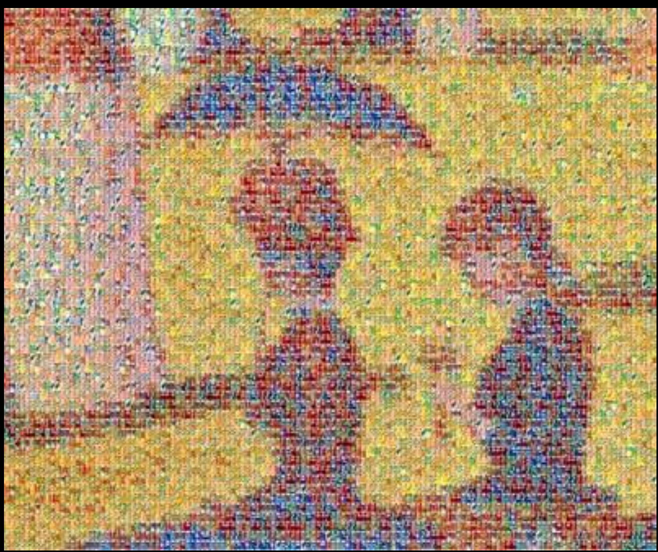
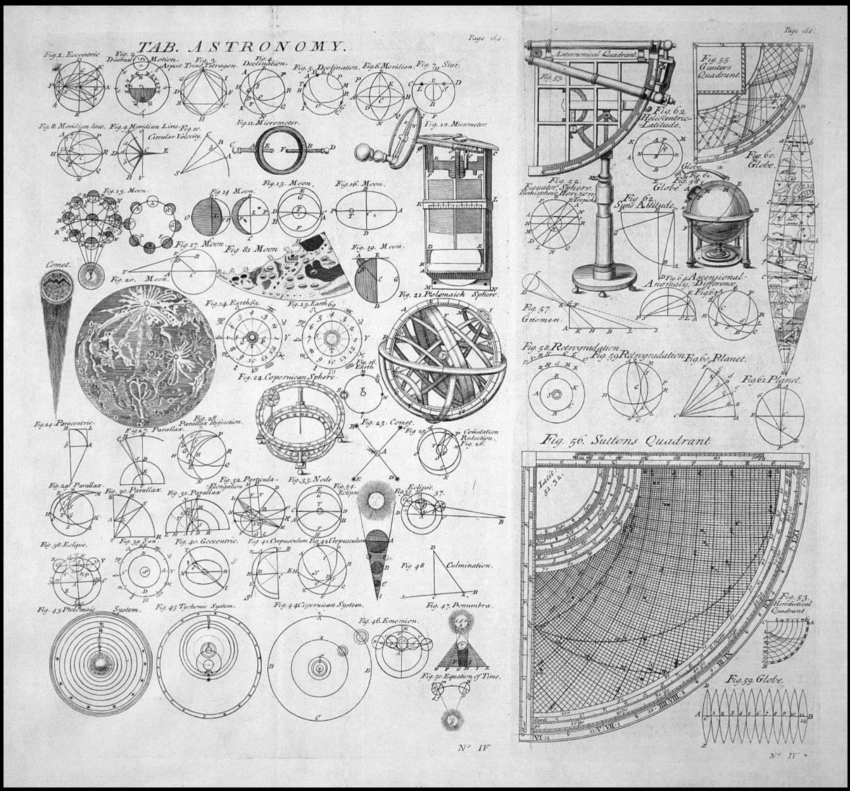


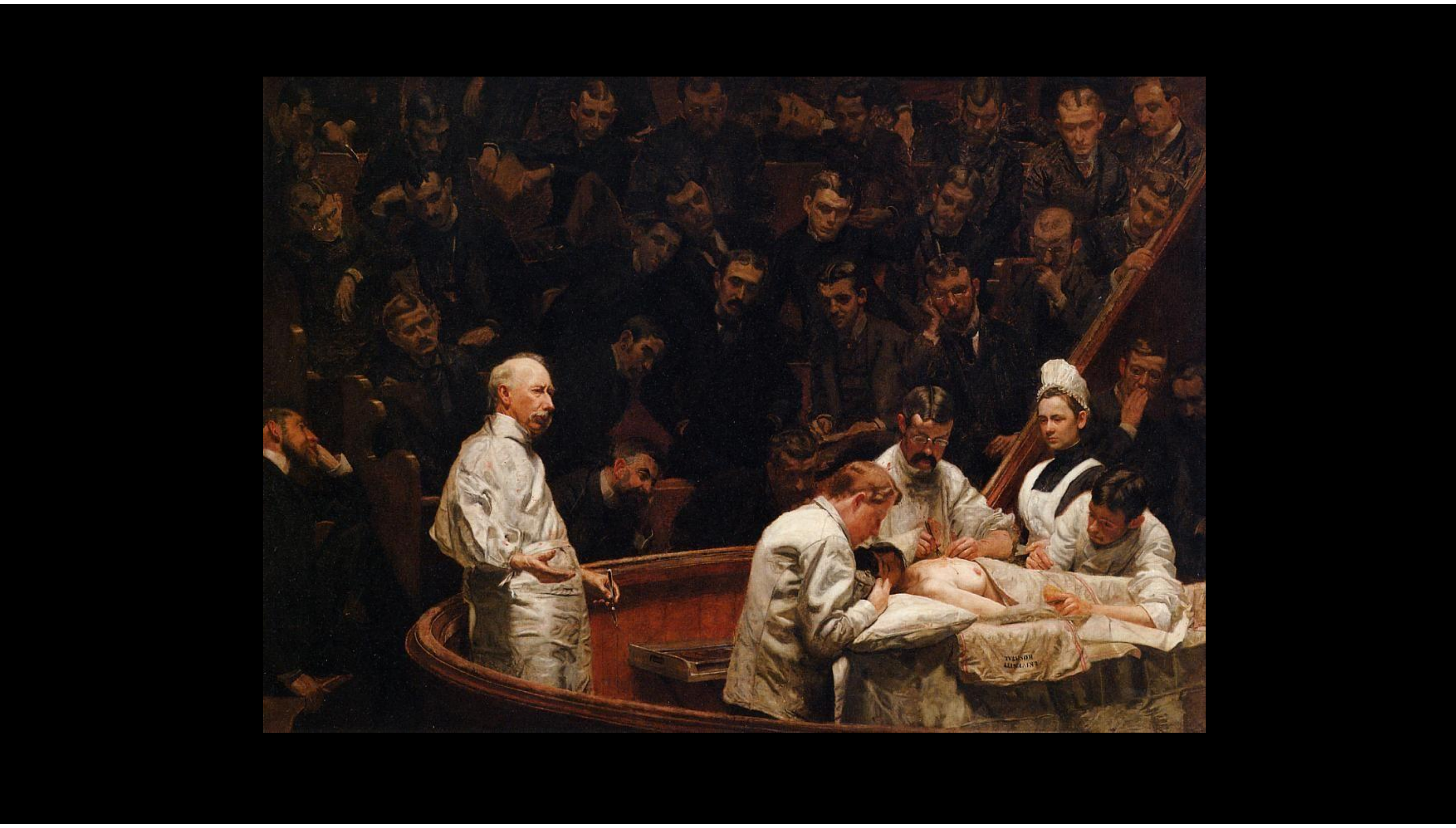


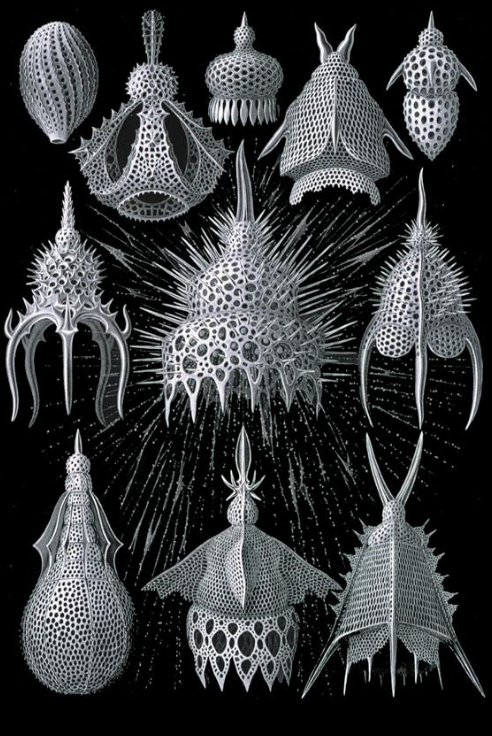
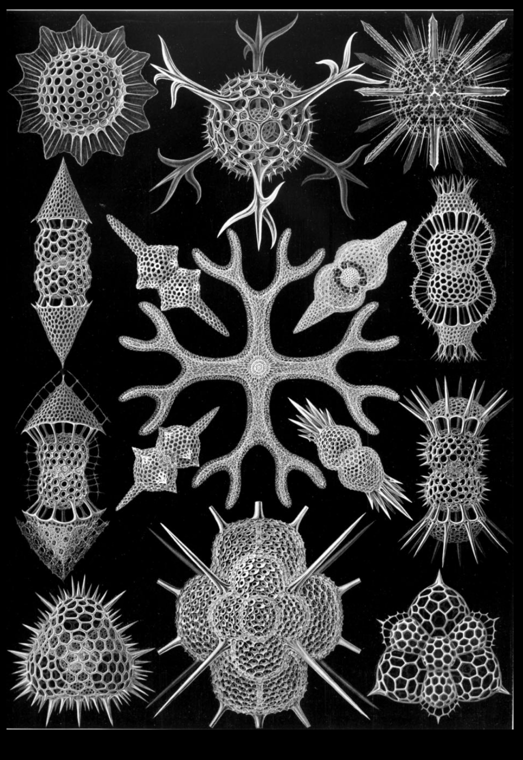

gregadunn.com

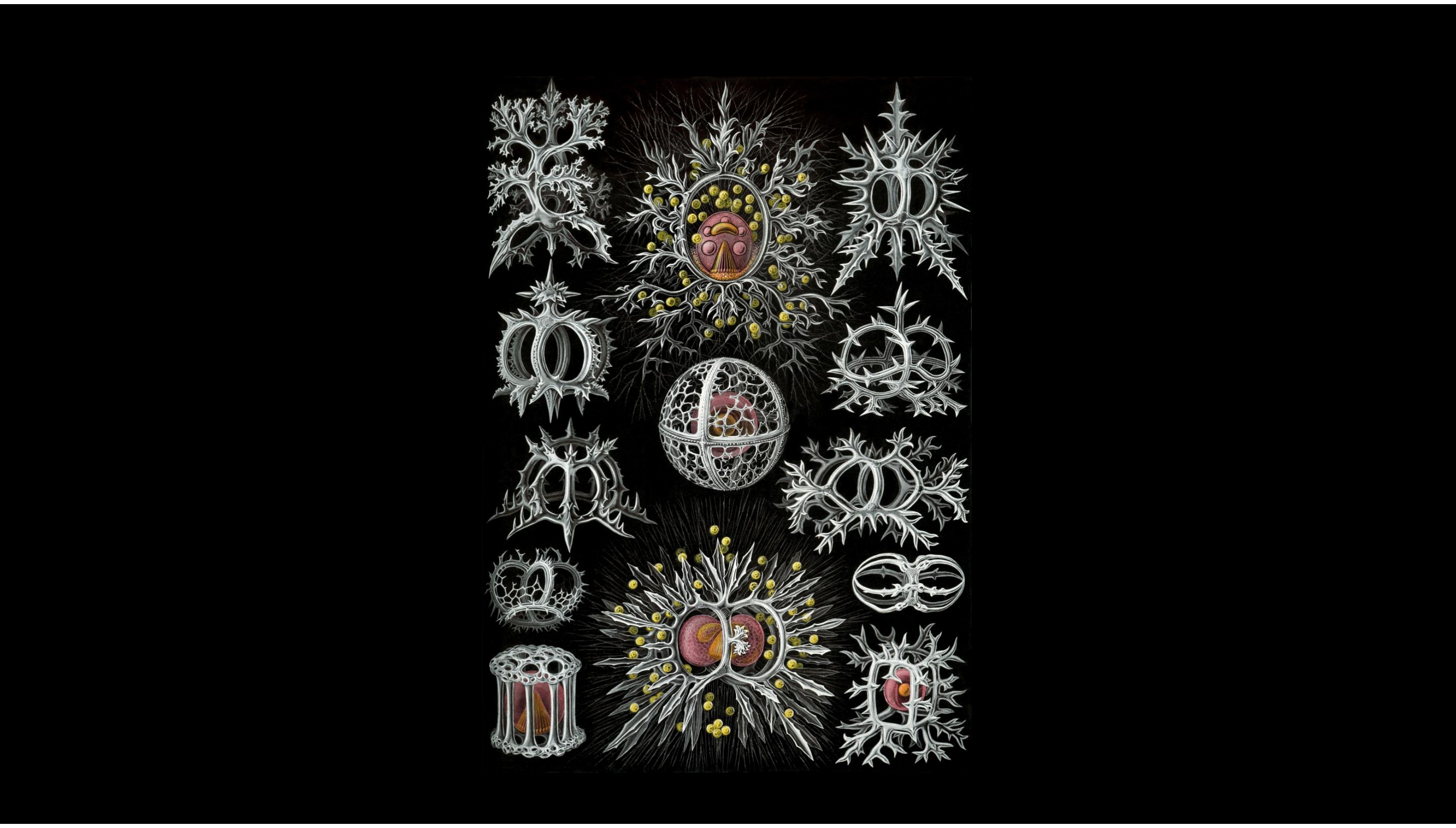
Mughal Painting
Mansur
Dodo



TAB. ASTRONOMY.
Page 162
Page 161
Fig. 56. Suttons Quadrant
Nº IV
Nº IV

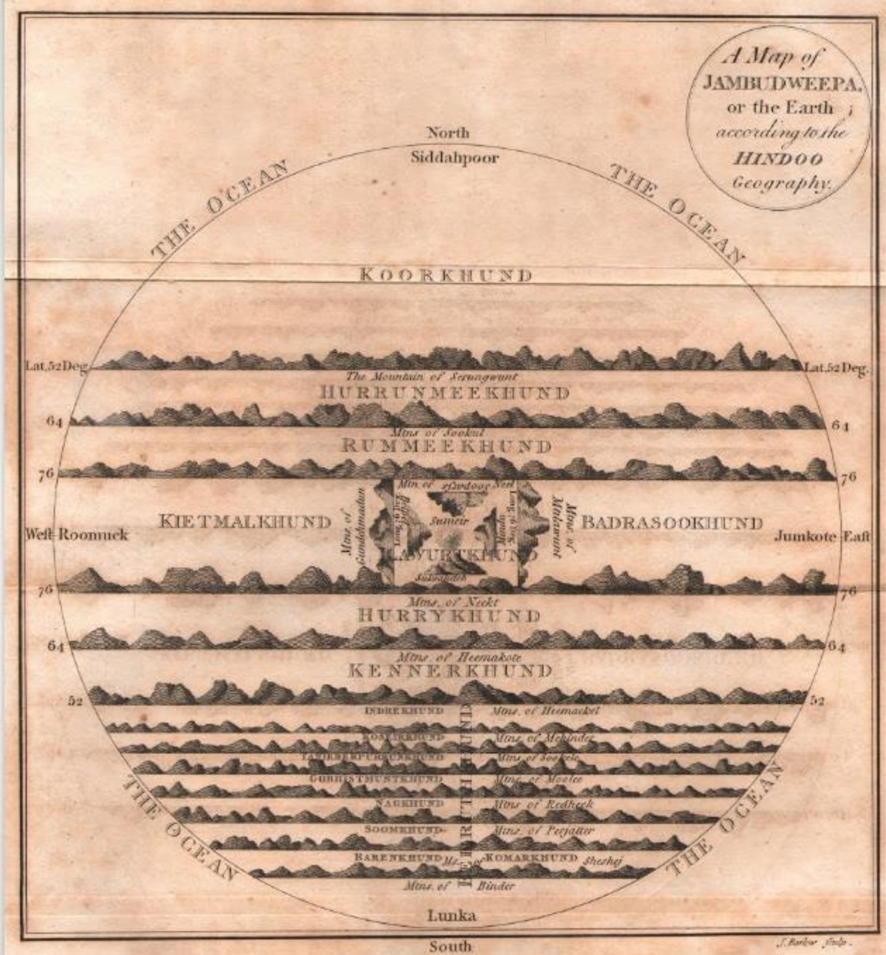




1.13 Lecture 8

SCIENCE AND RELIGION



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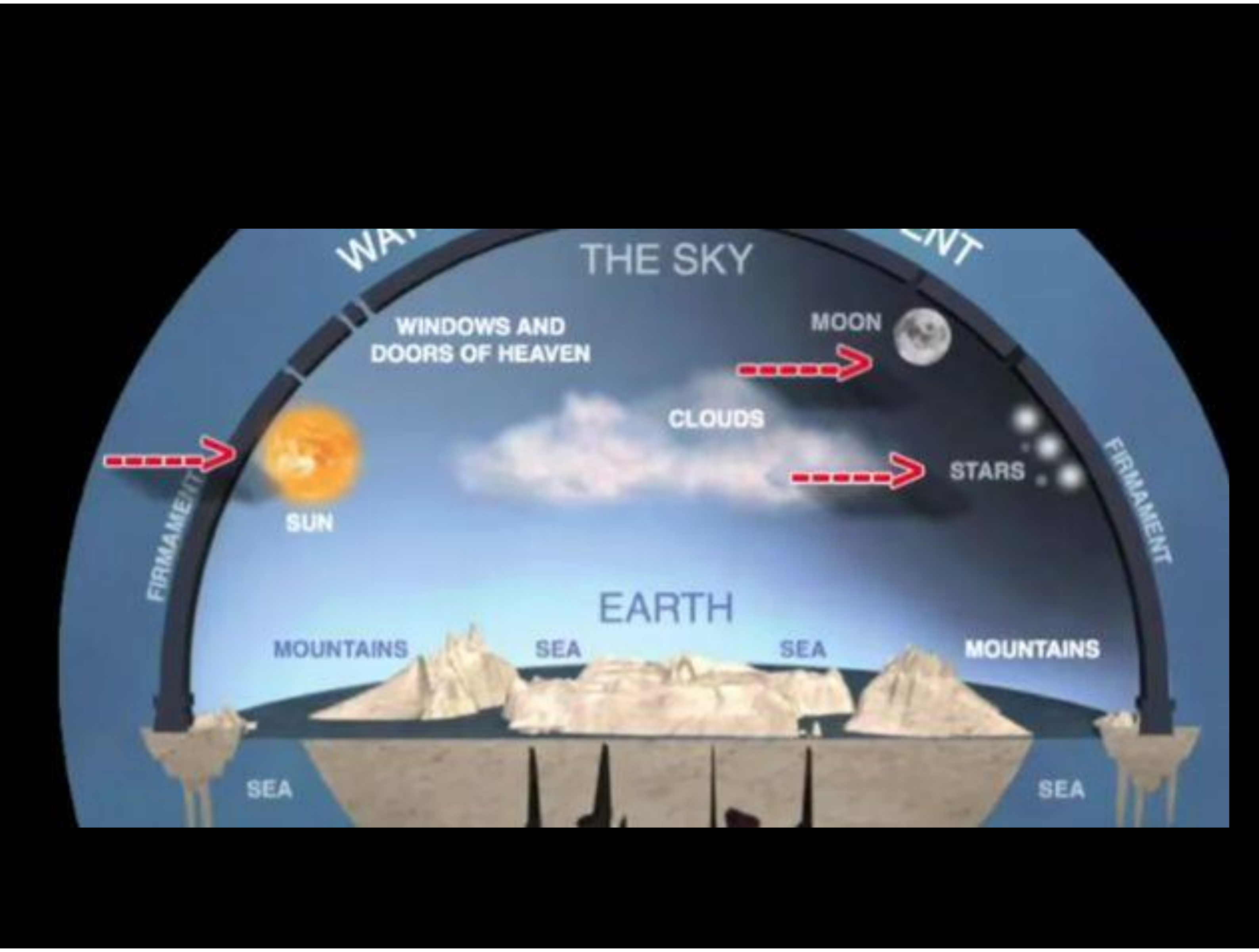

THE SKY
WINDOWS AND
DOORS OF HEAVEN
MOON
CLOUDS
SUN
STARS
FIRMAMENT
EARTH
MOUNTAINS
SEA
SEA
MOUNTAINS
SEA
SEA

FLAT EARTH | By Daniel Oberhaus | Mar 26 2018, 7:42pm

Flat Earther Survives Rocket Launch, Earth Still Round

Watch "Mad" Mike Hughes beat his own previous record by launching himself to just under 1,900 feet in a homebrew rocket.

ABC NEWS

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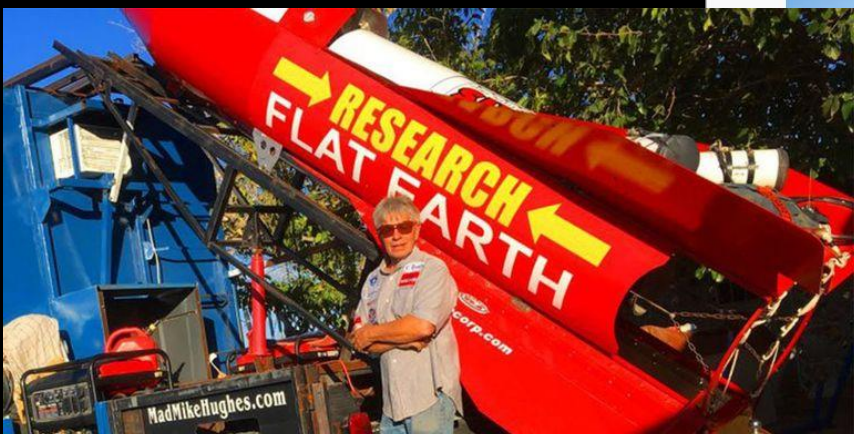
Flat Earth believer 'Mad' Mike Hughes launches himself into California's sky, quickly returns

Updated 26 Mar 2018, 2:30pm



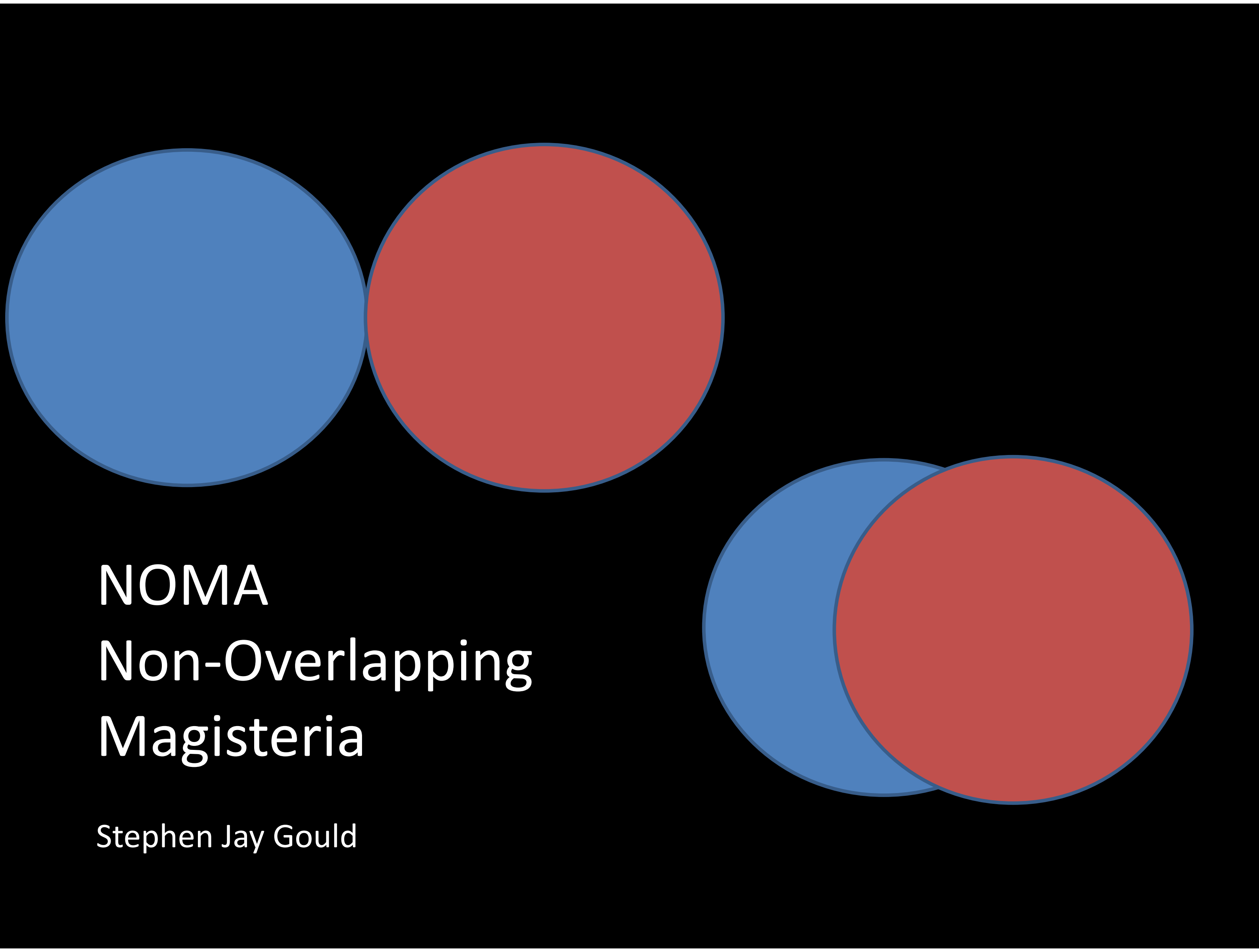
Theoretical,
Empirical, Experiential

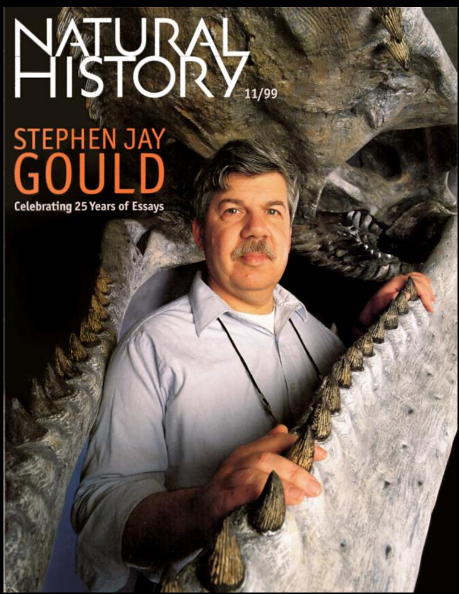
We can create theoretical models for empirical knowledge
We can create theoretical models for experiential knowledge

Empirical knowledge is reproducible! Experiential is not always!

THE SUFI SHAYKH AND THE SULTAN: A CONFLICT OF CLAIMS TO AUTHORITY IN MEDIEVAL INDIA

Simon Digby


NOMA
Non-Overlapping
Magisteria
Stephen Jay Gould

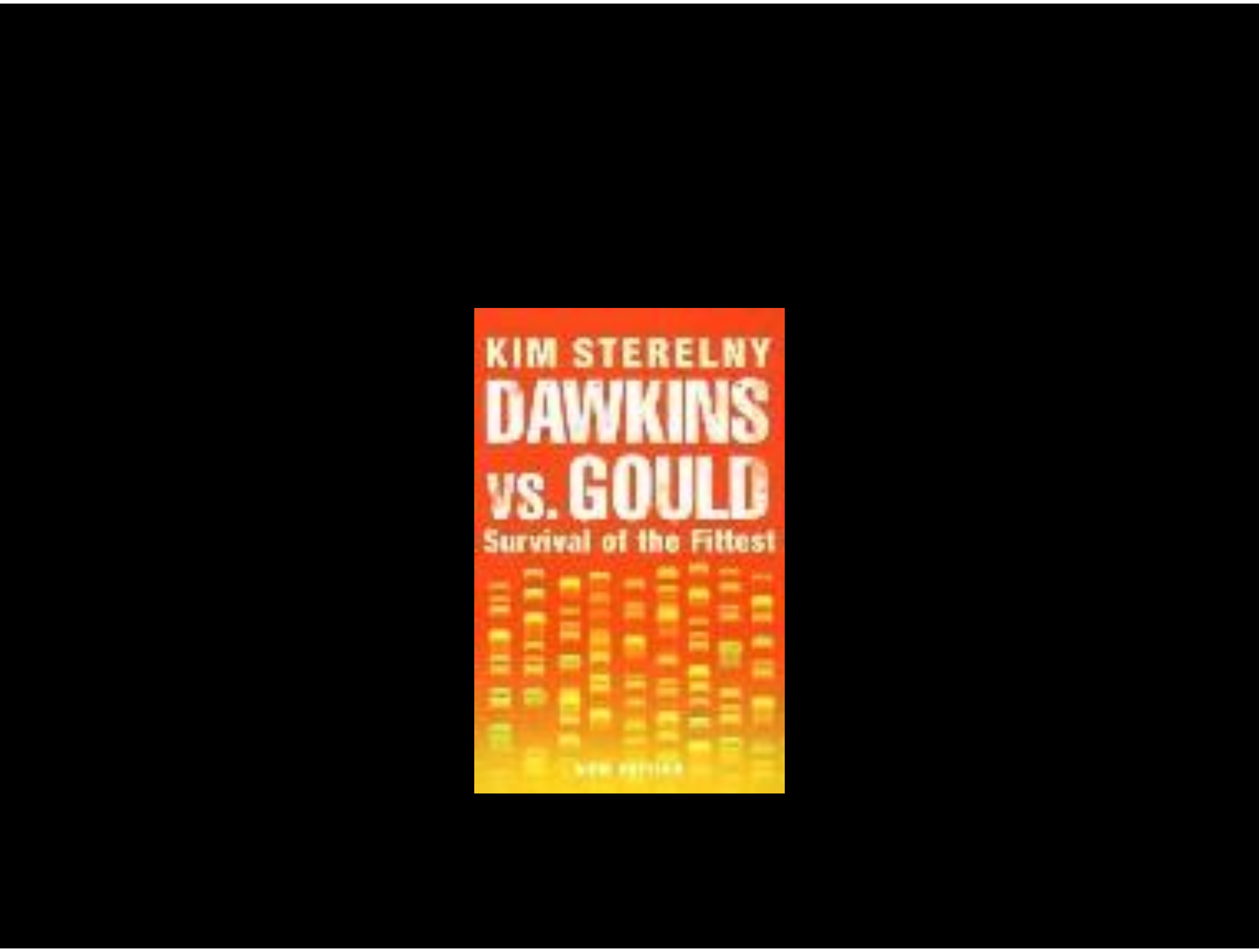


“Nothing is more dangerous than a dogmatic worldview – nothing more constraining, more blinding to innovation, more destructive of openness to novelty.”

The National Academy of Sciences adopted a similar stance. Its publication *Science and Creationism* stated :
“Scientists, like many others, are touched with awe at the order and complexity of nature. Indeed, many scientists are deeply religious. But science and religion occupy two separate realms of human experience. Demanding that they be combined detracts from the glory of each.”

"…not only is science corrosive to religion; religion is corrosive to science. It teaches people to be satisfied with trivial, supernatural non-explanations and blinds them to the wonderful real explanations that we have within our grasp. It teaches them to accept authority, revelation and faith instead of always insisting on evidence."

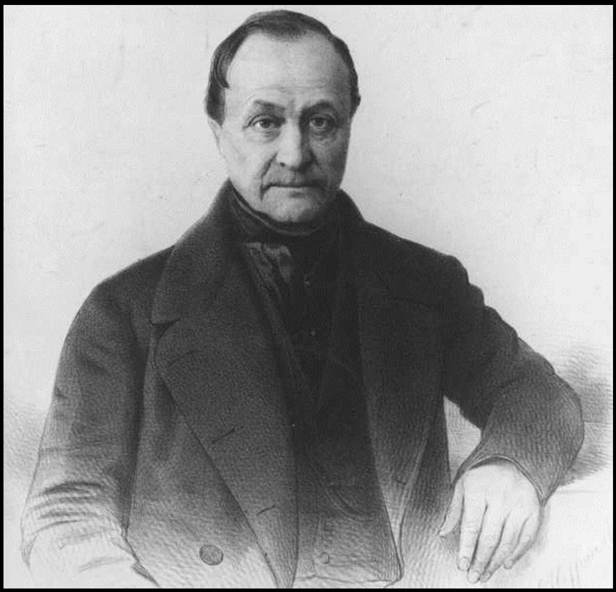
-Richard Dawkins


KIM STERELNY
DAWKINS
vs. GOULD
Survival of the Fittest

Science = reason, rationality
Religion = irrationality

Therefore, science opposed to religion.

Logic and the Existence of God

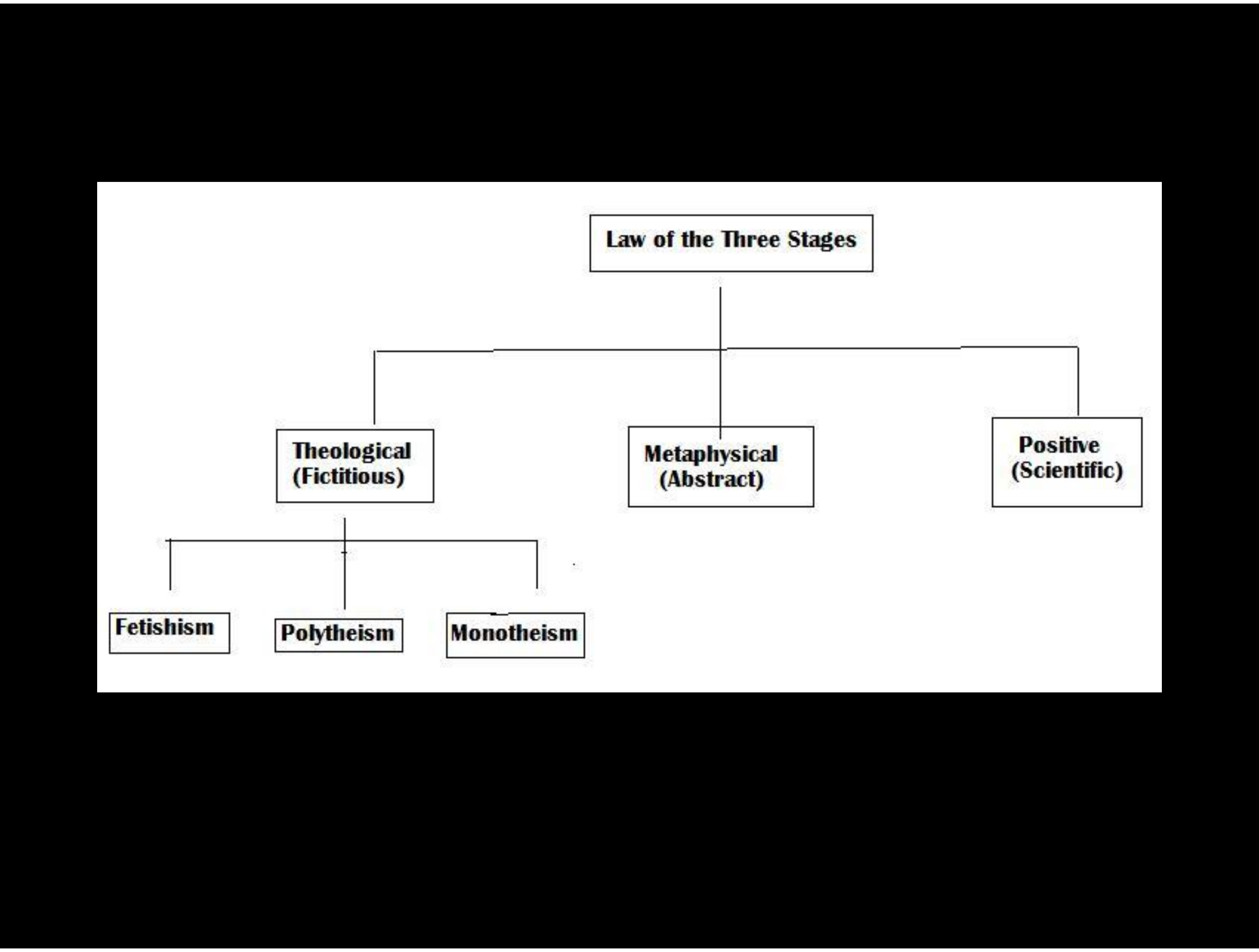


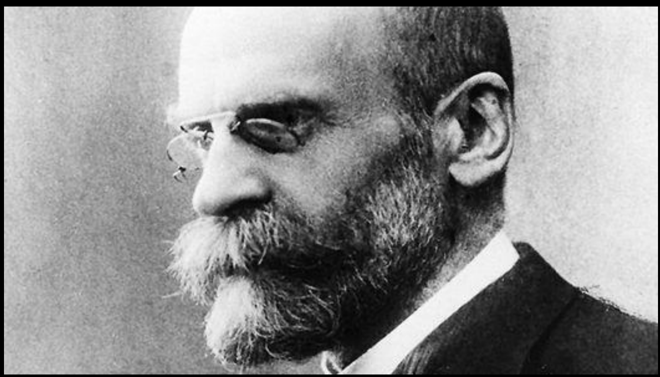
Auguste Comte (1798-1857)

Positivism

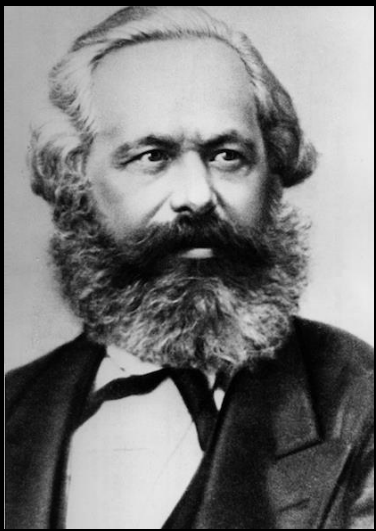
Social Evolution

1) Theological stage (2) Metaphysical stage (3) Positive stage

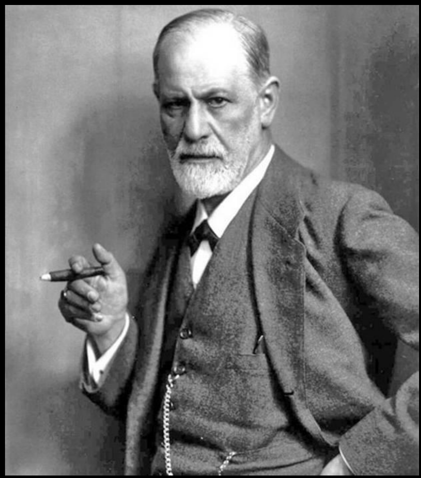

Law of the Three Stages
Theological (Fictitious)
Metaphysical (Abstract)
Positive (Scientific)
Fetishism
Polytheism
Monotheism



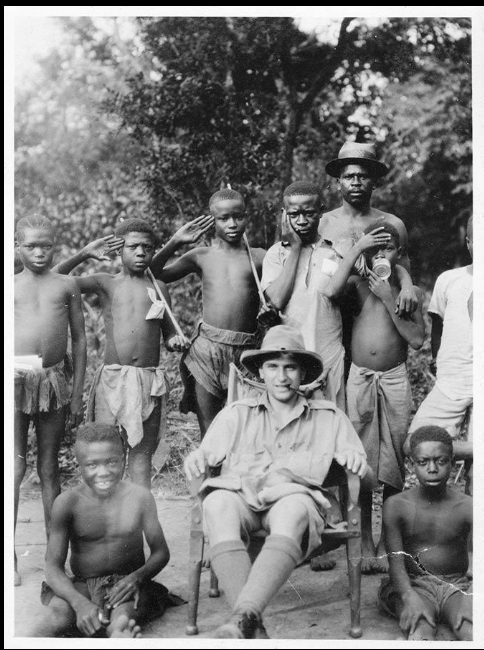
David Emile Durkheim (1858-1917)



Karl Marx (1818-1883)

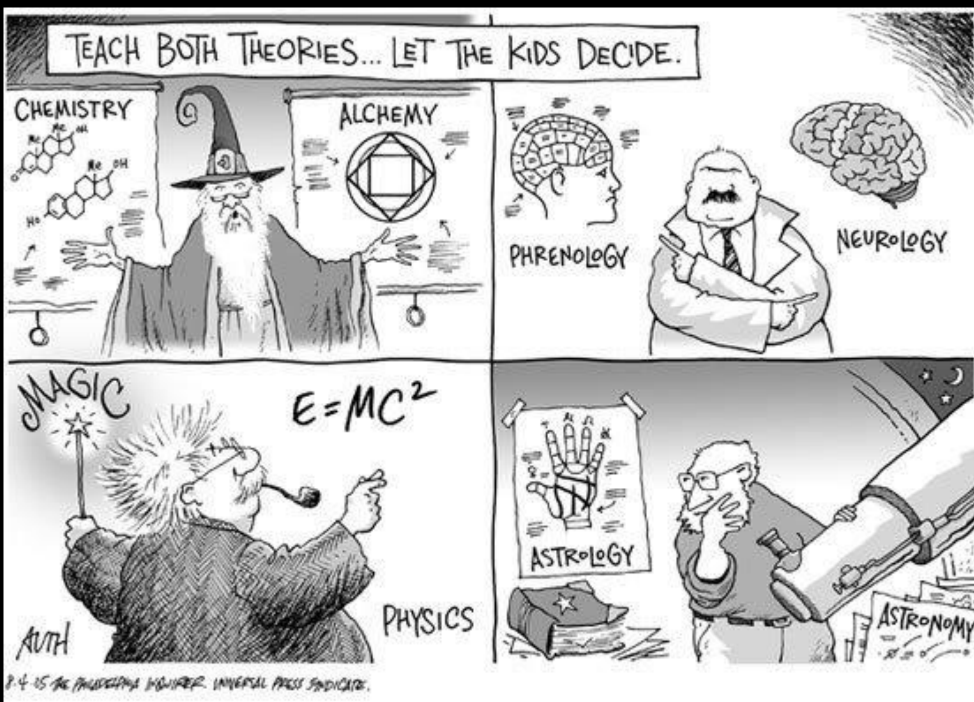


Sigmund Freud (1856-1939)



E.E. Evans-Pritchard (1902-1973)

Witchcraft, Oracles and Magic Among the Azande


TEACH BOTH THEORIES... LET THE KIDS DECIDE.
CHEMISTRY
ALCHEMY
PHRENOLOGY
NEUROLOGY
MAGIC
$E=MC^2$
PHYSICS
ASTROLOGY
ASTRONOMY
AUTH
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BIZARRO Piraro
CAPRICORN: TODAY IS A GOOD DAY TO MAKE IMPORTANT DECISIONS ABOUT YOUR LIFE BASED ON ARBITRARY NONSENSE WRITTEN BY AN ANONYMOUS STRANGER IN A NEWSPAPER.
PIRARO. © CHRONICLE FEATURES

1.14 Lecture 9

Ethics and Science

What is ethics?

- Ethics is a system of moral principles, which determines, and is determined by, what is good for individuals and society.
- Term comes from the Greek word *ethos* which can mean custom, habit, character or disposition.
- Ethics covers the following dilemmas:
    - how to live a good life
    - our rights and responsibilities
    - the language of right and wrong
    - moral decisions: what is good and bad?
- Ethics play an important role in debates on topics like abortion, euthanasia, human rights, and professional conduct.

Where do we derive our ethics/moral philosophy from?

- God and religion
- Human conscience and intuition
- a rational moral cost-benefit analysis of actions and their effects
- the example of “good” human beings
- a desire for the best for people in each unique situation

Ethics doesn’t always give one answer

- There may not always be ONE right answer; sometimes, all we have are less “wrong” ones, and the individual must choose between them.
- Sometimes, moral ambiguity is difficult because it forces us to take responsibility for our own choices and actions, rather than falling back on convenient rules and customs.
  For example, Nietzsche's “God is dead” statement.

Flipsides: Ethics is about the "Other"

- Ethics is concerned with other people. At the heart of ethics is a concern about something or someone other than ourselves and our own desires and self-interest

- Ethics is often used as a weapon. If a group believes that a particular activity is "wrong" it can then use morality as the justification for attacking those who practice that activity

Can ethical statements be objectively true?

- Do ethical statements provide information about anything other than human opinions and attitudes?

  - <u>Ethical realists</u> think that human beings *discover* ethical truths that already have an independent existence.

  - <u>Ethical non-realists</u> think that human beings *invent* ethical truths.

Moral absolutism vs. Moral relativism

- Moral absolutism argues that there are some moral rules that are always true, that these rules can be discovered and that these rules apply to everyone
- Moral relativists say that if you look at different cultures or different periods in history you'll find that they have different moral rules, and therefore nothing applies to everyone at all times

Formalized Ethics

Many professions have a formalized system of ethical practices that help guide professionals in the field:

- Doctors: the Hippocratic Oath, which, among other things, states that doctors "do no harm" to their patients.
- Engineers: an ethical guide that states that they "hold paramount the safety, health, and welfare of the public.”

Examples that have made us question the ethics of scientific practices

- Tuskegee Syphilis Study (1932)
- Fritz Haber
- Dr J Marion Sims (‘Father of modern gynaecology’)
- Wernher von Braun (Apollo Mission)
- Charles Dawson
- C V Raman

The New York Times

Syphilis Victims in U.S. Study Went Untreated for 40 Years

By JEAN HELLER
The Associated Press

WASHINGTON, July 25—For 40 years the United States Public Health Service has conducted a study in which human beings with syphilis, who were induced to serve as guinea pigs, have gone without medical treatment for the disease and a few have died of its late effects, even though an effective therapy was eventually discovered.

The study was conducted to determine from autopsies what the disease does to the human body.

Officials of the health service who initiated the experiment have long since retired. Current officials, who say they have serious doubts about the morality of the study, also say that it is too late to treat the syphilis in any surviving participants.

Doctors in the service say they are now rendering whatever other medical services they can give to the survivors while the study of the disease's effects continues.

Dr. Merlin K. DuVal, Assistant Secretary of Health, Education and Welfare for Health and Scientific Affairs, expressed shock on learning of the study. He said that he was making an immediate investigation.

The experiment, called the Tuskegee Study, began in 1932 with about 600 black men,

Formalized Ethics for Scientists

- UNESCO hosted a World Conference on Science in 1999 in Hungary, and charted the <u>Science Agenda – Framework for Action</u> of 96 points pertaining to all aspects of scientific research and dissemination. It includes ethical practices in Science such as
  - "The international scientific community, in cooperation with other actors, should foster a **debate**, including a public debate, promoting **environmental ethics** and environmental codes of conduct",
  - "University curricula for science students should include field work that relates their studies to **social needs** and realities",
  - "Scientific institutions are urged…to respect the **freedom** of scientists **to express** themselves on ethical issues and to denounce misuse or abuse of scientific or technological advances."

Scientific Ethics

- Scientific Ethics now refers to a standard of conduct for scientists that is generally delineated into two broad categories :

-First, <u>standards of methods and process</u> address the design, procedures, data analysis, interpretation, and reporting of research efforts

- Second, <u>standards of topics and findings</u> address the use of human and animal subjects in research and the ethical implications of certain research findings

Some core principles of scientific ethics

- Honesty in reporting of scientific data
- Careful transcription and analysis of scientific results to avoid error
- Independent analysis and interpretation of results that is based on data and not on the influence of external sources
- Open sharing of methods, data, and interpretations, through publication and presentation
- Sufficient validation of results through replication and collaboration with peers
- Proper crediting of sources of information, data, and ideas
- Moral obligations to society in general, and, in some disciplines, responsibility in weighing the rights of human and animal subjects

Codes of ethics in Indian Institutions

- Indian Academy of Sciences
- TIFR Guidelines on Academic Ethics
- Indian Council of Medical Research

Sources

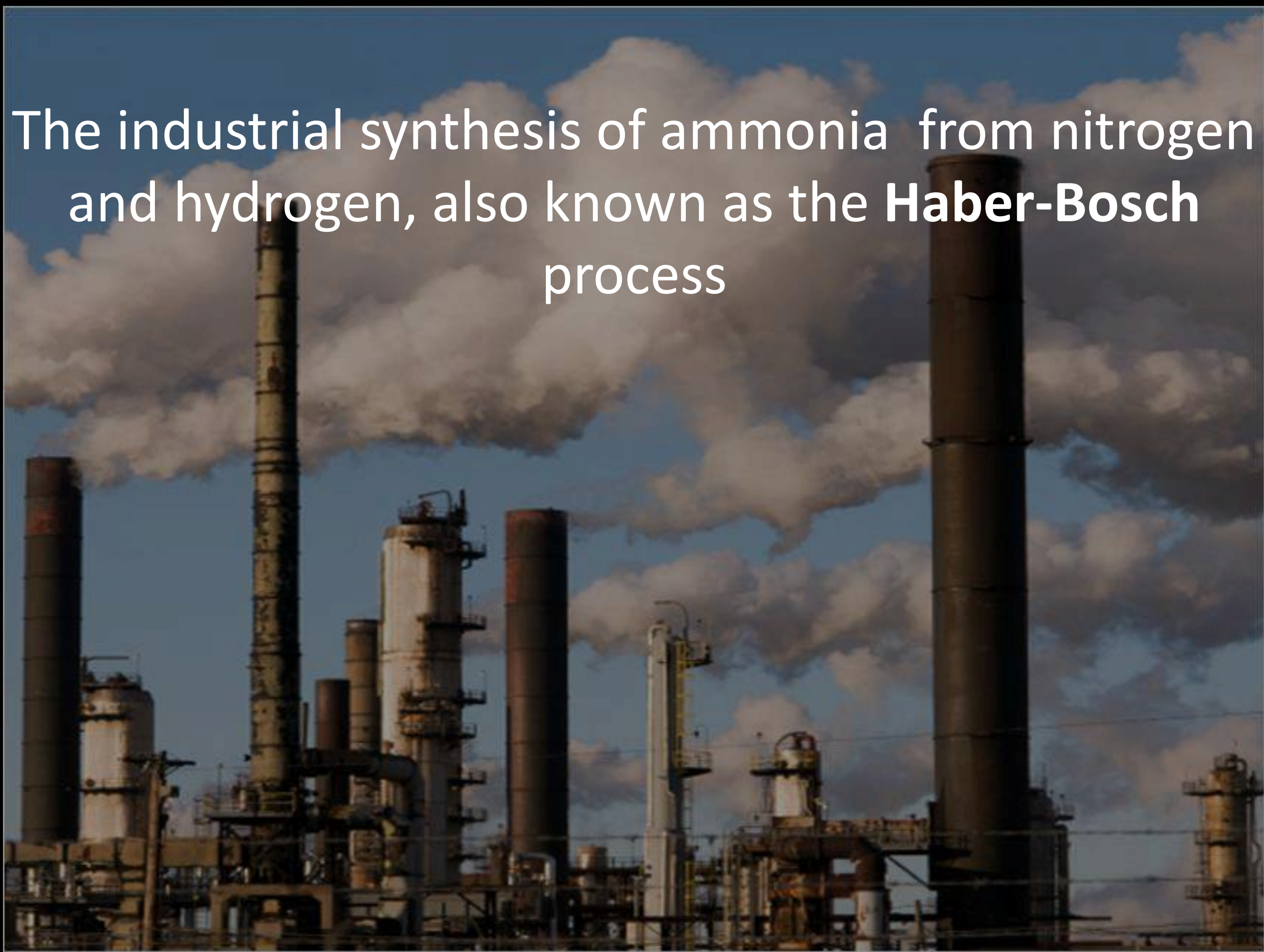
- http://www.bbc.co.uk/ethics/introduction/intro_1.shtml
- https://www.visionlearning.com/en/library/Process-of-Science/49/Scientific-Ethics/161
- http://www.unesco.org/science/wcs/eng/declaration_e.htm
- https://www.etikkom.no/globalassets/documents/english-publications/1/guidelines-for-research-ethics-in-science-and-technology-2008.pdf

A scientific-technological invention of the 20th century that has massively impacted human society

Science and Technology

- **Science**: a system of knowledge concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation.
- **Technology**: the application of scientific knowledge to the practical aims of human life or to the change and manipulation of the human environment.

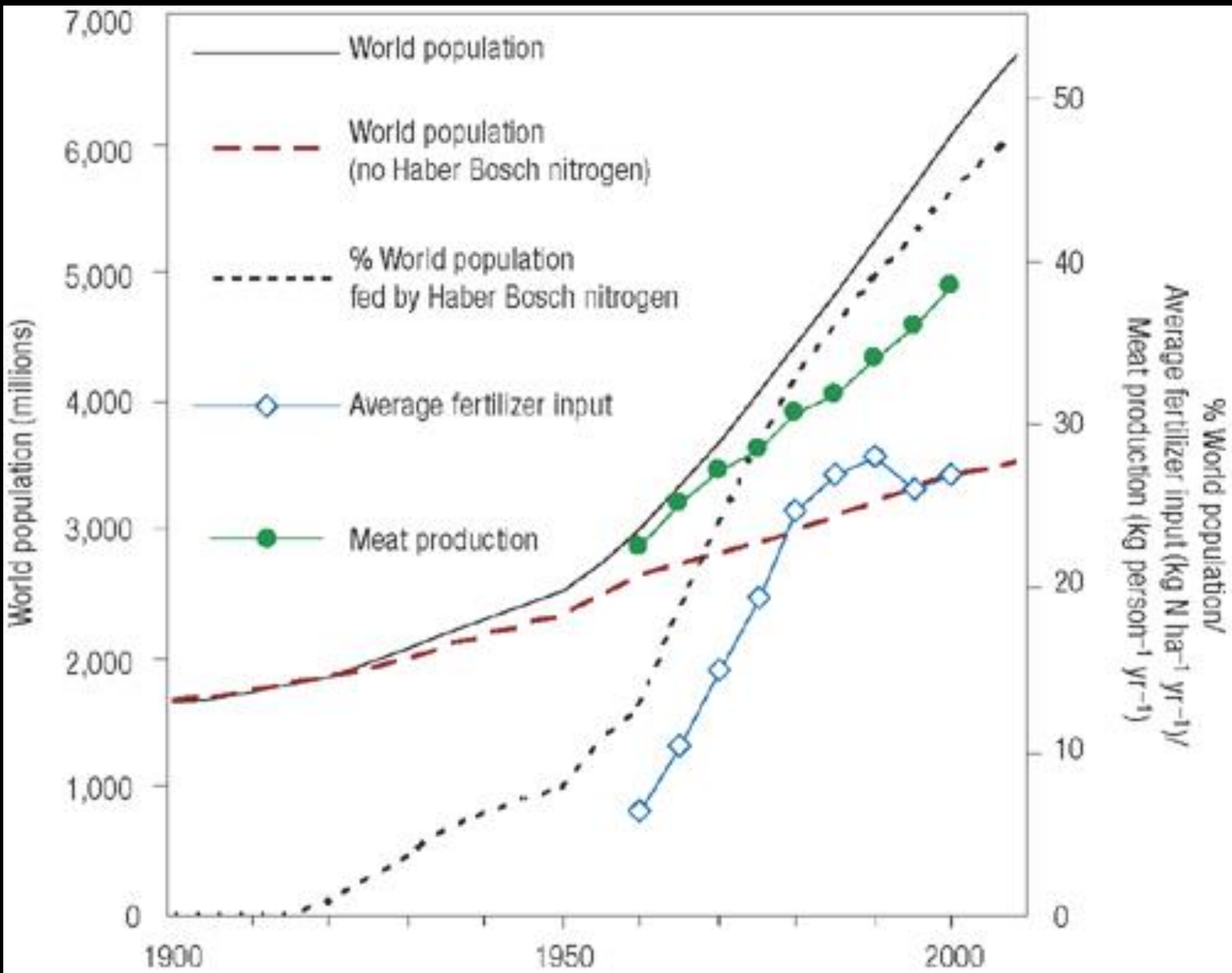
(www.britannica.com)


The industrial synthesis of ammonia from nitrogen and hydrogen, also known as the **Haber-Bosch** process

Vaclav Smil says…

“What is the most important invention of the twentieth century? Aeroplanes, nuclear energy, space flight, television and computers will be the most common answers. Yet none of these can match the synthesis of ammonia from its elements. The world might be better off without Microsoft and CNN, and neither nuclear reactors nor space shuttles are critical to human well-being. But the world’s population could not have grown from 1.6 billion in 1900 to today’s six billion without the Haber–Bosch process”

- (Canadian scientist and science policy expert Vaclav Smil in *Nature*, 1999).



World population
World population
(no Haber Bosch nitrogen)
% World population
fed by Haber Bosch nitrogen
Average fertilizer input
Meat production
World population (millions)
% World population/
Average fertilizer input (kg N ha^{-1} yr^{-1})/
Meat production (kg person^{-1} yr^{-1})
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
50
40
30
20
10
0
1900
1950
2000

Agriculture in the late 19th Century in Europe/US

- Scientific practices in agriculture: techniques such as crop rotation, selective breeding to enhance produce
- In the 1840s, nitrogen was identified as a critical element for agriculture
- Nitrogen-rich natural fertilizers at the time included bird and bat guano (prized and imported) and nitrates extracted from Chilean mines. In fact, guano had caused wars!
- By the early 20th century, it was recognized that such organic replacement was increasingly not enough— and would not last for ever

FOR

COTTON, CORN, AND ALL SPRING CROPS

ALLISON & ADDISON'S

"STAR BRAND"

GUANO

Spring of 1884.

We again offer this standard trustworthy Fertilizer to Planters and Farmers as having stood the test of **THIRTEEN YEARS'** use in Virginia and North Carolina, on all varieties of soils, and in good and bad seasons.

The "**STAR BRAND**" **GUANO**, as a fertilizer for all crops, is justly ranked with the very best made, and no brand has given more general satisfaction.

FOR COTTON

When used on Cotton, it not only starts the plant early and gives it a vigorous growth, but causes it to fruit well and mature early and perfectly, making the finest lint. It does not impoverish the soil, but improves it. There is not a single article which enters into the composition of this Manure which is not a first-rate fertilizing material.

FOR CORN

There is no crop upon which the use of a good commercial fertilizer pays better than corn. In an ordinary season it will pay 100 per cent. profit on the cost—and, in case of drought, many instances have come to our knowledge in which, in consequence of the early start and vigorous growth given the crop by the fertilizer, it has made a large yield, while other fields, of as good or better land, were cut off by the drought and scarcely yielded anything.

Its very high grade, fine condition, and low price commend it to those farmers who want to use the best fertilizer for the above crops.

Every bag is Guaranteed to be of Standard quality.

ALLISON & ADDISON, - - Manufacturers,

RICHMOND, VA.

[OVER.]

The Haber-Bosch Process

Fritz Haber and Carl Bosch invented the process of ammonia synthesis from abundantly available nitrogen and hydrogen for commercial and industrial production

The Haber Bosch Process

- The process of fixing atmospheric nitrogen to produce synthetic nitrate under high pressure and temperature, leading to ammonia production
- German chemist **Fritz Haber**: successful laboratory process of ammonia synthesis in 1909
- The process is purchased by a German chemical firm, BASF
- BASF appoints **Carl Bosch** to convert this to industrial/commercial scale
- Industrial synthesis of ammonia to produce fertilizers begins in 1913

Points to Remember

- WWI – Germany did not have access to Chilean saltpeter mines (controlled by British companies). The industrially manufactured ammonia was used to produce nitric acid, a precursor of the nitrates used in explosives
- Today:

  - the Haber Bosch process produces more than 100 million tonnes of ammonia per year

  - This process feeds about half the world's population

  - 3-5% of the world's natural gas production is consumed by this process

  - Almost 50% of the nitrogen found in human tissue is thanks to this process

  - Also called the "detonator of population explosion", allowing the human population to grow from 1.6 billion in 1900 to the 7.7 billion we are today

Fritz Haber

"During peacetime, a scientist belongs to the world, but during war time, he belongs to his country" - Haber

About Fritz Haber

- 1868-1934
- Born in a Jewish family in Germany but converted to Lutheranism in 1892
- Identified himself as a German more than with his religion
- Nobel Prize in Chemistry in 1918 for the Haber-Bosch Process
- Also called the “father of chemical warfare” – did pioneering work in the development of weaponised chlorine and other poisonous gases that were used by the German military during WWI
- Was present in person in Belgium the first time chlorine was used in trench warfare, caused 67,000 deaths
- Also developed gas masks
- Headed a “gas troops” elite unit for the military, actively recruited physicists, chemists, engineers to develop weaponised gases
- Haber's law: a mathematical statement of the relationship between the concentration of a poisonous gas and how long the gas must be breathed to produce death, or other toxic effect.
- By 1931, anti-Jewish sentiment was on the rise in Germany, and Haber, along with others, was targeted
- 1933 – resigned from the post of Director of the Kaiser Wilhelm Institute and traveled to various parts of Europe
- 1934 – died in Basel

Carl Bosch

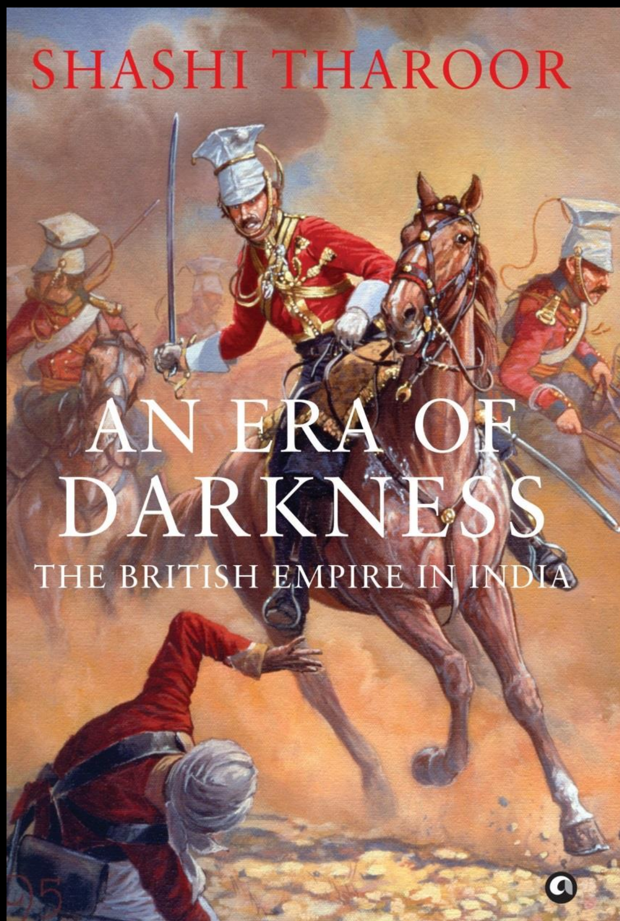
About Carl Bosch

- 1874-1940
- German chemist and engineer, also the founder of IG Farben, at one point the world's largest chemical company
- Nobel Prize in Chemistry in 1931 for high pressure chemistry
- Joined BASF in 1899
- Constructed a plant and the equipment required to convert Haber's tabletop reaction to an industrial scale
- Also worked on synthetic fuel and methanol production through high-pressure techniques
- Was a critic of many Nazi policies, and once Hitler became Chancellor, he lost most of his high positions
- Fell into despair and alcoholism
- 1940 – died in Heidelberg
- Asteroid 7414 is named after him

A few decades later:
The possibility of a global food crisis

Bengal famine in the 1940s

“Everything else can wait, but not agriculture.” Nehru


SHASHI THAROOR
AN ERA OF DARKNESS
THE BRITISH EMPIRE IN INDIA

Agricultural practices in India

- Centuries-old practice in the subcontinent
- Colonial India: expansion of agricultural land (deforestation)
- Addressing regional famines as well as serving colonial demands (Cotton, tea, spices, opium…)
- Beginning of agricultural research: establishment of institutes and colleges since late 1800s
- Use of synthetic fertilizers and pesticides began by first few decades of 20th century

Green Revolution

Norman Borlaug (Nobel peace prize 1970), Father of the Green Revolution

(invited to India by M S Swaminathan in 1961 to deal with the mass famine that India was on the brink of)

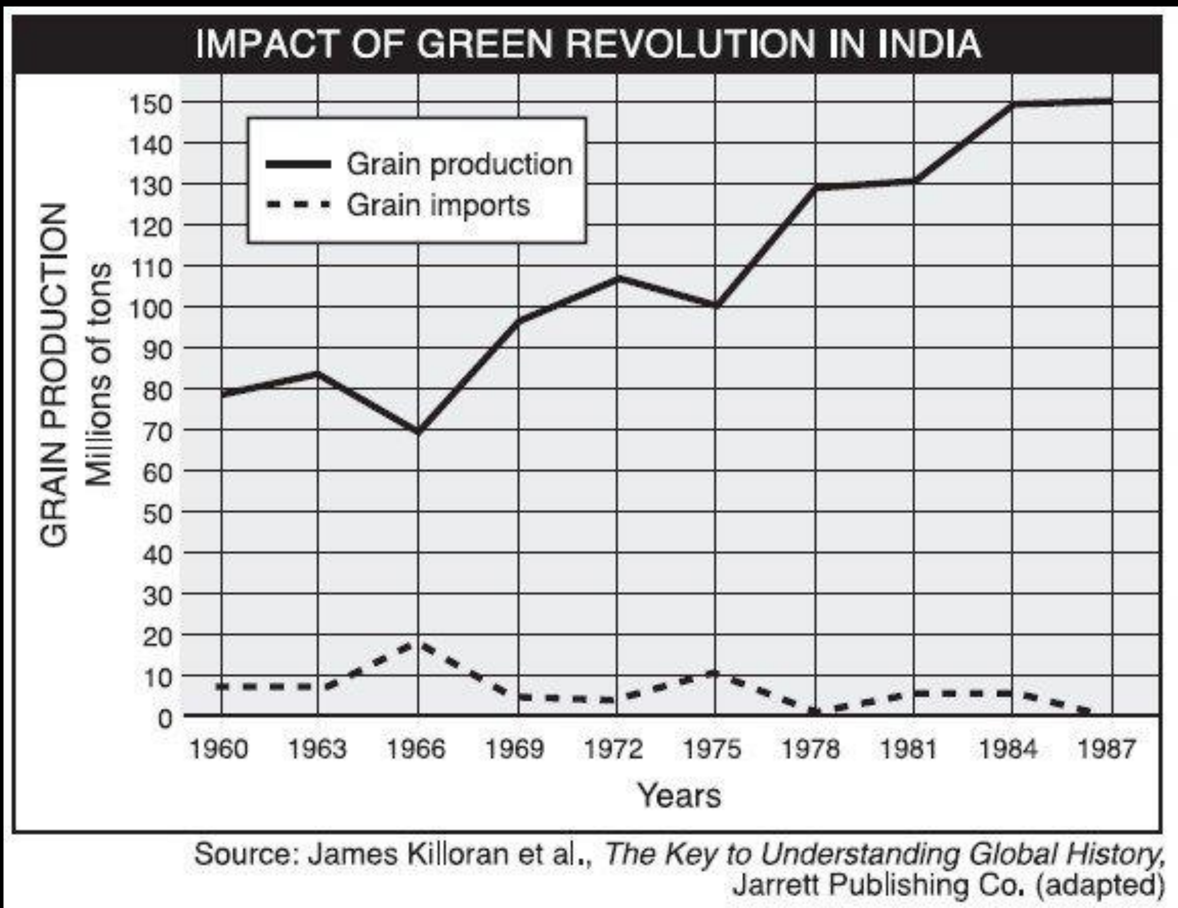
- 1950-60s
- Experimental research in the US with high-breeding and disease-resistant strains of wheat and rice + technologies
- Expansion of irrigation techniques + increased use of synthetic fertilizers and pesticides
- Introduction in 1960s into developing countries—Mexico, India, Pakistan
- Weapon grade urea suddenly available in US, Europe—developing countries as markets
- Led to considerable self-sufficiency of food grains in India

Green Revolution

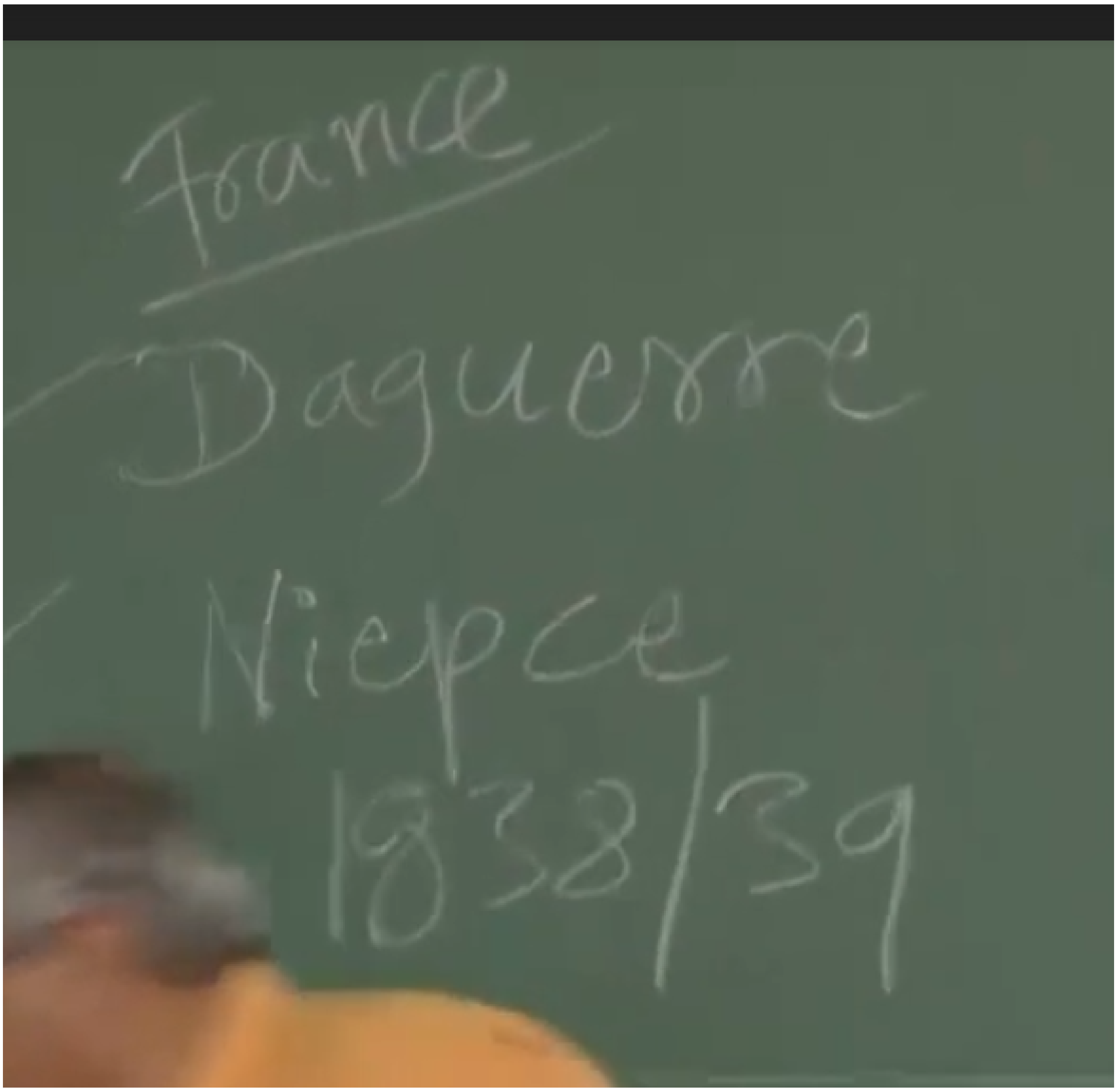
- Selective breeding of plants
  - that had the largest seeds
  - that were not sensitive to day length
- High yield varieties of crops
  - domesticated plants that respond to fertilizers
  - produce an increased amount of grain
- Intensified use of fertilizers and pesticide
- Gradual deterioration of soil as well as decline in biodiversity—monocultures

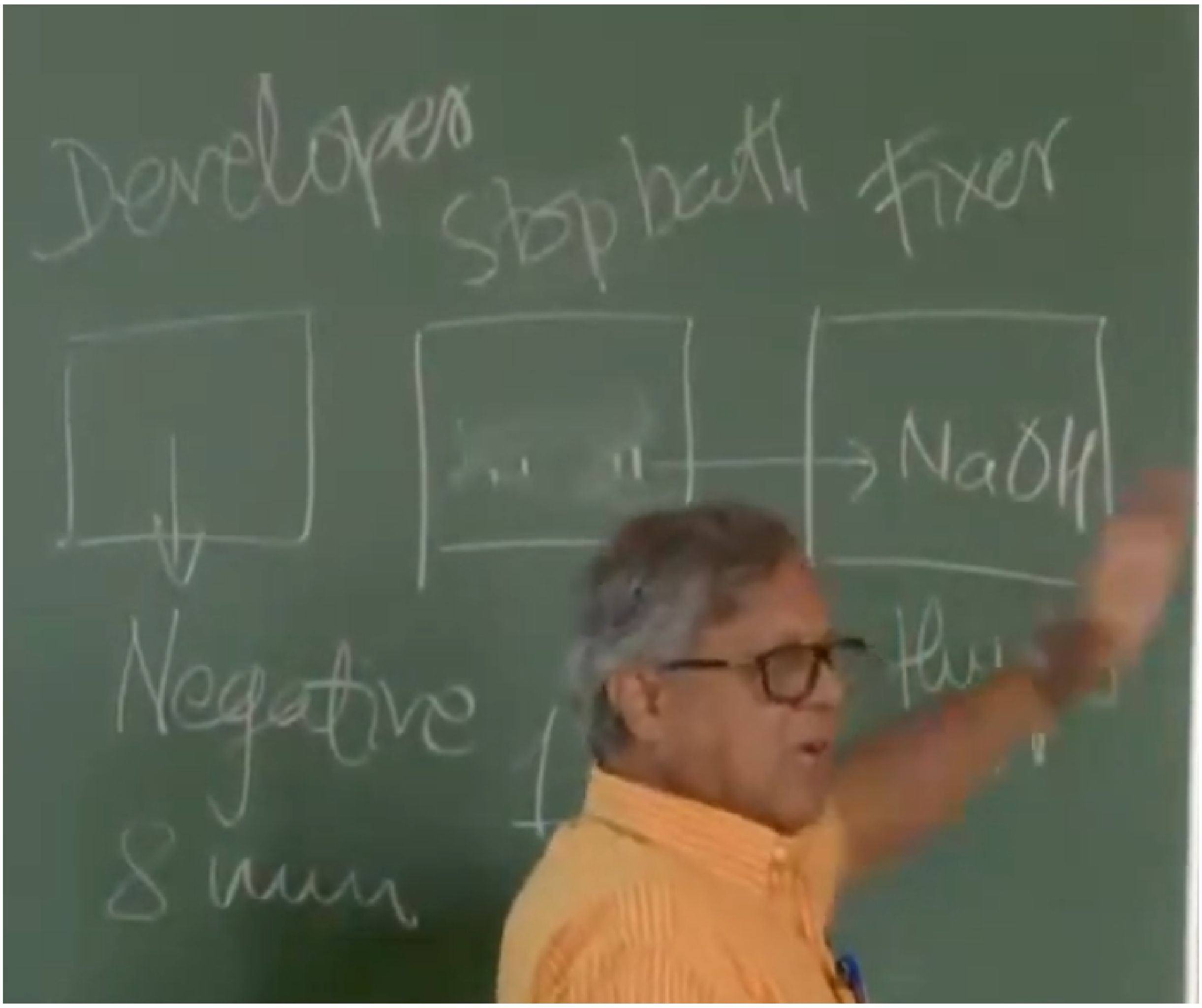
Green Revolution in India

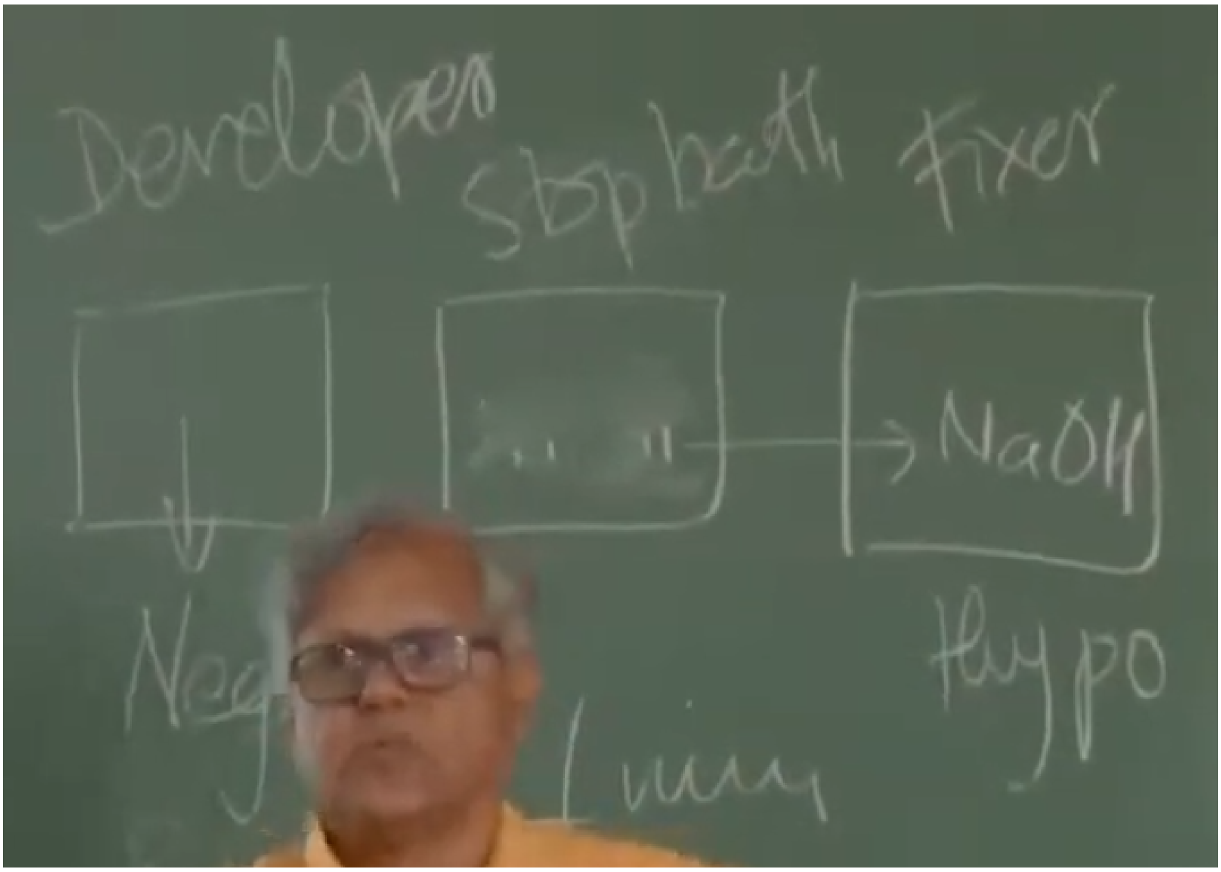
The impact of the Green Revolution

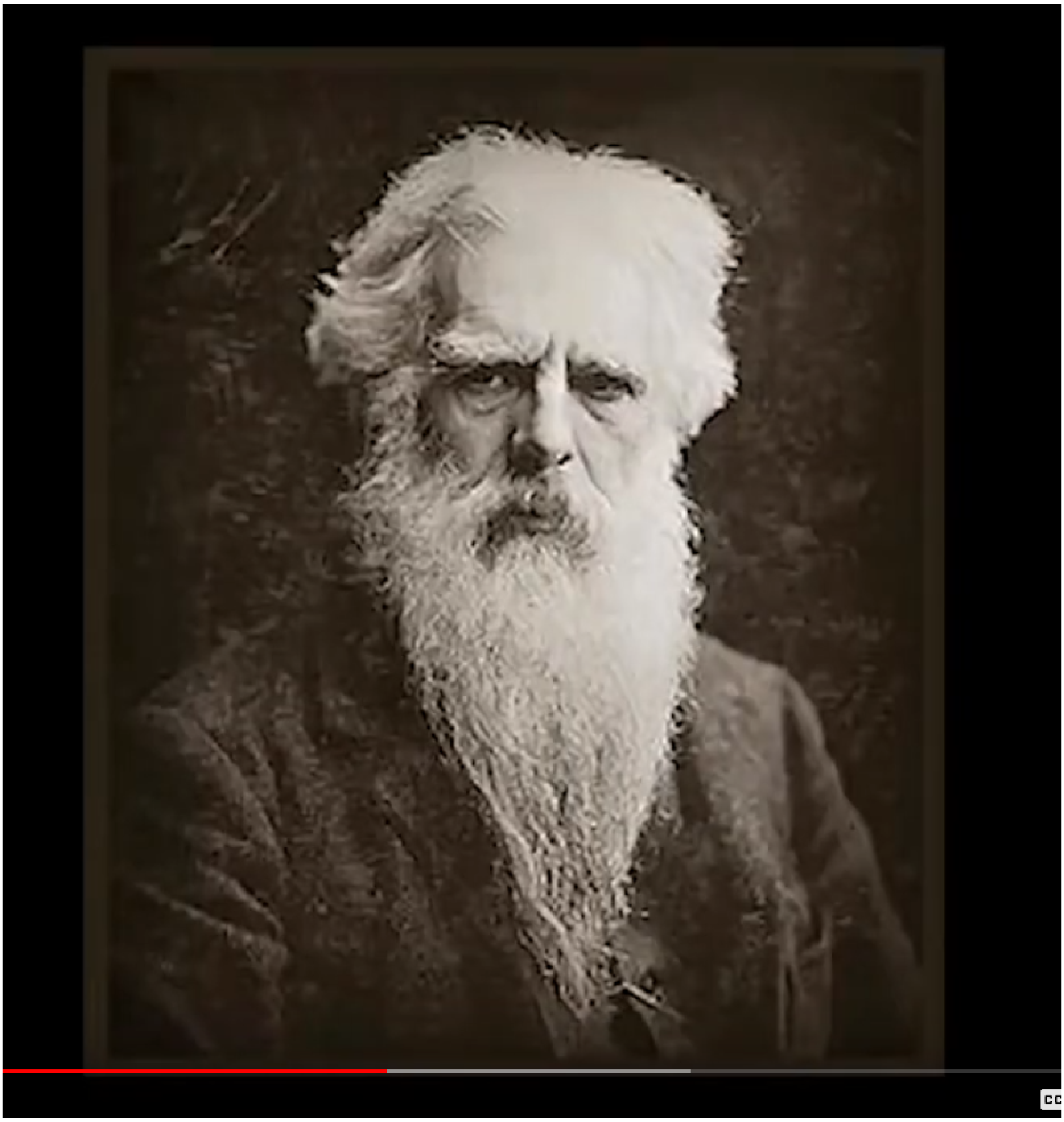


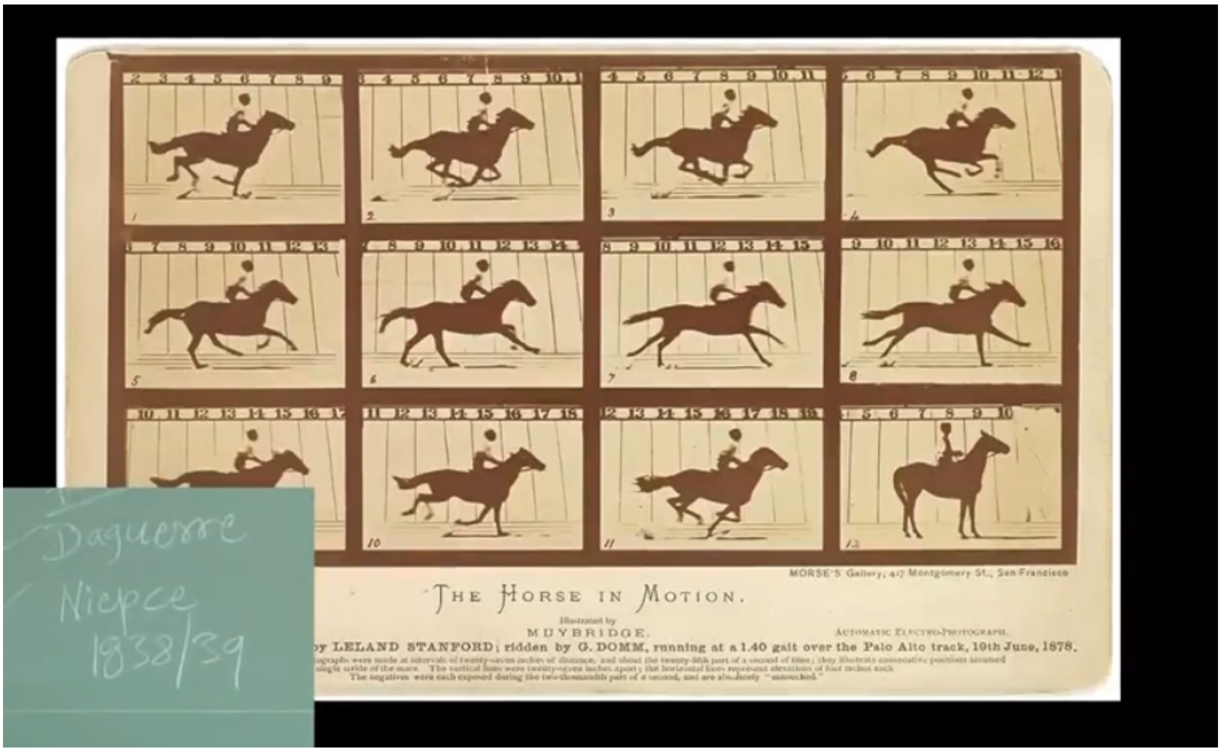
1.15 Lecture 10


France
Daguerre
Niepce
1838/39

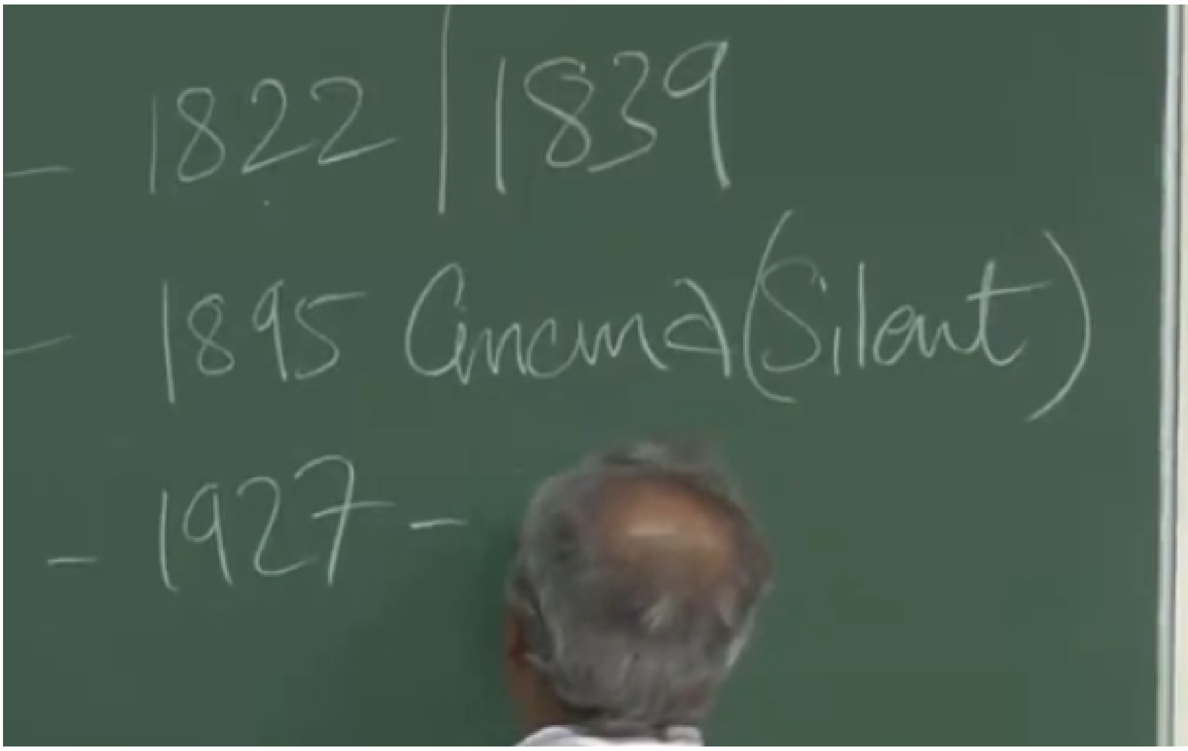

Developer
Stop bath
Fixer
NaOH
Negative
8 min

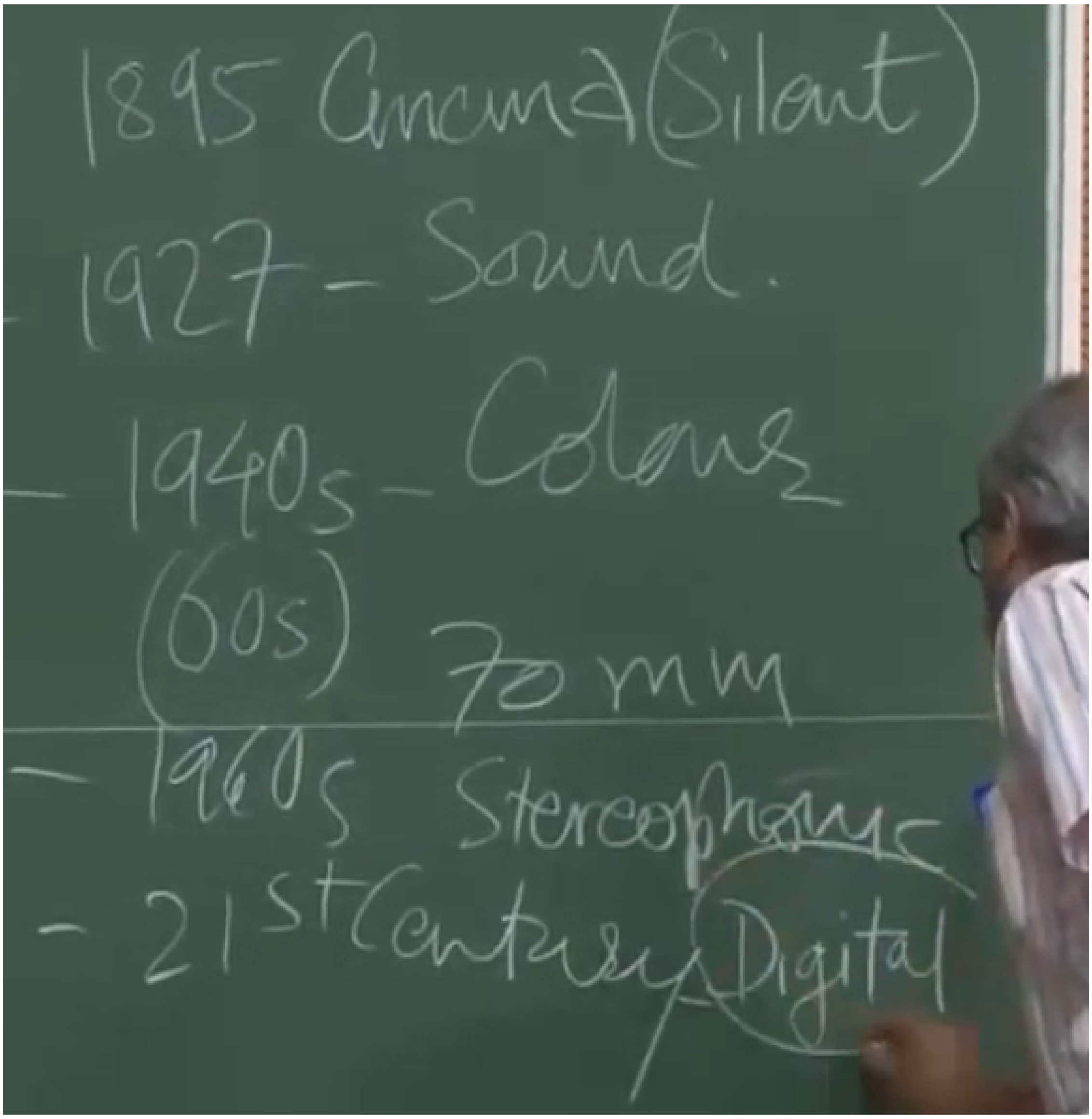

Developer
Stop bath
Fixer
NaOH
Hypo
1 min

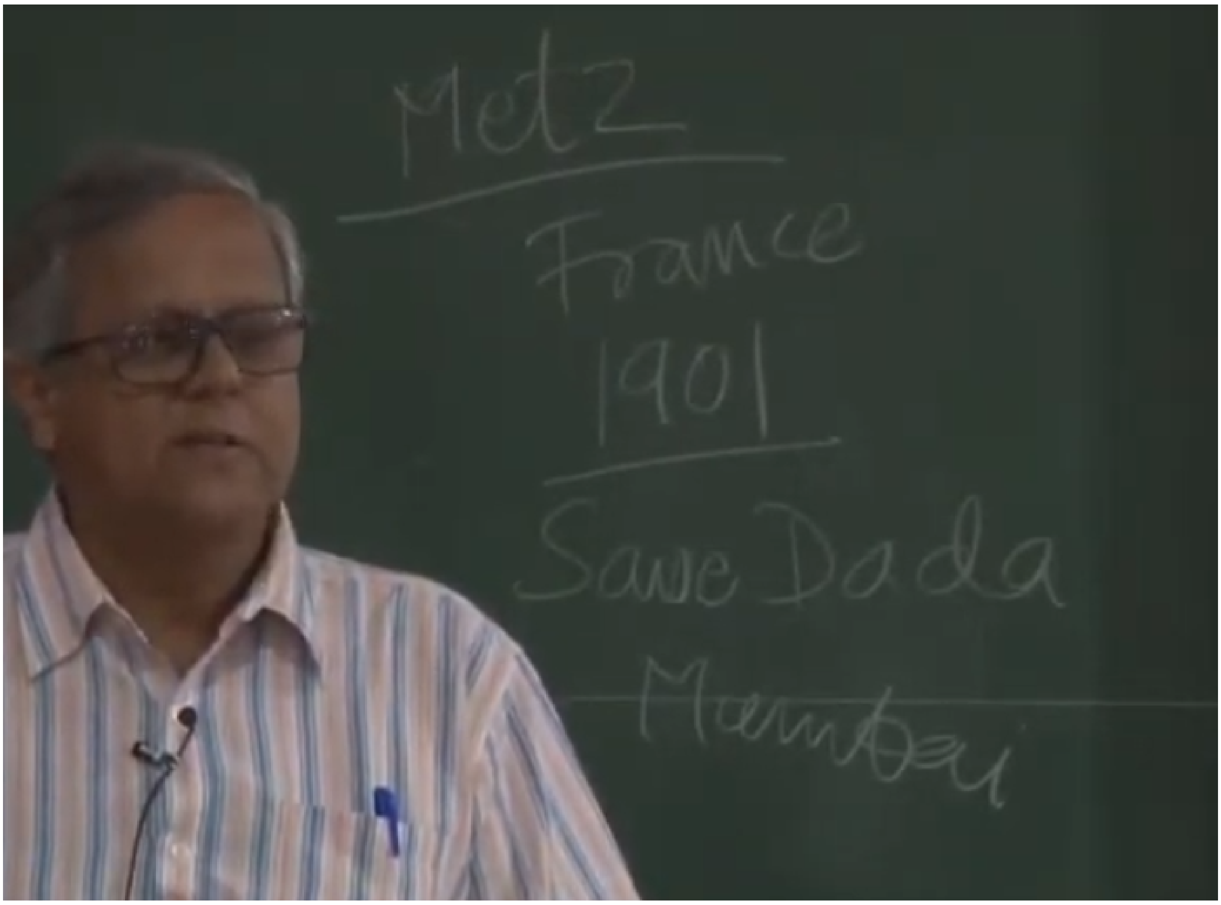


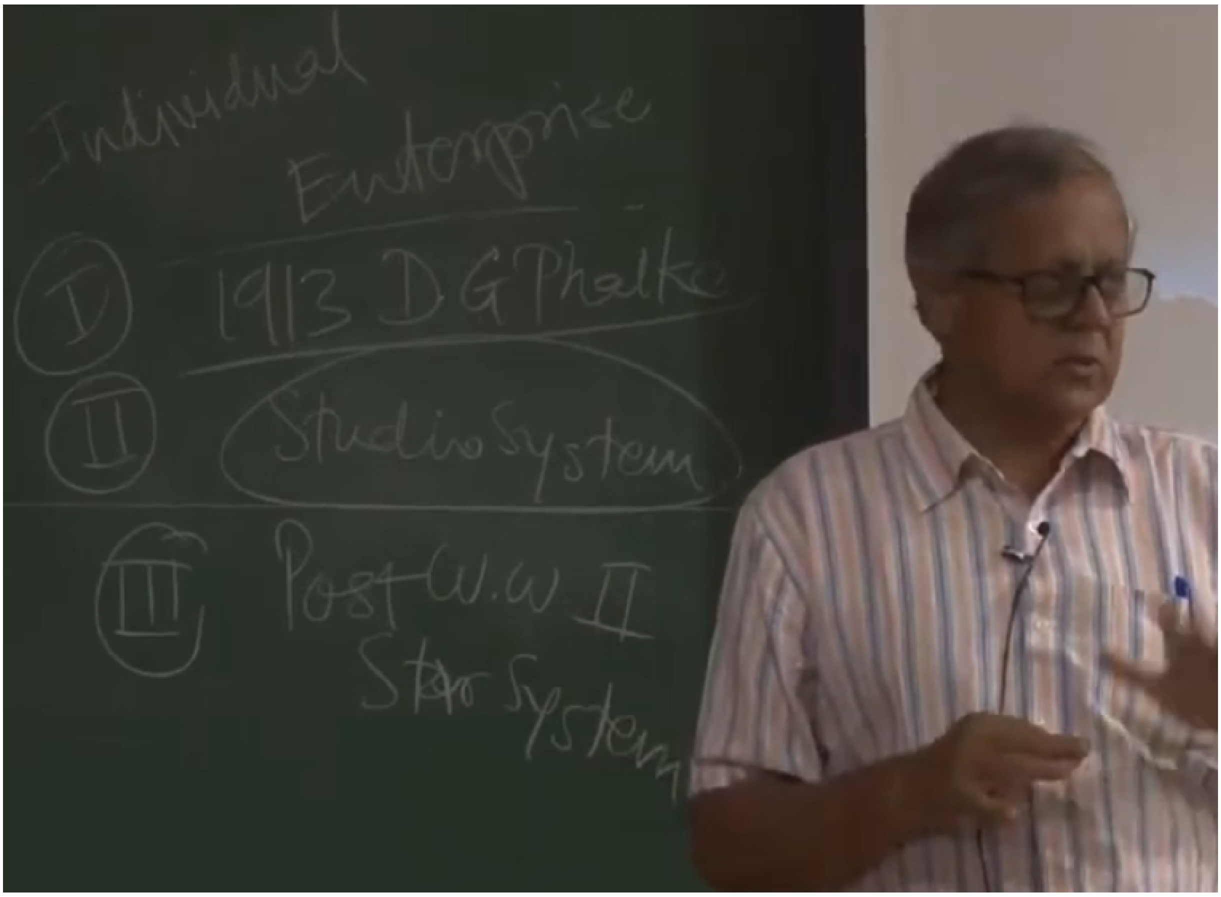

MORSE'S Gallery, 417 Montgomery St., San Francisco
THE HORSE IN MOTION.
Illustrated by
MUYBRIDGE.
AUTOMATIC ELECTRO-PHOTOGRAPH.
by LELAND STANFORD; ridden by G. DOMM, running at a 1.40 gait over the Palo Alto track, 19th June, 1878.
Daguerre
Niepce
1838/39

1.16 Lecture 11


1822 | 1839
1895 Cinema (Silent)
1927 –


1895 Cinema (Silent)
1927 – Sound.
1940s – Colours
(60s) 70 mm
1960s Stereophonic
21st Century – Digital


Metz
France
1901
Save Dada
Mumbai


Individual Enterprise
I 1913 D G Phalke
II Studio System
III Post W.W II
Star System

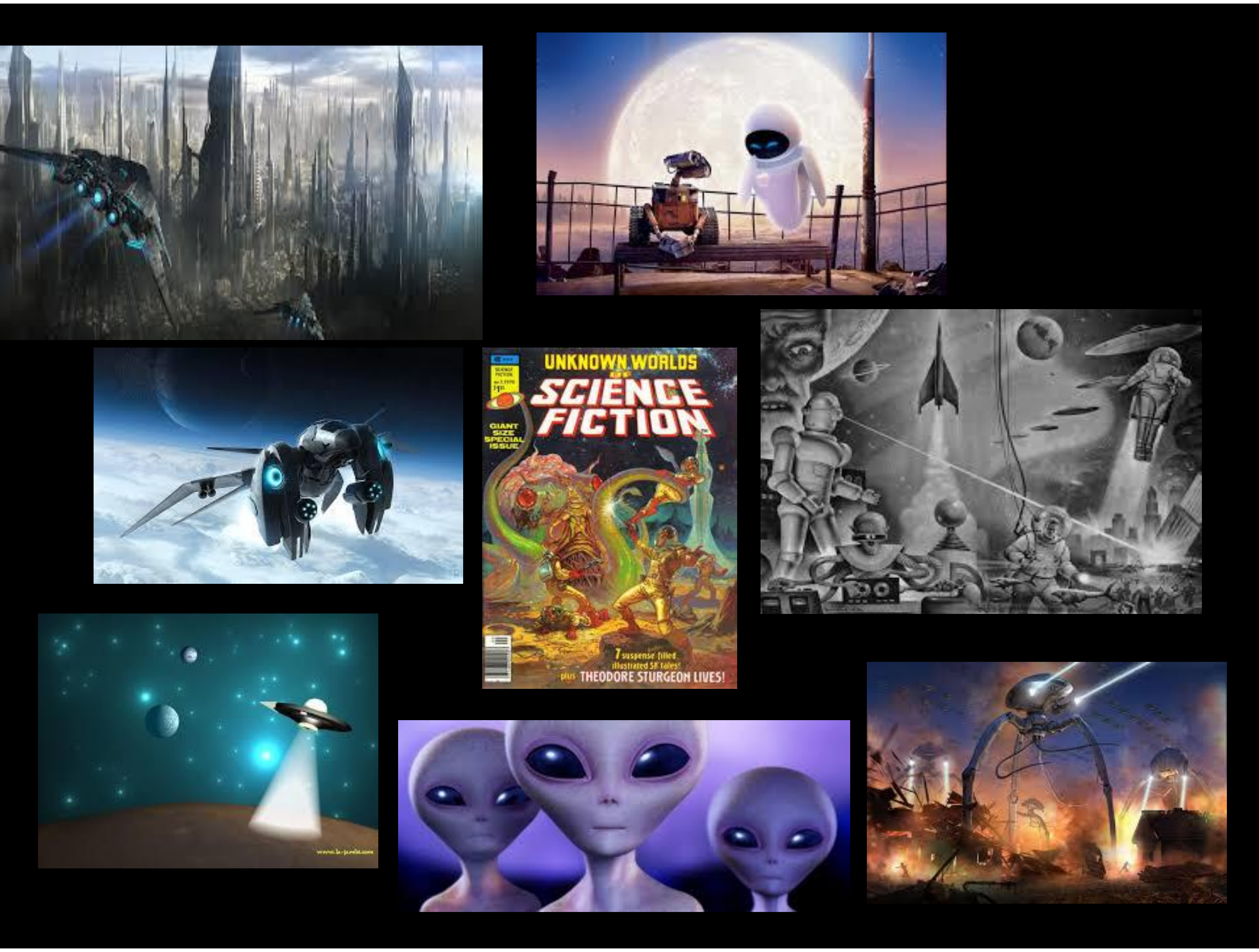
1.17 Lecture 12

Science Fiction

HSS102

SF frequently features…

- spaceships, interplanetary or interstellar travel
- aliens and encounters with alien life forms
- mechanical robots, genetic engineering, androids
- computers, advanced technology, virtual reality
- time travel
- alternative histories
- futuristic utopias and dystopias


UNKNOWN WORLDS OF
SCIENCE FICTION
GIANT SIZE SPECIAL ISSUE
7 suspense filled illustrated SF tales!
plus THEODORE STURGEON LIVES!

Several definitions of SF

- "a combination of romance, science, and prophecy" (Hugo Gernsback)
- "realistic speculation about future events" (Robert Heinlein)
- "…imaginative fiction based on postulated scientific discoveries or spectacular environmental changes, frequently set in the future or on other planets and involving space or time travel" (OED)

What sets SF apart from…

- Fantasy fiction (*Lord of the Rings*, *Harry Potter, Game of Thrones* etc.)
- Fairy tales (*Snow White*, *Sleeping Beauty* etc.)
- Realist fiction (*Oliver Twist*, *Sea of Poppies* etc.)



Darko Suvin (1979)

SF is "a literary genre or verbal construct whose necessary and sufficient conditions are the presence and interaction of **estrangement** and **cognition**, and whose main device is an imaginative framework alternative to the author's empirical environment".

What are "estrangement" and "cognition"?

Cognition: rational, logical implications, helps us understand the alien landscape

Estrangement: the unfamiliar, the new

Two Crucial Features of SF

- Encounter with **difference** – through unfamiliar technology or encounters with aliens or interstellar travel, which provides a creative space to develop “alterity” (Roberts 17)
- Usually written in reaction to **real world concerns**—about the author’s and reader’s present and/or the past that has led to this present, or feared projections about the future.

What about the “science” in SF?

- Do we look for scientific or technological knowledge/accuracy in SF?
- The science/tech in SF may be completely unrealistic for its context, or predictive at times, or (rarely) contemporaneous
- SF is not necessarily about the present/future of science or technology
- SF may be <u>completely unrealistic</u>, but it is <u>set within the context of scientific method</u> and gives some material or technological <u>rationalization/explanation</u> about how something has come to be. That is, “<u>unreal” matters</u> like faster than light travel, matter transportation devices, bringing dinosaurs back to life are “<u>made plausible</u>” or “rationalized” in the world of the text using a “<u>pseudo-scientific” idiom</u> or the <u>“*language* of science</u>”
- The discourse does not rest on the emotional or supernatural
- It is “not the ‘truth’ of science that is important to SF; it is the … the logical working through of a particular premise.” (Roberts 10)

Early instances of SF

Cicero's *Somnium Scipionis* in 51 BC; Plutarch's *The Circle of the Moon* in circa 80 AD etc.

Imaginational framework: Pre 1600 AD texts deal with outer space in a "religious realm" including believing that everything above the level of the moon was incorruptible and eternal

16-18th Century…

- 1600 - Kepler - *Somnium, sive Astronomia Lunaris* (‘A Dream, or Lunar Astronomy)
- 1638 - Bishop William Godwin - *The Man in the Moone*
- 1638 - John Wilkins - *Discovery of a World in the Moone*
- 1657 - Cyrano de Bergerac - “*The Other World, or the States and Empires of the Moon*”
- 1744 - Eberhard Christian Kindermann - “*The Rapid Journey by Airship to the Upper World, recently taken by five people*”

- By the 18th century, in Europe, interplanetary space travel was already a popular theme in literature, given that travel to exotic lands was already a popular undertaking

A popularly accepted starting point

Mary Shelley's *Frankenstein; or, The Modern Prometheus* (1818) – inspired by Gothic literature, considered by many to be the first genuinely SF text

Consolidation

The work of writers like **Jules Verne** (1828-1905) and **H G Wells** (1866-1946) consolidated SF as a genre, and much of their fiction is written in response to particular historical/cultural phenomena such as the Industrial Revolution, religion, class differences, WWI and II etc.

Two ways of approaching the science in SF

"I make use of physics. He invents. I go to the moon in a cannon-ball, discharged from a cannon. Here there is no invention. He goes to Mars in an airship, which he constructs of a material which does away with the laws of gravitation. *Ça c'est très joli* [that's all very well] …but show me this metal. Let him produce it." - Verne on Wells

The term “science fiction”

- Coined only in 1927 by **Hugo Gernsback**, an inventor, writer, editor, and publisher of the first science fiction magazines
- Sometimes also referred to as the “Father of Science Fiction”
- It is in his honour that the Hugo awards for SF writing are given

Some Persistent Key Themes

- Utopia – Dystopia
- Alien Encounters – Space Travel
- Artificial Intelligence
- Technology – beneficial and disastrous
- Colonization (War, imperialism, genetics)
- Morality and Ethics
- Misogyny – Representation of Women

Three Laws of Robotics

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm;
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law;
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

- Isaac Asimov, *Foundation Series*

Marvin the Android: “Here I am, brain the size of a planet, and they ask me to take you to the bridge. Call that job satisfaction? ‘Cause I don’t.”

Douglas Adams' Hitchhiker's Guide to the Galaxy
(1979)

He came across this entry.

It said: 'The History of every major Galactic Civilization tends to pass through three distinct and recognizable phases, those of Survival, Inquiry and Sophistication, otherwise known as the How, Why and Where phases. "For instance, the first phase is characterized by the question How can we eat? the second by the question Why do we eat? and the third by the question Where shall we have lunch?"'

Take Away

- The binding concerns of SF have, more or less, remained constant even though the science has changed:
  - The relation between the creator and the creation
  - The ethics of rulers, creators, thinkers, machines
  - Varieties of perception and reality
  - Encounters with the "Other" – themes of colonization, war, tribes, civilizations
  - Retelling of histories
  - How technology and science create utopian or dystopian worlds

Some famous SF writers

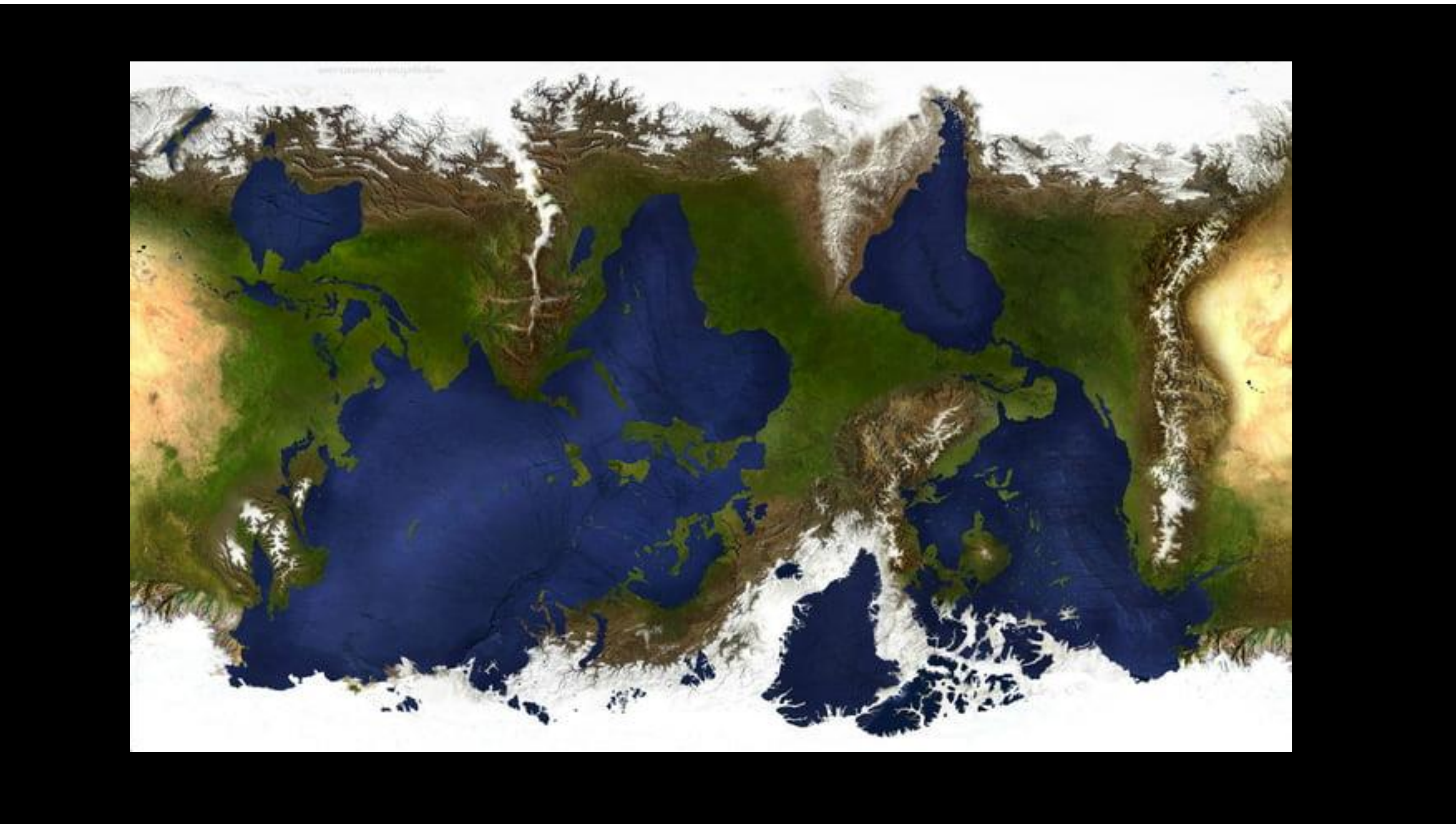
Ray Bradbury, Octavia Butler, Frank Herbert, Ursula K Le Guin, Arthur C Clarke, Isaac Asimov, Lester del Rey, Robert Heinlein, Samuel Delaney, Theodore Sturgeon, Daniel Keyes, James Tiptree Jr, Douglas Adams, N K Jemison, Clifford Simak, Philip K Dick, Marion Zimmer Bradley, Frank Herbert, Robert Zelazny, Robert Silverberg, Larry Niven, C J Cherryh, Kim Stanley Robinson, Yoon Ha Lee, Ada Palmer

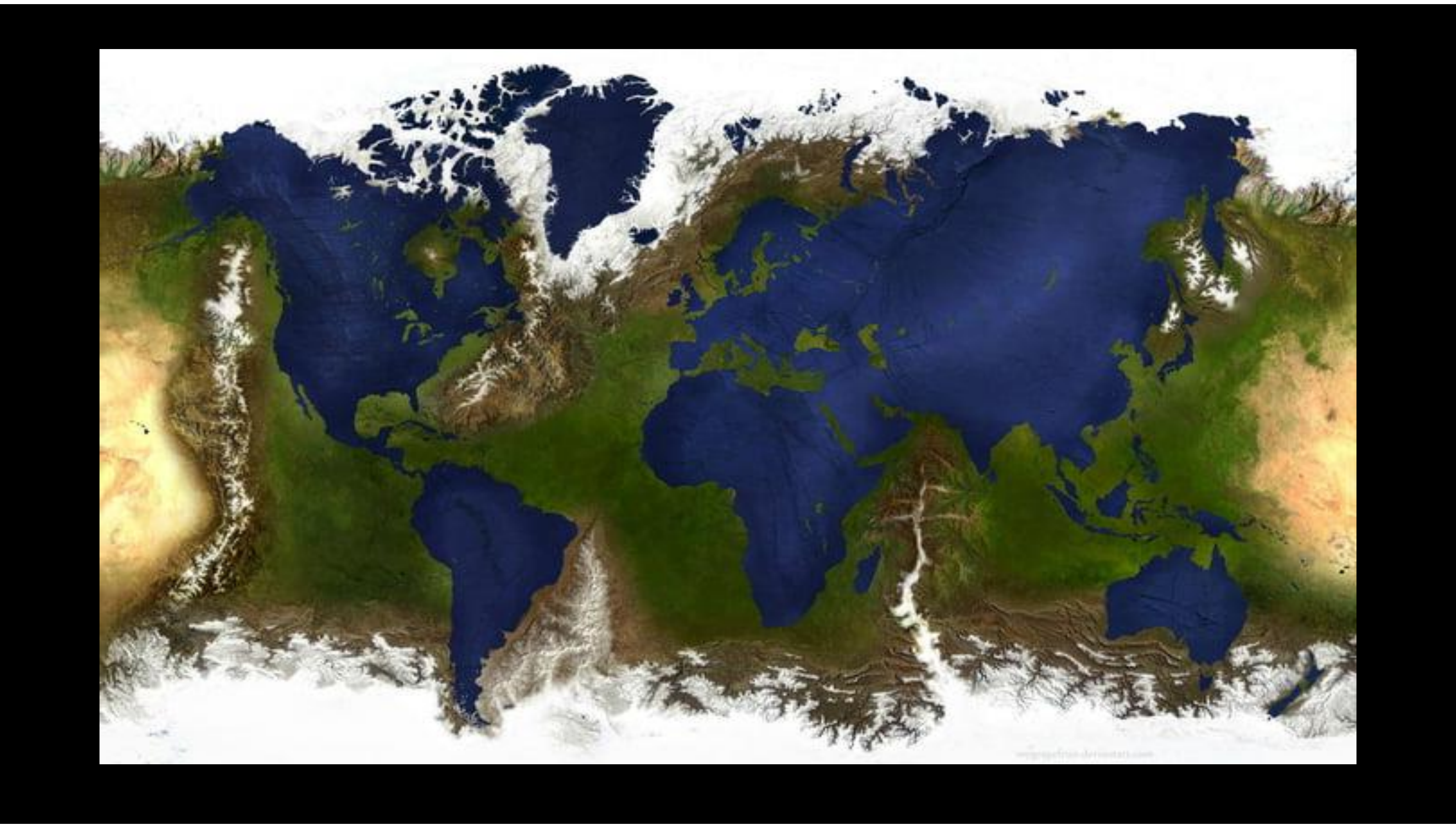
Recommended movies: *Frankenstein*, *Arrival*, *Ex Machina, Blade Runner, The Martian, Interstellar*

1.18 Lecture 13

Cartography and Calendars

Conventions of Representing Space and Time





"O day and night, but this is wondrous strange"

FLATLAND

A ROMANCE OF MANY DIMENSIONS

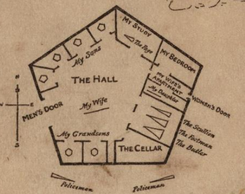
No Dimensions POINTLAND

One Dimension LINELAND

By A Square

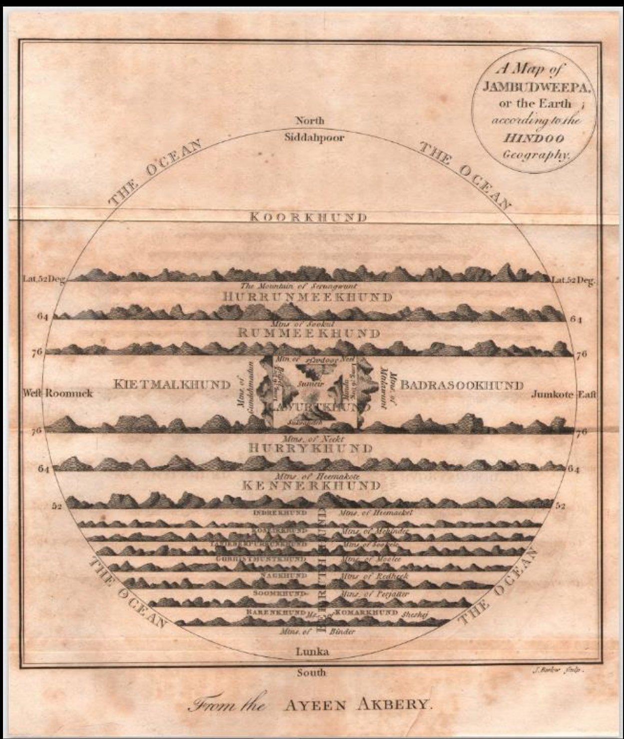
Two Dimensions FLATLAND

Three Dimensions SPACELAND



LONDON
SEELEY & Co., ESSEX STREET, STRAND
Price Half-a-crown

"And therefore as a stranger give it welcome"


A Map of
JAMBUDWEEPA,
or the Earth;
according to the
HINDOO
Geography.
North
Siddahpoor
THE OCEAN
THE OCEAN
KOORKHUND
Lat. 52 Deg.
Lat. 52 Deg.
The Mountain of Serungwunt
HURRUNMEEKHUND
64
64
Mtns of Sookul
RUMMEEKHUND
76
76
KIETMALKHUND
BADRASOOKHUND
West Roomuck
Jumkote East
Mtns of Gundehmadun
Mtns of Mahawunt
Sumeir
76
76
Mtns. of Neekt
HURRYKHUND
64
64
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KENNERKHUND
52
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INDREKHUND
Mtns. of Heemackel
Mtns. of Mehinder
Mtns. of Sookele
Mtns. of Moolee
NAGKHUND
Mtns. of Redheek
SOOMEHUND
Mtns. of Perjatter
BARENKHUND
KOMARKHUND
Mtns. of
Binder
THE OCEAN
THE OCEAN
Lunka
South
From the AYEEN AKBERY.


Arctic Ocean
Greenland Sea
Kara Sea
Laptev Sea
Beaufort Sea
Baffin Bay
Barents Sea
East Siberian Sea
Norwegian Sea
Hudson Bay
Labrador Sea
Gulf of Alaska
North Sea
Sea of Okhotsk
Bering Sea
North Pacific Ocean
North Atlantic Ocean
North Pacific Ocean
Med. Sea
Gulf of Mexico
East China Sea
Caribbean Sea
Arabian Sea
Bay of Bengal
South China Sea
South Atlantic Ocean
Indian Ocean
Coral Sea
South Pacific Ocean
Tasman Sea
© 2007 Geology.com

Sandeśakāvya

Itinerarium

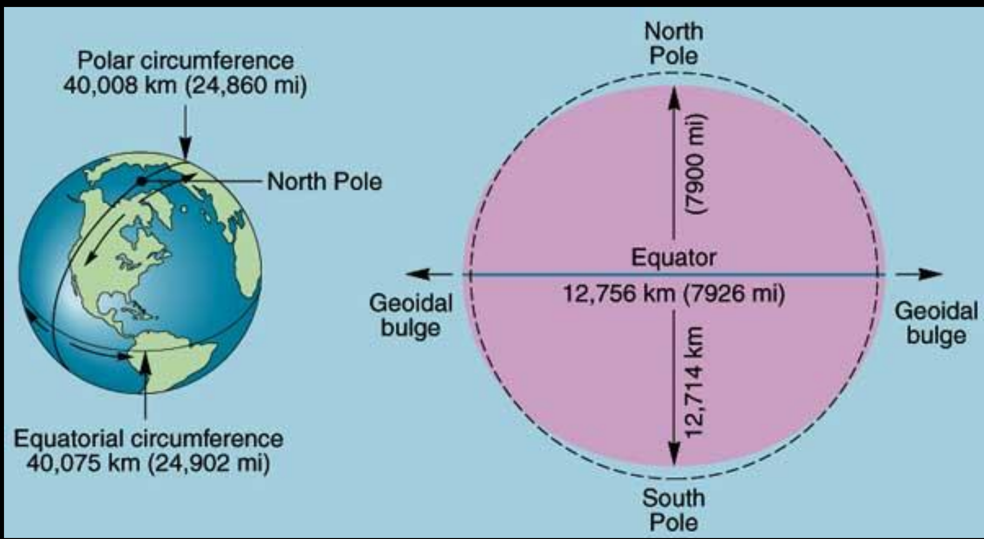
Periplus

Guidebook

Meghadūta

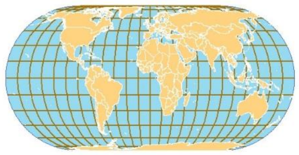
Travelogue


THE PERIPLUS OF THE ERYTHRAEAN SEA
1st century CE
LEGEND:
Cities
COUNTRIES
RULERS
PEOPLE
Locations
ROMAN EMPIRE
MARE INTERNUM
ITALY
Wine
GREEKS
GREEKS
GETES
PONTUS
ALANS
ARMENIANS
CASPIAN SEA
TOKHARIANS
MASSAGETES
SACES
BACTRIA
"The very warlike nation of the Bactrians" (Chap.47)
KUCHANS
PARTHIANS
Euphrates
Laodicea
Diospolis
Wine
Brass
Copper
Iron
Arsinoe
NABATAEANS
Petra
MALICHAS
White Village
Cloth
Mussel Harbour (MyosHormos)
BERBERS
LYBIA
Berenice
ARABIAN GULF
ARABIA
CARNAITES
BERBERS
Ptolemais of the Hunt
Wine
Grain
Frankincense
ELEAZUS
CHARIBAEL
Sabath
Meroe
Adulis
ZOSCALES
CHOLAEBUS
Muza
SABAITES
Saphar
Cana
HOMERITES
OCELIS
Axumites (Axum)
Coloe
Ivory
AETHIOPIA
Avalites
Eudaemon Arabia (Aden)
Mosyllum
Malao
Mundus
Pearls
Cape Elephant
Cape of Spices
Dioscoridus Island
BERBERS
Spices
Cinnamon
Slaves
Pano
Opone
CYENEUM
AFRICA
AZANIA
Sarapion
Nicon
"The people of Muza now hold it under his authority and send thither many large ships" (Chap.16)
Pyralax Island
Menuthras Island
Rhapta
Ivory
"Beyond these places, the unexplored ocean curves around towards the west (...) and mingles with the western sea" (Chap.18)
WESTERN SEA
Charax Spasini
Apologus
PERSIA
PARSIDS
ARACHOSII
Semiramis Mts
PERSIAN SEA
Asabon Mts
Wine
Dates
Gold
GEDROSIA
Oraea
Ommana
Calxi Islands
Zenobian Isl.
Asich
Moscha
GANDAREI
POCLAIS
PARTHIANS
Alexandria
Bucephalus
Minnagara
SCYTHIA
Barbaricum
Agate
Carnelian
Cloth
Abiria
Ozene (Ujjain)
Syrastrene
ARIACA
Barigaza
NAMBANUS
Iron Steel Cloth
Suppala (Sopara)
Calliena (Kalyan)
Semylla (Chaul)
Paethan (Paithan)
Tagara
Mandagora
Palaepatmoe
Melizigara
Byzantium
Togarum
Aurannoboas
Naura (Cannanore)
Tyndis
Muziris
Nelcynda
DAKINABADES
(DAKSHINAPATHA)
SANDANES
Spices
CEROBOTHRA (CHERAS)
Damirica
PANDIAN
Sopatma
Poduca (Pondicherry)
Argaru (Uraiyur)
Camara (Kalapattana)
Colchi (Korkai)
Cape Comari
Palaesimundu Island, Taprobane
DOSARENE (Orissa)
MASALIA
Ganges
Ganges
Cloth
ERYTHRAEAN SEA
"The regions beyond these places are difficult of access because of their excessive winters and great cold." (Chap.66)
Silk yarn
Silk cloth
Thinae
(Tenduc, Luoyang)
"Under the very north, the sea outside ending in a land called Thys, there is a very great inland city called Thinae, from which raw silk yarn and silk cloth are brought on foot through Bactria to Barigaza" (Chap.64)
THYS
BESATAE
CHRYSE
Tortoise shells
OUTSIDE SEA

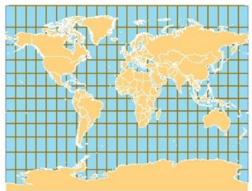


Polar circumference
40,008 km (24,860 mi)
North Pole
Equatorial circumference
40,075 km (24,902 mi)
North
Pole
(7900 mi)
Equator
12,756 km (7926 mi)
12,714 km
Geoidal
bulge
Geoidal
bulge
South
Pole

Four World Map Projections



Eckert IV



Gall Stereographic

Polyconic

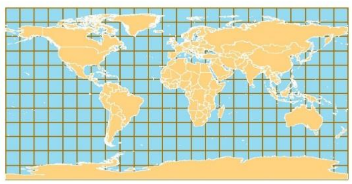
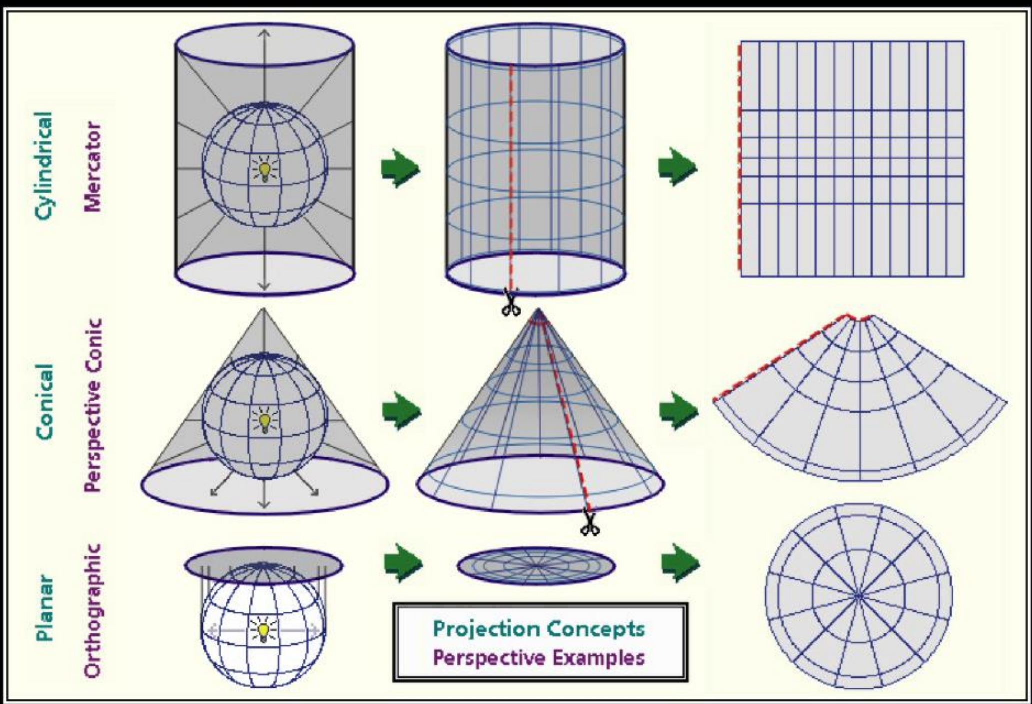
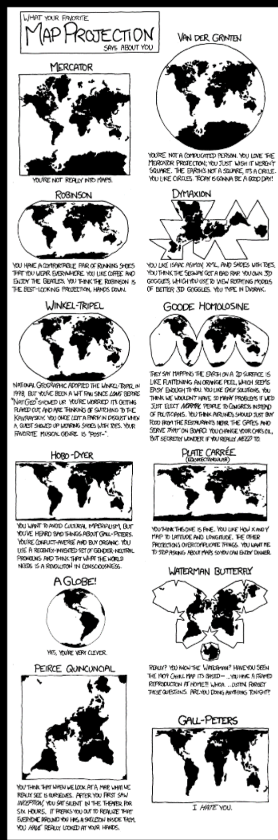


Plate Carree

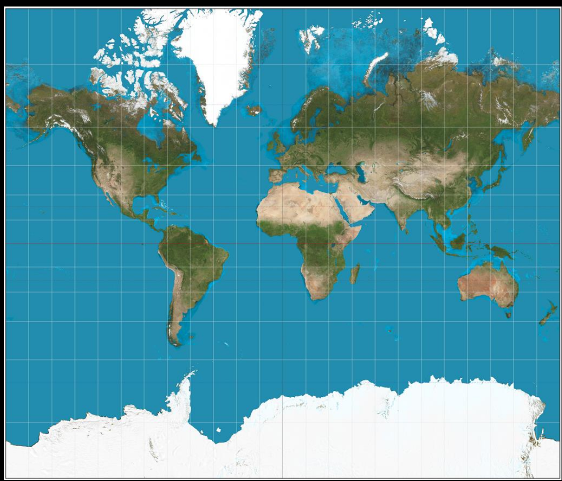
Principal Scale 1:375,000,000
Created by Matt Sandee 02/10
Data Source: ESRI 2008


Cylindrical
Mercator
Conical
Perspective Conic
Planar
Orthographic
Projection Concepts
Perspective Examples

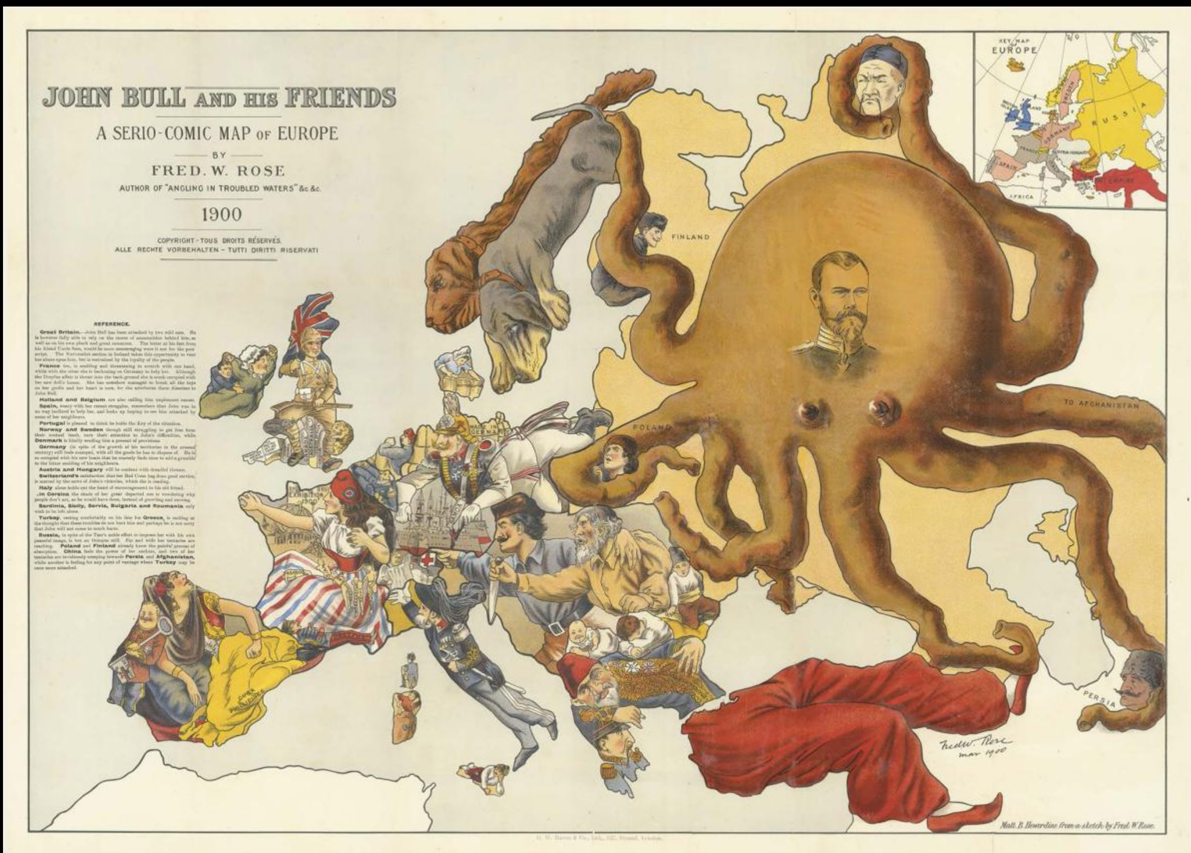

WHAT YOUR FAVORITE
MAP PROJECTION
SAYS ABOUT YOU
MERCATOR
YOU'RE NOT REALLY INTO MAPS.
VAN DER GRINTEN
YOU'RE NOT A COMPLICATED PERSON. YOU LOVE THE MERCATOR PROJECTION; YOU JUST WISH IT WEREN'T SQUARE. THE EARTH'S NOT A SQUARE, IT'S A CIRCLE. YOU LIKE CIRCLES. TODAY IS GONNA BE A GOOD DAY!
ROBINSON
YOU HAVE A COMFORTABLE PAIR OF RUNNING SHOES THAT YOU WEAR EVERYWHERE. YOU LIKE COFFEE AND ENJOY THE BEATLES. YOU THINK THE ROBINSON IS THE BEST-LOOKING PROJECTION, HANDS DOWN.
DYMAXION
YOU LIKE ISAAC ASIMOV, XML, AND SHOES WITH TOES. YOU THINK THE SEGWAY GOT A BAD RAP. YOU OWN 3D GOGGLES, WHICH YOU USE TO VIEW ROTATING MODELS OF BETTER 3D GOGGLES. YOU TYPE IN DVORAK.
WINKEL-TRIPEL
NATIONAL GEOGRAPHIC ADOPTED THE WINKEL-TRIPEL IN 1998, BUT YOU'VE BEEN A W-T FAN SINCE LONG BEFORE "NAT GEO" SHOWED UP. YOU'RE WORRIED IT'S GETTING PLAYED OUT, AND ARE THINKING OF SWITCHING TO THE KAVRAYSKIY. YOU ONCE LEFT A PARTY IN DISGUST WHEN A GUEST SHOWED UP WEARING SHOES WITH TOES. YOUR FAVORITE MUSICAL GENRE IS "POST-".
GOODE HOMOLOSINE
THEY SAY MAPPING THE EARTH ON A 2D SURFACE IS LIKE FLATTENING AN ORANGE PEEL, WHICH SEEMS EASY ENOUGH TO YOU. YOU LIKE EASY SOLUTIONS. YOU THINK WE WOULDN'T HAVE SO MANY PROBLEMS IF WE'D JUST ELECT NORMAL PEOPLE TO CONGRESS INSTEAD OF POLITICIANS. YOU THINK AIRLINES SHOULD JUST BUY FOOD FROM THE RESTAURANTS NEAR THE GATES AND SERVE THAT ON BOARD. YOU CHANGE YOUR CAR'S OIL, BUT SECRETLY WONDER IF YOU REALLY NEED TO.
HOBO-DYER
YOU WANT TO AVOID CULTURAL IMPERIALISM, BUT YOU'VE HEARD BAD THINGS ABOUT GALL-PETERS. YOU'RE CONFLICT-AVERSE AND BUY ORGANIC. YOU USE A RECENTLY-INVENTED SET OF GENDER-NEUTRAL PRONOUNS AND THINK THAT WHAT THE WORLD NEEDS IS A REVOLUTION IN CONSCIOUSNESS.
PLATE CARRÉE
(EQUIRECTANGULAR)
YOU THINK THIS ONE IS FINE. YOU LIKE HOW X AND Y MAP TO LATITUDE AND LONGITUDE. THE OTHER PROJECTIONS OVERCOMPLICATE THINGS. YOU WANT ME TO STOP ASKING ABOUT MAPS SO YOU CAN ENJOY DINNER.
A GLOBE!
YES, YOU'RE VERY CLEVER.
WATERMAN BUTTERFLY
REALLY? YOU KNOW THE WATERMAN? HAVE YOU SEEN THE 1909 CAHILL MAP IT'S BASED— ...YOU HAVE A FRAMED REPRODUCTION AT HOME?! WHOA. ...LISTEN, FORGET THESE QUESTIONS. ARE YOU DOING ANYTHING TONIGHT?
PEIRCE QUINCUNCIAL
YOU THINK THAT WHEN WE LOOK AT A MAP, WHAT WE REALLY SEE IS OURSELVES. AFTER YOU FIRST SAW INCEPTION, YOU SAT SILENT IN THE THEATER FOR SIX HOURS. IT FREAKS YOU OUT TO REALIZE THAT EVERYONE AROUND YOU HAS A SKELETON INSIDE THEM. YOU HAVE REALLY LOOKED AT YOUR HANDS.
GALL-PETERS
I HATE YOU.

Gerardus Mercator (1512-1594)

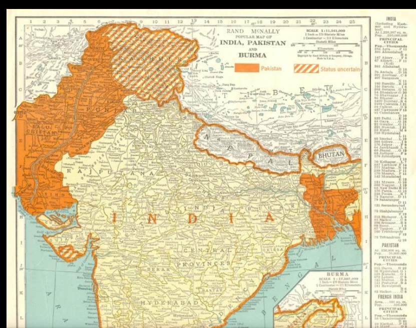
Map Projection Systems for the Earth



Formulas for the Web Mercator are fundamentally the same as for the standard spherical Mercator, but before applying zoom, the "world coordinates" are adjusted such that the upper left corner is (0, 0) and the lower right corner is (256, 256)


JOHN BULL AND HIS FRIENDS
A SERIO-COMIC MAP OF EUROPE
BY
FRED. W. ROSE
AUTHOR OF "ANGLING IN TROUBLED WATERS" &c &c.
1900
COPYRIGHT - TOUS DROITS RÉSERVÉS.
ALLE RECHTE VORBEHALTEN - TUTTI DIRITTI RISERVATI
REFERENCE.
KEY MAP
EUROPE
RUSSIA
AFRICA
FINLAND
POLAND
TO AFGHANISTAN
PERSIA
Fred. W. Rose
Matt. B. Hewerdine from a sketch by Fred. W. Rose.


Railroad
Expressway
Principal highway
Highway
Provincial road (paved in parts)
Secondary road, cart track, path
International boundary
Line of separation
State (India)* or province (Pakistan) boundary**
Region boundary
Traditional boundary claimed by the former princely state of Jammu and Kashmir
Indian-administered area of Kashmir
Pakistani-administered area of Kashmir
Disputed area between India and China
*Chandigarh is a union territory.
** Azad Kashmir and Northern Areas are not constitutionally part of Pakistan.
Territory ceded by Pakistan to China in 1963 and never recognized by India
Tajikistan
Afghanistan
China
Hindu Kush
Gilgit
Northern Areas
Karakoram Range
Baltistan
North-West Frontier Province
Aksai Chin
Indian claim
Line of Actual Control
Kashmir
Azad Kashmir
Vale of Kashmir
Jammu and Kashmir
Ladakh
Jammu
Chinese claim
Punjab
Pakistan
India
Himachal Pradesh
Islamabad
Rawalpindi
Lahore
Amritsar
Ludhiana
Uttaranchal


RAND McNALLY
POPULAR MAP OF
INDIA, PAKISTAN
AND
BURMA
Pakistan
Status uncertain
INDIA
BHUTAN
NEPAL
TIBET

Wrong depiction of India map can land you in jail, Rs 100 crore fine

India PTI May 06, 2016 07:33:56 IST

Comment 0 Share 0 Tweet

New Delhi: Wrong depiction of the map of India could land the violators in jail with a maximum term of seven years and fine upto Rs 100 crore.

This measure has been envisaged by the government against the backdrop of instances where certain social networking sites showed Jammu and Kashmir and Arunachal Pradesh as part of Pakistan and China respectively.

Courtesy: Google Maps

Recently, Twitter had shown the geographical location of Kashmir in China and Jammu in Pakistan triggering protests from the Indian government after which it was corrected.

According to the draft 'The Geospatial Information Regulation Bill 2016', it will be mandatory to take permission from a government authority before acquiring, disseminating, publishing or distributing any geospatial information of India.

"No person shall depict, disseminate, publish or distribute any wrong or false topographic information of India including international boundaries through internet platforms or online services or in any electronic or physical form.

Al Jazeera in India showed a blue screen on Wednesday with a sign saying "as instructed by the Ministry of Information and Broadcasting, this channel will not be available". — AFP

NEW DELHI: India's government took Al Jazeera news channel off the air on Wednesday for five days after officials insisted it had repeatedly shown wrong maps of disputed Kashmir.

Al Jazeera in India showed a blue screen on Wednesday with a sign saying "as instructed by the Ministry of Information and Broadcasting, this channel will not be available".

An official said the order was made earlier this month over the maps that showed parts of the Himalayan Kashmir region in Pakistan and in China — an extremely sensitive issue in India.

NATIONAL AFFAIRS

Wrong map ignites university fury

The Australian | 1:23PM August 24, 2017 251 Save

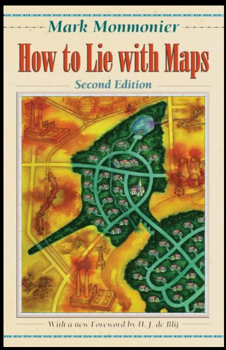
PRIMROSE RIORDAN
Political reporter | Canberra | @primroseriordan

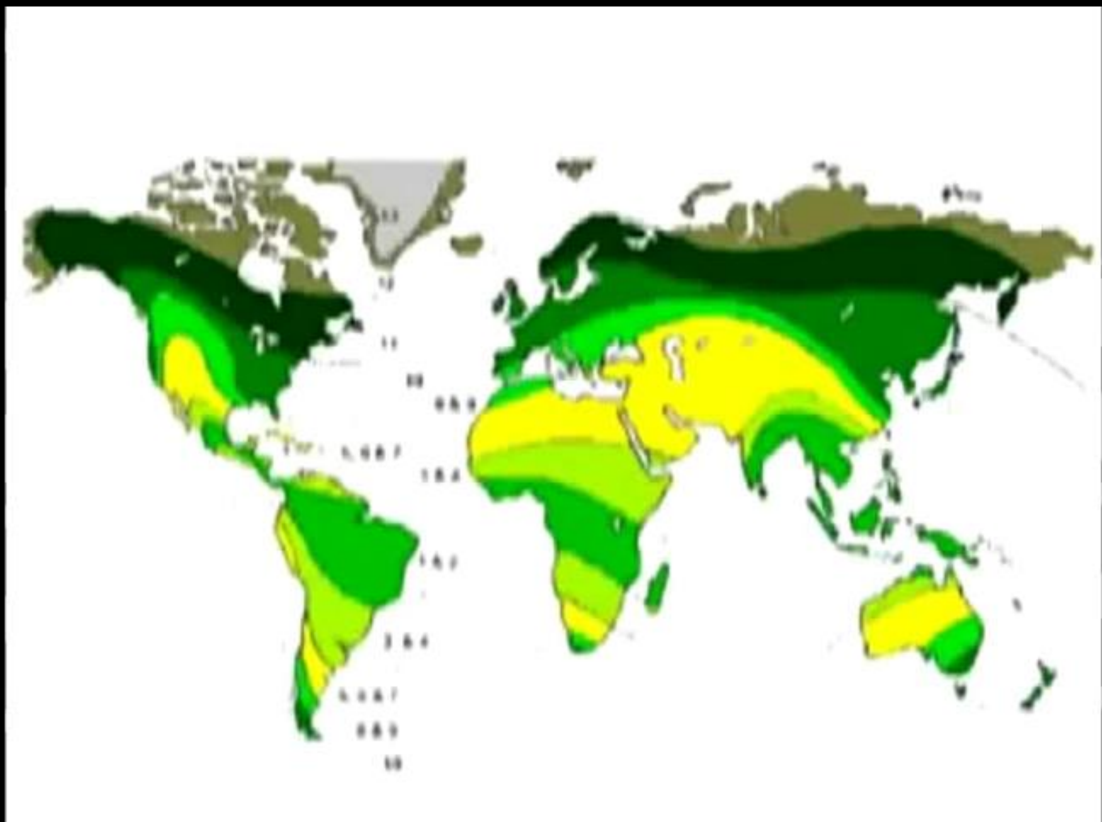
A Sydney University IT lecturer has been forced to issue a public apology after international students were outraged by his use of a map showing Chinese claimed territory as part of India.

UPDATE: Newcastle uni academic suggests Taiwan, Hong Kong are separate countries.

The incident is the third prominent case this year where academic staff or Australian universities have apologised after their actions were attacked on Chinese social media.

Earlier this month, an Australian National University lecturer said he had made a "poor decision" after translating a warning about cheating into Mandarin.

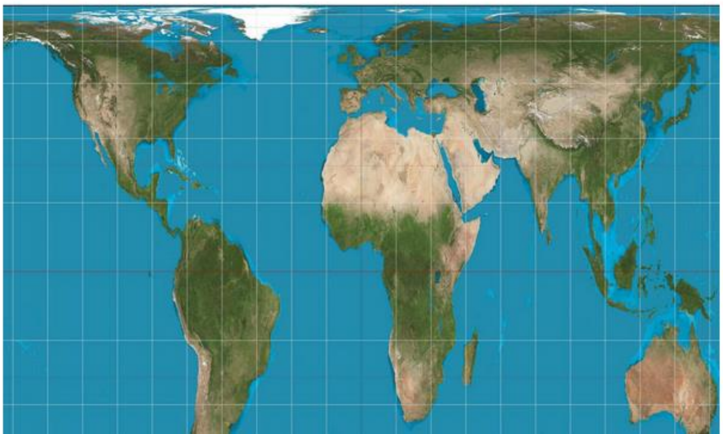

Mark Monmonier
How to Lie with Maps
Second Edition
With a new Foreword by H. J. de Blij

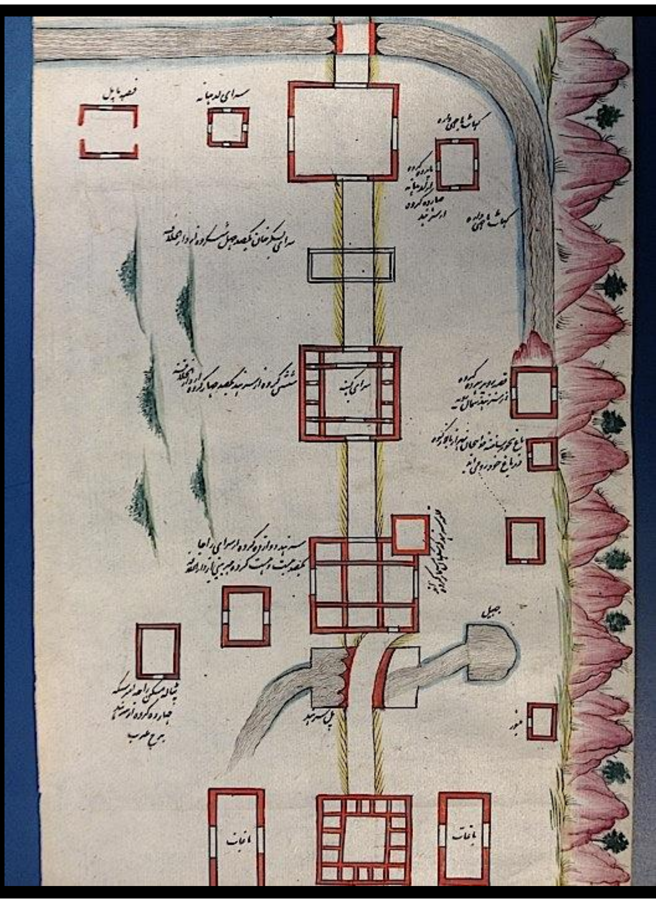


US schools to get new world map after 500 years of 'colonial' distortion

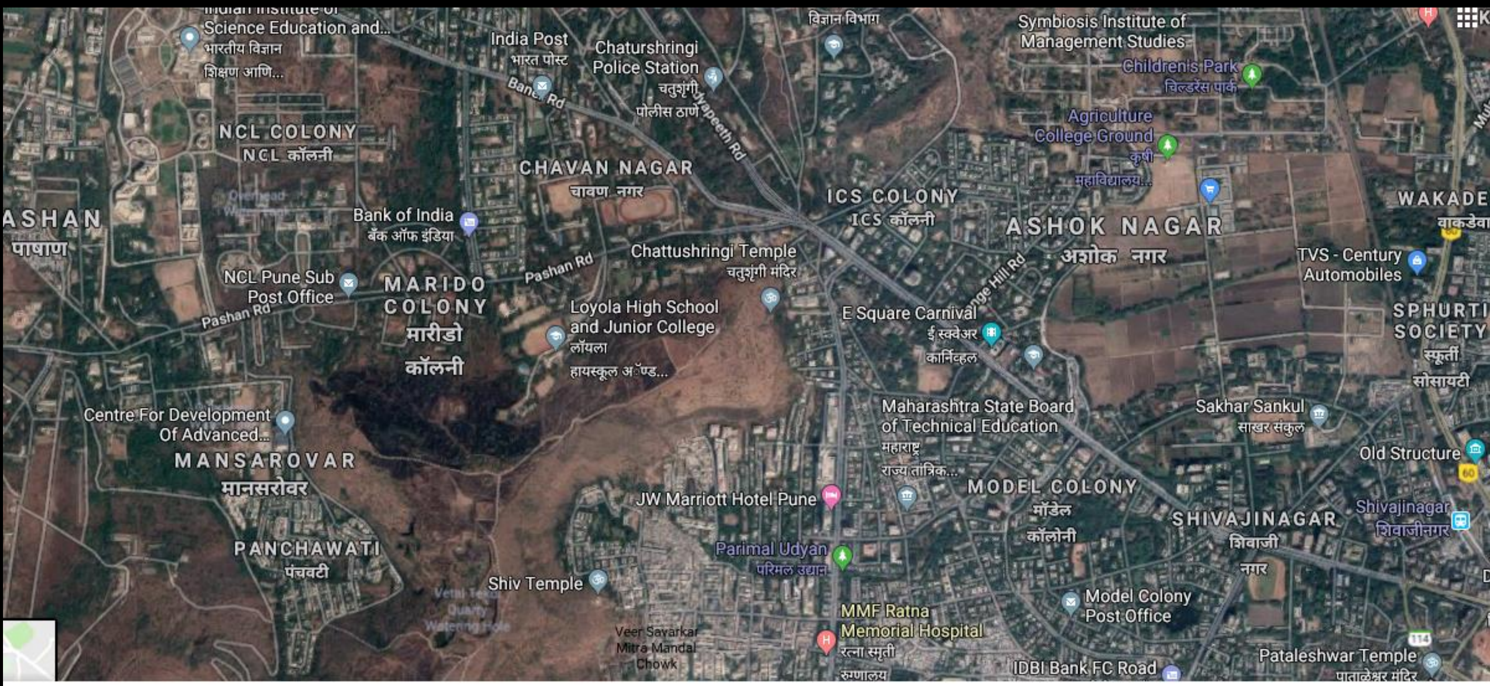
Expert explains why maps of Britain show Cornwall 'ever so slightly' bigger than it actually is

Ian Johnston Science Correspondent | @montaukian | 2 days ago | 9 comments





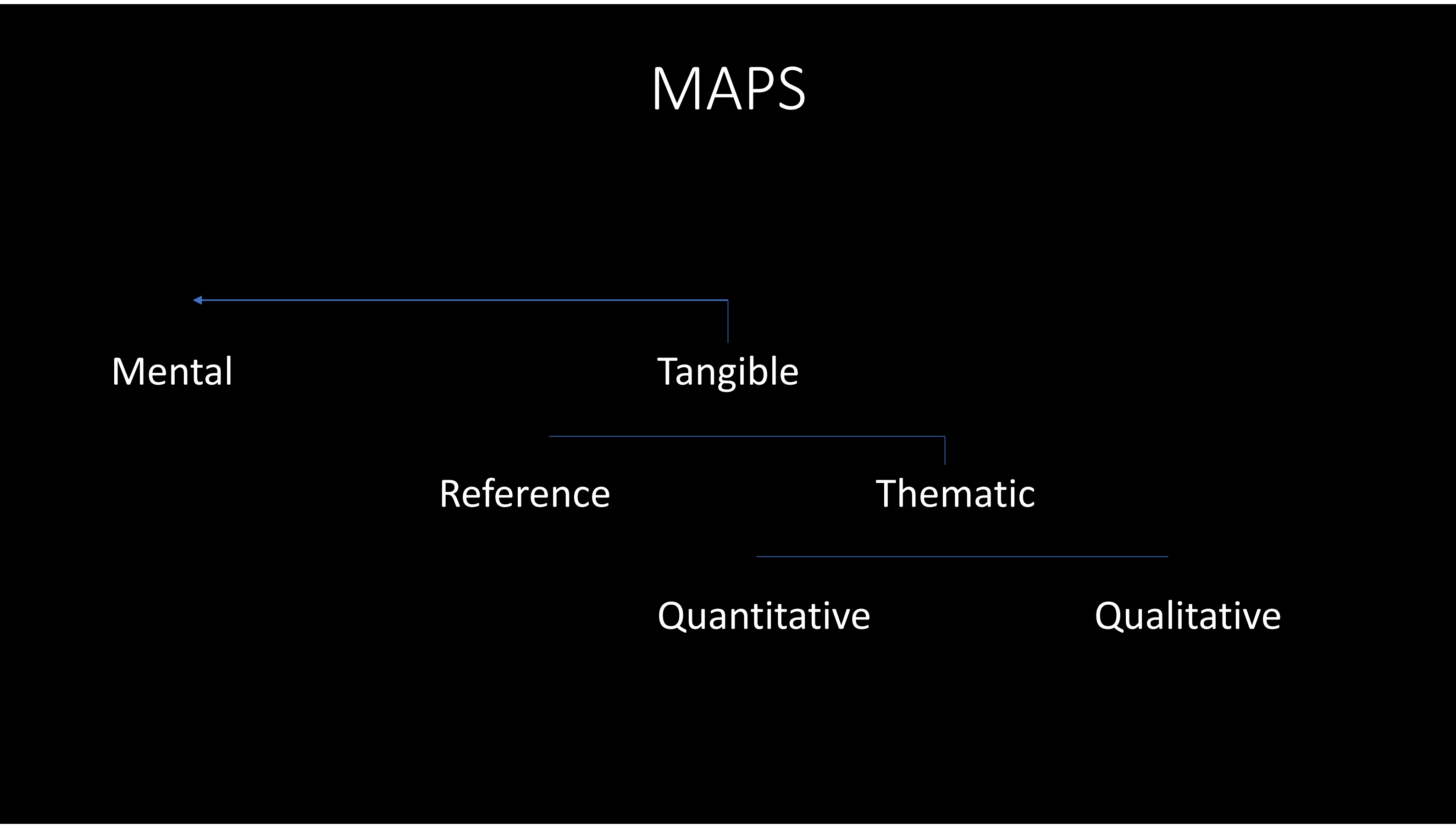
پل سرهند
باغات
باغات


Science Education and...
भारतीय विज्ञान
शिक्षण आणि...
India Post
भारत पोस्ट
Chaturshringi
Police Station
चतुश्रृंगी
पोलीस ठाणे
विज्ञान विभाग
Symbiosis Institute of
Management Studies
Children's Park
चिल्ड्रेंस पार्क
Agriculture
College Ground
NCL COLONY
NCL कॉलनी
CHAVAN NAGAR
चावण नगर
ICS COLONY
ICS कॉलनी
ASHOK NAGAR
अशोक नगर
WAKADE
ASHAN
पाषाण
Bank of India
बँक ऑफ इंडिया
NCL Pune Sub
Post Office
MARIDO
COLONY
मारीडो
कॉलनी
Pashan Rd
Chattushringi Temple
चतुश्रृंगी मंदिर
TVS - Century
Automobiles
SPHURTI
SOCIETY
स्फूर्ती
सोसायटी
Loyola High School
and Junior College
E Square Carnival
Centre For Development
Of Advanced...
Maharashtra State Board
of Technical Education
Sakhar Sankul
साखर संकुल
Old Structure
MANSAROVAR
मानसरोवर
MODEL COLONY
मॉडेल
कॉलनी
SHIVAJINAGAR
शिवाजी
नगर
Shivajinagar
शिवाजीनगर
JW Marriott Hotel Pune
Parimal Udyan
परिमल उद्यान
PANCHAWATI
पंचवटी
Shiv Temple
Model Colony
Post Office
MMF Ratna
Memorial Hospital
रत्ना स्मृती
रुग्णालय
Veer Savarkar
Mitra Mandal
Chowk
IDBI Bank FC Road
Pataleshwar Temple
पाताळेश्वर मंदिर

Every maps is made for a purpose.

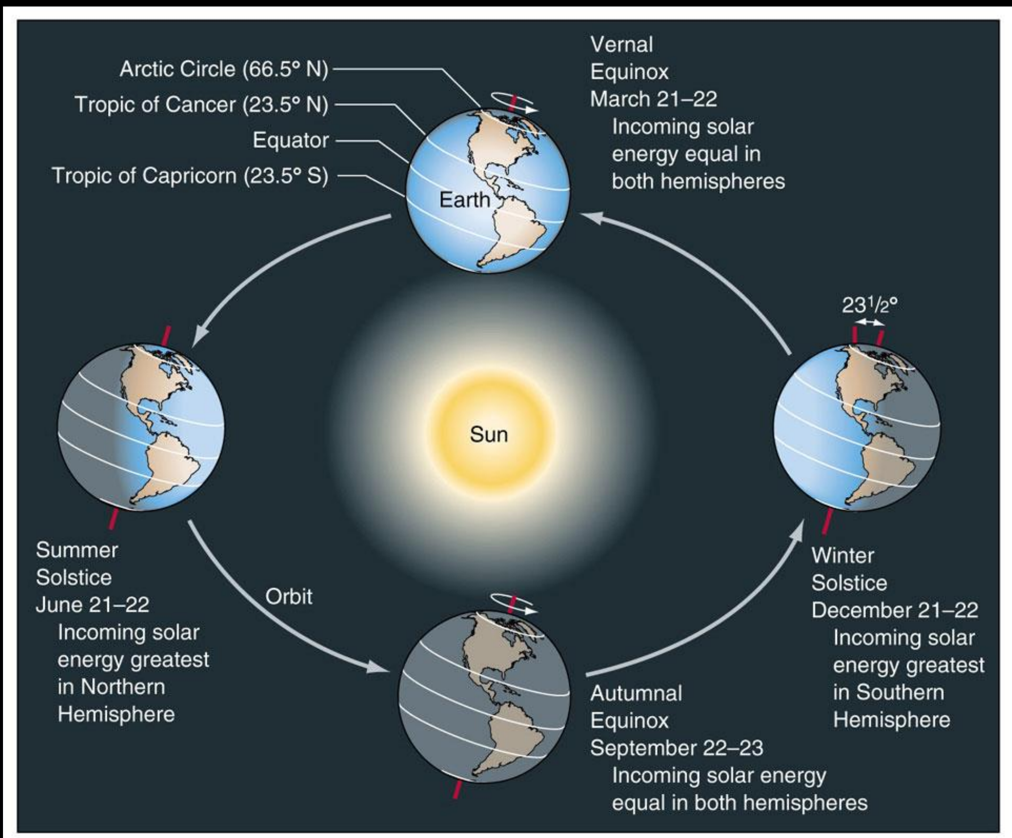
Along with these overt agendas, maps also embody inadvertently other aspirations, ambitions, and claims.

In short, all representations have errors and biases, and are not a substitute for reality.

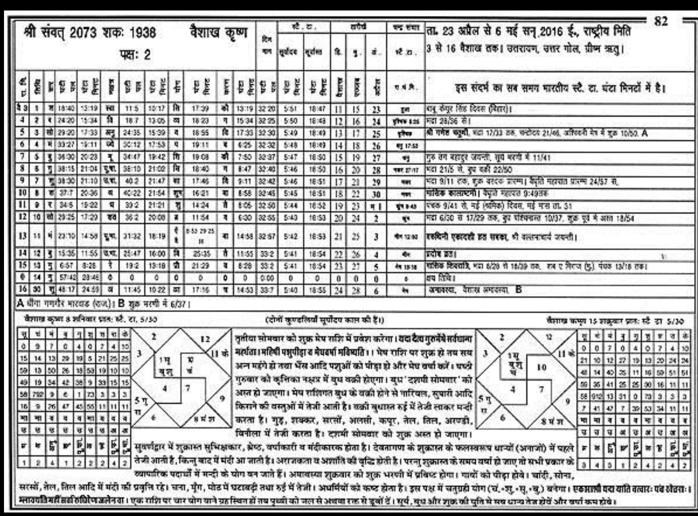

MAPS
Mental
Tangible
Reference
Thematic
Quantitative
Qualitative

One Second

The duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the Caesium 133 atom



Arctic Circle (66.5° N)
Tropic of Cancer (23.5° N)
Equator
Tropic of Capricorn (23.5° S)
Earth
Vernal
Equinox
March 21–22
Incoming solar
energy equal in
both hemispheres
$23^{1}/_{2}°$
Sun
Summer
Solstice
June 21–22
Incoming solar
energy greatest
in Northern
Hemisphere
Orbit
Winter
Solstice
December 21–22
Incoming solar
energy greatest
in Southern
Hemisphere
Autumnal
Equinox
September 22–23
Incoming solar energy
equal in both hemispheres



श्री संवत् 2073 शकः 1938 वैशाख कृष्ण पक्षः 2

82

ता. 23 अप्रैल से 6 मई सन् 2016 ई., राष्ट्रीय मिति 3 से 16 वैशाख तक। उत्तरायण, उत्तर गोल, ग्रीष्म ऋतु।

इस संदर्भ का सब समय भारतीय स्टै. टा. घंटा मिनटों में है।

वै 3	1	श	18:40	13:19	स्वा	11:5	10:17	सि	17:39	कौ	13:19	32:20	5:51	18:47	11	15	23	तुला	बाबू कुंवर सिंह दिवस (बिहार)।
4	2	र	24:20	15:34	वि	18:7	13:05	व्य	18:23	ग	15:34	32:25	5:50	18:48	12	16	24	वृश्चिक 8:25	भद्रा 28/36 से।
5	3	सो	29:20	17:33	अनु	24:35	15:39	व	18:55	वि	17:33	32:30	5:49	18:49	13	17	25	वृश्चिक	श्री गणेश चतुर्थी, भद्रा 17/33 तक, चन्द्रोदय 21/46, अश्विनी मेष में शुक्र 10/50. A
6	4	मं	33:27	19:11	ज्ये	30:12	17:53	प	19:11	ब	6:25	32:32	5:48	18:49	14	18	26	धनु 17:53	
7	5	बु	36:30	20:23	मू	34:47	19:42	शि	19:08	कौ	7:50	32:37	5:47	18:50	15	19	27	धनु	गुरु तेग बहादुर जयन्ती, बुध भरणी में 11/41
8	6	गु	38:15	21:04	पू.षा.	38:10	21:02	सि	18:40	ग	8:47	32:40	5:46	18:50	16	20	28	मकर 27:17	भद्रा 21/5 से, बुध वक्री 22/50
9	7	शु	38:30	21:10	उ.षा.	40:2	21:47	सा	17:46	वि	9:11	32:42	5:46	18:51	17	21	29	मकर	भद्रा 9/11 तक, शुक्र वार्द्धक प्रारम्भ। वैधृति महापात प्रारम्भ 24/57 से.
10	8	श	37:7	20:36	श्र	40:22	21:54	शुभ	16:21	बा	8:58	32:45	5:45	18:51	18	22	30	मकर	मासिक कालाष्टमी। वैधृति महापात 9:49तक
11	9	र	34:6	19:22	ध	39:2	21:21	शु	14:24	तै	8:06	32:50	5:44	18:52	19	23	म 1	कुंभ 8:43	पंचक 9/41 से, मई (श्रमिक) दिवस, मई मास ता. 31
12	10	सो	29:25	17:29	शत	36:2	20:08	ब्र	11:54	व	6:30	32:55	5:43	18:53	20	24	2	कुंभ	भद्रा 6/30 से 17/29 तक, बुध परिवर्तन 10/37, शुक्र पूर्व में अस्त 18/54
13	11	मं	23:10	14:58	पू.भा.	31:32	18:19	ऐ वै	8:53 29:25 16	बा	14:58	32:57	5:42	18:53	21	25	3	मीन 12:30	वरूथिनी एकादशी व्रत सबका, श्री वल्लभाचार्य जयन्ती।
14	12	बु	15:35	11:55	उ.भा.	25:47	16:00	वि	25:35	तै	11:55	33:2	5:41	18:54	22	26	4	मीन	प्रदोष व्रत।
15	13	गु	6:57	8:28	रे	19:2	13:18	प्री	21:29	व	8:28	33:2	5:41	18:54	23	27	5	मेष 13:18	मासिक शिवरात्रि, भद्रा 8/28 से 18/39 तक, शब ए मेराज (मु.) पंचक 13/18 तक।
0	14	गु	57:42	28:46	0	0	0	0	0	0	0	0:00	0	0	0	0	0	0	क्षय तिथि।
16	30	शु	48:17	24:59	अ	11:45	10:22	आ	17:16	च	14:53	33:7	5:40	18:55	24	28	6	मेष	अमावस्या, वैशाख अमावस्या. B

A धींगा गणगौर मारवाड़ (राज.)। B शुक्र भरणी में 6/37।

वैशाख कृष्ण 8 शनिवार प्रातः स्टै. टा. 5/30 (दोनों कुण्डलियाँ सूर्योदय काल की हैं।) वैशाख कृष्ण 15 शुक्रवार प्रातः स्टै. टा. 5/30

सू	चं	मं	बु	गु	शु	श	रा	के
0	9	7	0	4	0	7	4	10
15	14	13	29	19	5	21	25	25
59	13	50	26	18	53	19	10	10
49	19	34	42	38	9	33	15	15
58	792	9	6	1	73	3	3	3
16	9	26	47	45	55	11	11	11
1	2	4	1	2	2	2	4	2

तृतीया सोमवार को शुक्र मेष राशि में प्रवेश करेगा। यदा दैत्य गुरुर्मेषे सर्वधान्य महर्घता। महिषी पशुपीड़ा च मेघवर्षा भविष्यति।। मेष राशि पर शुक्र हो तब सब अन्न महंगे हो तथा भैंस आदि पशुओं को पीड़ा हो और मेघ वर्षा करें। षष्ठी गुरुवार को कृत्तिका नक्षत्र में बुध वक्री होएगा। बुध 'दशमी सोमवार' को अस्त हो जाएगा। मेष राशिगत बुध के वक्री होने से नारियल, सुपारी आदि किराने की वस्तुओं में तेजी आती है। वक्री बुधास्त रुई में तेजी लाकर मन्दी करता है। गुड़, शक्कर, सरसों, अलसी, कपूर, तेल, तिल, अरण्डी, बिनौला में तेजी करता है। दशमी सोमवार को शुक्र अस्त हो जाएगा।

सू	चं	मं	बु	गु	शु	श	रा	के
0	0	7	0	4	0	7	4	10
21	10	12	27	19	13	20	24	24
48	14	40	35	11	16	59	51	51
59	36	41	25	25	30	16	11	11
58	912	13	31	0	73	3	3	3
7	41	47	7	39	53	34	11	11
3	4	3	1	2	4	2	4	2

सुवर्णद्वार में शुक्रास्त सुभिक्षकार, श्रेष्ठ, वर्षाकारी व मंदीकारक होता है। देवतागण के शुक्रास्त के फलस्वरूप धान्यों (अनाजों) में पहले तेजी आती है, किन्तु बाद में मंदी आ जाती है। अराजकता व अशांति की वृद्धि होती है। परन्तु शुक्रास्त के समय वर्षा हो जाए तो सभी प्रकार के व्यापारिक पदार्थों में मन्दी के योग बन जाते हैं। अमावस्या शुक्रवार को शुक्र भरणी में प्रविष्ट होगा। गायों को पीड़ा होवे। चांदी, सोना, सरसों, तेल, तिल आदि में मंदी की प्रवृत्ति रहे। चना, मूंग, मोठ में घटाबढ़ी तथा रुई में तेजी। अधर्मियों को कष्ट होता है। इस पक्ष में चतुर्ग्रही योग (चं.-शु.-सू.-बु.) बनेगा। एकराशौ यदा यान्ति चत्वारः पंच खेचराः। प्लावयन्ति महीं सर्वां रुधिरेणजलेन वा। एक राशि पर चार योग वाले ग्रह स्थित हों तब पृथ्वी को जल से अथवा रक्त से डूबो दें। सूर्य, बुध और शुक्र की युति से सब धान्य तेज होवें और वर्षा कम होवे।

Diwan Bahadur **Lewis Dominic Swamikannu Pillai** CIE, ISO (b. 11 February 1865 - d. 10 September 1925) was an Indian politician, historian, linguist, astronomer and administrator who served as the second President of the Madras Legislative Council.

Lewis Dominic Swamikannu Pillai CIE, ISO	
President of the Madras Legislative Council	
In office February 1925 – 10 September 1925	
Governor	George Goschen, 2nd Viscount Goschen
Preceded by	P. Rajagopalachari
Succeeded by	V. S. Narasimha Raju
Chief Secretary of the Madras Presidency	
In office 1920–1925	
Succeeded by	G. T. Boag
Personal details	
Born	11 February 1865 Madras
Died	10 September 1925 (aged 60) Royapuram, Madras
Nationality	Indian
Profession	Politician, astronomer, linguist, philosopher

Contents [hide]

1 Life
2 Death
3 Honours
4 Works
5 Notes
6 References

Life [edit]

Swamikannu Pillai was born in a poor Indian Christian family of Madras Presidency on 11 February 1865.[1]

Pillai had his schooling in Madras and graduated in law before doing his LIB.[2]

When the then President of the Madras Legislative Council, P.Rajagopalachari resigned his post in 1924 to join the India Council, elections were held for the post of President. In February 1925, Swamikannu Pillai took charge as the first elected President of the Madras Legislative Council.[3]

During his tenure as President of the Madras Legislative Council, Pillai created the Legislative Council library.[4]

In his honour, the LD Swamikannu Pillai Endowment Lectures in philosophy were later established at the University of Madras. Some of the major figures in comparative philosophy, such as Klaus Klostermaier, Ignatius Puthiadam, Richard De Smet, Ignatius Hirudayam, Jean de Marneffe, Ignatius Viyagappa, Bede Griffiths, William Sweet, and George F. McLean, have been invited to deliver these lectures.

A.D 1408. **Solar Eclipse ●** **Lunar Eclipse ○**

Mêsha Sankrânti. (Commencement of Indian sidereal year)
(Surya Sid.) March 26 31. **Śaka 1330** **Kaliyuga 4509**
(Arya Sid.) March 26 24 (S Cycle) Sarvadhârin.

SOLAR reckoning: Cyclic sidereal year, month and day	SOLAR reckoning: Week day, English month and day	LUNAR reckoning: Tithi ending Moment	LUNAR reckoning: Nakshatra ending Moment	LUNAR reckoning: Muhammadan year, month and day
	Jan			
5	Sun 1	3 80	23 43	1
6	Mon 2	4 87	24 52	2
7	Tues 3	5 91	25 59	3
8	Wed 4	6 94	26 68	4
9	Thur 5	7 95	27 49	5
10	Fri 6	8 93	1 70	6
11	Sat 7	9 89	2 69	7
12	Sun 8	10 84	3 67	8
13	Mon 9	11 78	4 63	9
14	Tues 10	12 70	5 58	10
15	Wed 11	13 61	6 52	11
16	Thur 12	14 52	7 45	12
17	Fri 13	P 42	8 38	13
18	Sat 14	1 32	9 31	14
19	Sun 15	2 23	10 25	15
20	Mon 16	3 15	11 20	16
21	Tues 17	4 07	12 15	17
22	Wed 18	[illegible]	[illegible]	[illegible]

Sarvajit Makara—Tai. Magha. Phâlguna. Sarvajit Kumbha—Mâsi. Sarvajit Mîna—Panguni. Chaitra. Sarvadhârin Mêsha—Chittirai. Adhika Vaiśâkha. Sarvadhârin Vrishabha—Vaigâsi. Nija Vaiśâkha. Sarvadhârin Mithuna—Âni. Jyeshtha.

March. **April** **May** **June** **Feb**

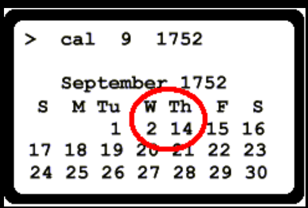
A.D. 1408. **A—Amâvâsyâ.** **P—Paurnimâ.**

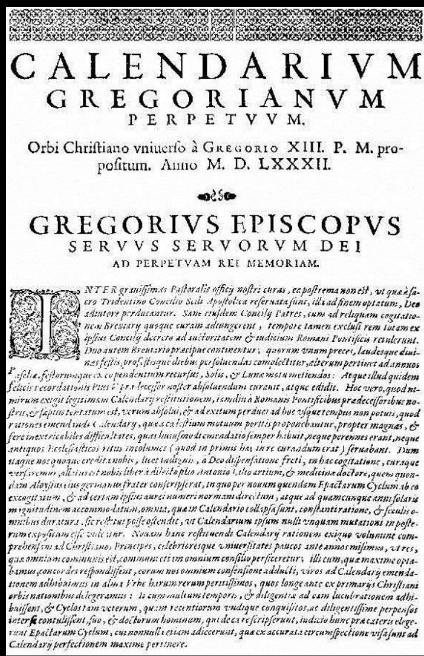
Kollam 584, Commences { **N. Malabar—Aug** **S. Malabar—July.** **Hijra 811.** Commences **May 27.** **Vikrama 1465.** **Bengal San. 814** **(N Cycle) Jaya**

SOLAR reckoning: Cyclic sidereal year, month and day	SOLAR reckoning: Week-day, English month and day	LUNAR reckoning: Tithi ending Moment	LUNAR reckoning: Nakshatra ending Moment	LUNAR reckoning: Muhammadan year, month and day
	July			
	Aug			
	Sep			
	Oct			
	Nov			
	Dec			

Sarvadhârin Karkataka—Âdi. Âshâdha. Śrâvana. Sarvadhârin Simha—Âvani. Bhâdrapada. Sarvadhârin Kanyâ—Purattâsi. Âśvina. Sarvadhârin Tulâ—Aippasi. Kârt. Sarvadhârin Vṛiśchika—Kârttigai. Kârttika. Mârgaśîrsha. Sarvadhârin Dhanus—Mârgali. Pausha.

Natural observations and mathematical calculations to be synchronized, in agreement



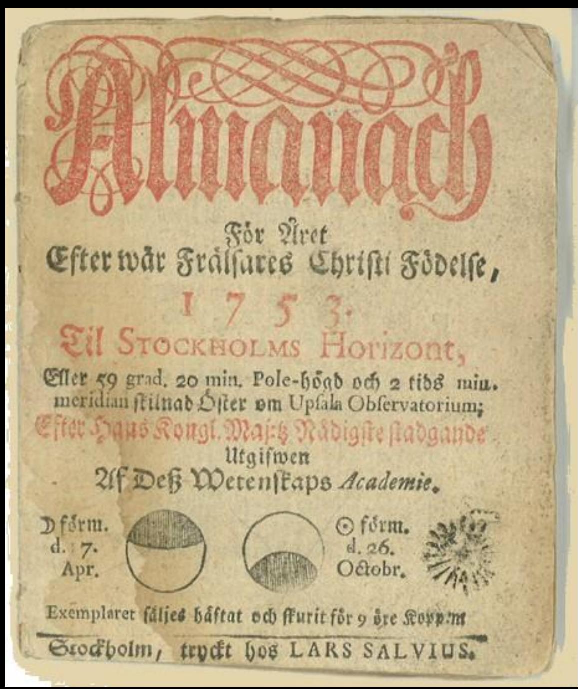


CALENDARIVM GREGORIANVM PERPETVVM.

Orbi Christiano vniuerso à GREGORIO XIII. P. M. propositum. Anno M. D. LXXXII.

GREGORIVS EPISCOPVS SERVVS SERVORVM DEI AD PERPETVAM REI MEMORIAM.

INTER grauissimas Pastoralis officij nostri curas, ea postrema non est, vt quæ à sacro Tridentino Concilio Sedi Apostolicæ reseruata sunt, illa ad finem optatum, Deo adiutore perducantur. Sane eiusdem Concilij Patres, cum ad reliquam cogitationem Breuiarij quoque curam adiungerent, tempore tamen exclusi rem totam ex ipsius Concilij decreto ad auctoritatem & iudicium Romani Pontificis retulerunt. Duo autem Breuiario præcipue continentur: quorum vnum preces, laudesque diuinas festis, profestisque diebus persoluendas complectitur, alterum pertinet ad annuos Paschæ, festorumque ex eo pendentium recursus, Solis, & Lunæ motu metiendos: Atque illud quidem felicis recordationis Pius V. prædecessor noster absoluendum curauit, atque edidit. Hoc vero, quod nimirum exigit legitimam Calendarij restitutionem, iamdiu à Romanis Pontificibus prædecessoribus nostris, & sæpius tentatum est, verum absolui, & ad exitum perduci ad hoc vsque tempus non potuit, quod rationes emendandi Calendarij, quæ à cælestium motuum peritis proponebantur, propter magnas, & fere inextricabiles difficultates, quas huiusmodi emendatio semper habuit, neque perennes erant, neque antiquos Ecclesiasticos ritus incolumes (quod in primis hac in re curandum erat) seruabant. Dum itaque nos quoque credita nobis, licet indignis, à Deo dispensatione freti, in hac cogitatione, curaque versaremur, allatus est nobis liber à dilecto filio Antonio Lilio artium, & medicinæ doctore, quem quondam Aloysius eius germanus frater conscripserat, in quo per nouum quendam Epactarum Cyclum ab eo excogitatum, & ad certam ipsius aurei numeri normam directum, atque ad quamcunque anni solaris magnitudinem accommodatum, omnia, quæ in Calendario collapsa sunt, constanti ratione, & sæculis omnibus duratura, sic restitui posse ostendit, vt Calendarium ipsum nulli vnquam mutationi in posterum expositum esse videatur. Nouam hanc restituendi Calendarij rationem exiguo volumine comprehensam ad Christianos Principes, celebrioresque vniuersitates paucos ante annos misimus, vt res, quæ omnium communis est, communi etiam omnium consilio perficeretur: illi cum, quæ maxime optabamus, concordes respondissent, eorum nos omnium consensione adducti, viros ad Calendarij emendationem adhibuimus in alma Vrbe harum rerum peritissimos, quos longe ante ex primarijs Christiani orbis nationibus delegeramus: Ii cum multum temporis, & diligentiæ ad eam lucubrationem adhibuissent, & Cyclos tam veterum, quam recentiorum vndique conquisitos, ac diligentissime perpensos inter se contulissent, suo, & doctorum hominum, qui de ea re scripserunt, iudicio hunc præ cæteris elegerunt Epactarum Cyclum, cui nonnulla etiam adiecerunt, quæ ex accurata circumspectione visa sunt ad Calendarij perfectionem maxime pertinere.



Almanach

För Året
Efter wår Frälsares Christi Födelse,
1753.
Til STOCKHOLMS Horizont,
Efter 59 grad. 20 min. Pole-högd och 2 tids min.
meridian skilnad Öster om Upsala Observatorium;
Efter Hans Kongl. Maj:ts Nådigste stadgande
Utgifwen
Af Dess Wetenskaps *Academie*.

☽ förm. d. 7. Apr.

☉ förm. d. 26. Octobr.

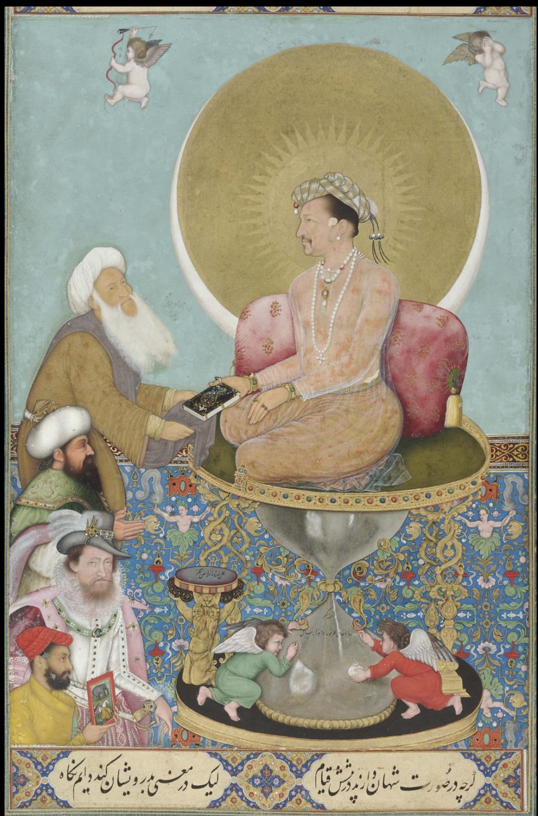
Exemplaret säljes häftat och skurit för 9 öre Kopp:m

Stockholm, tryckt hos LARS SALVIUS.

COUNTRY	NEW YEAR ON JAN 1st	GREGORIAN CALENDAR
Venice	1522	1582
Spain, Poland, Portugal	1556	1582
France	1564	1582
Southern Netherlands	1576	1582
Dutch Republic	1583	1582
Holy Roman Empire (Catholic states)	1544	1583
Lorraine	1579	1682
Denmark	Gradual change from 13th to 16th centuries	1700
Holy Roman Empire (Protestant states)	1559	1700
Tuscany	1721	1750
Scotland	1600	1752
Great Britain and the British Empire except Scotland	1752	1752
Sweden	1559	1753
Russia	1700	1918

An Election Entertainment from *The Humours of an Election* series, 1755

William Hogarth



Hijri Lunar calendar from 622 CE

Fasli 971 + current Hijri year

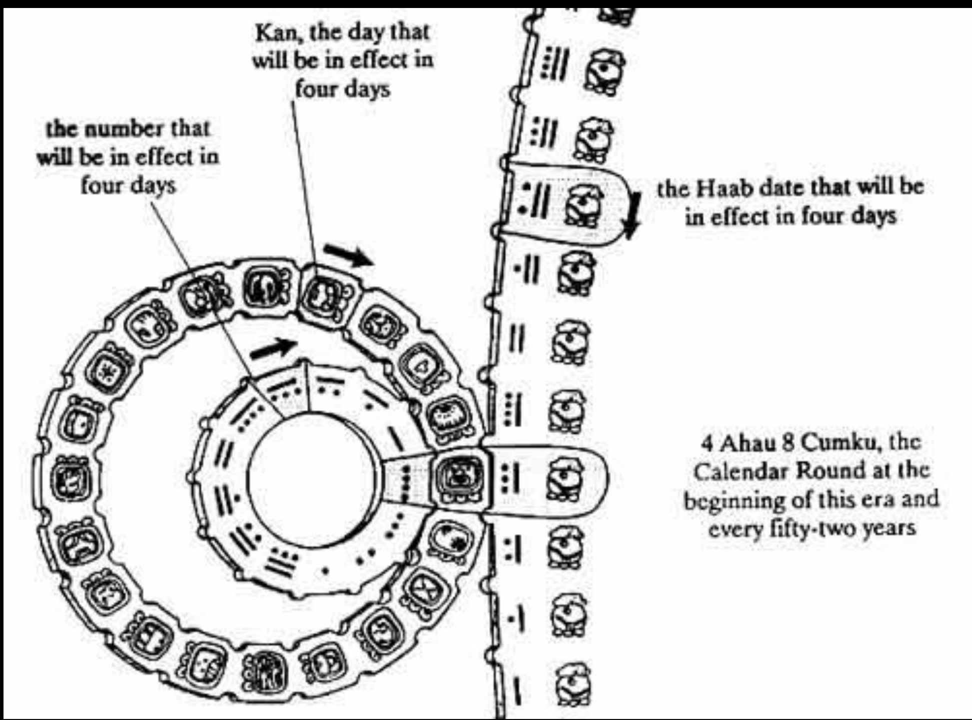
Shuhur San 592 + current Hijri year

Vikram Samvat Solar calendar from 57 BCE

Salivahana Saka Solar calendar from 78 CE

Ilahi Islamic year at Akbar's crowning (963 CE) + current Gregorian solar year - Gregorian solar year at Akbar's crowning.

- Kollam era (Kerala and Tamil Nadu)
- Lakmanasena era (Bengal)
- Kalacuri era
- Gupta or Vallabhi era
- Ganga era
- Jupiter’s 12– or 60– year cycle
- Vikrama era
- Bhauma – Kara era (Orissa)
- Chalukya – Vikrama era (Karnataka)
- Puduvaippu era (Kerala)
- Bhatika era
- Mavludi era (Mysore, Tipu)
- … and so on! About 30 more calendrical systems introduced and then forgotten.



Kan, the day that will be in effect in four days
the number that will be in effect in four days
the Haab date that will be in effect in four days
4 Ahau 8 Cumku, the Calendar Round at the beginning of this era and every fifty-two years

Divisions of time are arbitrary and there is a constant attempt to keep them synchronized with astronomical observations

1.19 Lecture 14A

Science and Medicine

The Gross Clinic (1875) by Thomas Eakins

“[T]he physician regards disease as a thing to be cured or prevented, while the investigator aims at discovering the causal relations between certain morbid changes and the conditions which give rise to them, both depend for their success upon the extent to which their faculties of observation have been developed.”

- Sir J. Burdon-Sanderson

Science has always been part of Western medicine, although what counts as scientific has changed over the centuries, as have the content of medical knowledge, the tools of medical investigation, and the details of medical treatments.

The Practice of Medicine
is an art and a science
under the umbrella term Medical Science.

Pre-scientific forms are traditional and folk medicine,
together known as alternative medicine.

Homeopathy

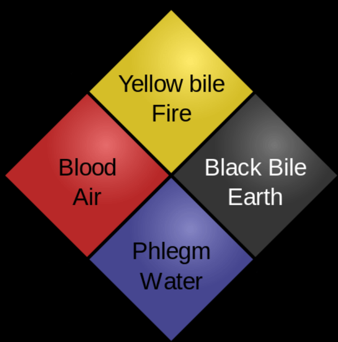
Naturopathy

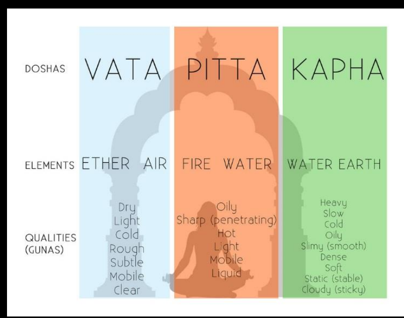
Ayurveda

Siddha

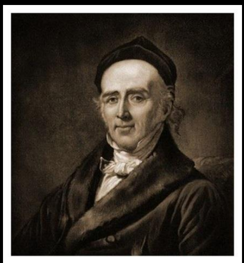
Unani

Tibb





Homeopathy



Samuel Hahnemann
1796

Hahnemann believed the underlying causes of disease were phenomena that he termed miasmas. The preparations are manufactured using a process of homeopathic dilution, in which a chosen substance is repeatedly diluted in alcohol or distilled water, each time with the containing vessel being struck against an elastic material, commonly a leather-bound book. Dilution typically continues well past the point where no molecules of the original substance remain.

Homeopathy Looks at the Horrors of Allopathy (1857)
by Alexander Beydeman

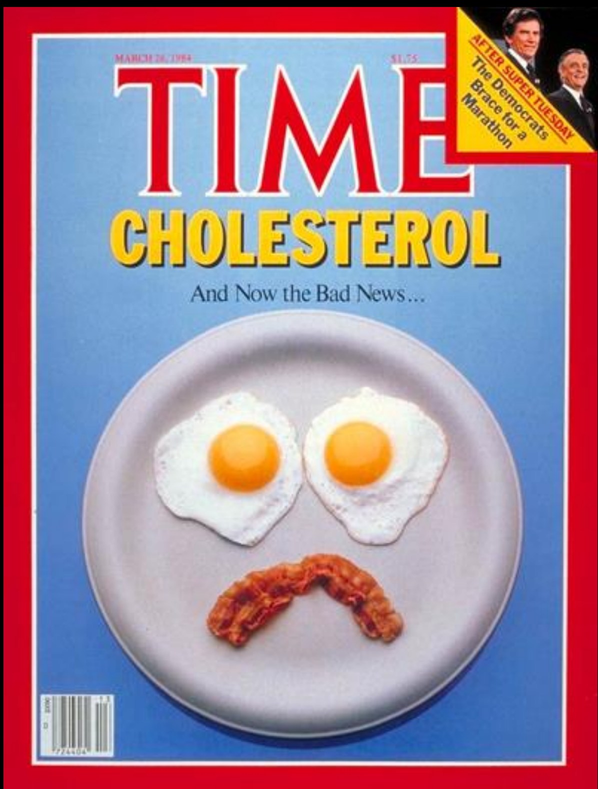
Plague in Pune:

In late 1896, Pune was hit by bubonic plague, part of the global Third plague pandemic; by the end of February 1897, the epidemic was raging, with a mortality rate twice the norm, and half the city's population having left. A Special Plague Committee was formed, under the chairmanship of W. C. Rand, an Indian Civil Services officer, and troops were brought in to deal with the emergency. The measures employed included forced entry into private houses, forced stripping and examination of occupants (including women) by British officers in public, evacuation to hospitals and segregation camps, removing and destroying personal possessions, and preventing movement from the city.

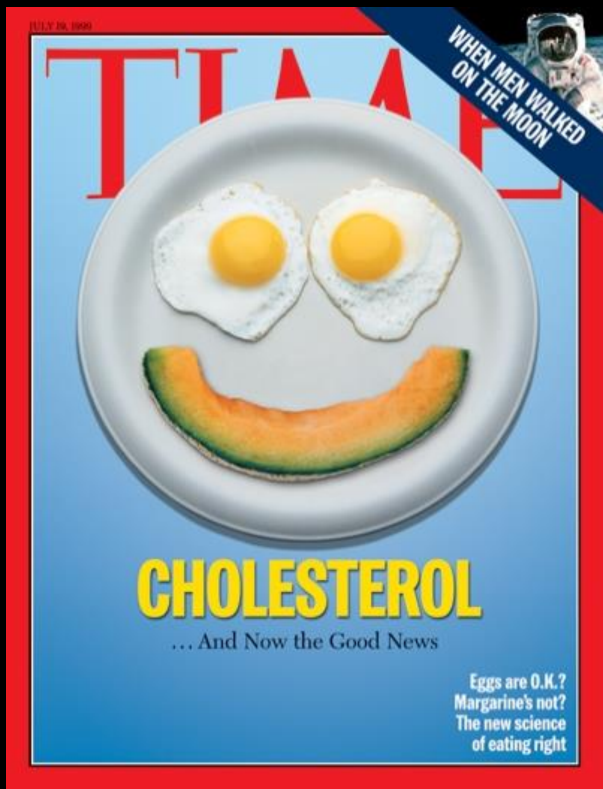
GERM THEORY

22 June 1897 - Marathi Movie

https://youtu.be/VXxQsgUgSPE



26 March 1984



19 July 1999


TIME
Eat Butter.
Scientists labeled fat the enemy. Why they were wrong
BY BRYAN WALSH

23 June 2018

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Int J Risk Saf Med. 2012;24(4):233-42. doi: 10.3233/JRS-2012-0574.

Sponsorship bias in clinical research.

Lexchin J[1].

Author information

Abstract

BACKGROUND: Pharmaceutical companies fund the vast majority of the clinical research that is undertaken on medications but face a conflict of interest between producing good science and results that will enhance the sales of their products.

OBJECTIVES: To document concrete examples of bias in clinical research induced by pharmaceutical industry sponsorship.

METHODS: This paper uses a thematic approach to documenting the extent of these biases in the following areas: research question/topic, choice of doses and comparator agents, control over trial design and changes in protocols, early termination of clinical trials, reporting to regulatory authorities, reinterpretation of data, restrictions on publication rights, use of fake journals, journal supplements and symposia, ghostwriting, publication and reporting of results and outcomes.

RESULTS: Bias in favour of industry is apparent in every one of the themes examined with the result that research funded by industry undermines confidence in medical knowledge.

CONCLUSIONS: Bias induced by commercial concerns can be countered in one of two ways. The first is to erect a firewall between the money and the people doing the research and the data analysis. The other approach is to develop an entirely separate funding source that is independent of the pharmaceutical industry.

PMID: 23135338 DOI: 10.3233/JRS-2012-0574

[Indexed for MEDLINE]

The Big Squeeze: Inside the fight over juice in Canada's Food Guide

Appearing to dim the 'health halo' that surrounds fruit juice, several proposals from the government's new Food Guide have received backlash from members of the beverage industry

ANN HUI › NATIONAL FOOD REPORTER
PUBLISHED NOVEMBER 22, 2018
COMMENTS

Vox FUTURE PERFECT EXPLAINERS THE GOODS POLITICS & POLICY CULTURE SCIENCE & HEALTH MORE

Nutrition research is deeply biased by food companies. A new book explains why.

The food industry has borrowed from the tobacco industry when it comes to distorting science.

By Julia Belluz | @juliaoftoronto | julia.belluz@voxmedia.com | Updated Nov 11, 2018, 9:32am EST

SHARE

Before you read another health study, check who's funding the research

Food companies have a bad history of funding biased research to support their products. We took a look at a few egregious recent examples

▲ New York University nutrition professor Marion Nestle began informally tracking studies funded by food and beverage companies, as well as trade groups, in 2015. Her research uncovered 168 such studies in that year alone

Scientific Medical Research

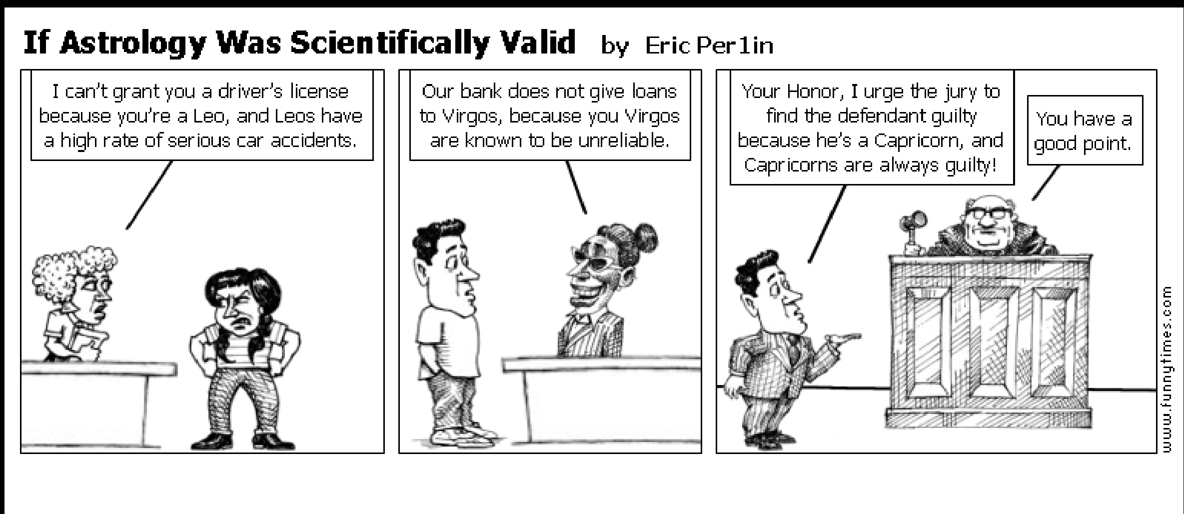
funding sources:
pharmaceutical companies
food and beverage industry

Science and Astrology

Astrology consists of a number of belief systems that hold that there is a relationship between astronomical phenomena and events or descriptions of personality in the human world.

writings of neither were directly known. The story of the absorption of Aristotle by the western schools does not belong to this book,[136] but it is fairly common knowledge that the great philosopher-theologians of the thirteenth century – Bonaventure, Aquinas, Scotus and Ockham were the most important – were all Aristotelians. Aristotle's ideas on what constituted *scientia*, that is, knowledge, were generally accepted in the schools, and for two hundred years or more Aristotelianism was the background philosophy of educated men. And Aristotle, as we have seen, said that all sublunary change was the result of and dependent upon motions in the heavens.

All of this meant that astrology could be and would be accepted as part of *astrologia*, as a science properly belonging to the Aristotelian scheme of things, to the whole scientific picture. It played an important part in medicine, and meteorology and alchemy, as well as in such semi-magical pursuits as all forms of divination and the making of amulets, for example. What had to be preserved through all this was the freedom of man's will, his responsibility to God. His physical make-up might be subject to the influences of the heavens, but never his personal being, his will. This was not always an easy


If Astrology Was Scientifically Valid by Eric Per1in
I can't grant you a driver's license because you're a Leo, and Leos have a high rate of serious car accidents.
Our bank does not give loans to Virgos, because you Virgos are known to be unreliable.
Your Honor, I urge the jury to find the defendant guilty because he's a Capricorn, and Capricorns are always guilty!
You have a good point.
www.funnytimes.com

Focuses on the natural world?
Aims to explain the natural world?
Uses testable ideas?
Relies on evidence?
Involves the scientific community?
Leads to ongoing research?
Researchers behave scientifically?

Science and Vastu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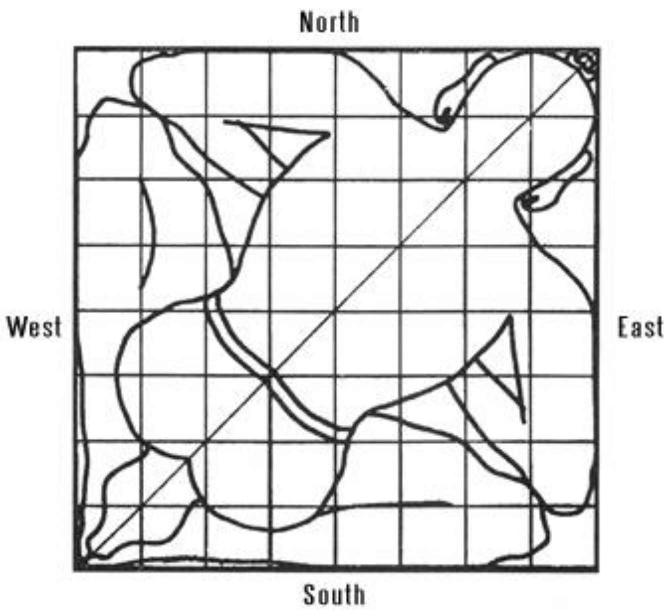
Citrine 3rd chakra



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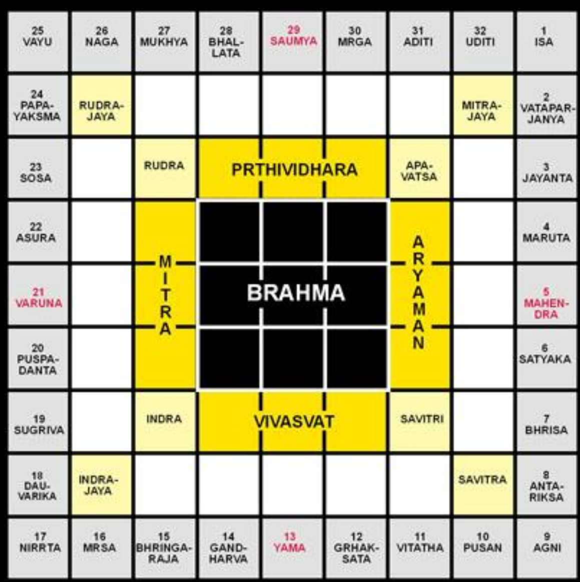
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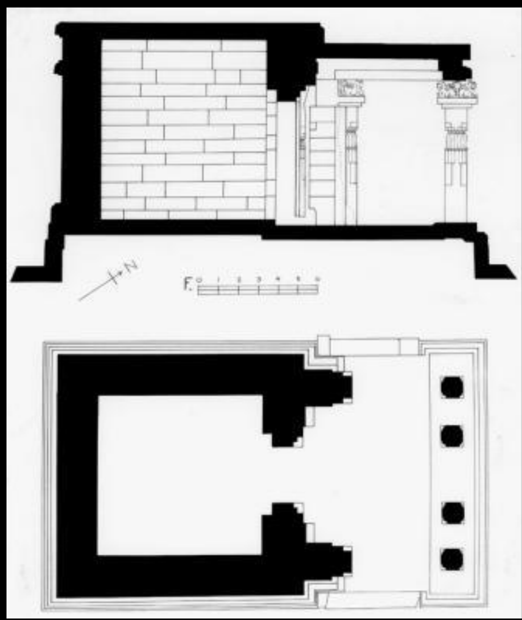
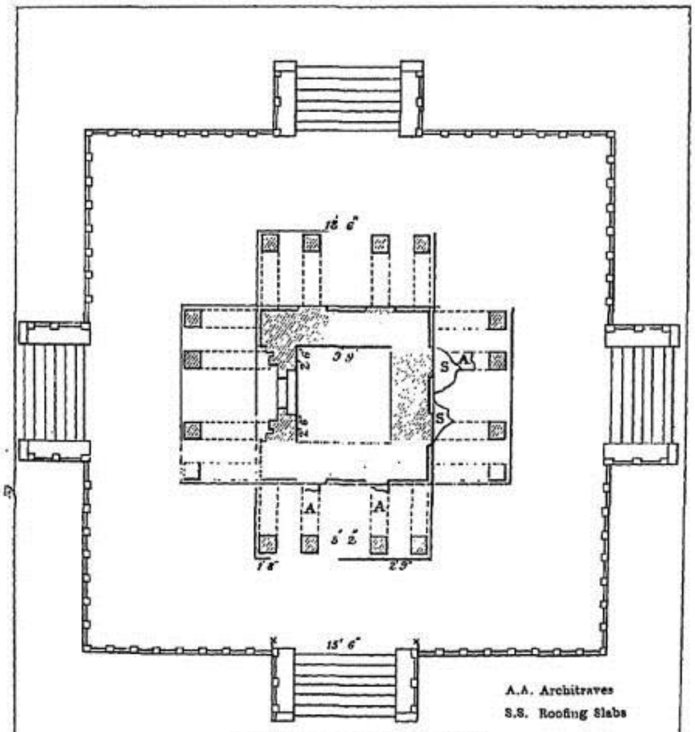
VIVASVAT
SAVITRI
7 BHRISA
18 DAU-VARIKA
INDRA-JAYA
SAVITRA
8 ANTA-RIKSA
17 NIRRTA
16 MRSA
15 BHRINGA-RAJA
14 GAND-HARVA
13 YAMA
12 GRHAK-SATA
11 VITATHA
10 PUSAN
9 AGNI

North West Air/ Vaayu Dev (Lord of Air) Field Staff Visitors Store Room Pantry/ Utilities	**North** Kuber (Lord of Money) Reception Visitors Junior Staff	**North East** Shiva (Lord of Universe) Junior Staff Reception Visitors Pooja Cashier
West Varun (Lord of Rain/Water) Directors Managers Senior Staff	**Center** Brahma Dev (Lord of Creation) Lounge No Fixtures No obstacles	**East** Indra Dev (Lord of Devas) Junior Staff Computer Room Pantry/ Utilities
South West Narratya Dev (Lord of Devils) Master Chamber No Pantry No Toilet	**South** Yam Dev (Lord of Death) Directors Managers Senior Staff	**South East** Agni Dev (Lord of Fire) Reception Visitors Accounts Dept Compter Room Pantry/ Utilities

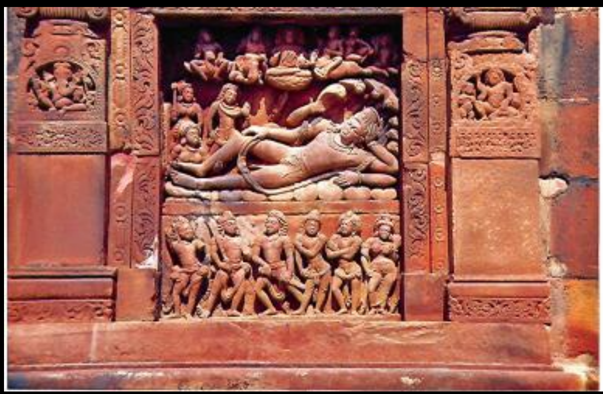


Temple 17, Sanchi (c. 400-450 CE)

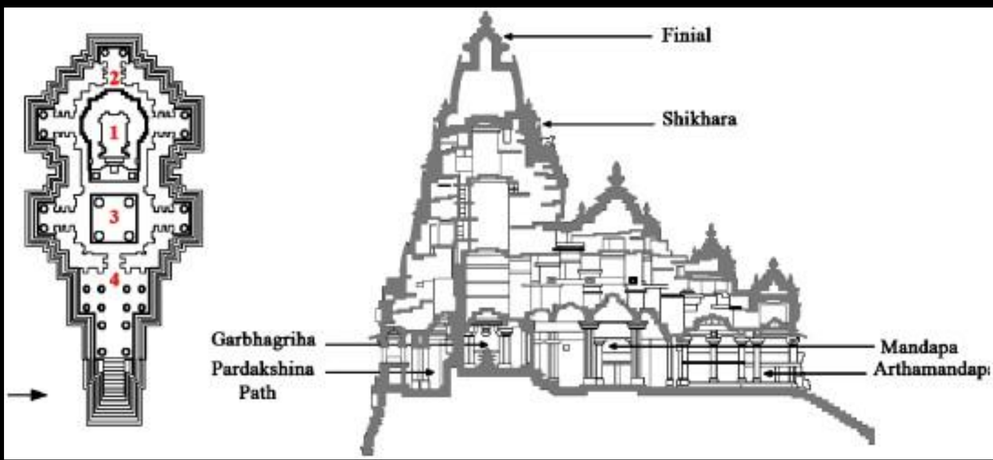


ELEVATION OF TERRACE WALLS.

Dashavatara Temple, Deogarh (c. 500-525 CE)




Parvati Temple, Nachna (c. 450-550 CE)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Garbhagriha
Pardakshina
Path
Mandapa
Arthamandapa

1.20 Lecture 14B

The Anthropocene

Coined by Paul Crutzen and Eugene Stoermer in 2000

"*anthropo*", meaning "human" with the root "-*cene*", the standard suffix for "epoch" in geologic time.

Not an officially accepted nomenclature yet; the International Commission on Stratigraphy and the International Union of Geological Sciences (IUGS) has not yet approved of it

The Anthropocene

“The Anthropocene defines Earth's most recent geologic time period as being human-influenced, or anthropogenic, based on overwhelming global evidence that atmospheric, geologic, hydrologic, biospheric and other earth system processes are now altered by humans….

The Anthropocene is distinguished as a new period either after or within the Holocene, the current epoch, which began approximately 10,000 years ago (about 8000 BC) with the end of the last glacial period.”

(http://www.anthropocene.info/index.php)

The Anthropocene Period

Different starting dates:

a. 12,000 - 15,000 years ago; the beginning of the Agricultural Revolution
b. 2000 years ago; the Roman Empire , the Middle kingdoms in India, the Olmecs in Mexico
c. Around the 1700s; the Industrial Revolution
d. Some suggest as recent a date as the Trinity Test in 1945 (first detonation of a nuclear weapon)

The most recent period (starting post WWII in 1945) has been referred to by several scholars as the **Great Acceleration** during which the socioeconomic and earth system trends are increasing dramatically.

Effects of human activity

- Changes in erosion and sediment transport
- Increased agriculture, urbanisation
- Changes in the chemical composition of the atmosphere, oceans and soils, with significant anthropogenic perturbations of the cycles of elements such as carbon, nitrogen, phosphorus and various metals
- Environmental conditions generated by these perturbations, including ocean acidification and spreading oceanic ‘dead zones’
- Changes in the biosphere on land and in the sea, as a result of habitat loss, predation, species invasions and extinction

Some animals that have gone extinct in the last hundred years

- Passenger pigeon (1914)
- Carolina Parakeet (1918)
- Heath Hen (1932)
- Tasmanian Tiger (1936)
- Gravenche (1950)
- Japanese Sea Lion (1974)
- Javan Tiger (1980s)
- Pyrenean Ibex (2000)
- Baiji River Dolphin (2005)
- Caribbean Monk Seal (2008)
- Western Black Rhino (2011)
- Pinta Island Tortoise (2012)

Ol Pejeta
@OlPejeta

Follow

It is with great sadness that Ol Pejeta Conservancy and the Dvůr Králové Zoo announce that Sudan, the world's last male northern white rhino, age 45, died at Ol Pejeta Conservancy in Kenya on March 19th, 2018 (yesterday). #SudanForever #TheLoneBachelorGone #Only2Left

10:47 PM - 19 Mar 2018

2 Readings

2.1 Reading 1

What is Science?

George Orwell

In last week's *Tribune*, there was an interesting letter from Mr. J. Stewart Cook, in which he suggested that the best way of avoiding the danger of a 'scientific hierarchy' would be to see to it that every member of the general public was, as far as possible, scientifically educated. At the same time, scientists should be brought out of their isolation and encouraged to take a greater part in politics and administration.

As a general statement, I think most of us would agree with this, but I notice that, as usual, Mr. Cook does not define science, and merely implies in passing that it means certain exact sciences whose experiments can be made under laboratory conditions. Thus, adult education tends 'to neglect scientific studies in favour of literary, economic and social subjects', economics and sociology not being regarded as branches of science. Apparently. This point is of great importance. For the word science is at present used in at least two meanings, and the whole question of scientific education is obscured by the current tendency to dodge from one meaning to the other.

Science is generally taken as meaning either (a) the exact sciences, such as chemistry, physics, etc., or (b) a method of thought which obtains verifiable results by reasoning logically from observed fact.

If you ask any scientist, or indeed almost any educated person, 'What is science?' you are likely to get an answer approximating to (b). In everyday life, however, both in speaking and in writing, when people say 'science' they mean (a). Science means something that happens in a laboratory: the very word calls up a picture of graphs, test-tubes, balances, Bunsen burners, microscopes. A biologist, and astronomer, perhaps a psychologist or a mathematician is described as a 'man of science': no one would think of applying this term to a statesman, a poet, a journalist or even a philosopher. And those who tell us that the young must be scientifically educated mean, almost invariably, that they should be taught more about radioactivity, or the stars, or the physiology or their own bodies, rather than that they should be taught to think more exactly.

This confusion of meaning, which is partly deliberate, has in it a great danger. Implied in the demand for more scientific education is the claim that if one has been scientifically trained one's approach to *all* subjects will be more intelligent than if one had had no such training. A scientist's political opinions, it is assumed, his opinions on sociological questions, on morals, on philosophy, perhaps even on the arts, will be more valuable than those of a layman. The world, in other words, would be a better place if the scientists were in control of it. But a 'scientist', as we have just seen, means in practice a specialist in one of the exact sciences. It follows that a chemist or a physicist, as such, is politically more intelligent than a poet or a lawyer, as such. And, in fact, there are already millions of people who do believe this.

But is it really true that a 'scientist', in this narrower sense, is any likelier than other people to approach non-scientific problems in an objective way? There is not much reason for thinking so. Take one simple test — the ability to withstand nationalism. It is often loosely said that 'Science is international', but in practice the scientific workers of all countries line up behind their own governments with fewer scruples than are felt by the writers and the artists. The German scientific community, as a whole, made no resistance to Hitler. Hitler may have ruined the long-term prospects of German science, but there were still plenty of gifted men to do the necessary research on such things as synthetic oil, jet planes, rocket projectiles and the atomic bomb. Without them the German war machine could never have been built up.

On the other hand, what happened to German literature when the Nazis came to power? I believe no exhaustive lists have been published, but I imagine that the number of German scientists — Jews apart — who voluntarily exiled themselves or were persecuted by the règime was much smaller than the number of writers and journalists. More sinister than this, a number of German scientists swallowed the monstrosity of 'racial science'. You can find some of the statements to which they set their names in Professor Brady's *The Spirit and Structure of German Fascism*.

But, in slightly different forms, it is the same picture everywhere. In England, a large proportion of our leading scientists accept the structure of capitalist society, as can be seen from the comparative freedom with which they are given knighthoods, baronetcies and even peerages. Since Tennyson, no English writer worth reading — one might, perhaps, make an exception of Sir Max Beerbohm — has been given a title. And those English scientists who do not simply accept the *status quo* are frequently Communists, which means that, however intellectually scrupulous they may be in their own line of work, they are ready to be uncritical and even dishonest on certain subjects. The fact is that a mere training in one or more of the exact sciences, even combined with very high gifts, is no guarantee of a humane or sceptical outlook. The physicists of half a dozen great nations, all feverishly and secretly working away at the atomic bomb, are a demonstration of this.

But does all this mean that the general public should *not* be more scientifically educated? On the contrary! All it means is that scientific education for the masses will do little good, and probably a lot of harm, if it simply boils down to more physics, more chemistry, more biology, etc., to the detriment of literature and history. Its probable effect on the average human being would be to narrow the range of his thoughts and make him more than ever contemptuous of such knowledge as he did not possess: and his political reactions would probably be somewhat less intelligent than those of an illiterate peasant who retained a few historical memories and a fairly sound aesthetic sense.

Clearly, scientific education ought to mean the implanting of a rational, sceptical, experimental habit of mind. It ought to mean acquiring a *method* — a method that can be used on any problem that one meets — and not simply piling up a lot of facts. Put it in those words, and the apologist of scientific education will usually agree. Press him further, ask him to particularize, and somehow it always turns out that scientific education means more attention to the sciences, in other words — more *facts*. The idea that science means a way of looking at the world, and not simply a body of knowledge, is in practice strongly resisted. I think sheer professional jealousy is part of the reason for this. For if science is simply a method or an attitude, so that anyone whose thought-processes are sufficiently rational can in some sense be described as a scientist — what then becomes of the enormous prestige now enjoyed by the chemist, the physicist, etc. and his claim to be somehow wiser than the rest of us?

A hundred years ago, Charles Kingsley described science as 'making nasty smell in a laboratory'. A year or two ago a young industrial chemist informed me, smugly, that he 'could not see what was the use of poetry'. So the pendulum swings to and fro, but it does not seem to me that one attitude is any better than the other. At the moment, science is on the upgrade, and so we hear, quite rightly, the claim that the masses should be scientifically educated: we do not hear, as we ought, the counter-claim that the scientists themselves would benefit by a little education. Just before writing this, I saw in an American magazine the statement that a number of British and American physicists refused from the start to do research on the atomic bomb, well knowing what use would be made of it. Here you have a group of same men in the middle of a world of lunatics. And though no names were published, I think it would be a safe guess that all of them were people with some kind of general cultural background, some acquaintance with history or literature or the arts — in short, people whose interests were not, in the current sense of the word, purely scientific.

2.2 Reading 2

Available soon:

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CONTEMPORARY ART Julian Stallabrass
THE CRUSADES Christopher Tyerman
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Samir Okasha

PHILOSOPHY OF SCIENCE

A Very Short Introduction

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© David Parker/Science Photo Library

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Chapter 1
What is science?

What is science? This question may seem easy to answer: everybody knows that subjects such as physics, chemistry, and biology constitute science, while subjects such as art, music, and theology do not. But when as philosophers we ask what science is, that is not the sort of answer we want. We are not asking for a mere list of the activities that are usually called 'science'. Rather, we are asking what common feature all the things on that list share, i.e. what it is that *makes* something a science. Understood this way, our question is not so trivial.

But you may still think the question is relatively straightforward. Surely science is just the attempt to understand, explain, and predict the world we live in? This is certainly a reasonable answer. But is it the whole story? After all, the various religions also attempt to understand and explain the world, but religion is not usually regarded as a branch of science. Similarly, astrology and fortune-telling are attempts to predict the future, but most people would not describe these activities as science. Or consider history. Historians try to understand and explain what happened in the past, but history is usually classified as an arts subject not a science subject. As with many philosophical questions, the question 'what is science?' turns out to be trickier than it looks at first sight.

Many people believe that the distinguishing features of science lie in the particular methods scientists use to investigate the world. This suggestion is quite plausible. For many sciences do employ distinctive methods of enquiry that are not found in non-scientific disciplines. An obvious example is the use of experiments, which historically marks a turning-point in the development of modern science. Not all the sciences are experimental though – astronomers obviously cannot do experiments on the heavens, but have to content themselves with careful observation instead. The same is true of many social sciences. Another important feature of science is the construction of theories. Scientists do not simply record the results of experiment and observation in a log book – they usually want to explain those results in terms of a general theory. This is not always easy to do, but there have been some striking successes. One of the key problems in philosophy of science is to understand how techniques such as experimentation, observation, and theory-construction have enabled scientists to unravel so many of nature's secrets.

The origins of modern science

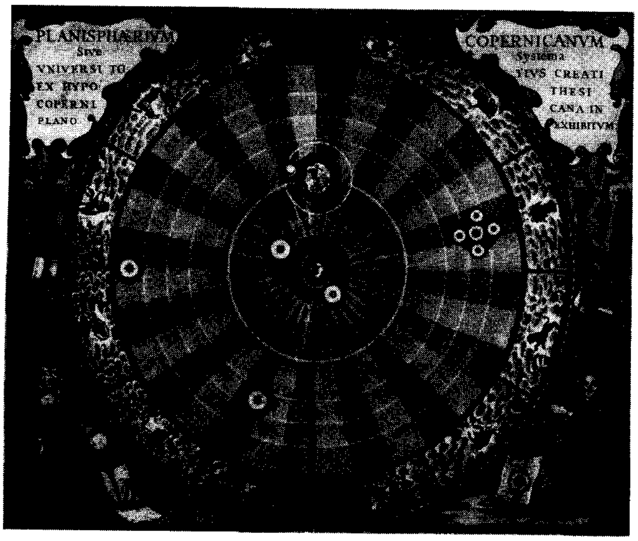
In today's schools and universities, science is taught in a largely ahistorical way. Textbooks present the key ideas of a scientific discipline in as convenient a form as possible, with little mention of the lengthy and often tortuous historical process that led to their discovery. As a pedagogical strategy, this makes good sense. But some appreciation of the history of scientific ideas is helpful for understanding the issues that interest philosophers of science. Indeed as we shall see in Chapter 5, it has been argued that close attention to the history of science is indispensable for doing good philosophy of science.

The origins of modern science lie in a period of rapid scientific development that occurred in Europe between the years 1500 and 1750, which we now refer to as the scientific revolution. Of course scientific investigations were pursued in ancient and medieval

times too – the scientific revolution did not come from nowhere. In these earlier periods the dominant world-view was Aristotelianism, named after the ancient Greek philosopher Aristotle, who put forward detailed theories in physics, biology, astronomy, and cosmology. But Aristotle's ideas would seem very strange to a modern scientist, as would his methods of enquiry. To pick just one example, he believed that all earthly bodies are composed of just four elements: earth, fire, air, and water. This view is obviously at odds with what modern chemistry tells us.

The first crucial step in the development of the modern scientific world-view was the Copernican revolution. In 1542 the Polish astronomer Nicolas Copernicus (1473–1543) published a book attacking the geocentric model of the universe, which placed the stationary earth at the centre of the universe with the planets and the sun in orbit around it. Geocentric astronomy, also known as Ptolemaic astronomy after the ancient Greek astronomer Ptolemy, lay at the heart of the Aristotelian world-view, and had gone largely unchallenged for 1,800 years. But Copernicus suggested an alternative: the *sun* was the fixed centre of the universe, and the planets, including the earth, were in orbit around the sun (Figure 1). On this heliocentric model the earth is regarded as just another planet, and so loses the unique status that tradition had accorded it. Copernicus' theory initially met with much resistance, not least from the Catholic Church who regarded it as contravening the Scriptures and in 1616 banned books advocating the earth's motion. But within 100 years Copernicanism had become established scientific orthodoxy.

Copernicus' innovation did not merely lead to a better astronomy. Indirectly, it led to the development of modern physics, through the work of Johannes Kepler (1571–1630) and Galileo Galilei (1564–1642). Kepler discovered that the planets do not move in circular orbits around the sun, as Copernicus thought, but rather in ellipses. This was his crucial 'first law' of planetary motion; his second and third laws specify the speeds at which the planets orbit the sun.



1. Copernicus' heliocentric model of the universe, showing the planets, including the earth, orbiting the sun.

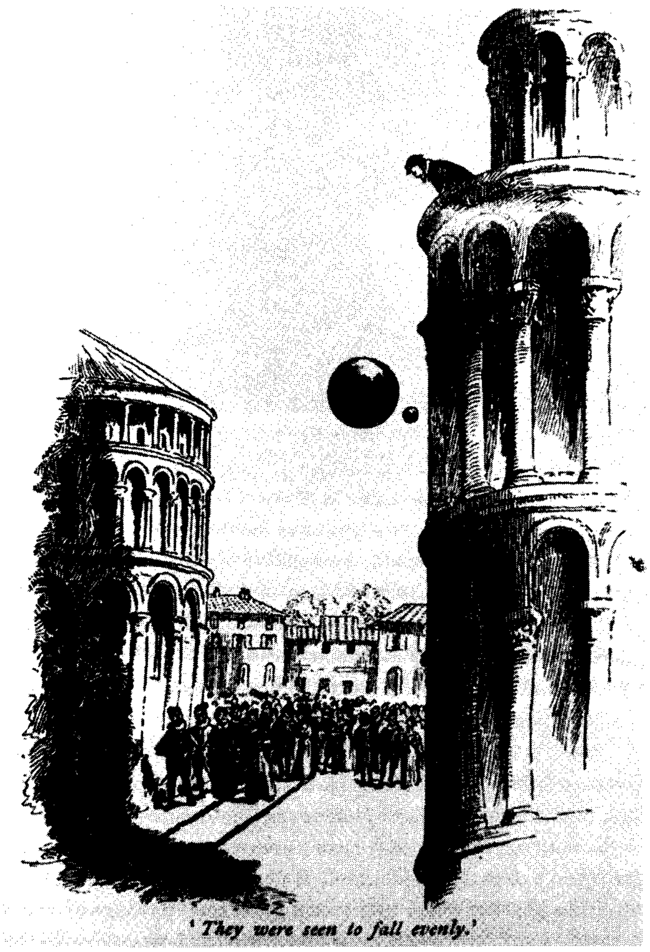
Taken together, Kepler's laws provided a far superior planetary theory than had ever been advanced before, solving problems that had confounded astronomers for centuries. Galileo was a life-long supporter of Copernicanism, and one of the early pioneers of the telescope. When he pointed his telescope at the heavens, he made a wealth of amazing discoveries, including mountains on the moon, a vast array of stars, sun-spots, and Jupiter's moons. All of these conflicted thoroughly with Aristotelian cosmology, and played a pivotal role in converting the scientific community to Copernicanism.

Galileo's most enduring contribution, however, lay not in astronomy but in mechanics, where he refuted the Aristotelian theory that heavier bodies fall faster than lighter ones. In place of this theory, Galileo made the counter-intuitive suggestion that all

freely falling bodies will fall towards the earth at the same rate, irrespective of their weight (Figure 2). (Of course in practice, if you drop a feather and a cannon-ball from the same height the cannon-ball will land first, but Galileo argued that this is simply due to air resistance – in a vacuum, they would land together.) Furthermore, he argued that freely falling bodies accelerate uniformly, i.e. gain equal increments of speed in equal times; this is known as Galileo's law of free-fall. Galileo provided persuasive though not totally conclusive evidence for this law, which formed the centrepiece of his theory of mechanics.

Galileo is generally regarded as the first truly modern physicist. He was the first to show that the language of mathematics could be used to describe the behaviour of actual objects in the material world, such as falling bodies, projectiles, etc. To us this seems obvious – today's scientific theories are routinely formulated in mathematical language, not only in the physical sciences but also in biology and economics. But in Galileo's day it was not obvious: mathematics was widely regarded as dealing with purely abstract entities, and hence inapplicable to physical reality. Another innovative aspect of Galileo's work was his emphasis on the importance of testing hypotheses experimentally. To the modern scientist, this may again seem obvious. But at the time that Galileo was working, experimentation was not generally regarded as a reliable means of gaining knowledge. Galileo's emphasis on experimental testing marks the beginning of an empirical approach to studying nature that continues to this day.

The period following Galileo's death saw the scientific revolution rapidly gain in momentum. The French philosopher, mathematician, and scientist René Descartes (1596–1650) developed a radical new 'mechanical philosophy', according to which the physical world consists simply of inert particles of matter interacting and colliding with one another. The laws governing the motion of these particles or 'corpuscles' held the key to understanding the structure of the Copernican universe, Descartes



2. Sketch of Galileo's mythical experiment on the velocity of objects dropped from the Leaning Tower of Pisa.

believed. The mechanical philosophy promised to explain all observable phenomena in terms of the motion of these inert, insensible corpuscles, and quickly became the dominant scientific vision of the second half of the 17th century; to some extent it is still with us today. Versions of the mechanical philosophy were espoused by figures such as Huygens, Gassendi, Hooke, Boyle, and others; its widespread acceptance marked the final downfall of the Aristotelian world-view.

The scientific revolution culminated in the work of Isaac Newton (1643–1727), whose achievements stand unparalleled in the history of science. Newton's masterpiece was his *Mathematical Principles of Natural Philosophy*, published in 1687. Newton agreed with the mechanical philosophers that the universe consists simply of particles in motion, but sought to improve on Descartes' laws of motion and rules of collision. The result was a dynamical and mechanical theory of great power, based around Newton's three laws of motion and his famous principle of universal gravitation. According to this principle, every body in the universe exerts a gravitational attraction on every other body; the strength of the attraction between two bodies depends on the product of their masses, and on the distance between them squared. The laws of motion then specify how this gravitational force affects the bodies' motions. Newton elaborated his theory with great mathematical precision and rigour, inventing the mathematical technique we now call 'calculus'. Strikingly, Newton was able to show that Kepler's laws of planetary motion and Galileo's law of free-fall (both with certain minor modifications) were logical consequences of his laws of motion and gravitation. In other words, the very same laws would explain the motions of bodies in both terrestrial and celestial domains, and were formulated by Newton in a precise quantitative form.

Newtonian physics provided the framework for science for the next 200 years or so, quickly replacing Cartesian physics. Scientific confidence grew rapidly in this period, due largely to the success of

Newton's theory, which was widely believed to have revealed the true workings of nature, and to be capable of explaining everything, in principle at least. Detailed attempts were made to extend the Newtonian mode of explanation to more and more phenomena. The 18th and 19th centuries both saw notable scientific advances, particularly in the study of chemistry, optics, energy, thermodynamics, and electromagnetism. But for the most part, these developments were regarded as falling within a broadly Newtonian conception of the universe. Scientists accepted Newton's conception as essentially correct; all that remained to be done was to fill in the details.

Confidence in the Newtonian picture was shattered in the early years of the 20th century, thanks to two revolutionary new developments in physics: relativity theory and quantum mechanics. Relativity theory, discovered by Einstein, showed that Newtonian mechanics does not give the right results when applied to very massive objects, or objects moving at very high velocities. Quantum mechanics, conversely, shows that the Newtonian theory does not work when applied on a very small scale, to subatomic particles. Both relativity theory and quantum mechanics, especially the latter, are very strange and radical theories, making claims about the nature of reality that many people find hard to accept or even understand. Their emergence caused considerable conceptual upheaval in physics, which continues to this day.

So far our brief account of the history of science has focused mainly on physics. This is no accident, as physics is both historically very important and in a sense the most fundamental of all scientific disciplines. For the objects that other sciences study are themselves made up of physical entities. Consider botany, for example. Botanists study plants, which are ultimately composed of molecules and atoms, which are physical particles. So botany is obviously less fundamental than physics – though that is not to say it is any less important. This is a point we shall return to in Chapter 3. But even

a brief description of modern science's origins would be incomplete if it omitted all mention of the non-physical sciences.

In biology, the event that stands out is Charles Darwin's discovery of the theory of evolution by natural selection, published in *The Origin of Species* in 1859. Until then it was widely believed that the different species had been separately created by God, as the Book of Genesis teaches. But Darwin argued that contemporary species have actually evolved from ancestral ones, through a process known as natural selection. Natural selection occurs when some organisms leave more offspring than others, depending on their physical characteristics; if these characteristics are then inherited by their offspring, over time the population will become better and better adapted to the environment. Simple though this process is, over a large number of generations it can cause one species to evolve into a wholly new one, Darwin argued. So persuasive was the evidence Darwin adduced for his theory that by the start of the 20th century it was accepted as scientific orthodoxy, despite considerable theological opposition (Figure 3). Subsequent work has provided striking confirmation of Darwin's theory, which forms the centrepiece of the modern biological world-view.

The 20th century witnessed another revolution in biology that is not yet complete: the emergence of molecular biology, in particular molecular genetics. In 1953 Watson and Crick discovered the structure of DNA, the hereditary material that makes up the genes in the cells of living creatures (Figure 4). Watson and Crick's discovery explained how genetic information can be copied from one cell to another, and thus passed down from parent to offspring, thereby explaining why offspring tend to resemble their parents. Their discovery opened up an exciting new area of biological research. In the 50 years since Watson and Crick's work, molecular biology has grown fast, transforming our understanding of heredity and of how genes build organisms. The recent attempt to provide a molecular-level description of the complete set of genes in a human

3. Darwin's suggestion that humans and apes have descended from common ancestors caused consternation in Victorian England.

being, known as the Human Genome Project, is an indication of how far molecular biology has come. The 21st century will see further exciting developments in this field.

More resources have been devoted to scientific research in the last hundred years than ever before. One result has been an explosion of new scientific disciplines, such as computer science, artificial intelligence, linguistics, and neuroscience. Possibly the most significant event of the last 30 years is the rise of cognitive science,

4. James Watson and Francis Crick with the famous 'double helix' – their molecular model of the structure of DNA, discovered in 1953.

which studies various aspects of human cognition such as perception, memory, learning, and reasoning, and has transformed traditional psychology. Much of the impetus for cognitive science comes from the idea that the human mind is in some respects similar to a computer, and thus that human mental processes can be understood by comparing them to the operations computers carry out. Cognitive science is still in its infancy, but promises to reveal much about the workings of the mind. The social sciences, especially economics and sociology, have also flourished in the 20th century, though many people believe they still lag behind the natural sciences in terms of sophistication and rigour. This is an issue we shall return to in Chapter 7.

What is philosophy of science?

The principal task of philosophy of science is to analyse the methods of enquiry used in the various sciences. You may wonder why this task should fall to philosophers, rather than to the scientists themselves. This is a good question. Part of the answer is that looking at science from a philosophical perspective allows us to probe deeper – to uncover assumptions that are implicit in scientific practice, but which scientists do not explicitly discuss. To illustrate, consider scientific experimentation. Suppose a scientist does an experiment and gets a particular result. He repeats the experiment a few times and keeps getting the same result. After that he will probably stop, confident that were he to keep repeating the experiment, under exactly the same conditions, he would continue to get the same result. This assumption may seem obvious, but as philosophers we want to question it. *Why* assume that future repetitions of the experiment will yield the same result? How do we know this is true? The scientist is unlikely to spend too much time puzzling over these somewhat curious questions: he probably has better things to do. They are quintessentially philosophical questions, to which we return in the next chapter.

So part of the job of philosophy of science is to question assumptions that scientists take for granted. But it would be wrong to imply that scientists never discuss philosophical issues themselves. Indeed, historically, many scientists have played an important role in the development of philosophy of science. Descartes, Newton, and Einstein are prominent examples. Each was deeply interested in philosophical questions about how science should proceed, what methods of enquiry it should use, how much confidence we should place in those methods, whether there are limits to scientific knowledge, and so on. As we shall see, these questions still lie at the heart of contemporary philosophy of science. So the issues that interest philosophers of science are not 'merely philosophical'; on the contrary, they have engaged the attention of some of the greatest scientists of all. That having been

said, it must be admitted that many scientists today take little interest in philosophy of science, and know little about it. While this is unfortunate, it is not an indication that philosophical issues are no longer relevant. Rather, it is a consequence of the increasingly specialized nature of science, and of the polarization between the sciences and the humanities that characterizes the modern education system.

You may still be wondering exactly what philosophy of science is all about. For to say that it 'studies the methods of science', as we did above, is not really to say very much. Rather than try to provide a more informative definition, we will proceed straight to consider a typical problem in the philosophy of science.

Science and pseudo-science

Recall the question with which we began: what is science? Karl Popper, an influential 20th-century philosopher of science, thought that the fundamental feature of a scientific theory is that it should be falsifiable. To call a theory falsifiable is not to say that it is false. Rather, it means that the theory makes some definite predictions that are capable of being tested against experience. If these predictions turn out to be wrong, then the theory has been falsified, or disproved. So a falsifiable theory is one that we might discover to be false – it is not compatible with every possible course of experience. Popper thought that some supposedly scientific theories did not satisfy this condition and thus did not deserve to be called science at all; rather they were merely pseudo-science.

Freud's psychoanalytic theory was one of Popper's favourite examples of pseudo-science. According to Popper, Freud's theory could be reconciled with any empirical findings whatsoever. Whatever a patient's behaviour, Freudians could find an explanation of it in terms of their theory – they would never admit that their theory was wrong. Popper illustrated his point with the following example. Imagine a man who pushes a child into a river with the intention of murdering him, and another man who sacrifices his life in order to save the child. Freudians can explain both men's behaviour with equal ease: the first was repressed, and the second had achieved sublimation. Popper argued that through the use of such concepts as repression, sublimation, and unconscious desires, Freud's theory could be rendered compatible with any clinical data whatever; it was thus unfalsifiable.

The same was true of Marx's theory of history, Popper maintained. Marx claimed that in industrialized societies around the world, capitalism would give way to socialism and ultimately to communism. But when this didn't happen, instead of admitting that Marx's theory was wrong, Marxists would invent an *ad hoc* explanation for why what happened was actually perfectly consistent with their theory. For example, they might say that the inevitable progress to communism had been temporarily slowed by the rise of the welfare state, which 'softened' the proletariat and weakened their revolutionary zeal. In this sort of way, Marx's theory could be made compatible with any possible course of events, just like Freud's. Therefore neither theory qualifies as genuinely scientific, according to Popper's criterion.

Popper contrasted Freud's and Marx's theories with Einstein's theory of gravitation, also known as general relativity. Unlike Freud's and Marx's theories, Einstein's theory made a very definite prediction: that light rays from distant stars would be deflected by the gravitational field of the sun. Normally this effect would be impossible to observe – except during a solar eclipse. In 1919 the English astrophysicist Sir Arthur Eddington organized two expeditions to observe the solar eclipse of that year, one to Brazil and one to the island of Principe off the Atlantic coast of Africa, with the aim of testing Einstein's prediction. The expeditions found that starlight was indeed deflected by the sun, by almost exactly the amount Einstein had predicted. Popper was very impressed by this. Einstein's theory had made a definite, precise prediction, which was confirmed by observations. Had it turned out that starlight was not deflected by the sun, this would have showed that Einstein was wrong. So Einstein's theory satisfies the criterion of falsifiability.

Popper's attempt to demarcate science from pseudo-science is intuitively quite plausible. There is certainly something fishy about a theory that can be made to fit any empirical data whatsoever. But some philosophers regard Popper's criterion as overly simplistic. Popper criticized Freudians and Marxists for explaining away any data that appeared to conflict with their theories, rather than accepting that the theories had been refuted. This certainly looks like a suspicious procedure. However, there is some evidence that this very procedure is routinely used by 'respectable' scientists – whom Popper would not want to accuse of engaging in pseudo-science – and has led to important scientific discoveries.

Another astronomical example can illustrate this. Newton's gravitational theory, which we encountered earlier, made predictions about the paths the planets should follow as they orbit the sun. For the most part, these predictions were borne out by observation. However, the observed orbit of Uranus consistently differed from what Newton's theory predicted. This puzzle was solved in 1846 by two scientists, Adams in England and Leverrier in France, working independently. They suggested that there was another planet, as yet undiscovered, exerting an additional gravitational force on Uranus. Adams and Leverrier were able to calculate the mass and position that this planet would have to have, if its gravitational pull was indeed responsible for Uranus' strange behaviour. Shortly afterwards the planet Neptune was discovered, almost exactly where Adams and Leverrier had predicted.

Now clearly we should not criticize Adams' and Leverrier's behaviour as 'unscientific' – after all, it led to the discovery of a new planet. But they did precisely what Popper criticized the Marxists for doing. They began with a theory – Newton's theory of gravity – which made an incorrect prediction about Uranus' orbit. Rather than concluding that Newton's theory must be wrong, they stuck by *the theory and attempted to explain away the conflicting observations by postulating a new planet. Similarly, when capitalism showed no signs of giving way to communism, Marxists did not conclude that Marx's theory must be wrong, but stuck by the theory and tried to explain away the conflicting observations in other ways. So surely it is unfair to accuse Marxists of engaging in pseudo-science if we allow that what Adams and Leverrier did counted as good, indeed exemplary, science?*

This suggests that Popper's attempt to demarcate science from pseudo-science cannot be quite right, despite its initial plausibility. For the Adams/Leverrier example is by no means atypical. In general, scientists do not just abandon their theories whenever they conflict with the observational data. Usually they look for ways of eliminating the conflict without having to give up their theory; this is a point we shall return to in Chapter 5. And it is worth remembering that virtually every theory in science conflicts with some observations – finding a theory that fits all the data perfectly is extremely difficult. Obviously if a theory persistently conflicts with more and more data, and no plausible ways of explaining away the conflict are found, it will eventually have to be rejected. But little progress would be made if scientists simply abandoned their theories at the first sign of trouble.

The failure of Popper's demarcation criterion throws up an important question. Is it actually possible to find some common feature shared by all the things we call 'science', and not shared by anything else? Popper assumed that the answer to this question was yes. He felt that Freud's and Marx's theories were clearly unscientific, so there must be some feature that they lack and that genuine scientific theories possess. But whether or not we accept Popper's negative assessment of Freud and Marx, his assumption that science has an 'essential nature' is questionable. After all, science is a heterogeneous activity, encompassing a wide range of different disciplines and theories. It may be that they share some fixed set of features that define what it is to be a science, but it may not. The philosopher Ludwig Wittgenstein argued that there is no fixed set of features that define what it is to be a 'game'. Rather, there is a loose cluster of features most of which are possessed by most games. But any particular game may lack any of the features in the cluster and still be a game. The same may be true of science. If so, a simple criterion for demarcating science from pseudo-science is unlikely to be found.

2.3 Reading 3

CHAPTER ONE

Alienation

A. Commentary

Marx's notion of alienation came most directly from Hegel, though its roots are much earlier. For Hegel, reality was Spirit realising itself. Later Spirit perceived this world to be its own creation. Spirit, which existed only in and through its productive activity, gradually became conscious that it was externalising or alienating itself. Alienation, for Hegel, consisted in this failure to realise that the world was not external to Spirit. Alienation would therefore cease when men saw that their environment and culture were creations of Spirit. When men saw this, they would be free, and this freedom was that aim of history. Marx summed up what he conceived to be Hegel's view as follows:

> For Hegel, the human essence, man, is the same as self-consciousness. All alienation of man's essence is therefore nothing but the alienation of self-consciousness. The alienation of self-consciousness is not regarded as the expression of the real alienation of man's essence reflected in knowledge and thought. The real alienation (or the one that appears to be real) in its inner concealed essence that has first been brought to the light by philosophy, is nothing but the appearance of the alienation of the real human essence, self-consciousness.[1]

Marx's central criticism of Hegel was that alienation would not cease with the supposed abolition of the external world. The external world, according to Marx, was part of man's nature and what was vital was to establish the right relationship between man and his environment.

> An objective being [Marx wrote] has an objective effect and it would not have an objective effect if its being did not include

[1] *KMSW*, p. 102.

an objective element. It only creates and posits objects because it is posited by objects, because it is by origin natural. Thus in the act of positing it does not degenerate from its 'pure activity' into creating an object; its objective product only confirms its objective activity, its activity as an activity of an objective, natural being.[1]

Marx thus rejected the notion of Spirit and replaced its supposed antithesis to the external world by the antithesis between man and his social being.

Particularly in his early writings Marx discusses several types of alienation, moving, in the rapid process of secularisation common to the thinking of all the Young Hegelians, from religious alienation to philosophical, political and finally to economic alienation. This last Marx considered to be fundamental in as much as work was man's fundamental activity. In all fields the common idea was that man had forfeited to someone or something what was essential to his nature – principally to be in control of his own activities, to be the initiator of the historical process. In the different forms of alienation some other entity obtained what was proper to man.

In religion, for example, it was God who had usurped man's own position; religion served the double function of a compensation for suffering and a projection of man's deepest desires. Religion was 'the imaginary realisation of the human essence because the human essence possesses no true reality'.[2] And Marx's conclusion was: 'The abolition of religion as the illusory happiness of the people is the demand for their real happiness. The demand to give up the illusions about their condition is a demand to give up a condition that requires illusion.'[3]

Philosophy, too (and here Marx had in mind particularly Hegel's philosophy), could constitute an alienation. Speculative philosophy reduced history and man to a mental process, and, putting the Idea in the place of God, was no better than a secularised theology. 'In Hegel', said Marx, 'the appropriation of man's objectified and alienated faculties is thus firstly only an appropriation that occurs in the mind, in pure thought, i.e. in abstraction.'[4]

Marx applied the same analysis to political alienation: the

[1] *KMSW*, pp. 103 f. [2] *KMSW*, p. 63. [3] *KMSW*, p. 64. [4] *KMSW*, p. 100.

state contained a description of human nature, but at the same time deprived man of the opportunity of attaining it:

> The political constitution was formerly the religious sphere, the religion of the people's life, the heaven of its universality over against the earthly and real existence. This political sphere was the only state sphere in the state, the only sphere in which the content as well as the form was a content of the species and the genuine universal; but at the same time this was in such a manner that, because this sphere stood over against the others, its content too became a formal and particular one. Political life in the modern state is the scholasticism of the people's life. Monarchy is the perfected expression of this alienation. Republicanism is its negative inside its own sphere.[1]

The passages where Marx talks most fully about alienation are contained in the *Paris Manuscripts*, where he first applied the notion to economics. Here, in the section on 'alienated labour', Marx divided the alienated situation of the worker under capitalism into four aspects.

> The worker [Marx wrote] is related to the product of his labour as to an alien object. The object he produces does not belong to him, dominates him, and only serves in the long run to increase his poverty. Alienation appears not only in the result, but also in the process of production and productive activity itself. The worker is not at home in his work which he views only as a means of satisfying other needs. It is an activity directed against himself, that is independent of him and does not belong to him. Thirdly, alienated labour succeeds in alienating man from his species. Species life, productive life, life creating life, turns into a mere means of sustaining the worker's individual existence, and man is alienated from his fellow men. Finally, nature itself is alienated from man, who thus loses his own inorganic body.

Although the above passages refer to the workers, who were the most obviously alienated part of capitalist society, Marx conceived the state of alienation to be common to all members of that society. In the *Holy Family* he said: 'The propertied class and the class of the proletariat represent the same human self-alienation.

[1] *KMSW*, p. 29 f.

But the former feels comfortable and confirmed in this self-alienation, knowing that this alienation is its own power and possessing in it the semblance of a human existence. The latter feels itself ruined in this alienation and sees in it its impotence and the actuality of an inhuman existence.'[1]

The concept of alienation is one that remains central to Marx's writings. He tended to use the actual word less, probably because of its exclusively philosophical connotation. Indeed, in the *Communist Manifesto* he poured scorn on the German *literati* who 'beneath the French criticism of the economic functions of money wrote *Alienation of Humanity*'.[2] However, the concept is obviously fundamental to the *Grundrisse* where Marx is concerned to underline 'not the state of objectification but the state of alienation, estrangement and abandonment, the fact that the enormous objectified power which social labour has opposed to itself as one of its elements belongs not to the worker but to the conditions of production that are objectified in capital'.[3]

The same notion reoccurs at the very beginning of *Capital* under the heading 'Fetishism of Commodities'. Marx says:

> A commodity is therefore a mysterious thing, simply because in it the social character of men's labour appears to them as an objective character stamped upon the product of the labour; because the relation of the producers to the sum total of their own labour is presented to them as a social relation, existing not between them, but between the products of their labour. This is why the products of labour become commodities, social things whose qualities are at the same time perceptible and imperceptible by the senses. . . . There is a definite social relation between men that assumes, in their eyes, the fantastic form of a relation between things. . . . This I call the Fetishism which attaches itself to the products of labour, so soon as they are produced as commodities.[4]

Since several writers have stated that 'alienation' is a term only used by Marx in his philosophical youth, it is important to note that it occurs repeatedly in *Capital*.[5] Indeed, in so far as it

[1] *KMSW*, p. 134 f. [2] *KMSW*, p. 241.
[3] *KMSW*, p. 384. [4] *KMSW*, p. 435 f.
[5] See, for example, the index to the London 1937 edition of *Capital*. The continuity of Marx's thought in terms of the concept of alienation has been

implies that relations between people have been replaced by relations between things, it may be said to be one of *Capital*'s basic themes. For example, Marx writes: 'The character of independence and estrangement which the capitalist modes of production as a whole give to the instruments of labour and the product, as against the workman, is developed by means of machinery into a thorough antagonism.'[1] Yet it is not only a question of terminology: the content, too, of *Capital* is a continuation of Marx's early thoughts. The main discussion of Volume I of *Capital* rests on the equation of work and value that goes back to the conception of man as a being who creates himself and the conditions of his life – a conception outlined in the *Paris Manuscripts*. It is man's nature, according to the Marx of the *Paris Manuscripts*, to be constantly developing, in co-operation with other men, himself and the world about him. What Marx in *Capital* is describing is how this fundamental role of man, to be the initiator and controller of the historical process, has been transferred, or alienated, and how it belongs to the inhuman power of capital. The counterpart of alienated man, the unalienated or 'total' man of the *Manuscripts*, also appears in *Capital*. In the chapter of Volume I on 'Machinery and Modern Industry' Marx makes the same contrast between the effects of alienated and unalienated modes of production on the development of human potentiality. He writes:

> Modern industry, indeed, compels society, under penalty of death, to replace the detail-worker of today, crippled by the life-long repetition of one and the same trivial operation, and thus reduced to the mere fragment of a man, by the fully developed individual, fit for a variety of labours, ready to face any change of production, and to whom the different social functions he performs, are but so many modes of giving free scope to his own natural and acquired powers.[2]

The fact that, in *Capital*, the conclusion is supported by a detailed analysis of the effects of advanced technology should not obscure the continuity.

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dealt with by R. Dunayevskaya, *Marxism and Freedom* (New York, 1958) pp. 103 ff., and E. Fromm, *Marx's Concept of Man* (New York, 1961) pp. 50 ff. and 69 ff. See also the books by Ollman and Seigel.

[1] *Capital* I 432. [2] Ibid. 488.

However, the writing that best shows the centrality of the concept of alienation to Marx's thought is the *Grundrisse*, the thousand-page draft that served Marx as a basis for *Capital* but remained unpublished until 1941. The *Grundrisse*, of which the *Critique of Political Economy* and *Capital* are only partial elaborations, is the centrepiece of Marx's work. It is the basic work which permitted the generalisations in the famous *Preface* to the *Critique of Political Economy*. For *Capital* is only the first of the six volumes in which Marx wished to develop his *Economics*, the title by which he referred to his *magnum opus* on the alienation of man through capital and the state.

The scope of the *Grundrisse* being wider than that of *Capital*, Marx's thought is best viewed as a continuing meditation on themes begun in 1844, the high point in which mediation occurred in 1857–8. The continuity between the *Manuscripts* and the *Grundrisse* is evident. Marx himself talked of the *Grundrisse* as 'the result of fifteen years of research, thus the best period of my life'. This letter was written in November 1858, exactly fifteen years after Marx's arrival in Paris in November 1843. He also says, in the *Preface* of 1859: 'The total material lies before me in the form of monographs, which were written at widely separated periods, for self-clarification, not for publication, and whose coherent elaboration according to the plan indicated will depend on external circumstances.'[1] This can only refer to the *Paris Manuscripts* of 1844 and the London notebooks of 1850–2. Marx constantly used, and at the same time revised, material from an earlier date: for instance, he used his notebooks of 1843–5 while writing *Capital*.

The content of the *Grundrisse* only serves to confirm what is plain from the external evidence: the beginning of the chapter on Capital reproduces almost word for word the passages in the *Manuscripts* on human need, man as a species-being, the individual as a social being, the idea of nature as, in a sense, man's body, the parallels between religious and economic alienation, the utopian and almost millennial elements, etc. One point in particular emphasises this continuity: the *Grundrisse* is as Hegelian as the *Paris Manuscripts* and the central concept of both of them is alienation.[2]

[1] *KMSW*, p. 388.

[2] See particularly *KMSW*, pp. 365 ff. and pp. 371 ff.

B. Texts

Selling is the practice of externalisation. As long as man is imprisoned within religion, he only knows how to objectify his essence by making it into an alien, imaginary being. Similarly, under the domination of egoistic need he can only become practical, only create practical objects by putting his products and his activity under the domination of an alien entity and lending them the significance of an alien entity – money.

On the Jewish Question (1843); *KMSW*, pp. 61 f.

What this fact expresses is merely this: the object that labour produces, its product, confronts it as an alien being, as a power independent of the producer. The product of labour is labour that has solidified itself into an object, made itself into a thing, the objectification of labour. The realisation of labour is its objectification. In political economy this realisation of labour appears as a loss of reality for the worker, objectification as a loss of the object or slavery to it, and appropriation as alienation, as externalisation. . . .

All these consequences follow from the fact that the worker relates to the product of his labour as to an alien object. For it is evident from this presupposition that the more the worker externalises himself in his work, the more powerful becomes the alien, objective world that he creates opposite himself, the poorer he becomes himself in his inner life and the less he can call his own. It is just the same in religion. The more man puts into God, the less he retains in himself. The worker puts his life into the object and this means that it no longer belongs to him but to the object. So the greater this activity, the more the worker is without an object. What the product of his labour is, that he is not. So the greater this product the less he is himself. The externalisation of the worker in his product implies not only that his labour becomes an object, an exterior existence but also that it exists outside him, independent and alien, and becomes a self-sufficient power opposite him, that the life that he has lent to the object affronts him, hostile and alien.

1844 Manuscripts; KMSW, pp. 78 f.

Religion, family, state, law, morality, science and art are only particular forms of production and fall under its general law. The positive abolition of private property and the appropriation of human life is therefore the positive abolition of all alienation, thus the return of man out of religion, family, state, etc., into his human, i.e. social being. Religious alienation as such occurs only in man's interior consciousness, but economic alienation is that of real life and its abolition therefore covers both aspects. It is obvious that the movement begins differently with different peoples according to whether the actual conscious life of the people is lived in their minds or in the outer world, is an ideal or a real life.

1844 Manuscripts; KMSW, pp. 89 f.

Supersession as an objective movement absorbing externalisation. This is the insight expressed within alienation of the reappropriation of objective being through the supersession of its alienation. It is the alienated insight into the real objectification of man, into the real appropriation of his objective essence through the destruction of the alienated character of the objective world, through its supersession in its alienated character of the objective world, through its supersession in its alienated existence. In the same way, atheism as the supersession of God is the emergence of theoretical humanism, and communism as the supersession of private property is the indication of real human life as man's property, which is also the emergence of practical humanism. In other words, atheism is humanism mediated with itself through the supersession of religion, and communism is humanism mediated with itself through the supersession of private property. Only through the supersession of this mediation, which is, however, a necessary precondition, does positive humanism that begins with itself come into being.

1844 Manuscripts; KMSW, p. 108.

I have produced for myself and not for you, as you have produced for yourself and not for me. You are as little concerned by the result of my production in itself as I am directly concerned by the result of your production. That is, our production is not a production of men for men as such, that is, social production.

Thus, as a man none of us is in a position to be able to enjoy the product of another. We are not present to our mutual products as men. Thus, neither can our exchange be the mediating movement which confirms that my product is for you, because it is an objectification of your own essence, your need. For what links our production together is not the human essence. Exchange can only set in motion and activate the attitude that each of us has to his own product and thus to the product of another. Each of us sees in his own product only his own selfish needs objectified, and thus in the product of another he only sees the objectification of another selfish need independent and alien to him.

Of course as man you have a human relationship to my product; you have a need for my product. Therefore, it is present to you as an object of your desires and will. But your need, your desires, your will are powerless with regard to my product. This means, therefore, that your human essence, which as such necessarily has an intrinsic relationship to my production, does not acquire power and property over my production, for the peculiarity and power of the human essence is not recognised in my production. They are more a fetter that makes you depend on me because they manœuvre you into a position of dependence on my product. Far from being the means of affording you power over my production, they are rather the means of giving me power over you.

1844 Notebooks; KMSW, pp. 119 f.

The propertied class and the class of the proletariat present the same human self-alienation. But the former class finds in this self-alienation its confirmation and its good, its own power: it has in it a semblance of human existence. The class of the proletariat feels annihilated in its self-alienation; it sees in it its own powerlessness and the reality of an inhuman existence. In the words of Hegel, the class of the proletariat is abased and indignant at that abasement, an indignation to which it is necessarily driven by the contradiction between its human nature and its condition of life, which is the outright, decisive and comprehensive negation of that nature.

Within this antithesis the private owner is therefore the conservative side, the proletarian, the destructive side. From the former arises the action of preserving the antithesis, from the latter, that of annihilating it.

The Holy Family (1845); *KMSW*, p. 134.

The social character of activity, and the social form of the product, as well as the share of the individual in production, are here opposed to individuals as something alien and material; this does not consist in the behaviour of some to others, but in their subordination to relations that exist independently of them and arise from the collision of indifferent individuals with one another. The general exchange of activities and products, which has become a condition of living for each individual and the link between them, seems to them to be something alien and independent, like a thing.

In exchange value, the social relations of individuals have become transformed into the social connections of material things, personal power has changed into material power. The less social power the means of exchange possess and the closer they are still connected with the nature of the direct product of labour and the immediate needs of those exchanging, the greater must be the power of the community to bind the individuals together: the patriarchal relationship, the ancient communities, feudalism and the guild system. Each individual possesses social power in the form of a material object. If the object is deprived of its social power then this power must be exercised by people over people.

Relationships of personal dependence (which were at first quite spontaneous) are the first forms of society in which human productivity develops, though only to a slight extent and at isolated points. Personal independence founded on *material* dependence is the second great form: in it there developed for the first time a system of general social interchange, resulting in universal relations, varied requirements and universal capacities. Free individuality, which is founded on the universal development of individuals and the domination of their communal and social productivity, which has become their social power, is the third stage. The second stage creates the conditions for the third. Patriarchal and ancient societies (feudal also) decline as trade, luxury, money and exchange value develop, just as modern society has grown up simultaneously alongside these.

Marx's Grundrisse (1857–8), pp. 66 f.

The independent and autonomous existence of value as against living labour power –

hence its existence as capital –

the objective, self-centred indifference, the alien nature of objective conditions of labour as against living labour power, reaching the point that –

(1) these conditions face the worker, as a person, in the person of the capitalist (as personifications with their own will and interest), this absolute separation and divorce of ownership (i.e. of the material conditions of labour from living labour power); these conditions are opposed to the worker as alien property, as the reality of another legal person and the absolute domain of their will –

and that –

(2) labour hence appears as alien labour as opposed to the value personified in the capitalist or to the conditions of labour –

this absolute divorce between property and labour, between living labour power and the conditions of its realisation, between objectified and living labour, between the value and the activity that creates value –

hence also the alien nature of the content of the work vis-à-vis the worker himself –

this separation now also appears as the product of labour itself, as an objectification of its own elements.

For through the new act of production itself (which merely confirmed the exchange between capital and living labour that had preceded it), surplus labour and thus surplus value, surplus product, in brief, the total result of labour (that of surplus labour as well as of necessary labour) is established as capital, as exchange value which is independently and indifferently opposed both to living labour power and to its mere use value.

Labour power has only adopted the subjective conditions of necessary labour – subsistence indispensable for productive labour power, i.e. its reproduction merely as labour power divorced from the conditions of its realisation – and it has itself set up these conditions as objects and values, which stand opposed to it in an alien and authoritarian personification.

It comes out of this process not only no richer but actually poorer than when it entered it. For not only do the conditions of necessary labour that it has produced belong to capital; but also the possibility of creating values which is potentially present in labour power now likewise exists as surplus value, surplus product, in a word, as capital, as dominion over living labour power, as value endowed with its own strength and will as opposed to the abstract, purposeless, purely subjective poverty of labour power. Labour power has not only produced alien wealth and its own poverty, but also the relationship of this intrinsic wealth to itself as poverty, through the consumption of which wealth puts new life into itself and again makes itself fruitful. This all arose from the exchange in which labour power exchanged its living power for a quantity of objectified labour, except that this objectified labour – these conditions of its existence which exist outside it, and the independent external nature of these material conditions – appears as its own product. These conditions appear as though set up by labour power itself, both as its own objectification, and as the objectification of its own power which has an existence independent of it and, even more, rules over it, rules over it by its own doing.

Grundrisse (1857–8); *KMSW*, pp. 366 f.

Already in its simple form this relation is an inversion – personification of the thing and materialisation of the person; for what distinguishes this form from all previous forms is that the capitalist does not rule over the labourer through any personal qualities he may have, but only in so far as he is 'capital', his domination is only that of materialised labour over living labour, of the labourer's product over the labourer himself.

The relation grows still more complicated and apparently more mysterious because, with the development of the specifically capitalist mode of production, it is not only these directly material things (all products of labour; considered as use-values, they are both material conditions of labour and products of labour; considered as exchange-values, they are materialised general labour-time or money) that get up on their hind legs to the labourer and confront him as 'capital', but also the forms of socially developed labour – co-operation, manufacture (as a form of division of labour), the factory (as a form of social labour organised on machinery as its material basis) – all these appear as *forms* *of the development of capital*, and therefore the productive powers of labour built up on these forms of social labour – consequently also science and the forces of nature – appear as *productive powers of capital.* In fact, the unity [of labour] in co-operation, the combination of labour through the division of labour, the use for productive purposes in machine industry of the forces of nature and science alongside the products of labour – all this confronts the individual labourers themselves as something *extraneous* and *objective*, as a mere form of existence of the means of labour that are independent of them and control them, just as the means of labour themselves confront them, in their simple visible form as materials, instruments, etc., as functions of *capital* and consequently of the *capitalist.*

In this process, in which the *social* character of their labour confronts them to a certain degree as *capitalised* (as for example in machinery the visible products of labour appear as dominating labour), the same naturally takes place with the forces of nature and science, the product of general historical development in its abstract quintessence – they confront the labourers as *powers* of capital. They are separate in fact from the skill and knowledge of the individual labourer – and although, in their origin, they too are the product of labour – wherever they enter into the labour-process they appear as *embodied in capital.* The capitalist who makes use of a machine need not understand it. But science realised *in the machine* appears as *capital* in relation to the labourers. And in fact all these applications of science, natural forces and products of labour on a large scale, these applications founded on *social labour*, themselves appear only as *means for the exploitation* of labour, as means of appropriating surplus-labour, and hence confront labour as *powers* belonging to capital. Capital naturally uses all these means only to exploit labour; but in order to exploit it, it must apply them in production. And so the development of the *social* productive powers of labour and the conditions for this development appear as *acts of capital*, towards which the individual labourer not only maintains a passive attitude, but which take place in opposition to him.

Theories of Surplus Value (1862); *KMSW*, p. 393 f.

Capital shows itself more and more as a social power, whose agent the capitalist is, and which stands no longer in any possible relation to the things which the labour of any single individual can create. Capital becomes a strange, independent, social power, which stands opposed to society as a thing, and as the power of capitalists by means of this thing. The contradiction between capital as a general social power and as a power of private capitalists over the social conditions of production develops into an ever more irreconcilable clash, which implies dissolution of these relations and the elaboration of the conditions of production into universal, common, social conditions. This elaboration is performed by the development of the productive powers under capitalist production, and by the course which this development pursues.

Capital, vol. III (1864–5) p. 310.

Capital is not a thing. It is a definite interrelation belonging to a definite historical formation of society. . . . Capital signifies the means of production monopolised by a certain part of society, the products and material requirements of labour made independent of labour-power in living human beings and antagonistic to them, and personified in capital by this antagonism. Capital means not merely the products of the labourers made independent of them and turned into social powers, the products turned into rulers and buyers of their own producers, but also the forces and social relations – forms of this labour – which antagonise the producers in the shape of qualities of their products. Here, then, we have a definite and, at first sight, very mystical, social form of one of the factors in a historically produced process of social production.

Capital, vol. III (1864–5); *KMSW*, p. 492.

The capitalist fulfils his function only as personified capital; he is capital turned into a person. Similarly, the worker is only the personification of labour. . . . In material production, therefore, we have exactly the same relationship that obtains, in the domain of ideology, with religion: the subject transformed into object and vice versa.

From the historical point of view, this inversion appears as a transitional stage that is necessary in order to obtain, by force and at the expense of the majority, the creation of wealth as such, i.e. the unlimited productivity of social labour which alone is able to constitute the material basis of a free human society. It is necessary to traverse this antagonistic form just as it is inevitable that man begin by giving his spiritual forces a religious form by erecting them opposite himself as autonomous powers.

This is the *process of alienation* of man's own labour. From the start, the worker is superior to the capitalist in that the capitalist is rooted in his *process of alienation* and is completely content therein, whereas the worker who is its victim finds himself from the beginning in a state of rebellion against it and experiences the process as one of enslavement. . . . The self-valorisation of capital – the creation of surplus value – is the determining, supreme and dominant aim of the capitalist, the complete motive and content of his actions, the rationalised instinct and aim of the miser – a poor content which demonstrates that the capitalist is in the same slavish relation to capital as the worker, although at the opposite pole.

Results of the Immediate Process of Production (1865);
KMSW, pp. 508 ff.

On examination, we notice that capital regulates, according to its need to exploit, this production of the labour force itself, the production of human masses to be exploited. Thus capital does not only produce capital, it also produces a growing mass of workers, the substance thanks to which it can function alone as additional capital. Consequently, not only does labour produce, on an ever widening scale and in opposition to itself, the conditions of labour in the form of capital, but also capital produces, on an ever growing scale, the productive wage labourers that it needs. Labour produces its conditions of production as capital, and capital produces labour as a means of realising capital, as wage labour. Capitalist production is not simply a reproduction of this relationship, it is its reproduction on an ever increasing scale; and precisely to the extent that, with the capitalist mode of production, the social productivity of labour increases, the wealth over against the worker grows and dominates him as capital. Opposite him is deployed the world of wealth, this world which is alien to him and oppresses him, and his poverty, shame and personal subjection increase in the same proportion. His nakedness is the correlative of this plenitude. At the same time there increases the mass of capital's living means of production: the labouring proletariat.

Results of the Immediate Process of Production (1865); *KMSW*, p. 518.

A commodity is therefore a mysterious thing, simply because in it the social character of men's labour appears to them as an objective character stamped upon the product of that labour; because the relation of the producers to the sum total of their own labour is presented to them as a social relation, existing not between themselves, but between the products of their labour. This is the reason why the products of labour become commodities, social things whose qualities are at the same time perceptible and imperceptible by the senses. . . . To find an analogy, we must have recourse to the mist-enveloped regions of the religious world. In that world the productions of the human brain appear as independent beings endowed with life, and entering into relation both with one another and the human race. So it is in the world of commodities with the products of men's hands. This I call the Fetishism which attaches itself to the products of labour, so soon as they are produced as commodities, and which is therefore inseparable from the production of commodities.

This Fetishism of commodities has its origin, as the foregoing analysis has already shown, in the peculiar social character of the labour that produces them.

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THE THOUGHT OF KARL MARX

An Introduction

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Second Edition

PAPERMAC

2.4 Reading 4

Towards an Understanding of Gandhi's Views on Science
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Towards an Understanding of Gandhi's Views on Science

Gandhi, it is argued in this paper, was not anti-science as is commonly misunderstood. Through a look at his various experiments, many unrealised in his time, it is shown that Gandhi's life defined a space for an alternative science for civil society that would operate with different methods. Gandhi's focus on the non-physical resources in organising for science, the satyagrahi scientist, for instance, is a radical departure from science policy as expressed by Nehru in his famous Scientific Policy Resolution of 1956 and followed in India since independence. He also had a universal message by providing a new cosmology of man-nature and fact-value relations that he articulated and put in place through his various experiments. With this outline of a theoretical framework for Gandhian science, the case of the khadi movement is taken up for detailed explication.

SHAMBHU PRASAD

A reading of the rather extensive literature on Gandhi reveals that his views on science rarely find mention, almost to the point of exclusion. Based on his critique of modern civilisation and the sheer lack of material on his views on science, Gandhi has been labelled as anti-science. This has not been addressed adequately either by his followers or by social analysts of Gandhi's philosophy and practice. In this paper focusing on his *Collected Works* (1888-1948) we seek to address this lacuna by presenting a detailed contextual collation and analysis of his views on science over the years. We look at the responses of scholars to these representations. We then present new material on Gandhi's views on the subject that have been ignored and stand in need of analysis. The readings presented here would in our opinion have the potential of answering squarely some of Gandhi's critics who saw his views as retrograde. This 'archive', it is hoped, will contribute to equalising the focus in Gandhian studies from an overemphasis on his political philosophy to his contribution to intellectual history and the sociology of knowledge.

Gandhi's views on science have often been seen as presumed upon his views on machinery, the machine age and modern civilisation. However, as we shall show, there is ample direct reference to science in Gandhi's discussions with co-workers or talks with fellow countrymen. The new data presented here would also strengthen the existing critique of modern science and development. While the contours of this 'alternative' view need working out in detail, the present collation will correct the situation of indifference, if not negation, of Gandhi's views on science by science policy proponents in India. While Nehru's views on science have been written about and quoted extensively, Gandhi's have not received any scholarly attention so far.

Aldous Huxley was among the first to brand Gandhi and the khadi movement as anti-science:

> Tolstoyans and Gandhiites tell us that we must 'return to nature', in other words, abandon science altogether and live like primitives, or, at best, in the style of our medieval ancestors. The trouble with this advice is that it cannot be followed – or rather, it can be followed if we are prepared to sacrifice at least 8-900 million human lives. Science, in the form of modern industrialisation and agricultural technology, has allowed the world's population to double itself in about three generations. ...Tolstoy and Gandhi are professed humanitarians, but they advocate slaughter, compared with which the massacres of Timur and Jinghiz Khan seem imperceptibly trivial [Quoted in Singh 1988: 15].

Huxley's criticism of Gandhi was representative of contemporary understandings of Gandhi on science. Even Nehru, one of Gandhi's closest followers, revealed the extent of his misunderstanding when he responded to Huxley above:

> It [Gandhi's] may not be a correct attitude; its logic may be faulty... Even this attitude is not necessarily accepted by the political associates and followers of Gandhi. Personally, I do not agree with it and I should make it clear that the Indian Congress and the national movement have not adopted it... I have mentioned these considerations to you not to defend the spinning wheel but so that you may realise that Indian nationalism is not opposed to big scale machinery and much less to science. I have no doubt that when it is in a position to do so, it will industrialise the country as rapidly as possible. Meanwhile, helpless as we are, we have to carry out such makeshifts as possible... My whole outlook on life and its problems is a scientific one and I have never felt attracted towards religion and its methods [Singh 1988: 15-18].

Nehru while seeking to explain Gandhi's attitude to science actually ends up furthering the divide between the so-called personal view of Gandhi and the public view of the Congress. His view shared by a large section of the Indian intelligentsia even today acknowledges Gandhi's ability merely to mobilise people and rally them around the call for freedom. The charkha is consequently important for its immediate economic and instrumental value in achieving freedom, to be discarded later. Nehru makes a clear divide between himself as a science person and Gandhi as a religious man. This stereotype that sees Gandhi in purely religious terms alone and thereby outside science, was expressed several years later by one of the few social scientists who interacted with Gandhi – the anthropologist Nirmal Kumar Bose.

As part of Gandhi's Noakhali effort of 1946, Bose had to soon confront his own serious disagreements with some of Gandhi's experiments which led to his departure from Gandhi's camp. What is significant is that Bose sought to explain his actions as those of a scientist with politics being undertaken only in emergencies (1974: 49-68). For Bose, science and politics were clearly separate entities with little possibility of one including the other. He thus unwittingly cast Gandhi as a political and religious person alone in contrast to himself as a scientist.[1] This image has stuck and been made unforgettable by Einstein's famous quote on Gandhi where he sees Gandhi as a saint and politician who was well versed with the art, not science of peace.[2]

Bose and Nehru indicate an attitude of discomfort and ambivalence to their leader Gandhi and are unable to reconcile his public persona with the more controversial 'private' one. The response by Indian scientists to Gandhi on the other hand shares none of this discomfort. Meghnad Saha, the scientist-architect of the planning and industrialisation model in independent India, for instance saw Gandhian science as entirely retrograde:

> Amongst our leaders [are] a considerable number incapable of seeing the great and inevitable part which the new age of technic will play in India's destiny... One comes across overdrawn pictures of the imaginary good old days when nobody was supposed to have anything to complain of and a tendency to attribute all the troubles of the world to the evils of science ... We do not for a moment believe that better and happier conditions could be created by discarding modern scientific technique and reverting back to the spinning wheel, the loin cloth and the bullock cart [Quoted in Visvanathan 1985: 100-101].

Saha believed that the primary task of science in India was in "weeding out medieval passion" and training the populace for "a proper grip and sufficient operation of the beauty and power of science". In another context, Saha informed Russian scientists that he and his brother scientists had "as little regard for Gandhi's economic and social theories as you 'the Russians' have for Tolstoy [Quoted in Narayan 1960: 55].

Saha's caricature of Gandhi's views on science is important historically for the role he played in formulating the ideology of science policy in free India. Given such views, it is no wonder that science policy writings in India have made no mention of Gandhi. Sinha while reviewing the relation of science to the Indian National Congress charged Gandhi with an attitude that was revivalist and hostile to modern science [Kumar 1991: 161-81]. Tracing the history of science movements in India, Biswas in a recent study follows the received view on Gandhi and science. He believes the Gandhian view, unlike that of Vivekananda, is primarily spiritual and ignores the material foundations of Indian civilisation. Nehru, he argues, followed the model of Vivekananda more perfectly [Biswas 2000: 205-17]. This representation conforms to the stereotype of the spiritual Gandhi ignoring the fact that the spirit and practice of the khadi movement was primarily grounded in the material culture of Indian civilisation. Others like Mclure miss the point entirely when they try to fit Gandhi into standard models of science and find him lacking, rather than questioning modern experimental methods (1997).

To add to this 'missing' Gandhi in science policy studies is the missing 'science' in Gandhian studies. Studies on Gandhi have largely focused on his political philosophy with little, if any reference to his views on science. Though the political scientist Parekh has correctly argued that "a good deal needs to be done on his [Gandhi's] conception of the nature of science [and] his reasons for using the language of research and experiments" (1989b), work on Gandhi's science has been limited. Some recent scholarship has indeed attempted to make good this lack. For instance, Uberoi sees Gandhi as having a distinct theory and practice of the scientific experiment as well as a scientific explanation that presupposed the equality of man and nature (1982). Nandy argues that Gandhi was not opposed to technology per se but to technologism, which was a condition that created a hierarchical relationship between man (those who possess technology) and man (those who do not), and man and nature. Gandhi, according to him, judged a technology not on the grounds of what it was but on the grounds of what it replaced, represented or symbolised (1985).

Sahasrabuddhe whose work exclusively focuses on what he terms the 'science question' argues that there is little work from the Gandhian angle on science though a lot has been written on his opposition to machinery. He sees Gandhi's 'life-work' as paving the way for a new dynamic theory of man-man and man-nature relations that do not separate fact from value. He sees Gandhi's critique of modern science hidden in his critique of modern western civilisation and argues that it is only through his general philosophy – metaphysics, ontology, epistemology, ethics, logic and politics – that one can construct his view of science (1991, 1997). Visvanathan sees him as one of the great and most inventive of scientists of the swadeshi era. To escape the modern west, Gandhi had to subvert or transform science, playfully and politically. According to him Gandhi's was a fluid science of resistance. In Gandhi's altered organisation of science, science would need money the least and that there would be instead of big laboratories, ashrams and gurukuls of science (1997: 212-44).

While the above studies have challenged Huxley's portrayal of Gandhi without being apologetic like Nehru, there still remain some questions. They have all used *Hind Swaraj* (1909) as the main text in their analysis. While it is true that most of his radical critiques of science and modern professions appeared in *Hind Swaraj*, the keen interest that Gandhi expressed for an alternate path in science finds little mention in this book. In fact, science finds no direct mention in *Hind Swaraj*. Yet given its importance in Gandhi's critique of modern civilisation, it has been the main source or text for scholars studying Gandhian thought and by extension science. Our attempt here would be to show that such efforts are grossly inadequate in understanding Gandhi's views on science. There is enough evidence of Gandhi expressing himself directly on the subject in many of his other writings. On khadi and education, and almost throughout his *Collected Works*, in letters to his co-workers and speeches, Gandhi regularly uses the term 'science'.[3] These could be seen as new sites to explore his writings on science. Historically too, the emphasis on *Hind Swaraj* freezes Gandhi's view on science to 1909, ignoring 39 years of his scientific practice since then. Another site that is often used to study Gandhi's scientific views is his autobiography. The scientific metaphor that he used for his autobiography, *My Experiments with Truth*, is well known. Similarly, the fact that he made several experiments in the field of brahmacharya, dietetics and food. However, the notion of the experiment in his public life has not been examined adequately.

This paper has been organised into four parts. We first explore Gandhi's qualified critique of science by looking at his early writings on science covering his South African days. In it we highlight his critique of the separation of science and morality. We also explore his institutional experiments on his arrival in India and look at Gandhi's response to his science critics covering the period from 1915 to the mid-1920s. The period is significant for the non-cooperation movement and the spread of universal spinning through the Congress. The spread of the movement and his views on machinery received critical responses from intellectuals, which forced Gandhi to articulate his position on machinery and science.

In the second part we look at his fundamental critique of existing scientific practice through the case of vivisection – a part of normal science – and Ayurveda – a traditional Hindu system. We then, in the third part, examine khadi, perhaps the best site for his experiments in an alternative science practice. We trace his usage of the term "science of khadi" and see how he tries to make his khadi workers scientists. We examine his attempts to make improvements in machinery, highlighting his lesser-known creative attitude to science focusing on the thirties. We review some of the institutional innovations and constructive programmes that sought to take this science to the villages. We conclude in the last section, by highlighting the distinguishing features of his method and its underlying cosmology.

Gandhi's Early Critique of Science

> Modern civilisation, far from having done the greatest good to humanity, has forgotten that its greatest achievements are weapons of mass destruction, the awful growth of anarchism, the frightful disputes between capital and labour and the wanton and diabolical cruelty inflicted on innocent, dumb, living animals in the name of science, falsely so called (CW 1: 189-91).

The boast about the wonderful discoveries and the marvellous inventions of science, good as they undoubtedly are in themselves, is, after all, an empty boast (CW 3: 414).

The above quotes indicate Gandhi's strong views on science very early in his public life. The use of the phrase 'falsely so-called' indicates that Gandhi believed that the prevailing practice of science had defects but this was not necessarily intrinsic to the scientific quest. Nor was such a condition irremediable warranting a total rejection. There was a need for the scientific enterprise to undergo a course correction. This qualified criticism becomes clearer in his response to members of the British Association for the Advancement of Science who visited South Africa in 1904. Gandhi commended the association's efforts in popularising science and in bringing Britain and the colonies closer to each other. In pursuance of the latter, he suggested that the association should meet in India and be renamed as the 'British Empire Association for the Advancement of Science'. Such a visit, according to Gandhi, would be greatly to the advantage not only to India, but the association as well (CW 5: 46).

This seemingly innocuous move for a change of name is actually an early indication of his differences with the liberal view of the British and members of the Indian elite like Rammohun Roy who saw in the introduction of western science in India the key to India's emancipation. On the contrary, Gandhi placed science in the larger context of decolonisation. The scientist, he believed, was to benefit equally from interaction with the colonies and its subjects. Popularisation of science, Gandhi suggested was not a linear transfer of knowledge from the expert to the lay person but had to be a collaborative effort. It was only thus that science too could benefit from the process. The inclusion of the colonial subject was to Gandhi a starting point for the rearticulation of the content and not just the context of an alternate and non-violent science that had to include the claims of dumb, subhuman creatures as well.

Gandhi's critique of science emanates from his dissatisfaction with the divorce of science and progress from morality. He often quoted the scientist Alfred Wallace to argue that people's moral sense had in no way improved as a result of scientific discoveries. The advance of science had added "not an inch to the moral stature of Europe". It had not reduced hatred and injustice (CW 12: 146; 16: 106-08 and 18: 235-36).

Gandhi's early critique of civilisation and the modern professions found expression in some of his works, notably *Hind Swaraj*. However, despite his critique of modern science, he was appreciative of the spirit of modern scientists. Amongst the largely Indian readers of *Indian Opinion* (begun in 1903), Gandhi sought to inculcate the courage and spirit of inquiry of the scientist. The journal carried examples of scientists that Gandhi felt were worthy of emulation. In one such article, Gandhi praised Metussi's courage amidst danger in collecting data from the volcano Vesuvius while it was still active. He believed that, "when many Indians too of this calibre are born in India or South Africa, we shall cease to suffer as at present" (CW 5: 286). The above instances of Gandhi's views on science from his early writings indicate that Gandhi's position on science was taking shape in South Africa. However, it is in his later years of stay in India that science finds increasing mention in Gandhi's writings, partly as a response to very many critics.

During the Non-Cooperation movement of 1919-20 and the popularisation of khadi, in that period Gandhi was often questioned on his stand on machinery. Leaders like Tagore accused Gandhi of rejecting western science. Gandhi had to repeatedly clarify his stand on machinery and these have been extensively collated and quoted [Bhattacharya 1997, Parel 1997: 164-70]. This material tends to highlight however the moral critique and portray Gandhi as anti-machine. They reveal little about his alternative practice evident from Gandhi's keen interest in improvements in machinery and various kinds of hand tools indicate the contrary. Gandhi claimed that he had no design on machinery as such and had no intention to put back the hand of the clock of progress. No disturbance had been created by machinery that could not be corrected. It was a mental state that had to be put right (CW 19: 241; 21: 114). It is this principle that was to guide him in his search for improved tools.

This attitude is perhaps best revealed in his letter to Daniel Hamilton on the newly begun khadi movement. Gandhi requested Hamilton not to be prejudiced by "anything you might have heard about my strange views about machinery". He added, "India does not need to be industrialised in the *modern sense of the term*" (CW 22: 401, emphasis added). The modern way, Gandhi suggests, is not the only way to industrialise a nation. This different path of progress holds the key to Gandhi's science through which the khadi movement was seeking to re-define machinery. As he argued he was not a romantic or mystic out to "spiritualise machinery, but to introduce a human or the humane spirit among the men behind the machinery". The message of the charkha, he reminded his American friends, was universal and would show for Lancashire as well so that they would have to cease to use machinery for exploitation (CW 28: 188).

It is perhaps not a matter of accident that the more radical of his critiques on machinery and modern 'civilisation' was in interviews with the 'moderns' both in India and abroad. His writings on science addressed to his co-workers in India had a different colour altogether. It is in these letters, addresses and conversations that we get clues to the nature and scope of his alternative science. The Non-Cooperation movement placed Gandhi as the nation's foremost political leader. Strangely though, Gandhi's own self-image was not that of a politician or a saint but that of a scientist:

> It [saint] is too sacred a word to be lightly applied to anybody, much less to one like myself who claims only to be a humble searcher after truth, knows his limitations, makes mistakes, never hesitates to admit them when he makes them, and frankly confesses that he, like a scientist, is making experiments about some of 'the eternal verities' of life (CW 17: 405-6).

We will explore this in Gandhi's views on vivisection as a critique of the existing scientific practice and on Ayurveda as a critique of techno-revivalism. In the next section, we will focus instead on his understanding of khadi as practice of an alternate science. Defending himself against the charge of being anti-science Gandhi often admitted that though he was not an 'unmixed' admirer of science, he was not a sentimental proponent of tradition. This is evident from his ongoing dialogues with Ayurveda scholars. Gandhi remained aware that one could not live without science, provided though it was kept in its right place. He had seen the misuse of science in his travels round the world and believed that there were limitations even to scientific search.

Existing Scientific Practice: Vivisection and Ayurveda

The practice of vivisection for Gandhi was a shining example of the need for such limitation in modern scientific research particularly since the practice of inflicting pain and violence on live animals was a part of the experimental method 'normal' to modern science. Premised on a mechanistic notion of the body and the universe, it legitimated the subjugation of the inferior non-human creation by and for the human. This to Gandhi was ethically and epistemically unacceptable. Recent critiques have highlighted vivisectory practice not only in medicine as a machine, but in the concentration camps of Hitler and the bombing of Hiroshima during second world war [Visvanathan 1997: 15-47]. Gandhi's writings on a non-violent cosmology anticipated these criticisms as far back as the early 1920s and also argued that criticism must include a different conception of the experiment and not just be reduced to the realms of humanistic despair.

Vivisection according to Gandhi added had not added "an inch to our moral height". Though the scientific spirit of the west commanded his admiration it was qualified, because the scientist of the west took no note of god's lower creation:

> I abhor vivisection with my whole soul. I detest the unpardonable slaughter of innocent life in the name of science and humanity so-called, and all the scientists' discoveries stained with innocent blood I count as of no consequence. If the circulation of blood theory could not have been discovered with out vivisection the human kind could well have done without it. And I see the day clearly dawning when the honest scientist of the west will put limitations upon the present methods of pursuing knowledge. Future measurements will take note not only of the human family, but of all that lives and even as we are slowly but surely discovering that it is an error to suppose that Hindus can thrive upon the degradation of a fifth of themselves or that peoples of the west can rise or live upon the exploitation and degradation of the eastern and African nations, so shall we realise in the fullness of time, that our dominion over the lower order of creation is not for their slaughter, but for their benefit equally with ours. For I am as certain that they are endowed with a soul as that I am (CW 29: 325-26).

Through practices like vivisection modern medical science to him divorced itself from true religion and had separated the body and the soul. By disregarding the claims of subhuman creation, man, instead of being lord and protector of the lower animal kingdom, had become its tyrant:

> Vivisection in my opinion is the blackest of all the blackest crimes that man is at present committing against god and his fair creation. We should be able to refuse to live if the price of living be the torture of sentient beings (CW 19: 357-58).

Scientists, in Gandhi's conception, needed to recognise their own role in the cosmos. What science saw as progress, Gandhi wanted to qualify based on his experiences of the colonised and as a spokesperson for the dumb creation. For Gandhi, the real challenge of science lay in carrying out experiments not on the 'other' – the colonised, the excommunicated brothers, or the dumb creatures – but on the self. With this in view he exhorted the science students to work with their hands, as science was one of the few things that involved accuracy of thought and accuracy of handling:

> Students in India labour under one very serious disability. Those who go in for this class of education or for higher education are drawn from the middle class. Unfortunately for us and unfortunately for our country, the middle classes have almost lost the use of their hands... Science is essentially one of those things in which theory alone is of no value whatsoever... Unless our hands go hand in hand with our heads we would be able to do nothing whatsoever (CW 29: 326-7).

Asking the students to follow the two most brilliant examples of Indian scientists who carried their profession for the sake of it, namely, J C Bose and P C Ray, he remarked, "They cultivated it [science] for the sake of it... their researches have been devoted in order to enable us to come nearer to our maker ... I feel that we are placed on this earth to adore our maker, to know ourselves, in other words, to realise ourselves and therefore to realise our destiny" (CW 29: 326-27). Despite his radical criticism of the anthropomorphism of modern medicine inherent in the practice of vivisection, Gandhi was deeply appreciative of modern scientists' humility and spirit of inquiry, a spirit that he felt traditional practice solely lacked. This comes through in his dialogue with Ayurvedic scholars. Gandhi's severe critique of western medicine for practising vivisection and thereby disregarding the claims of the non-human creation was presumed upon a different cosmology of the god-man-nature relationship – one which was non-hierarchical and non-violent.

Traditional medicines like Ayurveda and Unani, Gandhi felt, had unlike western science, maintained a relation between science and religion, body and soul, but had not inculcated the spirit of research that fired modern science and gave it contemporary relevance. In 1921, inaugurating the Tibbia College at Delhi, Gandhi expounded his views on modern and traditional medicine. His speech started with his radical and then well known critique of modern medicine. In the same speech however, he lauded the spirit of inquiry of the modern scientists:

> I would like to pay my humble tribute to the spirit of research that fires the modern scientists. My quarrel is not against that spirit. My complaint is against the direction that the spirit had taken. It has chiefly

concerned itself with the exploration of laws and methods conducing to the merely material advancement of its clientele. But I have nothing but praise for the zeal, industry and sacrifice that have animated the modern scientists in the pursuit after truth. I regret to have to record my opinion based on considerable experience that our hakims and vaids not exhibit that spirit in any mentionable degree. They follow without question formulas. They carry on little investigation. The condition of indigenous medicine is truly deplorable. Not having kept abreast of modern research, their profession has fallen largely into disrepute. I am hoping that this college will try to remedy this grave defect and restore Ayurvedic and Unani medical science to its pristine glory. I am glad, therefore, that this institution has its western wing (CW 19: 357-58).

In 1925, he was asked to speak at the Ayurvedic Pharmacy, Madras and later in the same year to inaugurate the Ashtanga Ayurvedic Vidyalaya at Calcutta. On both these occasions, he reminded those who had gathered of his criticism of the vaids. He was pained by the large-scale advertisements primarily of Ayurvedic tonics as sexual stimulants, ample proof that Ayurvedic physicians were merely trying to capitalise on the past glories of Ayurveda for the market without any genuine research. He bemoaned the fact that there was no association of Ayurvedic physicians that protested against these immoral business and ethical practices. Testifying to the spirit of the western physicians, he remarked that despite his strong views on modern medicine the one thing that it had in its favour was the humility of its practitioners and its research. He wished that this spirit would fire the Ayurvedic physicians too. Ayurveda's lost glory could only be recovered if the vaids acquired honesty of purpose and pursued the research spirit of the west (CW 26: 388, 27: 44-45).

Gandhi's controversial speech at Calcutta evoked a letter from Kaviraj Gananath Sen, a senior practitioner, asking that Gandhi clarify his stand on Ayurveda. In his response, Gandhi repeated that many Ayurvedic practitioners were mere quacks pretending to know much more than they actually did and arrogating to themselves an infallibility and ability to cure all diseases. Instead of studying the Ayurvedic system and wresting from it secrets which appeared to be completely hidden from the world, they imputed to Ayurveda omnipotence making it a stagnant system instead of a gloriously progressive science. His criticism was about the lack of humility and complacency of professors of Ayurveda and not the discipline itself. He remarked provocatively that "I know of not a single discovery or invention of any importance on the part of Ayurvedic physicians as against a brilliant array of discoveries and inventions which western physicians and surgeons boast". Elaborating his position, as some vaids were not satisfied with Gandhi's response, Gandhi added:

> I do like everything that is ancient and noble, but I utterly dislike a parody of it. And I must respectfully refuse to believe that ancient books are the last word on the matters treated in them. As a wise heir to the ancients, I am desirous of adding to and enriching the legacy inherited by us (CW 27: 344).

Gandhi's position on science was not for empty revivalism. He maintained a fine yet distinct line that was critical of the prevalent practices of the vaids and full of praise for the modern doctors. At the same time it was also an endorsement of the Ayurvedic system as a coherent system comparable to modern medicine. The assertion that ancient texts were not the last word was to him an axiom that would pave the way for further research creating new textbooks in a contemporary context. The vaids he observed had not yet created a contemporary *Charkha Samhita* (the classic Ayurvedic treatise).

Gandhi's position can be appreciated better if one notes the contexts of his criticisms. His open criticisms were from within, those of an internal critique, made from platforms such as opening of Ayurvedic colleges or through his journal. He felt the need to revitalise a tradition whose self-reflective practices had either been lost or become blunt with disuse. He wanted to reform it from the inside and not by pitting it against a more competitive and organised system from the outside. This role of the internal reformer that Gandhi saw for himself becomes clear by examining the detailed correspondences he had with individual practitioners. Through dialogues with them, he sought to raise and answer questions and get them to undertake research. He even offered himself and his own institutions as sites for experimentation. Through this process, he wanted to create a few satyagrahi scientists amongst them. For he believed, like in the field of politics, that a few satyagrahis of purity of character and faith was all that it would take to turn the tide.

One such vaidya with whom he had a dialogue was Gangadhar Shastri Joshi. Gandhi enquired from him in what way was Ayurvedic treatment superior to the allopathic treatment? How was Ayurveda aimed at purifying the whole system rather than affording only temporary relief? Was there any progressive research work being done either in Ayurvedic materia medica or in any other branch of medicine or surgery in terms of Ayurveda (CW 33: 439)? The letter is indicative of Gandhi's intention to focus the critique of the discipline vis-à-vis allopathy and to learn about the discipline. A month later he wrote again to Joshi saying that he had found Ayurveda to be neither cheap nor simple or efficacious. Some of the prescriptions were most complicated. Even for simple home treatment, he had been obliged to use allopathic drugs. For instance, he remarked that he found nothing as efficacious as quinine for malaria or iodine for simple pains or Condy's fluid as a disinfectant (CW 34: 199).

This dialogue with the vaids continued for several years. While in Sevagram in January 1945, Gandhi became seriously ill experimenting with the Ayurvedic system. To Shiv Sharma the vaidya who treated him, he said that despite its failure to cure him, he was keen to spread Ayurveda. But it was only when a 'true practitioner' of Ayurveda went to the villages that this would happen. Through his dialogue with the vaids, Gandhi was seeking to explore if the system could be reformed and in a sense upgraded. He was curious to know for instance if Homeopathy or Ayurveda could cure the cholera that had broken out in Sevagram and if experiments could be conducted in that direction (CW 79: 42; 81: 222, 224).

Gandhi's search for a true practitioner, his satyagrahi scientist, was not a completely successful one. Yet, from his writings, especially his letters to the vaids, we can get an idea of the method that he would have pursued. To Vallabhram Vaidya, a practitioner who he believed had the qualities of the satyagrahi scientist he was looking for, Gandhi indicated that he and a few others should get together, form a team and train volunteers. He offered to absorb these volunteers in his own institutions even if they had no degrees (CW 85: 458). We find similar echoes in his *Key to Health* wherein he talks about the kind of organisation that would be required for a revitalised health care system. Though mentioned in the context of nature cure, the statements would be applicable to Ayurveda too. Nature cure to Gandhi was not a drug cure but a way of life to be learnt, which placed the onus on the patient's self-curing abilities. Gandhi felt that although the medical profession had taken up some nature cure methods, overall they had given a cold shoulder to naturopathy. The medical professionals presented an attitude of indifference, if not that of contempt, for anything that lay outside their groove. On the other hand, the nature curists nursed a feeling of grievance against the medicos and in spite of their very limited scientific knowledge, made tall claims. They also lacked the spirit of organisation with each one being self-satisfied and working in isolation instead of pooling their resources for the advancement of their system. No one tried to work out in a scientific spirit all the implications and possibilities of the system. It was his conviction that as long as some dynamic personality, from among the naturopaths themselves, did not come forward with the zeal of a missionary, the present state of affairs would continue. It would be asking for too much to expect the medical profession to put faith, all of a sudden, in things that were yet to be fully tested and scientifically proven (CW 77: 25-26).

Gandhi's experiments and suggestions in Ayurveda did not reach fruition in his time, as he could not see it through. We thus perhaps do not have a clear empirical case to see how Gandhi's science was translated in practice in the area of health. The above dimension however illustrates that in Gandhi's method for organising science it is the individual scientist, rather than physical resources, which hold the key to change. His whole method hinged on finding or creating such scientists. In khadi, Gandhi came closest to finding such a science and his ideal practitioner – the satyagrahi scientist, Maganlal Gandhi.

Alternative Scientific Practice: Khadi

It is in the khadi movement that the Gandhian understanding of science was translated most into practice leading to the coinage of new terms such as the 'science of the spinning wheel' and later 'khadi science'. Gandhi's extensive use of the term 'science' is found in speeches and discussions with khadi workers. He wanted these workers to become satyagrahi scientists. The Satyagraha Ashram at Ahmedabad provided the necessary institutional base for training satyagrahi scientists needed for the khadi movement. Foremost amongst them was Maganlal Gandhi, the manager of the Satyagraha Ashram and a long-standing associate of Gandhi. Maganlal was able to translate many of Gandhi's ideas and vision into reality. The ashram in Ahmedabad functioned as a laboratory, educational and training institution and a production house.

For Gandhi, the knowledge of the 'science of spinning' was critical to the success of the khadi movement and he therefore urged all community workers to be well versed in it. Gandhi believed that only those who had a thorough knowledge of both theoretical and practical aspects of the science of spinning could become village workers. The rigorous technical criteria for khadi workers indicate how Gandhi envisaged the community worker as a scientist. The worker was to be well versed in all aspects of cloth making. He was to know the different varieties of cotton and the method of picking cotton suitable for hand spinning. He had to know how to gin and the varieties of hand-gins used in Indian villages. The worker had also to be able to test the strength, evenness, and counts of yarn, know a good charkha from a bad one, be able to put dilapidated charkhas under repair and be able to straighten an incorrect spindle (CW 33: 151-52).

Gandhi warned workers that this science of the spinning wheel was by no means trivial, often the task involved greater care than in the mill processes. Unlike in mill-spinning cotton for hand spinning, if properly picked, would make the yarn stronger. Then again, the mills did not have to bother whether cotton seeds remained intact in ginning, but khadi workers could not afford to be careless in this matter. The seeds had to retain their properties and had to be fed to the cattle and oil extracted from them (CW 39: 222).

The charkha to Gandhi was also a grand and noble science:

> I call it grand because the more closely we study it the more we discover in it. And we need as much skill to attain proficiency in it as in any other major craft. I call this noble because it touches millions of people (CW 33: 401).

The rediscovery of the "cunning of the hands" that was presently lost but had earlier brought fame to Indian textiles, would require the same kind of attention that Bose and Raman gave to their work:

> The science of khadi requires technical and mechanical skill of a high order and demands as much concentration as is given by Sir J C Bose to the tiny leaves of plants in his laboratory before he wrests from them the secrets of nature held by these fellow creatures of ours (CW 59: 127).

While much of his attempts to inculcate the spirit of the science of the charkha were directed at khadi workers, students of his institutions and the Congress, he also sought to further his idea amongst modern scientists. He did not want khadi scientists to be working in isolation from the latter. In 1927 when he addressed students at the Indian Institute of Science, Bangalore, he reminded them of their responsibility to society and the need to combine both heart and mind in their research and experiments:

> If we were to meet the villagers and to explain to them how we are utilising their money on buildings and plants which will never benefit them, but might perhaps benefit their posterity, they will not understand it. They will turn a cold shoulder. But we never take them into our confidence; we take it as a matter of right, and forge that the rule of 'no taxation without representation' applies to them too. ... the properties of some ... chemicals ... take years of experiments to explore. But who will try to explore these villages? Just as some of the experiments in your laboratories go on for all the 24 hours, let the big corner in your heart remain perpetually warm for the benefit of the poor millions... I expect much more from you than from the ordinary man in the street. I tell you, you can devise a far greater wireless instrument, which does not require external research, but internal – and all research will be useless if it is not allied to internal research – which can link your hearts with those of the millions. Unless all the discoveries that you make have the welfare of the poor as the end in view, all your workshops will be really no better than satan's workshops (CW 34: 156-57).

Thus while on the one hand, Gandhi wanted his village workers to be confident of their science, on the other, he felt that the modern scientists had to take the villagers into confidence in their scientific pursuits.

Throughout his tours to various parts of the country, Gandhi emphasised the need for knowledge of the science of spinning and often personally inspected the various wheels in operation. While he did emphasise the importance of the technical aspects, he did not see the science of the charkha in purely material terms but as a social process that would create the right atmosphere. The task of the students of the national schools was not just in knowing the science of the wheel. This science had an important role in the creation of the 'charkha atmosphere'. Gandhi was clear that unless these scientists of the national schools were to spin themselves the movement was unlikely to succeed. This emphasis on 'spinning for sacrifice' (see below) and the creation of the 'charkha atmosphere' led him to introduce a spinning franchise in the Congress constitution that made it mandatory for every congressman to spin for half an hour a day. He was convinced that the middle classes should take actively to spinning. "Let me point out from my own experience and that of co-workers that khadi work will not flourish unless the principal workers know the science of ginning, carding, spinning" (CW 32: 30). In a letter to Purushottam, he linked the slow spread of the movement to the fact that there were sill very few persons who recognised "spinning as a science and are interested in it as a science" (CW 42: 127).

Improvements in Spinning

The charkha atmosphere created by Gandhi's army of committed scientists had an important consequence in bringing about improvements in the various processes and the machinery of spinning. The unique concept of 'spinning for sacrifice' was his and the khadi movement's original contribution to science in civil society:

> If you will yourself spin, the quality of spinning will improve. Those who spin for wages must naturally be impatient. They will continue to spin the count that they are accustomed to. *The task of improving the count of yarn essentially belongs to the research worker, the lover of spinning.* This has been proved by experience. If there had not arisen a class of spinners, including both men and women, who spin purely out of a spirit of service the amasing progress that has been achieved in the quality of yarn would not have been possible.
>
> If you spin, your talents can be utilised in effecting improvements in the mechanism of the spinning-wheel. *All the improvements that have been made in the mechanism of the spinning-wheel and the speed of spinning up till now are solely due to the efforts of those devoted workers who spin for sacrifice* (CW 30: 309-10, emphasis added).

Inaugurating the Khadi Service, he reiterated that:

> The science of hand-spinning is capable of progressive improvement. Researches that are being made from time to time show that there is room for the best among us to apply themselves to the development of the art so that without extra effort or time the income of the millions, for whom hand-spinning is designed, may be almost doubled (CW 32: 447).

Thus, it was only when there were several satyagrahi scientists who practised science for sacrifice that the charkha would acquire new meanings. Gandhi believed that meaning had to be given to the charkha and was not necessarily intrinsic to it. The spinning wheel has no such inherent property as the quinine pill. It was for the satyagrahi scientists to discover this meaning. He remarked despite the fact that village crafts like the wheel had been in India for a long time, the tremendous possibilities hidden in them could only be realised if they were plied by awakened masses as a means for attaining freedom (CW 68: 256, 69: 241). The charkha, Gandhi reminded students of the national school, was an instrument of service:

> In a national school therefore where the nation expects us to train national servants, the scheme of studies will centre round the charkha. It is a science in itself and it is a science which gives us a knowledge of the means of ameliorating the condition of the masses (CW 33: 56-7).

Gandhi's keen interest in improvements in machinery and various kinds of hand tools for spinning is evident from his correspondence with many inventors. These letters reveal a new dimension to his controversial views on machinery. Gandhi offered the ashram as a place where these implements could be tested. He instituted prizes for an improved spinning wheel. The first such prize in 1921 was for Rs 5,000, an amount that increased in 1929 to Rs 1 lakh hoping to attract inventors from all over the world. His journals often carried articles of machines that seemed to be in the spirit of the khadi movement in India but were invented elsewhere (CW 68: 399-400).

Apart from improvements in the spinning wheel, Gandhi was also on the lookout for a machine that would turn out good spindles. The straightening of the spindles at the ashram was a laborious process and imposed a strain upon the eyes of the mender. He was not in favour of hand tools in case there was drudgery in the work and was deeply concerned about the effect tools had on the worker's health. It was this concern that made him and the All-India Spinners Association (AISA) search for a machine to straighten spindles. To the superintendent of a government workshop, Gandhi wrote enquiring if there was any machine that could straighten out spindles that had become bent or crooked. Improvements in machines to Gandhi were to be carried out in detail in immediate contexts. He was no Luddite or traditionalist out to preserve dying techniques at any cost. Where "absolutely necessary" the khadi worker was not to hesitate to introduce machinery (CW 36: 347; 37: 211, 41: 511).

At the same time improvements in machinery were to be pursued without sacrificing certain limiting principles. The quote below in the context of the All-India Village Industries Association (AIVIA) that he instituted in 1934 (see below) indicates his view on speed and efficiency as the main criteria in improved machines:

> The village movement, as I conceive it, does not discount speed or efficiency of production. Our village folk need all the efficiency that we can give them and more. The AIVIA is doing its level best to increase the speed of production consistently with its ideal and self-imposed limits. Already the speed of the 'takli' (distaff) has been increased beyond the wildest expectations of its protagonists. But this was achieved without the slightest sacrifice of the principle of rural mindedness. More, I claim that the marvellous ingenuity and skill which rendered this possible could only spring from a village brain. The limiting principle that was kept in view in effecting improvement in the speed of the takli, the spinning-wheel and other domestic tools should hold good in respect of the writing pen too (CW 65: 210-11).

To a socialist friend who queried him on his views on electricity he said:

> If we could have electricity in every village home, I should not mind villagers plying their implements and tools with the help of electricity. But then the village communities or the state would own power houses, just as they have their grazing pastures. But where there is no electricity and no machinery, what are idle hands to do? (CW 61: 187).

Scientists in civil society could not ignore the question of ownership of their inventions. Ownership had to be with the commons. Thus far from a model of static continuation of existing technologies, Gandhi was for improvements in machinery when they were in favour of the villager.

By the mid-1930s these views were crystallised under the framework of khadi science and articulated in a series of articles in *Harijan* (begun in 1933). Gandhi's key axiom was that everything could be turned into a science or a romance if there was a scientific or a romantic spirit behind it. Khadi, he argued, would cease to be an object of ridicule if it was attributed with meaning. The potency of khadi could not be achieved as a mantra by pursuing it mindlessly as a needy artisan who gins, cards, spins or weaves because he must for his bread. Gandhi's scientist would pursue it in a deliberate, wise, methodical manner and in a scientific spirit realising that: "A science to be science must afford the fullest scope for satisfying the hunger of body, mind and soul" (CW 64: 268).

To Gandhi, Maganlal was one such scientist who had a 'living faith' in the potency of khadi. Maganlal had laid bare the foundation of khadi science in his classic book – *Vanaat Sastra* (*Charkha Sastra* in English, 1924). Richard Gregg, the American who was interested in industrial relations and attracted to the khadi movement, too had the same fire in him and gave khadi a universal meaning through his *Economics of Khaddar* (1928). Both had recognised that the spinning wheel was the technology par excellence of non-violence. He wanted Maganlal's classic *Vanaat Sastra* updated and extended to other fields too. Gandhi saw Maganlal as a model satyagrahi scientist and wanted others to follow him. Though Maganlal had not specialised in all the various crafts that were being pursued by the AIVIA, his khadi activity was its precursor providing the nucleus round which the village industries movement flourished. Gandhi believed that every field had to find its own 'science men'. The khadi movement had found one such in Maganlal but it and Gandhi needed more. Jhaverbhai Patel of Maganwadi was studying the 'ghani' (traditional oil making machine) in all its aspects "with the zeal and precision of a scientist". The village 'chakki' and the village sugar cane crusher, however, were yet to discover their science men (CW 64: 268, 362; 67: 256; 70: 120-21).

In 1933 Gandhi formally dissolved the Sabarmati Ashram. After his Harijan Tour to various parts of the country he shifted his base to Wardha and finally to Sevagram a year later. He had also resigned from the primary membership of the Indian National Congress. His years after 1933 were aimed at working on the content and structure of the independence that he visualised in *Hind Swaraj*. During his Harijan Tour it occurred to him that the khadi effort was inadequate in rejuvenating the villages and was becoming a 'lifeless symbol'. It was confined to a very few and he observed that even those who used khadi exclusively were under the impression that they might use other things irrespective of how and where they were made. If such a state of things was allowed to go on, he feared that khadi might even die of sheer inanition. In the following section, we look at how the basic khadi model for Gandhian science was applied in other areas and how its limiting principle was applied.

AIVIA and Science for the Villages

Keen on tackling the twin problems of Indian society – idleness and the snapped link between the villages and the town-dwellers – Gandhi's scientific activities expanded beyond khadi. During the tour it occurred to him that the village industries were gradually slipping out of the hands of the villager, who had become a mere producer of raw materials. The villager gave and got little in return. The artisan too had lost his creativity and partook of the resourcelessness of the rest of the village. It is with this vision of "reinstating the villager" that Gandhi constituted the AIVIA in November 1934.

Gandhi found the task was not easy. He felt out of his depth while researching it:

> Here the field is so vast, there is such an infinite variety of industries to handle and organise, that it will tax all our business talent, expert knowledge and scientific training. It cannot be achieved without hard toil, incessant endeavour and application of all our business and scientific abilities to this supreme purpose. Thus, I sent a questionnaire to several of our well known doctors and chemists, asking them to enlighten me on the chemical analysis and different food values of polished and unpolished rice, jaggery and sugar, and so on. Many friends, I am thankful to say, have immediately responded, but only to confess that there has been no research in some of the directions I had inquired about. Is it not a tragedy that no scientist should be able to give me the chemical analysis of such a simple article as gur? The reason is that we have not thought of the villager (CW 59: 409).

Elaborating on the organisational difficulties he would have, Gandhi emphasised the importance of the scientific challenge ahead:

> What kinds of laboratory research shall we have to go in for? We shall need a number of scientists and chemists prepared to lay not only their expert knowledge at our disposal, but to sit down in our laboratories and to devote hours of time, free of charge, to experiments in the direction I have indicated. We shall have not only to publish the results from time to time, but we shall have to inspect and certify various products (CW 59:409).

The board of advisers of 20 members of AIVIA thus included eminent scientists like C V Raman, P C Ray, J C Bose and Sam Higginbotham. Gandhi felt that there was a need for "centralisation not of administration, but of thought, ideas and scientific knowledge".

From 1934 onwards Gandhi's emphasis moves clearly to "science for the villages". In his speeches Gandhi emphasised "rural-mindedness" just as he had emphasised the creation of the "charkha atmosphere" in the 1920s. To him "rural-mindedness" was no "mere detail, but a prime necessity". Though the first step towards rural-mindedness was taken at the Ahmedabad exhibition in 1921, it was only in 1936 at the Khadi and Village Industries Exhibition at Lucknow that a concrete conception of a rural exhibition had reached maturity (CW 60: 152, 256; 69: 297-98).

The concept of rural-mindedness was to repeatedly appear in Gandhi's writings and speeches:

> You cannot build non-violence on a factory civilisation, but it can be built on self-contained villages. Even if Hitler was so minded, he could not devastate seven hundred thousand non-violent villages. He would himself become non-violent in the process. Rural economy as I have conceived it eschews exploitation altogether and exploitation is the essence of violence. You have therefore to be rural minded before you can be non-violent, and to be rural minded you have to have faith in the spinning wheel (CW 70: 295).

Crafts and Indian Science Education

One of Gandhi's earliest experiments, both at the Ashram and outside was in the field of science education. Gandhi's educational scheme was based on an emphasis on the role of manual work, practical training and the use of the vernacular as a medium of instruction. Gandhi was keen to break the vice like grip that the English medium had on education in science. He cited Japan as an example of an educational system that taught science in the vernacular. To teachers and students of the Gujarat Vidyapith he urged the learning of science through the vernacular, adopting English words wherever technically necessary but giving explanations only in Gujarati (CW 39: 396). This vision of using the vernacular for scientific matters was translated into action by the khadi movement both during and after his death. Amongst Gandhi's other major institutional innovation in the 1930s was Nai Talim (or basic education). It is in his writings on Nai Talim that we find Gandhi's unique explanation to the question that has troubled many sociologists of science, namely, 'Why did India not have the industrial revolution?'.

Gandhi's critique of education, both modern and traditional, was based on the place of manual and crafts work in its overall scheme. He was convinced that:

> The utterly false idea that intelligence can be developed only through book reading should give place to the truth that the quickest development of the mind can be achieved by artisan's work being learnt in a scientific manner. True development of the mind commences immediately the apprentice is taught at every step why a particular manipulation of the hand or a tool is required (CW 64: 219).

Indian education had separated the mind and body, reserving the former to the sciences and the latter to occupations through vocational education. He wanted teachers to make the distinction between vocational training as a science and vocational training as a trade. He did not want to teach industry and handicrafts in the traditional way but wanted crafts as a living medium of instruction (CW 65: 389; 69: 203-05). Indians, according to him had not developed its scientist-engineers like in the west because:

> We are apt to think lightly of the village crafts because we have divorced educational from manual training. Manual work has been regarded as something inferior, and owing to the wretched distortion of the varna we came to regard spinners and weavers and carpenters and shoemakers as belonging to the inferior castes and the proletariat. We have had no Cromptons and Hargreaves[4] because of this vicious system of considering the crafts as something inferior divorced from the skilled. If they had been regarded as callings having an independent status of their own equal to the status that learning enjoyed, we should have had great inventors from among our craftsmen. Of course the 'spinning-jenny' led on to the discovery of water power and other things which made the mill displace the labour of thousands of people. That was, in my view, a monstrosity. We will by concentrating on the villages see that the inventive skill that an intensive learning of the craft will stimulate will subserve the needs of the villager as a whole (CW 66: 137-38).

This quote, typical of Gandhi's writings starts firstly with a critique and explanation for the existing state of affairs but soon moves towards an alternative path. To Gandhi, it did not follow from the 'logic of history' or 'destiny' that the industrial revolution was inevitable firstly in the west and later in the rest of the world. On the contrary, Gandhi by giving primacy to the agency and intention of the scientist-experimenter, arguing that what had historically happened was an accident and not an immutable law. There could be another path, an alternate science, where the inventive genius of Crompton and Hargreaves need not necessarily lead to monstrous results but instead contribute to communities as a whole.

Pointing to the English 'genius' for developing crafts, he reiterated that unless the Indian educational system recognised this, the creative capacities of the populace could not be awakened. His reform of the system was based on the fact that the occupational training then was not serving an educational purpose. Many skills were lost to the countryside resulting in poor workmanship that made it difficult to find an efficient carpenter or smith in a village. The remedy lay in imparting the whole art and science of a craft through practical training and through that imparting education (CW 66: 234). Following his critique of traditions from the standpoint of a believer, he argued that the stagnation in matters of science was inevitable if the practice of untouchability persisted.

> We look down upon those who do manual work. Had we assigned to craftsmen and artisans a place of dignity in society, like other countries we too would have produced many scientists and engineers (CW 88: 207).

It is clear that in Gandhi's Nai Talim, science education was not to proceed by pursuing islands of excellence in a sea of mediocrity. Work was to be done on the base of education so that no hierarchies of knowledge were created between the scientists as experts and the people. He wanted a proliferation of scientists and engineers in the villages, an increase in India's scientific manpower that would not be measured by the number of university degrees in science, but in creating scientists who would be true servants of the nation. Gandhi said that he was no opponent of higher education but the manner in which it was being imparted in the country. He remarked:

> Under my scheme there would be more and better libraries, laboratories, and research institutes. Under it we should have an army of chemists, engineers and other experts who will be real servants of the nation and answer the varied and growing requirements of a people who are becoming increasingly conscious of their rights and wants. These experts would speak not a foreign language but the language of the people. The knowledge gained by them will be the common property of the people. Only then would there be truly original work instead of mere imitation and the cost evenly and justly distributed (CW 73: 278).

Postgraduate Institute for Research

Significantly, most of Gandhi's attempts at institutional reorganisation had their base in scientific research. When he reconstituted the Satyagraha Ashram in 1928 following Maganlal's death, he emphasised that the ashram was "a scientific and prayerful experiment". A month before his assassination, at a constructive workers' committee meeting, he had reiterated that he wanted the various Sanghs to become research laboratories in their respective fields (YI 14-6-28, CW 90: 215-19).

The Gandhi Seva Sangh was started in 1923 as a support structure for volunteers interested in constructive work, or "real politics", as Gandhi referred to it. In 1940 he wanted to recast it into a 'postgraduate institute for research' to be used as a platform to speak about science and research for the villagers. In 1937 at Hudli, Gandhi was keen that the members of the Sangh participate in politics. However in February 1940 at Malikanda, West Bengal, Gandhi sought a radical change in the direction of the Sangh that not only meant eschewing politics, but its reconstitution as a centre for science. He envisioned the Sangh as an organisation for postgraduate studies that would undertake a great deal of research for organisations like the AISA, AIVIA and the Talimi Sangh. By themselves, these could not take up such work to the required extent, as their field of activity was limited. The main task of the Seva Sangh, in his conception, would be that of giving meaning to the wheel and disseminating this new knowledge. Towards this end he wanted the members to achieve perfection and specialise in some field and become experts by doing research and making discoveries in the post-graduate laboratory. These experts would specialise not for making money but for serving the poor and bettering their lot. On the method and task of such scientists in civil society, Gandhi emphasised:

> You should have expert knowledge not only of the science of the spinning wheel, but also of the art of spinning. Your spinning wheel should work more efficiently than that of the Charkha Sangh. Your yarn should be fine, strong and may not snap. For the expert, his tools should be of the highest quality. There should be something special about your slivers, your implements. Your implements would be out of the ordinary. I do not wish to make you just skilled labourers. I want to make you expert craftsmen and scientific researchers. I expect something unique from you (CW 71: 280).

This scientist would like Vinoba Bhave, considered his spiritual successor (and earlier Maganlal), study the smallest detail and build up a "science around everything". Mere changes in technical processes alone would not suffice. Here Gandhi breaks the fact-value dichotomy by insisting that the scientist should be engaged in creating meaning as well:

> You would not merely improve the tools and implements, but also see their conformity with our principles. You would have to see if the charkha increases your non-violent powers. There may not be politics in the spinning wheel of the Charkha Sangh; but you would have to see if it ... increases the strength of the people and whether, in free India, the economic provisions of swaraj could be based on the spinning wheel. Would it turn people into mere automatons capable of physical labour or would it make them non-violent soldiers of swaraj? (CW 71: 280).

Gandhi thus sought to create a new band of satyagrahis who would not march to Dandi and receive the blows of the lathi but who would become specialists in the science of non-violence. Gandhi's response to the Hitlerian science of violence was by engaging in research and experimentation in a new science of peace. Germany, he observed, was in need of specialists in the science of non-violence. The way of violence was old and established and it was not so difficult to do research in it (we have already noted his early views on vivisection and its violent cosmology). Now, he wanted his small centre of research to bring about a new social order based on truth and non-violence. He told the Sangh members that there was a wide scope for research and experiment in this field as it was new and it needed all their talents. Through these experiments, they would be placing before the country and the world the ideal of a new culture. The "unity of body, mind and spirit" was universal. The concept of non-violence it presumed belonged to the millions. Anything that could not reach the millions was not for him (CW 71: 260-76).

Without method and universalisability Gandhi was acutely aware that each of the individual constructive programmes like khadi, Nai Talim, etc, would end up being fetishised. It was the duty therefore of scientists to work out and demonstrate wider meanings and to be constantly reflexive. When asked by a scientist who wished to know what men of science were to do if they were asked by the Indian government to engage in researches in furtherance of war and the atom bomb, Gandhi replied categorically: "Scientists to be worth the name should resist such a state unto death" (CW 89: 52). Clearly Gandhi's method had a dissenting element and was against the political and social isolation inherent in paradigms of 'normal science'.

Gandhi's Scientific Method

For Gandhi, India was an ideal site for experiments on the self and he saw himself as a scientist experimenting to prove the fallacies of the dominant argument on science. Experience, he argued, enriched not contaminated his experiments. From being a serious critic of modern science in his early years, Gandhi later focused more on the possibilities of a new science and its practice. This has been brought out in his writings on Khadi and through novel institutional changes like Basic Education (Nai Talim) and a "post graduate research laboratory". We shall now point to some of the salient features of his method – in the choice of subject of research, the constitution of the scientific worker, the practice of science and finally, the underlying cosmology of non-violence.

Gandhi did not see science as an autonomous search independent of the individual scientist. In Gandhi's scheme, the agency of the scientist was of critical importance. The scientist had to be conscious and self-reflecting. He was not to flinch from the question of "what should the scientist be working on"? He was clear that the right place of the scientist lay neither with the exploiting market nor with the stifling state, but with the people. All Gandhi's experiments in science attempted to carve out and articulate this domain. To guide the scientist was his favourite talisman:

> Whenever in doubt recall the face of the poorest and the weakest man whom you may have seen, and ask yourself if the step you contemplate is going to be of any use to him (CW 89: 125).

The duty of the satyagrahi scientist was to work on those areas that required "tender nursing" which neither the state nor the market could institutionally provide for. This domain was large and had substantial scope for research (CW 24: 390). This considered and deliberate choice of the subject matter was the first step in his science. To aspiring scientists at the Indian Institute of Science, he pointed out the need to link external research to internal research. By internal research, Gandhi did not mean a private incommunicable domain of mystic experience but a public space where the questions of science, both moral and societal, kept within the purview of laypersons. Gandhi's science was thus to give voice to these inarticulate subjects as well, including the non-humans.

Underlying this considered choice of the subject of research was his conception of the scientific worker. In arguing for a science of non-violence, Gandhi insisted that standard methods and personnel could not pursue these goals. This science would need its own method and means of organisation:

> Attainment of world peace is impossible except for greater scientific precision, greater travail of the soul, greater patience and greater resources than required for the invention and consolidation of the means of mutual slaughter. It cannot be attained by a mere muster roll signed by millions of mankind desiring peace. But it can, if there is a science of peace, as I hold there is, by a few devoting themselves to the discovery of the means. Their effort being from within will not be showy but then it will not need a single farthing (CW 66: 72).

His own life he demonstrated was one of constant experimentation in this 'discovery of means' – a task that was not simple and could only be carried out by those who had been trained for it. The main purpose of Gandhi's ashrams and his reformed Gandhi Seva Sangh was in preparing such satyagrahi scientists. Gandhi's contribution lay in demonstrating this possibility as a universal truth through his life and that of his co-workers like Maganlal. Through his experiments, he sought to articulate the concept of a community worker as a scientist. He highlighted the need to embed the community in the practice of science. True progress of science would happen according to him once the satyagrahi scientist of Gandhi's science workers like Maganlal or Mirabehn were found or created. These scientists would then go about creating a text and manuals necessary for the spread of science. Though Gandhi's scientists were special, what he emphasised was the method, the fundamental possibility of every one being a person of science. Science was not an exclusive preserve of scientists working in laboratories. In a discussion with Rajagopalachari he pointed out that he treated his mother who was well versed in fasting as a scientist. "One who is pure, who adheres to truth and wants to cling to it is as much a scientist as a physicist" (CW 55: 441).

Gandhi did not provide a blueprint for *a* scientific method but gave general guidelines for experimentation. He saw his community workers as scientists. Though he was one of the foremost spokespersons of traditional technologies and the artisanal class in contemporary politics, he did not believe in a simple valorisation of the artisanal class. His community workers had to therefore go beyond learning the skill, which though important would not suffice for making experiments and discoveries. They were to see spinning and weaving not as a trade but as a science. Mastery of the art of spinning (sanitation, agriculture) was a necessary, but not sufficient condition in his scientific scheme. This mastery had to be transformed into a science and this was the duty, though not exclusive right, of the educated classes. The scientist had to have a living faith in his subject like Maganlal. His idea of reform was based on experiments carried out by this class.

> To clothe the Bhangi with the dignity and respect due to him is the especial task and privilege of the educated class. Some members of the class would first themselves master the science of sanitation to educate the Bhangi round them in the same. They would carefully study their present condition and the causes underlying it and set themselves to the task of eradicating the same by dint of inexhaustible perseverance and patience that never looks back and knows no defeat (CW 64: 86).

Gandhi's scientist would have to reduce the subject to a science and to prepare treatises on sanitation. Thus, Gandhi was also articulating his notion of community workers who would break the barriers of the 'elite' and the 'subaltern' in their own lives. Swaraj could not leave out experimentation on the self – the educated middle class. Advocacy alone would not do:

> It is no use merely making speeches or giving lectures; we must make scientific experiments and declare from the house-tops the results of our experiments (CW 78: 67).

The future of khadi (and all his programs) lay in workers not pursuing a Gandhian 'line' but in carrying out scientific experiments.

The practice of science Gandhi emphasised required an attitude for research more than scientific qualifications. In Gandhi's method, lack of resources could not be an excuse for not practising science. Contrary to the emphasis on physical resources which have been the focus of science policy in independent India, for Gandhi physical resources had to be presumed instead on a strong and moral fundamental base. He wanted from the scientists' sacrifice and dedication first. More than money Gandhi emphasised that there was a need for persons with strong faith and willing hands. He wanted that the new generations of scientists make original researches and not be imitative:

> I wish Indian medical men would make original researches and explore the possibilities of dietetic changes... Has Indian medicine no fresh contribution to make to the medical science? Or must it always rely upon the patented nostrums that, together with other foreign goods, are dumped down upon this unfortunate soil? Why should the West have a monopoly of making researches? (CW 35: 480).

The non-west too, he believed, could and should contribute to this universal resource of science. At the same time he was not being exclusive in ruling out the possible contribution of people of the west in this search:

> In one thing I do not mind being a beggar. I would beg of you your scientific talent. You can ask your engineers and agricultural experts to place their services at our disposal. They must not come to us as our lords and masters but as voluntary workers. A Mysore engineer who is a Pole (Maurice Frydman) has sent me a box of hand made tools made to suit village requirements. Supposing an engineer of that character comes and studies the tools and cottage machines, he would be of great service (CW 64: 99).

Such an attitude would not only provide new results but also contribute to the process of diffusion. In khadi if the key element lay in the fact that the distribution of wealth was concurrent to and not consequent to its production, so too in Gandhi's science issues of diffusion were not to be separated from the production of knowledge. The scientist community worker had to do it himself and be an active participant in the diffusion of ideas. However Gandhi does not stop by suggesting a different practice, instead he offers a new cosmology.

As we have seen in his views on vivisection, Gandhi's non-violent cosmology challenged the anthropomorphism of modern science and spoke on behalf of non-human nature as well. Unlike his scientific contemporaries, Gandhi saw no reason why science should inevitably be linked to the idea of progress. He remarked:

> We are dazzled by the material progress that western science has made. I am not enamoured of that progress. In fact, it almost seems as though God in His wisdom had prevented India from progressing along those lines, so that it might fulfil its special mission of resisting the onrush of materialism (CW 35: 524).

He also sought to reconstitute the relations between fact and value, science and religion in his method. By insisting that scientists are to provide meaning to what they do, he made clear that he was not interested in mere technical solutions to a problem. The role of the scientist lay not in the realm of fact alone but in creating meaning (value). To him they were not to be separated. Sahasrabuddhe has also explicated this aspect of the importance of the creation of meaning in his analysis of the Gandhian concept of technology-practice. Gandhi related and connected diverse programmes with the charkha. The charkha for Gandhi was the symbol of a new technology – a new relationship of man with nature, a relationship that could be brought into existence only by active, mutually cooperating persons. It would be meaningless for him if people who did not value cooperation practised it (1991: 27).

Unlike many reformers and secular scientists, Gandhi did not see science as outside of religion. On the contrary, he tried updating religion to include science and science too to include faith. But unlike the Vedantists, for Gandhi to be scientific was to practise one's dharma:

> If we had not become apathetic to our dharma, if we had not been indifferent to it, we would ... relinquished those ancient superstitions or ancient practices which have lost their utility or become harmful today... It is a sin to disregard the necessary dharma which is in keeping with the times under the pretext of following an

imaginary but ideal dharma which is not practicable (CW 41: 449-50).

Yet, Gandhi did not see the domain of science as all encompassing through the spread of universal reason, like many positivists. For him faith transcended reason. The intellect to him, took man along the battle of life to a 'certain limit' but at the crucial moment failed:

> Faith is the function of the heart and had to be enforced by reason. The two are not antagonistic as some think. The more intense one's faith is, the more it whets one's reason. Faith he believed enlightened the intellect and induced habits of industry (CW 71: 378).
>
> When faith materialises it manifests itself through reason. It is not self-luminous. For when faith transcends its bounds and finds another medium to express itself it shines forth all the more. Faith is never lost; in fact it grows and sharpens the intellect. And then faith can challenge reason (CW 78: 67).

Though a great believer in science, he was clear of its role in the cosmos. Science to him was not above truth and ahimsa, which were 'truer' than many so-called scientific facts. They were however difficult to put into practice and only with "proper previous preparation" could be rendered possible and easy (CW 63: 393). The Ashram as an institution was meant to facilitate this pursuit of truth of which science was a means. He also firmly believed that there were many aspects of life that science had yet to touch and it would be arrogant on the part of scientists to assume knowledge of these.

If the pursuit of science through instrumental rationality led to the Weberian position of "a disenchantment with the world", Gandhi's non-violent science argued that the combination of faith and reason could lead to territories hitherto unexplored by science. "Science has yet much to learn. It has so far touched only the hem of the garment" (CW 89: 273). Scientists to him also had no clue of the relation of moral behaviour with natural phenomena. He controversially linked the Bihar earthquake of 1932 to the Hindu practice of untouchability:

> *Yajna* does not merely mean work for the good of others; it also means body labour. If men did not do body labour, that is, did not cultivate land and grow crops, the rains would stop. My own belief is that natural phenomena are connected with moral behaviour. I have no proof for this. It is my faith. Such faith can do no harm in any case. Little research is done about such matters in the present age, and what is written about them in ancient books is treated as superstition (CW 49: 150).

In Gandhi's cosmology, the unity of body, mind and spirit was needed in exploring the relation between nature, man and God. This as we have seen comes through in his views on vivisection, the critique, as also in his reshaping the Gandhi Seva Sangh – the practice. His understanding of the scientific method is perhaps best summarised in his own words on khadi:

> It must be borne in mind that to make the spinners self-reliant and through their activity to achieve India's freedom is, and ought to be, the Association's goal. That we may not reach that goal should not cause undue worry. It is enough for us to know that it is the correct goal and, having started the activity, we have to correct our mistakes and go forward. That is the essence of the scientific method. No science has dropped from the skies in a perfect form. All sciences develop and are built up through experience. Perfection is not an attribute of science. Absolute perfection is not possible either for man or for the science that he creates (CW 83: 355-56).

We have in this paper shown that Gandhi is not anti-science as is commonly misunderstood. Through a look at his various experiments, many unrealised in his time; we have also shown that Gandhi's life defined a space for an alternative science for civil society that would operate with different methods. Gandhi's focus on the non-physical resources in organising for science, the satyagrahi scientist, for instance, is a radical departure from science policy as expressed by Nehru in his famous Scientific Policy Resolution of 1956 and followed in India since independence. He also had a universal message by providing a new cosmology of man-nature and fact-value relations that he articulated and put in place through his various experiments. With the above outline of a theoretical framework for Gandhian science in place, we take up for detailed explication the case of the khadi movement. EPW

Notes

1 See Srinivasan (1993) for a critique of Bose's method in Noakhali and his separation of the 'self' and the 'other' in field work.
2 See Veeravalli, A (1999) for a comparison of Einstein and Gandhi's views on the science of peace.
3 The 100 volume *Collected Works of Mahatma Gandhi* have been used extensively in this study and is referred to as CW in short with the volume number and page numbers as reference.
4 Samuel Compton, the inventor of the spinning mule in 1779 and James Hargreaves, the inventor of the spinning jenny in 1764.

2.5 Reading 5

The Observer

Thomas Kuhn: the man who changed the way the world looked at science

John Naughton

Sun 19 Aug 2012 00.05 BST

Fifty years ago this month, one of the most influential books of the 20th century was published by the University of Chicago Press. Many if not most lay people have probably never heard of its author, Thomas Kuhn, or of his book, *The Structure of Scientific Revolutions*, but their thinking has almost certainly been influenced by his ideas. The litmus test is whether you've ever heard or used the term "paradigm shift", which is probably the most used - and abused - term in contemporary discussions of organisational change and intellectual progress. A Google search for it returns more than 10 million hits, for example. And it currently turns up inside no fewer than 18,300 of the books marketed by Amazon. It is also one of the most cited academic books of all time. So if ever a big idea went viral, this is it.

The real measure of Kuhn's importance, however, lies not in the infectiousness of one of his concepts but in the fact that he singlehandedly changed the way we think about mankind's most organised attempt to understand the world. Before Kuhn, our view of science was dominated by philosophical ideas about how it *ought* to develop ("the scientific method"), together with a heroic narrative of scientific progress as "the addition of new truths to the stock of old truths, or the increasing approximation of theories to the truth, and in the odd case, the correction of past errors", as the *Stanford Encyclopaedia of Philosophy* puts it. Before Kuhn, in other words, we had what amounted to the Whig interpretation of scientific history, in which past researchers, theorists and experimenters had engaged in a long march, if not towards "truth", then at least towards greater and greater understanding of the natural world.

Kuhn's version of how science develops differed dramatically from the Whig version. Where the standard account saw steady, cumulative "progress", he saw discontinuities - a set of alternating "normal" and "revolutionary" phases in which communities of specialists in particular fields are plunged into periods of turmoil, uncertainty and angst. These revolutionary phases - for example the transition from Newtonian mechanics to quantum physics - correspond to great conceptual breakthroughs and lay the basis for a succeeding phase of business as usual. The fact that his version seems unremarkable now is, in a way, the greatest measure of his success. But in 1962 almost everything about it was controversial because of the challenge it posed to powerful, entrenched philosophical assumptions about how science did - and should - work.

What made it worse for philosophers of science was that Kuhn wasn't even a philosopher: he was a physicist, dammit. Born in 1922 in Cincinnati, he studied physics until the end of his days had he not been commissioned to teach a course on science for humanities students as part of the General Education in Science curriculum. This was the brainchild of Harvard's reforming president, James Conant, who believed that every educated person should know something about science.

The course was centred around historical case studies and teaching it forced Kuhn to study old scientific texts in detail for the first time. (Physicists, then as now, don't go in much for history.) Kuhn's encounter with the scientific work of Aristotle turned out to be a life- and career-changing epiphany.

"The question I hoped to answer," he recalled later, "was how much mechanics Aristotle had known, how much he had left for people such as Galileo and Newton to discover. Given that formulation, I rapidly discovered that Aristotle had known almost no mechanics at all... that conclusion was standard and it might in principle have been right. But I found it bothersome because, as I was reading him, Aristotle appeared not only ignorant of mechanics, but a dreadfully bad physical scientist as well. About motion, in particular, his writings seemed to me full of egregious errors, both of logic and of observation."

What Kuhn had run up against was the central weakness of the Whig interpretation of history. By the standards of present-day physics, Aristotle looks like an idiot. And yet we know he wasn't. Kuhn's blinding insight came from the sudden realisation that if one is to understand Aristotelian science, one must know about the intellectual tradition within which Aristotle worked. One must understand, for example, that for him the term "motion" meant change in general - not just the change in position of a physical body, which is how we think of it. Or, to put it in more general terms, to understand scientific development one must understand the intellectual frameworks within which scientists work. That insight is the engine that drives Kuhn's great book.

Kuhn remained at Harvard until 1956 and, having failed to get tenure, moved to the University of California at Berkeley where he wrote *Structure*... and was promoted to a professorship in 1961. The following year, the book was published by the University of Chicago Press. Despite the 172 pages of the first edition, Kuhn - in his characteristic, old-world scholarly style - always referred to it as a mere "sketch". He christened "normal science" - business as usual, if you like. In this phase, a community of researchers who share a common intellectual framework - called a paradigm or a "disciplinary matrix" - engage in solving puzzles thrown up by discrepancies (anomalies) between what the paradigm predicts and what is revealed by observation or experiment. Most of the time, the anomalies are resolved either by incremental changes to the paradigm or by uncovering observational or experimental error. As philosopher Ian Hacking puts it in his terrific preface to the new edition of *Structure*: "Normal science does not aim at novelty but at clearing up the status quo. It tends to discover what it expects to discover."

The trouble is that over longer periods unresolved anomalies accumulate and eventually get to the point where some scientists begin to question the paradigm itself. At this point, the discipline enters a period of crisis characterised by, in Kuhn's words, "a proliferation of compelling articulations, the willingness to try anything, the expression of explicit discontent, the recourse to philosophy and to debate over fundamentals". In the end, the crisis is resolved by a revolutionary change in world-view in which the now-deficient paradigm is replaced by a newer one. This is the paradigm shift of modern parlance and after it has happened the scientific field returns to normal science, based on the new framework. And so it goes on.

This brutal summary of the revolutionary process does not do justice to the complexity and subtlety of Kuhn's thinking. To appreciate these, you have to read his book. But it does perhaps indicate why *Structure*... came as such a bombshell to the philosophers and historians who had pieced together the Whig interpretation of scientific progress.

As an illustration, take Kuhn's portrayal of "normal" science. The most influential philosopher of science in 1962 was Karl Popper, described by Hacking as "the most widely read, and to some extent believed, by practising scientists". Popper summed up the essence of "the" scientific method in the title of one of his books: *Conjectures*

But what really set the cat among the philosophical pigeons was one implication of Kuhn's account of the process of paradigm change. He argued that competing paradigms are "incommensurable": that is to say, there exists no objective way of assessing their relative merits. There's no way, for example, that one could make a checklist comparing the merits of Newtonian mechanics (which applies to snooker balls and planets but not to anything that goes on inside the atom) and quantum mechanics (which deals with what happens at the sub-atomic level). But if rival paradigms are really incommensurable, then doesn't that imply that scientific revolutions must be based - at least in part - on irrational grounds? In which case, are not the paradigm shifts that we celebrate as great intellectual breakthroughs merely the result of outbreaks of mob psychology?

Kuhn's book spawned a whole industry of commentary, interpretation and exegesis. His emphasis on the importance of *communities* of scientists clustered round a shared paradigm essentially triggered the growth of a new academic discipline - the sociology of science - in which researchers began to examine scientific disciplines much as anthropologists studied exotic tribes, and in which science was regarded not as a sacred, untouchable product of the Enlightenment but as just another subculture.

As for his big idea - that of a "paradigm" as an intellectual framework that makes research possible -well, it quickly escaped into the wild and took on a life of its own. Hucksters, marketers and business school professors adopted it as a way of explaining the need for radical changes of world-view in their clients. And social masterwork is one.

comments (258)

2.6 Reading 6

July 25, 2014 1:40 pm

How botanical gardens helped to establish the British Empire

By Jim Endersby

The role plants played in Britain's colonies – a theme explored in a new BBC radio series about botanical science

'A View of Botanic Garden House and Reach' (1829) by James Baillie Fraser, from his 'Views of Calcutta' series

Sydney's botanic garden is a green jewel that lies alongside the city's opera house. The plants (along with the opera lovers and the animals at the zoo) have access to "absolute waterfront", the two words that set most Sydneysiders' pulses rating. Yet the garden's users – from the morning joggers to the Japanese brides and grooms getting their pictures taken – probably don't realise that the garden helped found an empire. Without Sydney and gardens like it, the great Victorian botanical empire that centred on the Royal Botanic Gardens at Kew might never have existed, and without Kew, the British Empire itself would have been very different and probably much less influential.

In October 1812, the government of the colony of New South Wales (NSW) issued a proclamation that informed the people of Sydney that "the whole of the Government Domain" was being "completely enclosed by stone walls". From that day forward, "no Cattle of any Description whatever" were permitted and any animals "found trespassing" would be impounded. The walls referred to are still visible within the garden, which trace their origin to this proclamation (although it was not formally founded until 1818).

NSW was, of course, a penal colony when the garden was founded and Sydney was a small, shabby town that faced repeated droughts and near famines. Everything from writing paper to seeds for the colony's farms had to be brought over from Britain, a hazardous voyage that typically took six months. It can hardly have been obvious that the colony needed a botanic garden, yet Sydney was far from unique. St Vincent, in the West Indies, was the first colony to found such a garden (in 1765), and Britain's East India Company decided it would be profitable to found one at Calcutta soon after (1787).

Eventually, there would be a network of gardens that spanned the globe, which would prove vital to the British Empire, allowing vital crops like rubber and cinchona (the tree from whose bark quinine was extracted) to be collected outside the empire and moved to colonies where they could be grown profitably.

Sir Joseph Banks (1771-72) by Sir Joshua Reynolds

(Think about all those rubber trees that now form forests in southeast Asia; their scientific name is Hevea brasiliensis, meaning "from Brazil".) However, during the years when most of the gardens were founded, grand imperial plant transfers were neither planned nor possible. So, why were they established?

Without Sydney and gardens like it, the botanical empire that centred on Kew might never have existed

The history of the Sydney botanic gardens, like that of NSW itself, is tightly connected to the history of Kew. In 1770, when Captain James Cook arrived on the east coast of the largely unknown Terra Australis, his ship's botanist, the 27-year-old Joseph Banks, was so astonished by the variety of new plants that he named the site "Botany Bay". After their return to Britain, Banks used his collections to turn himself into a scientific celebrity. He became Sir Joseph, friend and confidante of King George III, president of London's Royal Society and one of the world's most influential scientific men. In 1779, when the British government was looking for a new dumping ground for British convicts who were (understandably) no longer welcome in the former American colonies where they had previously been sent, Banks argued successfully that the land around Botany Bay was fertile enough to sustain a new convict settlement.

Peradeniya Royal Botanical Gardens in Kandy, Sri Lanka

One the many pies Banks got his increasingly fat fingers into was the royal garden at Kew, which he and his friend the king saw as vital to preserving the nation. The key was improvement, enclosing common land to make it private, creating new owners with the incentive to drain, manure and tend it, increasing yields and profits. (And higher yields also meant full bellies that would stave off the threat of French-style revolution.) The same ideology was at work in Sydney. When the governor, Lachlan Macquarie, decided to put his surplus convicts to work by walling in the land, it was with a view to improving it, creating a entrepôt for badly needed agricultural seeds, which the garden's first director bartered for rarities from Australia's still-mysterious flora. The cones of the gloomy, enigmatic Banksia trees, for example, a genus named in honour of Banks himself, were much sought after by Europe's botanists. In 1829, a plant collector called William Baxter thought his hard-won Banksia specimens valuable enough to risk a flogging by threatening to "knock down" anyone who tried to take them from him. Similarly, when the Calcutta gardens were founded, the East India Company hoped they would help them to break the Dutch spice monopoly.

Cinchona succirubra

In 1787, Banks hatched a scheme for improving the plantations in the West Indies. If a cheap, nutritious food source could be found, the cost of keeping the suffering slaves alive would fall and large-scale cotton cultivation could begin, feeding Lancashire's mills and increasing exports to Asia. Everyone's profits would rise, with no regard for the human cost. The task of transporting the chosen food, breadfruit, from the central Pacific was entrusted by Banks to William Bligh, captain of HMS Bounty. The voyage didn't go quite as planned, but when the breadfruit finally arrived from Tahiti in 1793, they were planted in the botanic garden at St Vincent. Local plantation owners could then obtain cuttings to start growing it themselves. A similar scheme was tried at Sydney with grapevines that were grown in the gardens and then distributed freely in the hope of fostering a profitable industry that would help the colony pay its own way. The Kew-trained botanist Allan Cunningham, who briefly had charge of the gardens in the 1830s, also expressed the hope that producing good local wines would "tend to diminish the pernicious use of ardent spirits among the lower classes of the Colony", thus adding "not a little to their comfort and happiness".

Breadfruit tree

Unlike the breadfruit scheme, Sydney's vines had nothing to do with Kew. Banks had died in 1820 and the royal garden went into a decline that almost proved terminal. It was dirty and dilapidated and, in an effort to reduce plant thefts by local nurserymen, the superintendent had hit on the ingenious solution of removing the labels from the plants in the hope that would-be thieves would be unable to identify valuable rarities. (An innovation that severely reduced the garden's usefulness to botanists.)

Gardens like Sydney responded by communicating directly with one another; any passing ship would be entrusted with a few plants or seeds and a letter, which were delivered free by enthusiastic captains to wherever they next called. The garden's archives are full of letters from Mauritius and India, Cape Colony and Ceylon, but from 1820-40, Kew's name is seldom mentioned.

Back in London, the government was (as ever) looking to cut public expenditure, and considered closing Kew. In 1838, the botanist John Lindley was asked to report on the plan, but instead of closure, he proposed the government should remove the garden from royal control and run it directly. His rationale was that there were already "many gardens in British Colonies and dependencies . . . in Calcutta, Bombay, Sahranpur, in

Latex drying on a rubber plantation in Kerala, India

the Isle of France [Mauritius], at Sydney, and in Trinidad, costing many thousands a year". Yet, the value of these gardens "is very much diminished by the want of some system under which they can all be regulated and controlled". Yet if proper co-ordination could be established, the empire's gardens were "capable of conferring very important benefits upon commerce and . . . colonial prosperity".

Lindley's report was accepted but he was disappointed when the task of running the "new Kew" went to William Jackson Hooker, Glasgow's professor of botany (who had been the intended recipient of Baxter's Banksia cones). Hooker got the post because he had a better sense of the government's priorities than Lindley; he was willing to work for a lower salary. Under Hooker and his son, Joseph, Kew would become the "great botanical exchange house for the empire" that Banks had envisaged.

A specimen and illustration of Banksia serrata from James Cook's first voyage

View of Sydney's central business district from the Royal Botanic Gardens

Packets of seeds, cuttings of plants and dried flowers still flow into Kew's collections from all over the world. Today, however, Kew is no longer at the centre of an empire, but a partner in a global network of gardens that are collaborating to record and protect the wealth of plants upon which virtually all life on this planet depends. Kew runs the Millennium Seed Bank, an international effort to preserve the seeds of as many plants as possible as insurance against future losses of genetic diversity. Yet without the unplanned, unco-ordinated efforts of men like Macquarie, Kew might not exist at all.

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Photographs: The Art Archive/Alamy; Bridgeman Images; Reinhard Schmid/4 Corners; Science Photo Library; Photocuisine/Alamy; H&J Eriksen/Nature Picture Library; Mary Evans/Natural History Museum; Vittorio Sciosia/4 Corners

2.7 Reading 7

Q **It all sounds pretty chaotic. It's no wonder that we need "map-makers," intellectuals to chart the depthless new world without a center. Who are some of these "map-makers"?**

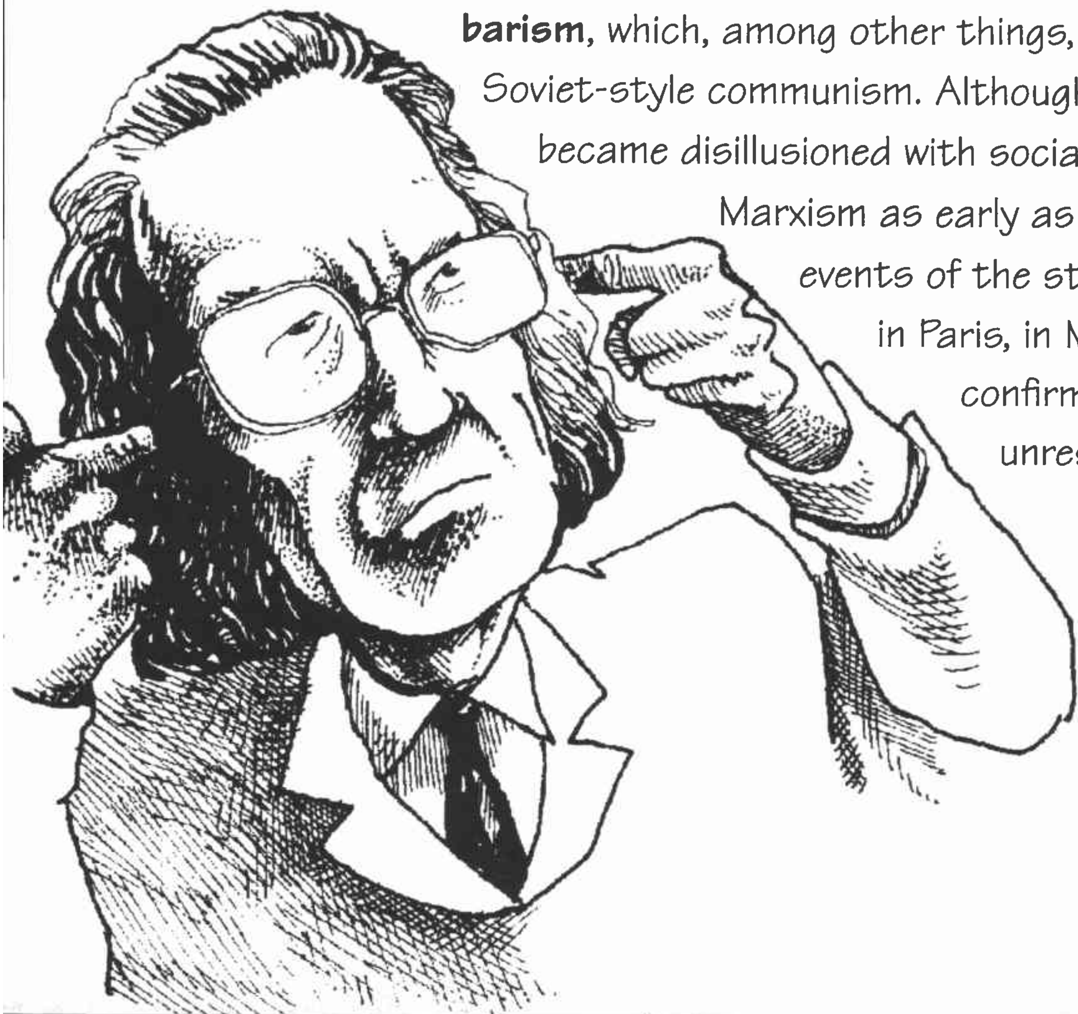
THE MAP-MAKERS

Important Postmodern Thinkers

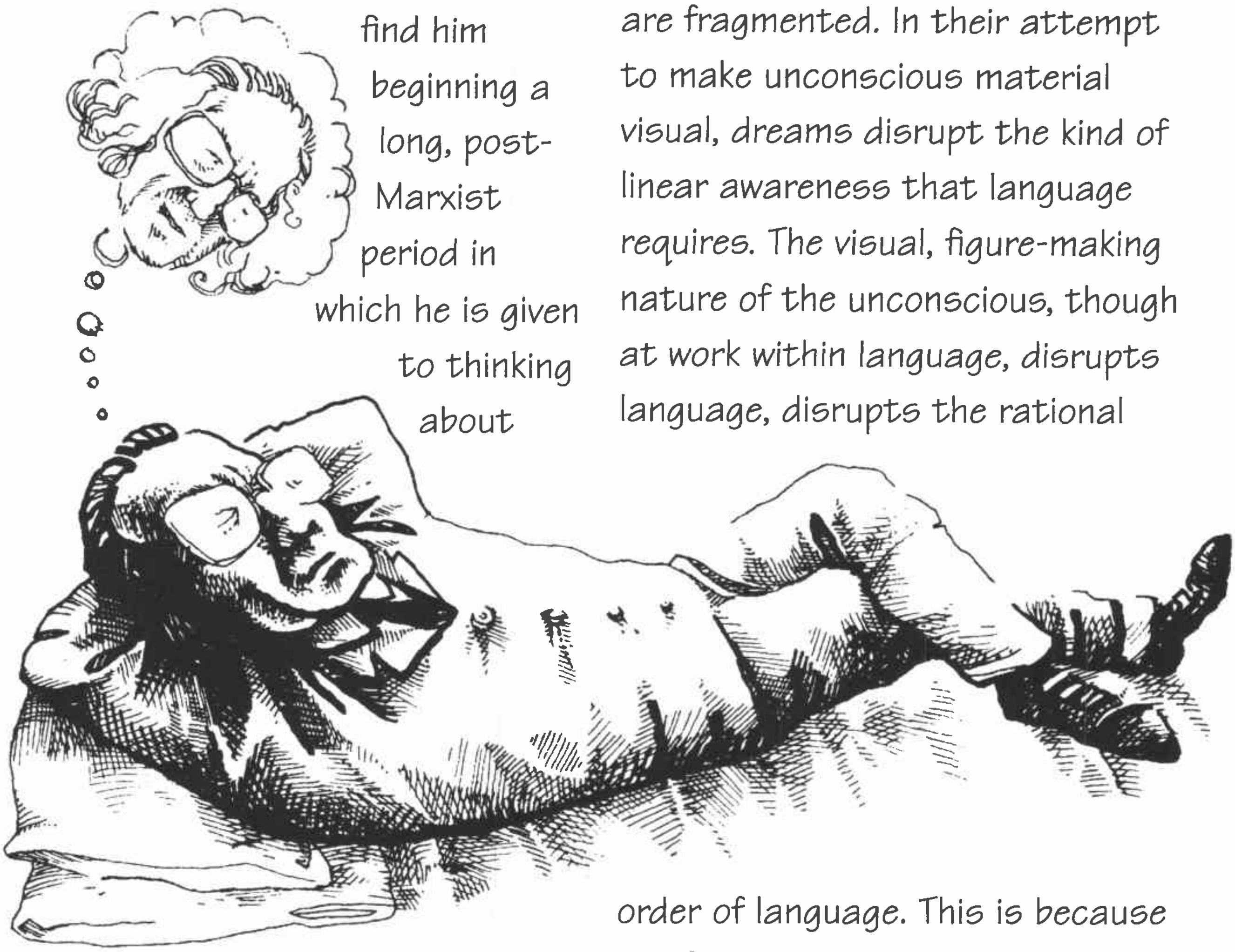
Jean-Francois Lyotard

A Jean-Francois Lyotard was born in France in 1924 and taught in Algeria, Brazil and California, before becoming professor of philosophy at the University of Paris in 1968. In 1985 he became director of the College International de Philosophie.

For some 15 years he was associated with a leftist group called **Socialism or Barbarism**, which, among other things, criticized Soviet-style communism. Although Lyotard became disillusioned with socialism and Marxism as early as 1964, the events of the student revolt in Paris, in May of 1968, confirmed his unrest.



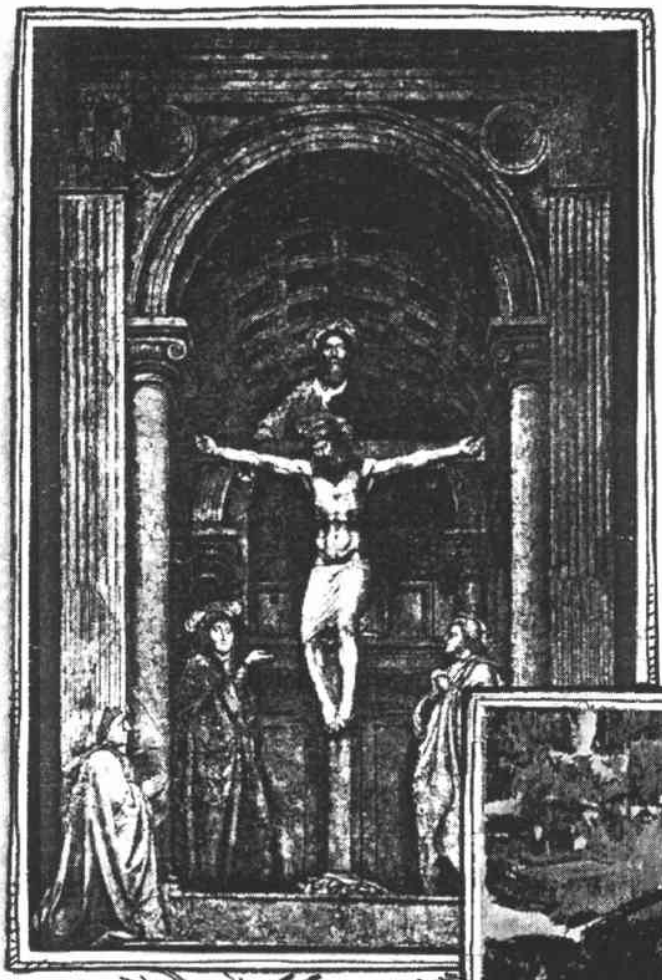
Discourse, figure



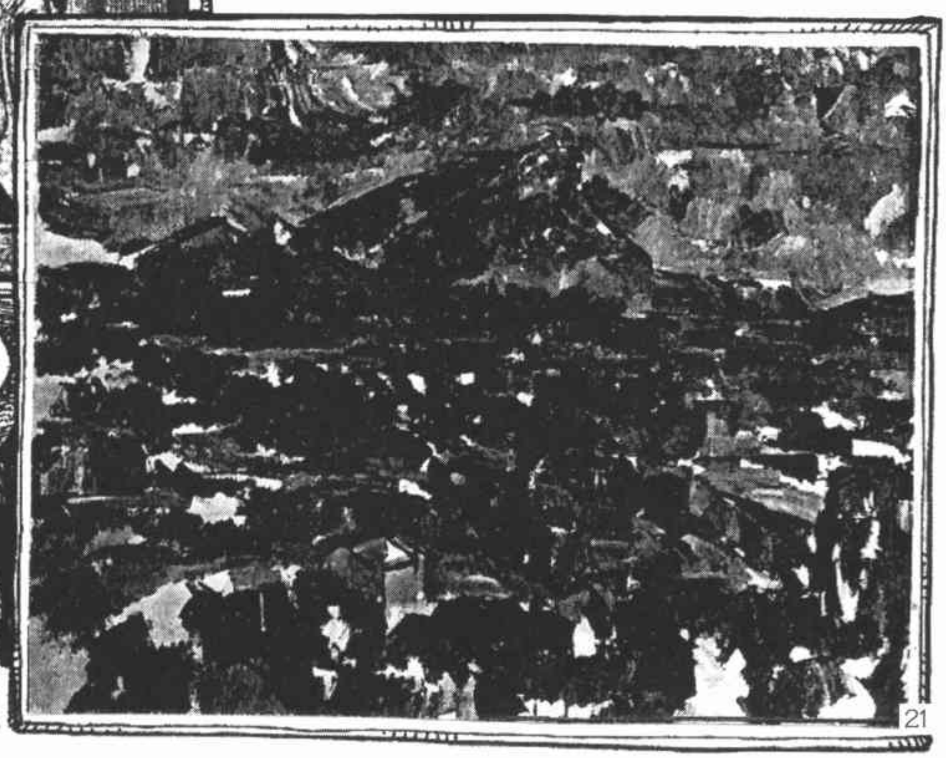
In 1971 we find him beginning a long, post-Marxist period in which he is given to thinking about philosophy, language and the arts. His book *Discourse, figure,* argues with the concept put forth by Jacques Lacan that the unconscious mind is like a language. Instead, Lyotard suggests that the unconscious is not so much like a language as it is visual and figural, like the figures one draws or paints. Language, after all, is flat, two dimensional. It represses desire. Dreams, on the other hand, are visual, figural, alive with three-dimensional dream figures, and dripping with desire. Like much modern painting, dreams are fragmented. In their attempt to make unconscious material visual, dreams disrupt the kind of linear awareness that language requires. The visual, figure-making nature of the unconscious, though at work within language, disrupts language, disrupts the rational order of language. This is because the figural nature of the unconscious is difficult to represent in language.

The figural resists representation in the same sense that the Holocaust resists representation. At Auschwitz the Nazis would drown out the screams of the victims in the death camps by playing music loudly. Similarly, to attempt to represent Auschwitz in language—to reduce the degradation, death and stench to a concept—drowns out the screams. According to Lyotard, it is therefore necessary that the Holocaust remains immemorial—that it remains being that which cannot be remembered—but also that which cannot be forgotten. Thus, any art attempting to represent the Holocaust should continue to haunt us with its inability to represent the unrepresentable, to say the unsayable. It should continue to haunt us with the feeling that there is something Other than representation.

Lyotard offers the example of Masaccio's ***Trinity***, painted on the walls of Santa Maria Novella, in Florence, which displays both medieval and Renaissance elements. By attempting to present two impossibly different eras, the painting seems to say that there is always an Other which cannot be truly represented.



Another example Lyotard offers is Cezanne's ***Mont Saint-Victoire***—a simultaneous attempt to present two different modes of vision: vision with a distinct focal center and vision which is peripheral, diffuse, indistinct. Again, two heterogeneous elements.



Q **Heterogeneous?**

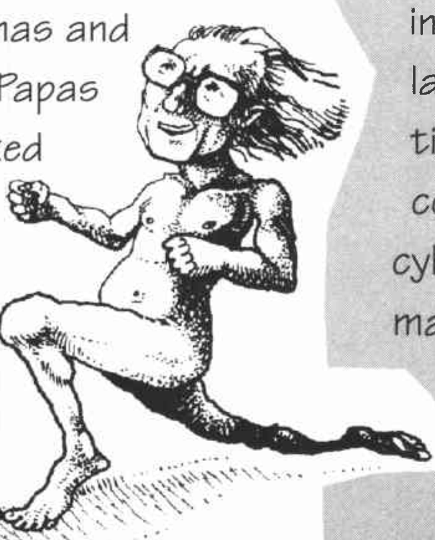
A Yes. Heterogeneous means "made up of dissimilar elements."

Poetic metaphor accomplishes the same. When I say "my love is a rose" I am invoking a heterogeneous difference. After all, a rose and my love may have very little in common.

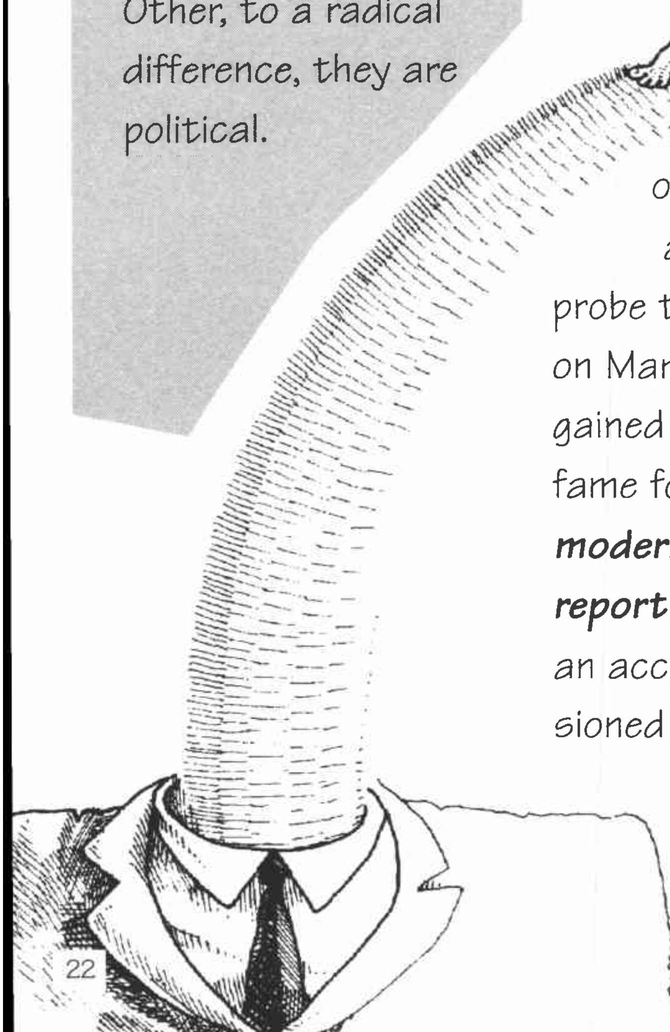
Because all these works of art bring our attention to the Other, to a radical difference, they are political.

The Postmodern Condition

In 1974, the year Postmodern novelist Thomas Pynchon's ***Gravity's Rainbow***, won the National Book Award, "streaking" became a fad in the United States, Mama Cass of the Mamas and the Papas choked



to death on a sandwich, and a Soviet probe touched down on Mars, Lyotard gained international fame for ***The Postmodern Condition: a report on knowledge,*** an account commissioned by the Council of Universities of the Quebec government. The report surveys the status of science and technology, and has become something of a bible of Postmodernism.



Lyotard argues that for the past few decades science has increasingly investigated language, linguistic theories, communications, cybernetics, informatics, computers and computer languages, information storage, data banks, and problems of translation from one computer language to another. He proclaimed that these technological changes would have a major impact on knowledge.

Thus, in 1974 he predicted that no knowledge will survive that cannot be

translated into computer language—into quantities of information. Learning will no longer be associated with the training of minds—with teachers training students. For the transmission and storage of information will no longer depend on individuals, but on computers. Information will be produced and sold. Nations will fight for information the way they used to fight for territory. Information will zip around the globe at the speed of electricity, and people will try to steal it. The role of the state will grow weaker. Taking the place of states, huge multinational corporations will dominate.

But having said all this about the direction of scientific knowledge, Lyotard adds that scientific knowledge is not the only kind of knowledge. His interest, it turns out, is not so much in scientific knowledge and the scientific method, per se, but in how scientific knowledge and method legitimize themselves—how they make themselves believable and trustworthy. And at this point Lyotard makes a distinction between scientific talk and narrative talk. Of course he doesn't use the word "talk." He uses scientific "discourse" and narrative "discourse."