

# **THE HISTORY OF MODERN SCIENCE AND MATHEMATICS**

**Volumes One through Four**

**Editor-In-Chief**  
**Brian S. Baigrie**

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**Craig Fraser**  
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**Mary P. Winsor**

**Volume 1 254 pp.**

**FRONT MATTER** **8 pp.**

**INTRODUCTION.** **10 pp.**

Author: Brian S. Baigrie, IHPST, University of Toronto, Toronto, Canada

**CHART OF ORGANIZATION OF SCIENCES** **2 pp.**

**INTERDISCIPLINARY TIMELINE** **22 pp.**

**TOPICAL ESSAYS** **42 pp.**

**Relationship Between History and Science** 6 pp.

Author: Larry Laudan

**The Scientific Foundations of Medicine** 14 pp.

Author: Helen Bynum

**What is a Proof?** 12 pp.

Author: Gila Hanna, Ontario Institute for Studies in Education, University of Toronto, Toronto, Canada

**What is Science? What is Technology?** 10 pp.

Author: Joseph Pitt, Science Studies Center, Virginia Polytechnic Institute, Blacksburg, Virginia

**OVERVIEW ARTICLES** **94 pp.**

**BIOLOGY** **32 pp.**

Author: George Cook and Mary P. Winsor, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1600:**

Aristotle's *anima* and ancient atomism

Aristotle's teleology

The material structure of life: elements and humors

The encyclopedic tradition

*Sidebar. Scientific Practice: The Alexandrian School of Anatomy*

**1600 – 1900:**

Spontaneous Generation

Redi's experiments

The mechanistic ideal (Harvey, Descartes, Boyle, and Ray)

Microscopy

*Sidebar. Scientific Practice: The Reciprocal Relationship Between Fact and Theory*

Spallanzani vs Buffon

Vitalism and reductionism

Evolution — convergence of biodiversity, genetics, paleontology, embryology

*Sidebar. Scientific Biography: Life of Darwin: The Voyage of the Beagle*

Cells: the fundamental units of metabolism, reproduction, growth

**The 1900s:**

Synthesis of chromosomes in reproduction (meiosis + fertilization) with inheritance (Mendelism)

*Sidebar. Scientific Practice: Simultaneous Discovery: Sutton and Bovari*

Individuality — cells, organisms, populations, and species

Synthesis of population genetics with biodiversity: Fisher, Haldane, and Wright

Mayr's proximal versus ultimate causation

**MATHEMATICS**

**30 pp.**

Author: Craig Fraser, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1543 Roots**

See also Algebra, Arithmetic, Geometry, and Calculus

**1543 to 1700:**

Beginning of Modern Mathematics (Cardano 1545)

*Sidebar. Scientific Institutions: Marin Mersenne and Informal Colleges of Mathematicians*

**The 1700s:**

Pure Mathematics (Algebra, Arithmetic, Geometry, and Calculus)

Mixed Mathematics (Mechanics, Optics)

See also Algebra, Arithmetic, Geometry, and Calculus

**The 1800s:**

Mathematics Stands apart from Physical Science

George Boole and Symbolic Logic (1854)

*Sidebar. Science & Society: Neohumanism and the Research Imperative: the Rise of the German University*

Georg Cantor's Set Theory and Gottlob Frege's Logicism

**The 1900s:**

Logic Refined (Russell and Whitehead, *Principia Mathematica*, 1910-13)

Mathematical Physics: Hilbert, Poincare, von Neumann, Einstein

Fractal Theory

Set Theory and Logic: Von Neumann and Turing

The Turing Machine

*Sidebar. Science & Technology: Set Theory, Logic and Computing*

The Bourbaki Influence

Chaos Theory

**PHYSICAL SCIENCES**

**32 pp**

Author: Brian S. Baigrie and Craig Fraser, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1543**

Aristotle and qualitative physics

Medieval dynamics

**1543-1700**

The rise of mathematization: Galileo, Descartes, Huygens and Newton

The culture of experimentation: Galileo, Hooke and Newton (optics)

*Sidebar: Francis Bacon and physics as empowerment*

**The 1700s**

Golden age of a priori physics: Euler, Lagrange and Laplace

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The second scientific revolution: the spread of mathematization in France

The emergence of theoretical physics: German physics and the vocation of mathematical physics

Philosophical debates: realism and positivism

**The 1900s**

The decline of the mechanical world view

Special and general relativity: the paradigm shifts

The old and new quantum theories: revolution in science

Physics, the military and big science

*Sidebar: The moral dilemma of the physicist: The case of Oppenheimer*

## **ALGEBRA**

**20 pp.**

Author: Israel Kliner, Dept. of Mathematics, York University, Toronto, Ontario, Canada.

### **Pre-1543 Roots**

#### **1543 to 1700:**

Solution of equations, the cubic and quartic: Tartaglia, Cardano, Bombelli

*Sidebar: Scientific Practice: Complex numbers*

Algebraic notation: Viete and Descartes

Logarithms: Napier and Briggs

Numerical solution of polynomial equations

#### **1700s**

The fundamental theorem of algebra: d'Alembert, Euler and Gauss

#### **1800s:**

Symbolical algebra: the problem with negative numbers

The unsolvability of the quintic and the rise of group theory: Galois, Abel and Cauchy

Commutative algebra: fields, rings and ideals

Noncommutative algebra: hypercomplex systems

Linear algebra

*Sidebar: Scientific Practice: Constructions with straightedge and compass*

Foundations of the number systems: Dedekind and Peano

#### **1900s:**

*Sidebar. Scientific Biography: Emmy Noether and Women in Mathematics*

Modern algebra: Noether and Van der Waerden

The legacy of modern algebra: algebraic topology, algebraic geometry and algebraic logic

## **ANATOMY AND PHYSIOLOGY**

**56 pp.**

### **Greeks to 1599:**

Author: Jole Shackelford, University of Minnesota

Classical era: Aristotle and Theophrastus to Galen

Medieval natural history: folk knowledge and scholarship

Human anatomy (Leonardo da Vinci 1490)

*De Fabrica* of Vesalius (1543)

*Sidebar. Science & the Arts: Printing and Illustration*

**1600 to 1799:**

Author: Jole Shackelford, University of Minnesota

Harvey and the circulation of the blood (1628)

*Sidebar. Scientific Institutions: Boyle and Hooke at Oxford and the Royal Society of London.*

Microscopic structures: Hooke, Leeuwenhoek, Malphigi, and Grew

Swammerdam and the comparative anatomy of insects (1650s)

Hales' experiments on blood pressure and the movement of sap (1719-25)

De La Mettrie's animal-machine (1745)

Reaumur and Spallanzani on digestion (1750s)

Respiration as combustion: Lavoisier, Laplace, and Ludwig (1790s – 1852)

Galvani on animal electricity (1797)

Plant metabolism (Priestley, Ingenhousz, Senebier, De Saussure, and J. von Sachs)

**1800 to 1899**

Author: Manfred Laubichler, Program in History of Science, Princeton University

*Sidebar. Science & the Arts: Frankenstein*

The cell as the fundamental unit of life: Schleiden and Schwann (1838)

*Sidebar. Scientific Practice: Fruitful Errors*

Protoplasm vs nucleus: M. Schultz vs Huxley

Cells arising from previous cells: Robert Remak (1840)

*Sidebar. Science & Society: Antivivisection*

Biometricians: Helmholtz and Du Bois-Reymond (1848)

*Sidebar. Science & Technology: The Microscope and the Microtome*

Claude Bernard and experimental determinism (1865)

*Sidebar: Scientific Biography: Robert Remak: Oppressed Jewish Scientist*

**1900s:**

Author: Otniel Dror, Getty Research Institute

Photosynthesis

*Sidebar. Pure vs Applied Science: Agriculture and Botanical research*

Enzymes, hormones — functioning biochemistry

Krebs cycle (tricarboxylic acid cycle) (1937)

The electron microscope (Hillier 1940)

*Sidebar. Scientific Practice: The Laboratory as the Site of Biology*

Radioactive Tracers

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### ANTHROPOLOGY

22 pp.

Author: J. Conor Burns, The Institute for History and philosophy of Science and Technology, University of Toronto, Toronto, Canada

#### Pre-1543 Roots

##### 1543 to 1700:

Edward Tyson's Comparative Anatomy of a Chimpanzee (1699)

##### 1700s:

Buffon's *Natural History* 1749

Taxonomy: Classification of Human Beings and Other Primates

*Sidebar. Science & the Arts: Camper's Facial Angle*

Founding of Physical Anthropology (Blumenbach 1798)

##### 1800s:

Biometry and Use of Statistics (Quetelet, 1835)

Agassiz and the American School of Anthropology (1850s)

*Sidebar: Scientific Institutions: Founding the Smithsonian Institution*

Lartlet and Cro-Magnon Man (1868)

Deepening the History of Humankind (Eugene Dubois 1891-92)

Classification of Races at Turn of the Century

Franz Boaz and the critique of cultural evolutionism

Introduction of Cultural Anthropology

##### 1900s:

A.S. Woodward and Piltdown Man (1912)

Influence of Mendel's Genetics

The Blood Group Principle (Landsteiner)

Elaboration of Cultural Anthropology

The Discovery of *Homo erectus* (Louis Leakey 1960)

### ASTRONOMY AND COSMOLOGY

74 pp.

#### Antiquity to 1699:

Author: Daryn Lehoux, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

Astronomy in antiquity

The Copernican System (1543)

Tycho Brahe and Observational Astronomy (1572-1600)

The Gregorian Calendar (1582)

Kepler's Laws of Planetary Motion (1609; 1619)

Galileo and the Telescope (1610; 1613)

*Sidebar. Science & Religion: Galileo and the Church*

Vortex Theory and the Cartesian Cosmos (1644)

The Paris Observatory (1667)

*Sidebar. Scientific Practice: The Construction of Greenwich Observatory (1675)*

Fontenelle's Plurality of Worlds (1686)

Newton and Universal Gravitation (1687)

*Sidebar. Science & the Arts: Locke's Letters on Toleration (1690, 1692, 1694)*

### **1700s:**

Author: Brian S. Baigrie, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

Halley's comet, Milky Way and other telescopic discoveries

Testing Newton's theory: The three-body problem

The shape of the earth (1735-36)

The Nebular Hypothesis and the Origin of the Solar System (Kant 1755; Laplace 1796)

Expanding the solar system: Herschel discovers Uranus (1781)

*Sidebar. Science & Technology: The First Nebula Catalog*

Herschel and the discovery of new satellites (1787, 1789)

### **1800s:**

Author: Brian S. Baigrie, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

Laplace's celestial mechanics (1799 - 1825)

Stellar Parallax (Friedrich Bessel 1838)

Bode-Titius Law

*Sidebar: Scientific Biography: William and Caroline Herschel*

Details about nebulas

*Sidebar: Scientific Practice: First Photograph of a Star (1850)*

Foucault and the rotation of the earth (1851)

The red shift (Huggins 1868)

Martian canals (Schiaparelli 1877; Lowell 1896)

Solar physics

### **The 1900s:**

Author: Craig Fraser, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

Finding the ends of the solar system: Pluto (Tombaugh 1930)

Radioastronomy (Jansky 1932)

More research into nebulas

Galaxies beyond the Milky Way: Hubble discovers Andromeda

*Sidebar. Scientific Biography: Edwin Hubble*

Hubble and the expanding universe (1929)

The big bang theory

*Sidebar: Science & Society: The Launch of Sputnik*

Black holes

The Great Attractor

*Sidebar: Science & Society: The Lunar Voyage (1969)*

## **ATOMIC AND NUCLEAR PHYSICS**

**28 pp.**

Author Brian Baigrie, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada M5S 1K7

### **Pre- 1700s:**

Boyle's corpuscular theory of matter (1660)

The revival of atomism: Gassendi, Newton

### **1800s:**

The chemical atom

Debates about cathode radiation: Cromwell and Varley

*Sidebar: Completion of the Cavendish Laboratory (1872)*

Roentgen Rays (1895)

*Sidebar: Science & Technology. X-rays and medicine*

The discovery of radioactivity (Becquerel 1896)

Discovery of the electron (Thomson 1897)

Alpha and beta rays (Rutherford 1899)

*Sidebar: Scientific Biography: Marie Curie*

### **1900s:**

Planck's Constant (1900)

*Sidebar: Science & Technology: C.T.R. Wilson's Cloud Chamber (1911)*

The nuclear model of the atom (Rutherford 1911)

Isotopes (Soddy 1913)

The quantum model of the atom and atomic spectra (Bohr 1913)

The Artificial Disintegration of the Atom (Rutherford 1919)

The Uncertainty Principle (Heisenberg 1927)

The Complementarity Principle (Bohr 1927)

The discovery of the neutron (Chadwick 1932)

Constructing the cyclotron (Lawrence and Livingston 1934)

*Sidebar: Science & Society: The Emigration of Scientists*

The first self-supporting nuclear-fission chain reaction (1942)

The Manhattan Project (1942)

The Standard Model

## CALCULUS

**22 pp.**

Author: Adrian Rice, Department of Mathematics, Randolph Macon University, Ashland, Virginia

### **1543 to 1700:**

The Beginnings of Calculus

Indivisibles (Cavalieri 1635)

Fluxional/infinitesimal calculus (Newton)

Differential calculus (1644); integral calculus (Leibniz, 1686)

The calculus dispute between Newton and Leibniz

*Sidebar: Scientific Biography: Gottfried Wilhelm Leibniz*

### **1700s:**

“The Century of Analysis” — expansion and specialization in calculus

*Crossing Disciplines: Calculus in the Aid of Mechanics*

Mathematical mechanics

Calculus and the geometry of curves

Calculus of variations

*Sidebar: Scientific Biography: The Bernoulli Family*

Separating calculus from geometry: the function (Euler 1748)

Completing Euler’s work: Lagrange (1797)

### **1800s:**

Cauchy’s foundations of calculus: the roots of mathematical analysis

Fourier’s proposition on functions and its challengers

Weierstrass moves Cauchy’s foundations forward

### **1900s:**

Functional Calculus

# CHEMISTRY

86 pp.

## Antiquity to 1699:

Author: Lawrence Principe, Johns Hopkins University, 34<sup>th</sup> and Charles Streets, Baltimore, MD 21218

Ancient beginnings

Middle Ages (Islamic and Latin)

Making gold/chrysopoeia; transmutation

Medical chemistry/iatrochemistry (Paracelsus/Paracelsians)

Technical and industrial chemistry

*Sidebar: Scientific Institutions: The Royal Society*

Van Helmont and Helmontians

Element theory

Atomism/corpuscularism

Chemistry as an emerging profession

Stahl and phlogiston

## 1700s:

Author: Maurice P. Crosland, History Department, University of Kent

Chemistry and pharmacy

New substances

Affinity theory

Gases

Phlogiston theory

Lavoisier and the chemical revolution

Chemical names

Chemical industry

*Sidebar: Scientific Instrumentation: The Gasometer*

## 1800s:

Author: Colin A. Russell

Atoms and molecules I: chemical atomism or how atoms differ (Dalton and Avogadro)

Organic chemistry: “out of the jungle” a new science emerges (Berzelius, Liebig and Wohler)

Atoms and molecules II: valency, or how atoms combine (Frankland and Kekulé)

Organic chemistry: order from chaos, classification (Gerhardt, Laurent, Kekulé)

Atoms and molecules III: structure, or how molecules exist (Butlerov, Frankland, Kekulé)

*Sidebar: Science & Society: Popular Chemical Education*

Inorganic chemistry: new elements and a new system (Berzelius to Mendeleev)

*Sidebar. Scientific Practice: The Periodic Table*

Atoms and molecules IV: stereochemistry, or molecules in space (van't Hoff and le Bel)

*Sidebar: Scientific Practice: 4 Different Kinds of Chemical Formulae*

Organic chemistry: synthesis and its application (Kolbe, Hofmann, Perkin, etc.)

*Sidebar: Scientific Practice: The Karlsruhe Conference (1860)*

**1900s:**

[20 pp.]

Author: Trevor Levere, Institute for History and Philosophy of Science and Technology,  
University of Toronto, Toronto, Canada

Noble-Gas compounds

Biochemistry and molecular biology

Polymers and plastics

Chemical physics — spectroscopy

*Sidebar: Science & Society: Industrial Chemistry*

Synthesizing new elements

*Sidebar: Science & Society: Pharmaceuticals*

Fullerenes

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**DEVELOPMENTAL BIOLOGY**

**26 pp.**

Author: Judith Schloegel, Max Planck Institute, Berlin, Germany; Brian Baigrie and Ted Everson,  
Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1600 Roots:**

Aristotelian and Galenic traditions

**1600s and 1700s:**

*Sidebar. Scientific Practice: Bacon and the Inductive Method*

Harvey's theory of oviparous reproduction (1651)

*Sidebar: Scientific Practice: René Descartes and the Deductive Method*

Leeuwenhoek's "animalcules" (1670s – 90s)

Swammerdam and the metamorphosis of insects (1669)

Preformation vs epigenesis debate: Wolff (1759)

**1800s:**

Mammalian egg (von Baer 1827)

Fertilization (Newport 1854)

Hofmeister and the unification of plant life cycles (1860s)  
A. Weismann and continuity of germ plasm (1886)  
Meiosis distinguished from mitosis (Hertwig and Bovari 1890s)

**1900s:**

Tissue culture (R. Harrison 1907-30s)  
Spemann, Mangold and the organizer (1920)  
J. Needham and chemical embryology

**EARTH SCIENCE AND GEOLOGY**

**42 pp.**

Author: Dr. Ezio Vaccari, Centro di Studio sulla Storia della Tecnica, Genoa, Italy

**Pre-1543 Roots**

Mining and Knowledge of the Earth in the Antiquity  
*Sidebar. Scientific Practice: Aristotle's Meteorology*  
The origin of rocks and mountains (Avicenna, 1021-23)  
*Sidebar. Scientific Practice: Ristoro d'Arezzo's observations on the Earth's surface (1282)*  
Leonardo da Vinci and the fossils

**1543 to 1700:**

Origins of mineralogy (Georgius Agricola 1546, 1556)  
Cosmography and cartography  
*Sidebar. Science & Technology: The first projection map (Mercator, 1569)*  
Size and shape of the Earth  
*Sidebar. Scientific Biography: The Earth as a magnet (William Gilbert, 1600)*  
The birth of Paleontology  
*Sidebar. Scientific Practice: The Stenonian Revolution (1669)*  
The Theories of the Earth  
*Sidebar: Science & Religion: Thomas Burnet, John Woodward, and the Book of Genesis (1681, 1695)*  
The meteorological and magnetic maps (Halley, 1688, 1701)

**The 1700s:**

The debate on the origin of springs  
*Sidebar. Scientific Practice: Robert Hooke's Discourse of Earthquakes (1688, 1705)]*  
Diluvialism and the order of strata  
*Sidebar. Scientific Practice: Buffon's Theory of the Earth (1749, 1778)*  
Geological Fieldwork and Geological Collections  
*Sidebar. Scientific Practice: The "classifications" of mountains (Lehmann 1756, Arduino 1760)*  
Volcanoes and volcanic rocks

*Sidebar: The basalt controversy*

Mining and geology

*Sidebar. Scientific Institutions: The Mining Academies and the early geological education*

Abraham G. Werner and Neptunism (1775-96)

James Hutton's uniformitarian theory of the Earth (1788-95)

**The 1800s:**

Vulcanists and Neptunists

*Sidebar. Scientific Practice: Leopold von Buch's "Craters of Elevation" theory (1809)*

The Beaufort Scale for Wind Speed (1806)

*Sidebar: Founding of the Geological Society (1807)*

The beginning of biostratigraphy (Cuvier and Brongniart, 1808)

*Sidebar. Scientific Biography: William "Strata" Smith (1815, 1819)*

Georges Cuvier's and Catastrophism (1812)

Élie de Beaumont and the early tectonic theories

Charles Lyell's Principles of geology (1830-33)

*Sidebar. Scientific Practice: The definition of the Geological Ages [periods]*

Systematic Mineralogy and Crystallography

*Sidebar. Science & Society: National Geological Surveys and Geological Mapping*

Vertebrate paleontology

*Sidebar. Scientific Biography: Gideon Mantell and the discovery of dinosaurs*

Charpentier, Agassiz, the glaciation theory and the Ice Age (1835, 1840)

Milne and the invention of the seismograph (1880)

Development of tectonics (Eduard Suess, 1883-88)

Lord Kelvin and the age of the Earth (1899)

**The 1900s:**

Geology as a scientific discipline

The tectonic structure of the Earth (Argand on the Alps, 1911)

*Sidebar. Science & Technology: The first quantitative geological time scale (A. Holmes 1913)*

Geochemistry and applied geology

Continental Drift (Alfred Wegener 1915)

Systematic paleontology and use of microfossils

*Sidebar. Scientific Practice: The convection-current theory (A. Holmes 1929)*

Internal Structure of the Earth

Plate Tectonics

## ECOLOGY

22 pp.

Author: Joe Cain, Science and Technology Studies, University College, Gower Street, London. WC1E 6BT

Basic autecology: agriculture

*Sidebar. Early Roots of Ecology*

Basic synecology: natural theology and natural selection

Biogeography and terrestrial physics

Reformers react against biogeography

Community ecology

Criticisms of community ecology

Population ecology as an alternative

*Sidebar: Science and society: political economy meets population biology*

Systems or ecosystems ecology

Combination of communities, populations, and systems

Ecology and environmentalism

*Sidebar. Science and society: Rachel Carson*

*Sidebar: Science and Society: Endangered Species Act 1973*

## ELECTROMAGNETISM

22 pp.

Author: Brian S. Baigrie, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

### Pre-1700s:

The earth as a magnet (Gilbert 1600)

Guericke's electrostatic machine (1660)

*Sidebar. Science and Society: Hobbes' Leviathan*

### 1700s:

The Two-Fluid theory of electricity (Du Fay 1733)

The Leyden Jar (Musschenbroek and Kleist 1745)

The single-fluid theory of electricity (Benjamin Franklin 1747)

Franklin and Lightning (1752)

Coulomb's memoirs (1785-89)

Galvani's animal electricity (1789)

*Sidebar: Science & Society: Founding of the Royal Institution (1799)*

### 1800s:

Volta's invention of the battery (1800)

Current phenomena: Oersted, Ampère, galvanometers  
Faraday's Rotations (1821)  
Faraday and field theory (W. Thomson and J. C. Maxwell)  
The German tradition: H. Helmholtz and H. Hertz  
Electrotechnology: communication and power technologies

**1900s:**

Theory of Electrodynamics (1943-50)

## **GENETICS AND MOLECULAR BIOLOGY**

**40 pp.**

Author: Brian S. Baigrie and Ted Everson, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1800:**

Aristotle's anti-pangensis

**1800s:**

Maupertius and the revival of pangensis (1744)

Darwin and Galton debate pangensis (1868)

*Sidebar: Scientific Biography: Mendel's Life and Neglect*

Mendel's laws (1866)

*Sidebar: Science & Society: Francis Galton and Eugenics (1883)*

**1900s:**

Bateson's Mendelism (1900)

De Vries mutations (1901)

Garrod links genes to chemistry (1908)

Thomas Hunt Morgan and chromosomes carrying genes (1915)

*Sidebar: Science & Technology: Drosophila melanogaster: a model organism*

Population genetics (Fisher, Haldane, and Wright 1930s)

*Sidebar: Science & Society: Lysenkoism in USSR (1948)*

Delbruck and bacteriophage: the smallest unit of replication (1940)

*Sidebar: Scientific Practice: Physicists invade Biology*

The structure of DNA (Watson and Crick 1953)

The mechanism of DNA's information translated into structure

*Sidebar: Science & Society: The beginnings of sociobiology: W. D. Hamilton and the Genetical Theory of Social Behavior*

One gene, one enzyme: Beadle and Tatum (1941)

The operon control of gene expression (Jacob Monod 1960)

Mitochondrial DNA (1963)

Human Genome Project  
Genetic Engineering and Cloning (Wilmut 1997)

## GEOMETRY

20 pp.

Author: John Anderson, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada.

### Pre-1543 Roots

#### 1543 to 1700:

The Cycloid Curve

*Science & Technology: Cycloids, Pendulum, and Timekeeping*

Analytic Geometry (Descartes 1637; Fermat 1670)

Projective Geometry (Desargues)

#### 1700s:

Geometric Astronomy

Revisiting Euclid (Saccheri 1733)

Euclid's Parallel Postulate Again (Lambert 1766; Legendre 1794)

*Sidebar. Science & the Arts: Kant and the Self-Evident Nature of Mathematics (1781)*

#### 1800s:

Emergence of the New Non-Euclidean Geometry (Gauss, Lobachevsky, Bolyai, 1820s)

Projective Geometry (Monge, Poncelet, Möbius ; Plucker; Steiner, von Staudt)

*Sidebar. Science & Technology: Monge's Syllabus for Projective Geometry at Ecole Polytechnique*

Duality of Points and Lines (Poncelet 1822)

Beltrami and Riemann: Refinements of Non-Euclidean Geometry (1850s-1860s)

Klein's Erlanger Program to systematize the New Geometries (1872)

#### 1900s:

Riemann's Surfaces

Manifolds, a New Conceptualization of Space: Poincaré and Lefschetz

Topology

## MECHANICS AND THERMODYNAMICS

24 pp.

Author: Herman Erlichson, Department of Engineering Science and Physics, City College, City University of New York

### Pre-1600 Roots

Study of mechanics in antiquity

Equilibrium (Simon Stevin 1586)

**1600s:**

The theory of impetus (Benedetti 1585)

*Sidebar. Science & Method: Bacon's Novum organum (1620)*

Dynamics: Galileo (1637)

*Sidebar: Science & Society: The Air Pump: The Witnessing of Experiments*

Huygens and the pendulum clock (1657)

Newton and the laws of motion (1687)

Jakob Bernoulli and elasticity (1697)

**1700s:**

Rise of analytical dynamics

Continuum mechanics: Euler and d'Alembert (1740-1760)

Lagrange and variational mechanics (1788)

Caloric theory of heat

**1800s:**

The Hamilton-Jacobi formalism (1830s)

Sadi Carnot and the motive power of fire (1837)

Conservation of energy: Joule and the mechanical equivalent of heat (1849)

*Sidebar: Science & Society: Maxwell's demon*

Boltzmann and entropy (1896)

Black-body radiation: Max Planck's early work

**1900s:**

Nernst and the third law of thermodynamics

Special and general theories of relativity (1905, 1915)

*Sidebar: Science & method: confirming a new theory? — Eddington's eclipse expedition.*

Quantum mechanics

Supergravity

**METEOROLOGY****30 pp.**

Author: James Rodger Fleming, Associate Professor, Colby College, Waterville, Maine

**Pre-1700:**

Distinguishing Water from Air

Otto von Guericke's Artificial Clouds

*Meteorology* (Descartes 1637)

Torricelli and the mercury barometer (1644)

**1700s:**

Air Currents: Ben Franklin (1749) and Johann Lambert (1765)

Barometric Pressure, Air Movement, and Temperature

Horace Saussure (*Essay on Hygrometry*, 1783)

*Sidebar. Science & Technology: Invention of Hot Air Balloon (Montgolfier Brothers, 1783)*

**1800s:**

Experiments with Atmospheric Pressure: Gay-Lussac's Hot Air Balloon Flights

Composition of the Atmosphere: John Dalton (1801)

Mechanics of Evaporation: Clausius' Kinetic Theory of Gases

Classification of Clouds (Luke Howard 1803)

Classification of Precipitation (Elias Loomis 1841)

Study of Storms (Dove, Redfield, Reid, Espy)

Recording and Forecasting Weather: Maps, Telegraphs, and Data

**1900s:**

New Instruments of Meteorology: Kites, Radio Meteorograph, Airplanes, and Satellites

Weather Forecasting: The Bjerknes Father and Son Team

Von Neumann and the First Computer Weather Models

Refinement of Cloud Theory

Structure of the Atmosphere

Discovery of Jet Streams

Cloud Seeding and Other Methods of Modifying Weather (Schaefer 1946)

*Sidebar. Science & Technology: Doppler Radar*

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**MICROBIOLOGY**

**32 pp.**

Author: James E. Strick, Program in Biology and Society, 9E Redondo Drive, Arizona State University, Tempe, Arizona

**Pre-1800s:**

Discovery of protozoa and bacteria (Leeuwenhoek 1670s)

*Sidebar: Scientific practice: Tacit knowledge*

**1800s:**

Ehrenberg on microbes as organisms in miniature (1838)

Fermentation: Dutrochet and Pasteur (1856)

Disease causing germs: cholera, cowpox, sheep anthrax, silkworm disease

*Sidebar. Science & Society: Ancient Domesticated Organisms: Milk to Cheese and Grapes to Wine*

Generation of microbes: Pasteur-Pouchet debate on abiogenesis (1860)

*Sidebar: Science & Society: Pasteur: Politics Within Science: Was the Jury Fair?*

Tyndall shows that air is full of germs (1877)

Symbiosis of algae and fungi (de Bary 1879)

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Koch and methods of bacteriology (1884)

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Submicroscopic virus (tobacco mosaic and hoof-and-mouth disease (1890s)

*Sidebar: Science & Medicine: Immunology: Footprints of microorganisms in host defense*

Chemosynthesis, sulphur bacteria (Winogradsky 1890)

*Sidebar: Scientific Practice: Escherichia coli, a Model Organism*

**1900s:**

Discovery of bacteriophage (d'Herelle 1917)

Symbiosis as origin of mitochondria and chloroplasts

Crystallization of virus (Stanley 1935)

## **NUMBER THEORY**

**22 pp.**

Author: Israel Kliner, Department of Mathematics, York University, Toronto, Ontario, Canada

**Pre-1543:**

**1543 to 1700:**

The founding of number theory (Fermat)

**1700s:**

Euler, Lagrange and Legendre

*Sidebar. Science & Technology: Waring's Problem*

**1800s:**

Gauss and the Disquisitiones Arithmeticae

Algebraic number theory: Gauss (biquadratic reciprocity); Kummer (ideal numbers)

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**1900s:**

Fermat's last theorem: the final resolution

**OCEANOGRAPHY**

**22 pp.**

Author: Anita McConnell

**Pre-1700:**

Dawn of marine science

**1700s and 1800s:**

1750-1850, the marine science data brought back from Polar voyages and circumnavigations, (French, British and American ships).

Work of the U.S. Coast Survey

*Sidebar. Scientific Biography: M. F. Maury, his oceanography and marine meteorology*

Tidal investigations, by mathematics (Whewell)

Mathematical analysis and prediction (Kelvin, Ferrel)

The later 19th century circumnavigations purely for science (Challenger and others).

Darwin, Murray and others on the theory of coral reefs

Submarine cables and the results for oceanography (1860-1900)

**1900s:**

Fisheries research, Prince Albert of Monaco, Agazziz and the U.S. Fish Commission, the Kiel Commission, ICES

Seawater chemistry and light in the sea

Ocean Currents (Nansen, Bjerknes and Ekman)

Echo sounding, side-scan sonar, and other mapping of the sea floor

Oceanic Ice Sheets

Recurring Systems: El Niño , La Niña , etc.

*Sidebar. Science & Society: "Sciences Never at War": Ideal nationalism*

**OPTICS AND LIGHT**

**23 pp.**

Author: Sungook Hong, Institute for History and Philosophy of Science and Technology, University of Toronto, Toronto, Canada

**Pre-1700s:**

Convex Lens/Camera Obscura (G. Della Porta 1541-1615)

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Light as Transverse vibrations (Young, Arago, and Fresnel 1816-17)  
The Faraday effect (1845)  
Robert Bunsen, Gustav Kirchoff and the spectroscope (1861)  
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Lord Rayleigh and the blue color of the sky (1899)

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Einstein and the photoelectric effect (1905)

*Sidebar: Science & Technology: the invention of polaroid film (1932)*

Dennis Gabor and the principles of wavefront reconstruction (holography) (1948)  
The construction of lasers (1960-1966)

## **PALEONTOLOGY**

**26 pp.**

Author: David Polly and Rebecca Spang, Molecular and Cellular Biology Section, Queen Mary & Westfield College, London, United Kingdom

**Pre-1543 Roots**

**1543 to 1700:**

Italian fossils

N. Steno on shark's teeth (1669)

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Robert Hooke and the organic nature of fossils (1667-68)

### **1700s and 1800s**

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Study of Strata Using Fossils (William Smith 1815)

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Missing Links: Archaeopteryx: reptile to bird (1860)

Ladder vs Tree: the horse sequence (Huxley to Simpson 1880s)

### **1900s:**

Carbon-14 Dating (Libby 1946)

Punctuated equilibrium (Gould and Eldredge 1972)

## **PSYCHOLOGY**

**30 pp.**

Author: Kenton Kroker, IHPST, University of Toronto, Toronto, Canada

### **Pre-1800s:**

Roots in Speculative Philosophy

### **1800s:**

Phrenology: Franz Joseph Gall and Johann Spurzheim (1800-1840)

Psycho-physics: Gustav Fechner and Dr. Mises (1840-1880)

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Population Psychology (1860s to present)

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*Scientific Biography: Sigmund Freud*

### **1900s:**

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*Sidebar. Scientific Institutions: Formation of the International Psycho-Analytical Association (1910)*

Cognitive psychology: machines and practices

## **STATISTICS AND PROBABILITY THEORY**

**20 pp.**

Author: Sylvia Svitak, Dept. of Mathematics/Computer Science, Queensborough College, New York City, New York

### **Pre-1543 Roots**

#### **1543 to 1700:**

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#### **1700s:**

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The probabilistic revolution

#### **1900s**

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## **SYSTEMATICS**

**22 pp.**

Author: Joe Cain, Science and Technology Studies, University College, Gower Street, London. WC1E 6BT

Key distinctions in ideas about systematics

Useful classifications

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*Sidebar: Science and society: art and Renaissance natural history*

System building by the ancients: Aristotle and Theophrastus

*Sidebar: Science and philosophy: Plato's ideal forms*

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*Parisian alternatives to Linnaeus*

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