Ministry of Higher Education and Scientific Research
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Philosophy Section

LECTURES IN HISTORY OF SCIECNCE

For Second Year License Students of Philosophy

A set of lectures intended for second-year Licence Students of General Philosophy (LMD)

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Semester	Third
Unit Title	Methodological Units
Module	History of Science
Credit	**3**
Coefficient	2
Lectures objectives	1- The student should be able to identify the paths of the emergence and development of sciences.
	2- To realize the communication and accumulation that occurs in the field of science.
	3- To identify the epistemological problems of the history of science.
Prior knowledge required	1) Cultural history of human civilizations 2) Sciences Classification 3) History of societies and their concerns throughout history
Acquired abilities	1) To understand the structure of scientific thought. 2) To realize the development of scientific knowledge 3) To realize the importance of the history of science for the philosophy of science and epistemology.
Subject vocabulary (the semester must include 15 educational vocabulary/lessons).	1) The concept of the history of science, its relationship to the philosophy of science, and the fields of research that intersect with it 2) The epistemological problems of the history of science (objectivity, and criticism of Western centrality) 3) The history of science according to George Sarton as an academic subject 4) The history of science between accumulation and rupture 5) The history of science in the perspective of Auguste Comte, Gaston Bachelard, Thomas Kuhn, Karl Popper ... 6) Rushdi Rashid's contributions to the history of science 7) Science in Mesopotamian civilizations 8) Science in Chinese civilization 9) The history of science in Pharaonic civilization 10) The history of science among Muslims. 11) The history of modern science in the European Renaissance
Evaluation method	Continuous + written exam

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Introduction:

The Integrated Landscape of History and Philosophy of Science (HPS)

The study of science is often perceived as the mastery of a finished product—a collection of immutable laws and objective facts. However, science is fundamentally a human endeavor, characterized by evolution, conflict, and deep social integration. This textbook serves as a comprehensive introduction to the History and Philosophy of Science (HPS), an interdisciplinary field that seeks to understand scientific expertise not in a vacuum, but within its broad social, historical, and philosophical contexts.

The Historiographical Framework

For much of the twentieth century, the history of science was dominated by internalism, an approach that focused on the "rational reconstruction" of ideas as an autonomous intellectual lineage. As this work explores, the rise of externalism—pioneered by figures like Boris Hessen and refined by Robert K. Merton—shifted the gaze toward the socioeconomic, religious, and institutional factors that drive scientific progress.

We acknowledge that the boundary between these two methodologies is "fuzzy"; a complete historical account must synthesize the internal logic of the laboratory with the external pressures of the marketplace and the state. From the "mechanical objectivity" of the nineteenth century described by Lorraine Daston to the "Big Science" of the post-war era, this text examines how the very definition of scientific truth has been shaped by the tools, norms, and spaces of its production.

Epistemology and the Sociological Turn

A central pillar of this work is **epistemological critique**. Following the revolutionary insights of Thomas Kuhn, we move away from viewing the history of science as a linear accumulation of truths. Instead, we analyze it as a succession of **paradigms**—socio-intellectual constructs that determine what counts as "legitimate" knowledge.

Furthermore, we delve into the "Sociological Turn," examining the **Strong Programme** and anthropological studies of scientific practice, such as the laboratory observations of Bruno Latour and Steve Woolgar. By treating science as a "knowledge system," we invite students to see the microscope, the telescope, and the computer not just as tools, but as active participants in the construction of reality.

A Global and Civilizational Perspective

While modern science is often framed as a Western phenomenon, this textbook restores the global narrative. We trace the roots of inquiry back to the mathematical and astronomical traditions of Ancient Egypt, Mesopotamia, China, and the Maya. A significant focus is dedicated to the **Islamic Golden Age**, exploring how Arab and Muslim scholars preserved, critiqued, and expanded upon Hellenistic knowledge. This section is not merely a historical record but a means

of reinforcing civilizational identity and illustrating how the transmission of knowledge between cultures is the true engine of human progress.

Pedagogical Objectives and Structure

This manual is specifically designed for students within the **General Philosophy** track of the LMD (Licence-Master-Doctorate) system. It aligns with the latest pedagogical standards to provide a balanced curriculum that is both academically rigorous and culturally resonant.

The primary goals of this work are:

- **To Cultivate Critical Thinking:** By engaging with the philosophy of science, students will learn to question the principles and methods that underpin objective claims.
- **To Bridge the "Two Cultures":** To harmonize the technical aspects of science with the humanistic insights of history and sociology.
- **To Foster Intellectual Belonging:** By introducing the historical "story" of a discovery before its technical "fact," we aim to create a sense of familiarity and inspiration for the next generation of researchers.

Organization of the Book

- **Foundations of HPS:** Defining the field and the internalist/externalist debate.
- **The Scientific Revolution and Beyond:** From the mechanistic worldview to the era of Big Science.
- **The Sociological Turn:** Examining the Strong Programme and Laboratory Life.
- **Global Contributions:** A deep dive into the Islamic Golden Age and non-Western scientific traditions.
- **Contemporary Issues:** Objectivity, ethics, and the role of science in modern policy.

The Interdisciplinary Mandate of History and Philosophy of Science (HPS)

The History and Philosophy of Science (HPS) represents a sophisticated academic intersection that examines the historical trajectory of scientific thought alongside the philosophical frameworks that validate it. Rather than treating science as an isolated set of facts, HPS analyzes the dynamics between science, technology, and broader human endeavors, providing a holistic understanding of how knowledge is constructed and maintained.[1]

Core Objectives and Methodologies

HPS pedagogy is designed to foster a critical understanding of the evolution of scientific inquiry. Students of the discipline explore several key dimensions of the scientific enterprise:

- **Origins of Practice:** Investigating the genesis of both theoretical frameworks and experimental methodologies.
- **Contextual Analysis:** Examining the social, political, and institutional environments that facilitate or hinder scientific progress.
- **Methodological Evolution:** Tracing the development and application of quantitative and qualitative research methods from antiquity to the modern era.
- **Ethical Dimensions:** Addressing critical issues of professional integrity, including scientific misconduct, fraud, and the evolving ethics of human-machine interaction.

Essential Inquiries in HPS

The discipline is driven by fundamental questions that challenge traditional narratives of progress. These inquiries are often categorized into three primary analytical lenses:

Analytical Lens	Central Questions
Historical	To what extent was the "Scientific Revolution" a radical rupture versus a gradual evolution? How have experimental norms shifted over centuries?
Philosophical	What constitutes a valid scientific explanation? How do scientists construct and justify their truth claims?
Sociological	How is scientific inquiry shaped by wider cultural and political contexts? In what ways does technology mediate our everyday lives and social structures?

[1] Ankeny, R., Chang, H., Chen, X., & Buchwald, J. (2011). Introduction: Philosophy of science in practice. *European Journal for Philosophy of Science*, *1*(3), 303–307. https://doi.org/10.1007/s13194-011-0036-4

The Integration of STS and the Social System

Modern HPS does not function in a vacuum; it increasingly incorporates **Science and Technology Studies (STS)**. This integration allows for a "co-production" model, where science and society are viewed as mutually shaping entities.[1] By investigating the interplay between cultural, economic, and institutional factors, HPS provides an overview of the role scientists play in public debate and the socio-economic influences that direct research agendas.

Ultimately, HPS offers students a meta-perspective on the "condition of the sciences." It prepares them to navigate a world where scientific authority is constantly negotiated within the public sphere. To fully grasp these complexities, one must first deconstruct the constituent components of the field: the nuances of **History**, the rigors of **Philosophy**, and the definition of **Science** itself.

What is History?

The conceptualization of history as an academic field is rooted in its diverse etymological origins and its evolving methodological rigor. As a discipline, history functions both as a record of human experience and as a systematic process of inquiry.

The Etymology and Definition of History

The term "history" is derived from two distinct linguistic traditions, each contributing a unique dimension to its modern academic application. While the Greek *historia* emphasizes the process of inquiry and knowledge gained through active investigation, the Latin *historia* prioritizes the narrative or the structured account of events.[2]

In a broad sense, history serves as an umbrella term encompassing the discovery, collection, and organization of information regarding past occurrences. It is often defined by its chronological structure, providing a sequential account of events through time.

The Linguistic Foundations of History

Root Language	Term	Primary Meaning	Scholarly Implication
Greek	*Historia*	Inquiry / Investigation	The empirical act of searching for truth.
Latin	*Historia*	Story / Account	The formal presentation and narration of findings.

[1] Jasanoff, S. (Ed.). (2004). *States of knowledge: The co-production of science and the social order*. Routledge.
[2] Achi, B. E. (2021). Introduction to historical methods and movements. Academic Press.

History as an Academic Discipline

Beyond simple record-keeping, history as a formal discipline employs **narrative techniques** to critically examine and analyze sequences of past events. The objective of historical scholarship is not merely to describe *what* happened, but to determine the **dynamics and root causes** underlying those events.[1]

Modern historical methodology involves:

- **Objective Analysis:** Attempting to minimize bias while interpreting primary and secondary sources.
- **Causal Determination:** Identifying the social, political, and economic factors that trigger historical shifts.
- **Systematic Organization:** Categorizing vast amounts of data into coherent, thematic, or chronological frameworks.

"To study history is to study causes; the historian continuously asks the question 'Why?' and seeks to establish a hierarchy of causes to explain the human past."[2]

What is Philosophy?

The term "philosophy" finds its linguistic origins in the Classical Greek compound philosophia (φιλοσοφία). This construction is derived from two distinct but related roots: the verb philein (to love) or the noun philos (friend/lover), and the noun sophia (wisdom). Consequently, the literal etymological definition of philosophy is the "love of wisdom".[3]

Linguistic Breakdown

To understand the disciplinary scope of philosophy, it is essential to analyze these constituent parts:

Greek Root	Transliteration	Translation	Conceptual Significance
φιλεῖν / φίλος	*Philein / Philos*	To love / Lover	Represents an active, purposeful pursuit or affinity toward an object.
σοφία	*Sophia*	Wisdom	Denotes not just knowledge, but deep insight and the practical application of truth.

From Etymology to Academic Discipline

[1] Carr, E. H. (1961). *What is history?* Cambridge University Press.
[2] Carr, E. H. (1961). *What is history?* Cambridge University Press.
[3] Anthony Achi. Basic Concepts in History and Philosophy of Science. November 2021. Themes in the History and Philosophy of Science.

While the literal translation—the love of wisdom—captures the fundamental spirit of the field, the academic discipline has evolved into a systematic study of the most fundamental questions regarding existence, knowledge, values, and reason. In a pedagogical context, this "love" is characterized by **critical inquiry, logical argumentation, and systematic doubt** (Russell, 1945).

"Philosophy, though it cannot answer as many questions as we could wish, has at least the power of asking questions which increase the interest of the world, and show the strangeness and wonder lying just below the surface even in the commonest things of daily life."[1]

What is Science

Science is a systematic body of knowledge which is made, popularized, confirmed enacted, promulgated, ratified and sometimes repealed / rejected by the scientific community. Etymologically, science means knowledge, from the Latin word 'Scientia'. Natural philosophy was the name under which science was studied before it broke away from philosophy when much emphasis was placed on the scientific method by Galileo Galilei, Francis Bacon and Thomas Hobbes. The Greek word "Episteme", the Latin word "Scientia", the German word "Wissenschaft", and the Russian word "Nauka" all refer to science as a systematic body of knowledge.[2]

"Science is a human activity, and scientific contributions have come from people from a wide range of different backgrounds and cultures. Historians of science increasingly see their field as part of a global history of exchange, conflict and collaboration." [3]

Contemporary scholarship conceptualizes science as a multifaceted human activity, deeply embedded in a diverse array of sociocultural contexts. Rather than viewing scientific development as the exclusive product of a single tradition, modern historians increasingly frame the field within a **global history of exchange, conflict, and collaboration**.[4] This perspective acknowledges that scientific knowledge is often the result of cross-cultural interactions and the synthesis of disparate intellectual traditions.

[1] Russell, B. (1997). *The problems of philosophy*. Oxford University Press. (Original work published 1912).
[2] Anthony Achi. Basic Concepts in History and Philosophy of Science. November 2021. Themes in the History and Philosophy of Science.
[3] Poskett, James (2022). Horizons: a global history of science. [London]. ISBN 978-0-241-39409-0.
[4] Poskett, James (2022). Horizons: a global history of science. [London]. ISBN 978-0-241-39409-0

What is Philosophy of Science?

Philosophy of science is the critical, rational and systematic investigation, probing and questioning of the assumptions, claims and findings of science. It attempts to evaluate the nature of scientific inquiry, the scientific procedure, theories and methods and examine the grounds of their validity. Philosophy of science has the demarcation of science from pseudo-science or non-science as one of its aims and objectives.[1]

(a) Philosophy of science consists in the formulation of world- views that are consistent with findings in science or based on scientific laws and theories.

(b) Philosophy of science is a pre-dispositionless discipline which seeks to uncover the presuppositions or predispositions of the scientists.

(c) Philosophy of science is the clarification and analysis of scientific theories and concepts with the aim of making their scientific usage clear.

(d) Philosophy of science plays a second order role to science by answering questions bordering on the meaning of scientific concepts such as law, theory and explanation, the nature of, and claims about, scientific knowledge, the logic and procedure of scientific explanation, and the cognitive statue of scientific laws principles.[2]

[1] Anthony Achi. Basic Concepts in History and Philosophy of Science. November 2021. Themes in the History and Philosophy of Science.

[2] Anthony Achi. Basic Concepts in History and Philosophy of Science. November 2021. Themes in the History and Philosophy of Science.

Preliminary:

Since man became aware of the importance of science in the lives of societies and its profound effects on the development of civilizations, as a result of the scientific transformations that emerged and to change human history course; historians from different schools of thought have been attracted to try to explain, study, understand the logic and causes of historical movement of science in order to anticipate its future. Perhaps what confirms this assumption and embodies this state of awareness and the tendency to chronicle scientific events are the scientific transformations that appeared with and after the Renaissance and Enlightenment and then the modern era, where man understood that they are the main mover towards civilizational progress in all aspects. A large number of historians, scientists and philosophers from that era to the present day have taken it upon themselves to chronicle this crucial period in the path of human knowledge, and then they came to study the path of this civilizational engine and the history of its development from its first roots with its complex relationships in human life to the current state. Given the complexity of this intellectual phenomenon and the overlap of its components with other multiple and different components on the one hand, and on the other hand the changes that have occurred in the perceptions, interests and priorities of historians, these histories and the interpretation of their logic have been characterized by difference and heterogeneity according to ideologies and philosophical and epistemological backgrounds.

The history of science has a long history, but awareness about it and its epistemological importance as a scientific discipline arose relatively by the eighteenth century, with the writings of William Whewell. Before we begin to explore its origins, we must define the concept and the subject of study.

Defining the Concept of History of Science

The history and philosophy of science is a study of the historical gradual development of the entire series of human activities which has culminated in what is now termed science and scientific knowledge. From the eighteenth century until the late twentieth century, history of science, especially of physics and biology, was often seen as narrations of correct theories in place of wrong ones, but there have recently been historical interpretations such as those of Thomas Kuhn, who envisioned history of science with more precise terms such as competing paradigms or the conceptual systems in a broader form that includes intellectual, cultural, economic and political topics, that is, outside scientific systems.

Thus, philosophical history of science goes beyond the narrative history of science and requires a scientific-philosophical method to investigate scientific facts and events, that is, a critical contemplative approach, from the interior of science to compare its components, and outside it within its entire social context. The investigation of it as a social institution and the rational and scientific reconstruction of its history is thus completed, as emphasized by Imre Lakatos in his article "The History of Science and its Rational Reconstruction".

When it comes to the historicity of science or the methodological reasoning of knowledge it means that it is a dynamic process as excessive social activity and development goes through time it is a social achievement material technical and the development level of thought that creates renewable social cultural framework, which appears across the long history of humanity, that is a human achievement picturing a dialectical movement between knowledge and scientific activity and social consciousness.

Foundations of History and Philosophy of Science (HPS)

History and Philosophy of Science (HPS) is a study of the gradual development of the entire series of human activities which has culminated in what is now termed science. **(HPS)** constitutes an integrated academic framework dedicated to the meta-theoretical analysis of scientific development. By synthesizing historical narrative with philosophical inquiry, the field provides a robust, interdisciplinary structure for the critical examination of scientific theories, methodologies, and institutional evolutions.[1] This dual approach allows scholars to investigate not only the chronological progression of discoveries but also the epistemological foundations that validate scientific knowledge.

History of science is the study of the development of scientific knowledge as representing the whole corpus of knowledge that it can be described too as a means of studying and understanding the world, it is formed in a piecemeal way since thousands of years ago; actually, the early beginnings of history is where some intellectual contemplations had developed that aims to highlight some secrets about the universe to understand them.

History of science is not mere narrative or storytelling process of chronological succession of a series of scientific discoveries but it is history of development of thought, history of ideas and the institutions that it's historical context that gave this ideas make these ideas appearing as well as the traditions that come to enrich this kind of thought as well as we have to distinguish between history of Science and history of techniques of course we find some correlation between the two but we cannot unified or correspond between the two one humans controlled the fire and built to do it all invent for me but it is not considered signs and knowledge that accumulated in this situation are not scientific knowledge but traditional professional knowledge practical knowledge history of science is very useful directly in constructing scientific knowledge it has its role epistemological and philosophical.

Therefore, this subject requires coupling with the philosophy of science, as we said earlier, so that the history and philosophy of science in its contemporary form becomes a subject and academic specialization within the fields of philosophy in most international universities. It studies theories, methods, practices, and scientific institutions from a historical and critical philosophical perspective, with the aim of providing an authentic and multi-disciplinary intellectual framework on science and all its manifestations.

[1] Ankeny, R., Chang, H., Chen, X., & Buchwald, J. (2011). Introduction: Philosophy of science in practice. European Journal for Philosophy of Science, 1(3), 303–307. https://doi.org/10.1007/s13194-011-0036-4

In other words, the history of science is a philosophical, critical, and contemplative study of the development of science throughout history, and an attempt to reconstruct it according to the available results, understand, analyze, explain and interpret it to reveal the logic of its course. Therefore, the subject of the history of science is about science by knowing the most important transformations, movements, stillness and trying to interpret them, that is, historiography of science, or writing and recording the history of science, on logical epistemic foundations that explain such developments of science course, just as historical facts are written down and investigated. In addition to contemplating science as an activity with, political, human, social, and civilizational dimensions, trying to reveal the complex interactive relationship between man and these dimensions. Through criticism and logical examination at the heart of scientific events, questions are formed about the conditions and requirements necessary for scientific revolutions about the future of science, based on studying its history, addressing for example the limits or restrictions that the culture of society draws for scientific development in it?

The Scope and Taxonomy of the Discipline

The history of science traces the trajectory of human inquiry from its ancient origins to its contemporary iterations. This historical survey is comprehensive, encompassing the three primary classifications of scientific endeavor:

1. **Natural Sciences:** The study of the physical world (e.g., physics, biology, chemistry).
2. **Social Sciences:** The study of human behavior and societies (e.g., sociology, psychology, economics).
3. **Formal Sciences:** The study of abstract systems and logic (e.g., mathematics, theoretical computer science).

Dimension	Focus of Inquiry
Historical Perspective	Diachronic analysis of how scientific ideas emerge, stabilize, or are superseded over time.
Philosophical Perspective	Synchronic analysis of the logic, ethics, and truth-claims inherent in scientific practice.
Institutional Perspective	Investigation into the laboratories, universities, and funding bodies that sustain scientific work.

In his seminal work on the reform of natural philosophy, Francis Bacon argued for the necessity of a comprehensive "literary history"—a systematic and exhaustive account of human intellectual development. Bacon posited that for science to progress, it required a rigorous

documentation of its ancient foundations, the evolution of various philosophical sects, and the technical traditions that have shaped human understanding.

According to Bacon's framework, this history must transcend a mere list of achievements. It should encompass the organizational structures of knowledge, pedagogical preparations, and the "oppositions" or intellectual conflicts that have historically hindered progress. Crucially, Bacon emphasized the documentation of failures and "forgetfulness"—the instances where knowledge was lost or stymied—alongside their specific socio-historical causes. By synthesizing these elements, Bacon aimed to provide practitioners with a "literary" map that would foster greater insight into the strategic management and application of scientific inquiry.[1]

Bacon's Vision for the History of Learning

Bacon believed that without a history of the "state of learning" throughout all ages, the "body of the world" would remain incomplete. This vision was central to his larger project, the Instauratio Magna (The Great Instauration), which sought to rebuild the foundation of human knowledge.

Essential Components of Baconian History

Category	Description
Genealogy of Sects	**The study of different schools of thought and their shifting influence.**
Mechanics of Invention	**A record of the traditions and practical skills involved in technical breakthroughs.**
Pathology of Knowledge	**An analysis of the causes of intellectual decline, errors, and the "forgetfulness" of past discoveries.**
Utility for Management	**The practical application of history to guide contemporary scientific decision-making.**

According to Sarton, "Some people seem to think that it is impossible to write the history of science as a whole, and that the subject is too large; I should rather say that it is the same impossibility to pick out from this inextricable web the development of one branch of human knowledge. Moreover, it is in fact impossible to write the history of any important discovery without writing, willingly or unwillingly, a chapter of the history of science, I mean the history of science as a whole. How can we explain, for example, the discovery of the circulation of the blood if we do not explain the development of anatomy, comparative zoology, general biology, natural philosophy, chemistry, and mechanics? In short, the purpose of the history of science, as

[1] Gaukroger, S. (2001). Francis Bacon and the transformation of early-modern philosophy. Cambridge University Press. See Also: Jardine, L. (1974). Francis Bacon: Discovery and the art of discourse. Cambridge University Press.

I understand it, is to determine the origin and development of scientific facts and ideas, taking into account all the intellectual exchanges and all the influences produced by the progress of civilization itself. It follows from this definition that the only rational way to divide this history is not to cut it according to countries or sciences, but only according to time. For each period of time, we must consider simultaneously the whole of its scientific and intellectual development.[1]

In order to develop our historical work, we must of course use the same methods that ordinary historians use to evaluate and criticize the materials available to them. But the historian of science must independently use some other methods of a more specific nature. I cannot explain them here, but it is easy to understand that, for example, in order to determine the date at which a discovery became a real part of science and enriched human experience, the historical interpretation must be supplemented by a scientific interpretation based on evidence from positive science.[2]

Hence, philosophers have been concerned with the history of science in light of its growth process, and therefore philosophical contents and taking into account all branches and their relationships with each other are necessary, i.e. how the progress of one science affects another. Therefore, the history of science, by virtue of its breadth, requires the combination of efforts and visions from different angles in order to be written in the best possible way. It needs the point of view of the practical practitioner, i.e. the man of science, the point of view of the logical philosopher of science, and the psychological study, i.e. related to the individual aspect that sees in the psychological foundations scientific perception and creativity, then the sociologist of knowledge, who is concerned with the social conditions and contexts in which scientific knowledge appears and helps scientific creativity, since science grows in a social climate and affects and is affected by social factors as a phenomenon and a social institution in itself before being an individual creativity. From all of this, the basic goal of these studies is evident in seeking the possibility of predicting scientific progress on the basis of what has been previously achieved, which can only be achieved through a comprehensive understanding of the entire historical process of the development of science, i.e., the researcher's task here is to be aware of and understand the development of science as a process with its own laws that organize it.

History of Science Studies

There are several distinctions in the history of science, most of which are organizational. On the historical level, we find that the history of science is generally divided into ancient, medieval, pre-modern, modern and contemporary. Others classify the history of science from a geographical or national perspective, such as American, Arab, European..., and others focus on a specific field of science, such as the history of mathematics, the history of astronomy, and other fields.

The importance of History of Science:

[1] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. pp.332-333.
[2] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.334.

Such importance of History of Science is represented in recognizing man, understand him indifferent ages on the places as well benefit from different Generation's experience; no one can deny the importance of History especially of science and knowledge it's usefulness so that all of intellectuals agree on the advantages of science that man become with conceiving and realizing himself in this world and benefit from his ancestors from different nations.

Leibniz was one of the many who believed that the study of the history of science could contribute towards an increased recognition of how scientific ideas come into existence. He viewed history of science as a contribution to the formulation of the ars inveniendi of which he and many others dreamt: "It is of great advantage to get to know the real sources of great discoveries, in particular of those that were made not by chance but by reflection. The result of this is not only that the history of science acknowledges what each individual has contributed (i.e. the establishing of objective historical facts) and that others are thus encouraged to acquire a similar reputation (i.e. a great model serving as an incentive), but also that the art of discovery (ars inveniendi) expands when one finds the path of research in outstanding examples."[1]

Although the idea of a logic of discovery was gradually discredited, the exemplary function of the history of science - that modern research can learn from the historical elucidation of the successes and failures of earlier research - remained an important theme. A century later, William Whewell dissociated himself from the idea of a logic of discovery as understood by Leibniz. But Whewell, too, regarded the study of the history of science as justified for similar reasons. In 1837 he wrote as follows: "The examination of the steps by which our ancestors acquired our intellectual estate . . . may teach us how to improve and increase our store . . . and afford us some indication of the most promising mode of directing our future efforts to add to its extent and completeness. To deduce such lessons from the past history of human knowledge, was the intention which originally gave rise to the present work."[2]

Scope, nature and the value of History of Science

If we want to give history of signs all of its volume and organize the research process in it in a fruitful way it is important at first to denote the formation that it's supposed to be and highlight all its dimensions.

In order for the history of science to perform its function, it must meet two conditions:

Since the history of science must be subject to and respect the principles of the historical method and requires a scientific knowledge within science that is much higher in level than that which is granted to it by general scientific culture, especially when it comes to the history of science since ancient times, it must seriously study the roots of science to its first ideas and principles. Moreover, arming oneself with epistemological methods and with what the philosophy of science provides is a decisive necessity for the process of history and its writing.

[1] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).p.05.
[2] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).pp.05,06.

The Historiography of Science: A Disciplinary Overview

The historiography of science functions as a meta-analytical framework, examining the methodology, theoretical underpinnings, and institutional evolution of the history of science as a distinct academic discipline. This field encompasses the critical study of historical practices—ranging from specific research methods to established schools of academic thought—while simultaneously documenting the "history of the history of science," or the discipline's own chronological development.[1]

A persistent challenge within this domain is the demarcation between historiographical discourse (disputes over methodology) and the substantive historical controversies inherent to scientific progress itself. Historically, the boundary between how science is recorded and the internal debates of the scientific community is often fluid. Consequently, many scholars identify these early substantive disputes regarding the trajectory and nature of scientific discovery as the foundational catalyst for the sub-discipline's emergence.[2]

[1] Kragh, H. (1987). An introduction to the historiography of science. Cambridge University Press.

[2] Golinski, J. (1998). Making natural knowledge: Constructivism and the history of science. Cambridge University Press. See also: Kuhn, T. S. (1970). *The structure of scientific revolutions* (2nd ed.). University of Chicago Press.

Historical account about the history of science:

History of science, origins and development:

Although the history of science as an autonomous academic discipline only developed in the 20th century, activities that might justifiably be described as early forms of history of science have been taking place for centuries. Historical descriptions and analyses have always followed the development of science. Indeed, even a superficial consideration of the history of science in former times reveals that many of the central historiographical problems discussed in modern history of science can also be encountered in earlier centuries.[1]

Science has developed since ancient times because man is curious by nature and has the ability to write down and record events. With time, he has developed experiments and discovered laws.

History of science has been neglected for a long. Of time it wasn't included and the big history of the whole history but science progress was appealing strongly mines better today does not care about its past but fortunately there were vast points of view more wisdom to be appearing today. That scientific development and its deep effects on civilization lead to ignite curiosity and asking many questions about the birth and phases of scientific knowledge formation and its methodology. A white community has become intending to history of science books and the most important is the growth and development noticed today that research in history of science is knowing.

Some, and they are the majority, see the history of science as the history of ideas in the well-known sense of the phrase, the history of mentalities, while others, and they are stricter and more astute, see the history of science as the history of scientific concepts, the history of their formation, development and modification. Others, and they are historians in their original formation, see that it does not care about concepts and their special nature, but rather that the history of science may be the history of cultural production, similar to the history of painting or the history of religions.

Preliminaries of Doing History of Science (Historiography of Science)

The process of writing a history of science began much earlier and has been going on for much longer than people usually think. Interest in the history of science first emerged in classical antiquity, and has since experienced many ups and downs. Work on the history of science first began in the late fourth century BC, when the earliest history of science was written. Then, long after the beginning of the work, interest in medieval Arabic culture again focused on the history Throughout most of the period in which science developed, it

was learnt and cultivated as part of a historical tradition that was indistinguishable from science proper. In Classical times and in the Middle Ages in particular, the usual form of cultivation of science involved relating to earlier thinkers. Critical commentaries and analyses of the Classical

[1] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).p.01.

works were made and these were used as a point of departure for new thought and contributions of current interest. When Aristotle wished to say something about atoms and the void, he reproduced parts of the history of atomism and embarked on a discussion with the long-departed Democritus. When a Greek mathematician wanted to solve a problem, the natural way to proceed was to begin by giving an account of the history of that particular subject, which was regarded as an integral part of the problem. of Greek science.[1]

According to the first histories of science were written by the Peripatetic Eudemus of Rhodes even before Euclid's Elements summed up the first three centuries of Greek mathematics.[2]

The history of science usually focuses on tasks quite different from those of science itself. The history of science becomes truly necessary for scientists only when, for whatever reason, the scientific tradition or, more generally, the cultural tradition, which normally ensures the transmission of knowledge from generation to generation, is disrupted. When foreign science is assimilated, the main question in the history of science – "Who discovered what?" – arises in the process of scientific research itself. The absence of clear answers to this question can hinder research, for example, by forcing scientists to spend time and energy proving what has already been proven or refuting what has already been disproved.[3]

The formal roots of the history of science are situated within the Lyceum, the peripatetic school founded by Aristotle. It was within this institutional setting that several influential historiographical genres were established, laying the groundwork for how intellectual achievements are recorded and analyzed. While biography emerged as a method of documenting the lives of thinkers—pioneered by figures such as Aristoxenus and Dicaearchus—the Lyceum also fostered the development of doxography.[4]

Doxography is a term describing the method of recording opinions (doxai) of philosophers frequently employed by ancient Greek writers on philosophy. It can also refer to texts or passages consisting of such accounts. The ancient tradition of doxographical writing finds its origin in the dialectical method of Aristotle and Theophrastus. Later works by authors such as Aëtius and Arius Didymus record much valuable material on ancient philosophers, although usually with little analysis or argumentation. Doxographical passages are also found in other ancient philosophical works, usually as a prelude to the discussion of a theme.[5]

Broadly speaking, doxography encompasses those writings, or parts of writings, in which the author presents philosophical views of some or other of the ancient philosophers or schools, in some or other areas, or on some or other topics, of philosophy, whether with or without

[1] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).p.01.
[2] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006). p.02.
[3] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.03.
[4] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.10.
[5] Runia, David T. Doxography, 1998, doi:10.4324/9780415249126-A045-1. Routledge Encyclopedia of Philosophy, Taylor and Francis, https://www.rep.routledge.com/articles/thematic/doxography/v-1.

presentation of the argumentation or analysis through which they offered philosophical support or reasons in favor of their ‘tenets’, and whether or not they also include critical evaluations and comments of the author's own. In other words, these are works (or sections of works) taking as their subject matter the tenets or doctrines of the philosophers, rather than independent works of philosophy in which the author addresses in the first instance issues or topics of philosophy, with ancillary discussion along the way of the opinions of other philosophers.[1]

"While primary treatises dedicated specifically to the historiography of science were comparatively rare, with their survival limited largely to fragmentary remains, the field is bolstered by a substantial corpus of historico-scientific material embedded within diverse literary genres. Although the historiography of science had not yet crystallized into a distinct, autonomous genre during this era, the continuity of a historico-scientific tradition—stretching from the classical period through the twilight of Antiquity—remains an indisputable feature of the intellectual landscape."[2]

"Since the mid-19th century, scholarship has increasingly recognized Peripatetic treatises as indispensable conduits for the reconstruction of early Greek scientific thought. These works provide seminal testimonies—such as Eudemus’ accounts of Thales’ geometry, Theophrastus’ observations on Anaximander’s astronomy, and Aristoxenus’ records of Pythagorean arithmetic—that serve as the primary evidence for the nascent stages of Greek inquiry. However, the modern scholarly challenge lies not merely in the isolated assessment of fragments or individual authors, but in developing a rigorous, holistic approach to Peripatetic historiography. This requires an integrated understanding of its diverse sub-genres, including doxography, biography, and specialized histories of science. Ultimately, because original pre-Socratic texts are largely non-extant, the reconstruction of early Greek science is fundamentally reliant upon this mediated historico-scientific evidence."[3]

"Comparative analyses of Platonic and Aristotelian epistemologies alongside modern scientific frameworks have consistently yielded productive insights; such juxtapositions clarify the distinct methodological nuances of ancient inquiry while simultaneously underscoring the enduring characteristics of the scientific phenomenon itself. It is imperative, however, to situate the perspectives of Plato and Aristotle within the broader heterogeneous intellectual milieu of Antiquity—specifically the viewpoints of those actively engaged in the primary development of scientific thought.

[1] Mansfeld, Jaap and David Runia, "Doxography of Ancient Philosophy", The Stanford Encyclopedia of Philosophy (Summer 2024 Edition), Edward N. Zalta & Uri Nodelman (eds.), URL = <https://plato.stanford.edu/archives/sum2024/entries/doxography-ancient/>.

[2] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.11.

[3] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.11.

Unlike numerous other Greek intellectual pursuits, the exact sciences—augmented in the fourth century BCE by the emergence of optics and mechanics—attained a level of rigorous disciplinary maturity. The privileged status of these fields is substantiated by the fact that ancient historiography focused almost exclusively on the mathemata. Within the surviving historical record, few other disciplines became the subject of dedicated historical inquiry, with the specialized field of medicine serving as a notable exception.".[1]

Admittedly, the Peripatetic history of science is linked with heurematography more intimately than by just employing it as a source of information on scientific discoveries. In Eudemus' history of the exact sciences, the traditional question of 'who discovered what' remains among the most important. As the earliest forerunner of the Peripatetic history of science, heurematography undoubtedly deserves to be considered in detail.[2]

While the Academy under Plato largely prioritized the philosophical implications of knowledge over its chronological development, Aristotle introduced a more expansive intellectual program. His contributions to the historiography of science remain unparalleled in Antiquity, both for his conceptual innovations and for the empirical historical inquiries he personally oversaw or inspired. Central to Aristotle's worldview was the historical character of human endeavors—such as the state, art, and the sciences—each of which he believed possessed an internal logic of development that could be systematically uncovered.

This pioneering approach established the foundation for the Peripatetic school. The historical surveys produced by his successors, most notably Theophrastus, Eudemus, and Meno, were not merely chronicles; they were rigorously framed within Aristotelian categories and predicated on his specific teleological conception of the progress of knowledge.[3]

The evident division of labor and meticulous coordination between Theophrastus and Eudemus suggest a centralized historiographical program within the Lyceum. This collective project was designed to systematically aggregate, categorize, and provide a preliminary analytical framework for the corpus of knowledge pertaining primarily to the theoretical sciences. While the precise extent of Aristotle's personal supervision remains a subject of scholarly debate, it is clear that he functioned as the intellectual architect of the endeavor. At a minimum, Aristotle served as the catalyst for this research, orchestrating—if not directly assigning—the historical investigation of various scientific disciplines among his disciples.[4]

Many authors of Modern Greek historiography of science who were conscious to write history of science. This was clear for those who wrote an historical preface to their scientific books. And it

[1] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.11.
[2] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).p.13.
[3] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.
[4] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.

is important to remark that writing a preface describing the history of the science treated in the book, became common in the Greek books of science of the 18th century.[1]

The history of science goes back in practice to the Greek era. All of Aristotle's scientific works (384-322 BC) contained historical introductory chapters to the sciences dealing with, i.e., a historical introduction presenting the works of predecessors in the field of research that the book will address. Thus, this model of writing remained during the Middle Ages, which can be noticed in the scientific writings of Muslim scholars and scientists who also adopted this approach, and this continued until the emergence of modern science in the era of the scientific revolution.

This is the first comprehensive study of what remains of the writings of Aristotle's student Eudemus of Rhodes on the history of the exact sciences. These fragments are crucial to our understanding of the content, form, and goal of the Peripatetic historiography of science.[2]

The historiography of science emerged in Greece not when it became necessary for the scientists, as happened in the Renaissance, but when it became possible. Aristotle's encyclopedic horizon and keen interest in the origins of human knowledge, on the one hand, and Eudemus' scientific competence and historical skill, on the other, constituted a unique constellation.[3]

After the Lyceum

Subsequently, though, unlike the other historiographical genres emerging in the Lyceum, such as biography, doxography, and the history of culture, the history of science was not carried forward by others, and especially not in the professional community.[4]

Our knowledge of the Classical form of history of science is greatly limited by the almost total absence of original source material. Thus, we know that Eudemus, who lived in the 4th century BC, wrote both a history of astronomy and a history of mathematics, but these works have disappeared. The knowledge that we do have comes mainly from later commentators working at the end of the Classical period or at the beginning of the Middle Ages. One example of these is Proclus (c. 420—485) who wrote a historical account of Euclid's mathematics. Simplicius (c. 540), who wrote detailed commentaries of Aristotle's works on natural philosophy and, in connection with these, also gave an account of the ideas held by earlier natural philosophers, is another example. The commentaries written by Proclus, Simplicius and others can reasonably be regarded as late-Classical history of science.[5]

[1] Efthymios Nicolaïdis, Historiography of science in Greece, Osmanlı Bilimi Araştırmaları, VI/2, 2005: 202-212.
[2] Zhmud, Leonid. The Origin of the History of Science in Classical Antiquity, Berlin, New York: De Gruyter, 2006.
[3] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.
[4] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.
[5] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).p.02.

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The period from the eighth to the tenth centuries was one of these, when the Arab world took over Greek science and it became an integral part of Arabic science. In contrast to medieval Europe, and in many respects to Byzantium, Arab culture borrowed, along with Greek science, the ancient historical scientific traditions and their main methodological approaches to science. It is not enough to say that Muslim scholars were very interested in their Greek predecessors. They respected them to the utmost, tried to find all available information about them, compiled reliable indexes of their works, translated the surviving biographies of prominent scientists and physicians, and compiled new ones. Later, on the basis of all this, a process of historiography of Arabic science and medicine arose, which in turn influenced the Byzantine and Western traditions. During the Renaissance, the historiography of science therefore remained as inseparable from the classical heritage as science itself; the Middle Ages, apart from the Arabs, were usually ignored.[1]

There is some uncertainty among historians of science as to when the history of science first appeared, its origin has never been widely discussed or properly considered, and the interested in the field will find a variety of starting points which reflect the professional preoccupations of historians. One is in the twentieth century with George Sarton, another in the nineteenth century with William Whewell, and yet another in the eighteenth century with Joseph Priestley.[2]

During the early stages of the eighteenth-century Enlightenment, the historiography of science was largely conducted by "natural philosophers" who utilized the discipline to validate and defend their own intellectual pursuits. These practitioners constructed historical narratives that framed contemporary discoveries as the teleological culmination of a protracted advancement of both knowledge and civilization. Within this framework, the mathematical sciences were viewed as having evolved through a gradual process of accretion rather than emerging in a perfected state. Arithmetic, for instance, was seen as a Phoenician invention subsequently refined by Pythagoras and expanded by Arabic scholars; geometry was traced from its Egyptian origins to its Hellenic transmission via Thales. Similarly, the origins of astronomy were variously attributed to Atlas, the Chaldeans, the Egyptians, or the Babylonians, depending on the specific tradition being cited.[3]

In the preceding sixteenth and seventeenth centuries, during the emergence of the "new science," history remained an indispensable component of scientific knowledge. Figures ranging from Copernicus to Harvey regarded Classical history as fundamentally relevant to the ongoing progress of their work. Throughout the Scientific Revolution, ancient authorities were frequently utilized as ideological foils in polemical arguments; simultaneously, history provided a vital

[1] Leonid Zhmud - The origin of the history of science in classical antiquity, Walter de Gruyter, (2006).pp.03,04.
[2] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.
[3] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.

source of legitimation for emerging scientific paradigms. By establishing a lineage that connected their work to the prestigious philosophers of Antiquity, early modern scientists were able to bestow a necessary degree of institutional respectability upon their innovative endeavors.[1]

[1] Zhmud L. Ancient Greek Historiography of Science. In: Taub L, ed. The Cambridge Companion to Ancient Greek and Roman Science. Cambridge Companions to Philosophy. Cambridge University Press; 2020:268-288.

Modern History of Science

The intellectual atmosphere that Europe witnessed in the seventeenth and eighteenth centuries was not only reflected on thinkers and philosophers, but also led to an interest in science and scientists. Consequently, these records were created to have historical documentary dimensions.

The integration of historical narrative into scientific inquiry is exemplified by Joseph Priestley's seminal works, The History and Present State of Electricity (1767) and History and Present State of Discoveries Relating to Vision, Light and Colors (1772). Although these texts functioned as pioneering contributions to contemporary research, they were explicitly framed as "histories." Priestley, like many of his contemporaries, viewed the chronological development of a discipline as an intrinsic component of the science itself—a necessary audit of attained milestones and a roadmap for addressing unresolved problems. Consequently, history was assigned a functional role within the scientific practice of the era. For Priestley, the value of the history of science was largely instrumental, serving as a pedagogical and methodological tool inextricably linked to the advancement of current research.[1]

As a result, the history of science began at the end of the seventeenth century with the likes of Francis Bacon (1561-1626) and then August Comte (1798-1857), that is, with the historical awareness accompanying the scientific revolution, where a set of principles were determined and a new concept of thought or mind emerged that assumes the existence of a non-individual human mind that carries human knowledge, which embodies the progress of human knowledge and gives it consistency and unity. This is the same idea that George Sarton (1884-1956) developed and emphasized in his book "The History of Science and the New Humanism."

As a professional academic discipline, the history of science emerged shortly after World War I, but its practitioners, usually scientists, had been writing histories of their respective disciplines for more than a century before. One early motivation for writing histories of particular sciences was to show that knowledge (and thus humanity) was capable of, and had indeed advanced to the present day. Depending on the context, histories of science were used to showcase the revelation of a new, enlightened human understanding, to offer a way for the general public to understand the fundamentals of a particular subject; or to gain legitimacy for a particular discipline by showing that it had a founding philosopher or principle from which everything after him developed. Figures such as Adam Smith, Joseph Priestley, Georges Cuvier, and Alexandre Brongniart wrote histories of astronomy, electricity, vision, zoology, botany, and geology, most of which were designed to celebrate the existence and legitimacy of new disciplines in different subjects. general and private history flourished.[2]

If science is systematic, organized knowledge, then the history of science is a description and explanation of the development of this knowledge. Thus, the historian of science is not only concerned with the latest scientific achievements or the narrative of the most important ones, but

[1] Helge S. Kragh - An Introduction to the Historiography of Science. Cambridge University Press. (1989).p.02.
[2] Rob Iliffe, History of Science, p.3.

also with the whole of its thoughts, discoveries, and what these achievements led to. Interest in the history of science began recently, as there were early and few pioneers in this field since the end of the seventeenth century. The first to apply the idea in its comprehensive context (i.e. according to a comprehensive concept of history) was August Comte (1798-1857) in his book Lectures on Positive Philosophy 1830-1842, and then his heir in that was Paul Tannery (1843-1904), who was a mathematician and historian. Then came William Whewell (1794-1866), whose contribution to the history of science was distinguished as the first original and pure work on the history and philosophy of science.

From here, the awareness was formed among historians of science, knowledge and thought that their history of scientific achievements is ultimately the history of a necessary path aimed at reaching the truth, which is what Comte tried to establish on the basis of a general law that assumes the development of human thought and knowledge over time, i.e. the law of the three states, as he was aware of the epistemological and scientific importance of this subject - the history of science - as he says: "We cannot study the nature of the human mind, and determine the rules of its operations a priori, but only a posteriori, that is, based on its results, and on our observations of its subjects, which are the sciences. We cannot arrive at useful, certain rules about the way in which we lead our mind except by precise observations about how the mind works in each science, about the various methods it follows to reach discoveries, and in a word about the methods."[1]

Auguste Comte, in his Cours de Philosophie Positive (1830–42), presented a three-stage account of the development of science. These stages were theological, metaphysical, and scientific (or positive), the latter expressing the fruitful search for the causes of phenomena in favor of the discovery of general laws. Comte argued that all sciences were capable of reaching the final stage of development, although only the mathematical sciences (not including chemistry or experimental physics) had done so. He believed that scientific progress began when knowledge became more abstract and freed itself from its literal origins and then from any remaining superfluous metaphysical elements.[2]

Sarton believes that Comte should be considered the founder of the history of science, or at least the first to have a clear and precise understanding of this subject. In his Cours de Philosophie positive, published from 1830 to 1842, he clearly presented the following three basic ideas: 1) no such comprehensive work could be accomplished without constant recourse to the history of science; 2) it is necessary to study the development of the various sciences in order to understand the development of the human mind and the history of humanity; 3) it is not enough to study the history of one or any particular science. One must study the history of all the sciences, taken together.[3]

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[2] Rob Iliffe, History of Science, p.4.

[3] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. pp. 330,331.

Then with August Comte (1798-1857) where he spoke in his book "Lectures on Positive Philosophy" (1830-1842) about the history of science and its importance and the classification of sciences where he says in the second lesson of the lessons of positivism: "We are firmly convinced that knowing the history of sciences is of the utmost importance, indeed we do not know a science completely unless we know its history."[1] Comte envisions the history of sciences according to his method as one that must take into account first and foremost the logical sequence of knowledge without being satisfied with the method of historical presentation, and the orientation towards the rational history of sciences that looks at scientific facts within the framework of the unity of human knowledge. Paul Tannery had spoken about the history of science according to Comte in his article published after his death in 1905 entitled "Auguste Comte and the History of Science" where he says: Comte's philosophy is a philosophy characterized by its precise contemporaneity with the science of his time..."[2]

Another French philosopher, Antoine Cournot, also contributed to the clarification of our ideas, namely by publishing in 1861 his Traité de l'enchainement des idées fondamentales dans les sciences et dans l'histoire. But the true heir to Comte's thought is Paul Tannery. It is hardly necessary to say much about him, since anyone who has the slightest knowledge of the history of science needs to have come across one of his numerous memoirs, all of which are remarkable for their originality and accuracy. Tannery himself praises the importance of his intellectual relationship with Comte, and often expresses his admiration for the founder of positivism. However, his philosophy is quite different from Comte's, but the greatest difference between them is that Comte's knowledge of the history of science was very superficial, while Tannery was very educated and had a wealth of historical research that did not exist in the 1830s, which made him more knowledgeable about the history of science than anyone else in the world. Sarton certainly believed that no one was better prepared to write a complete history of science, at least of European science, than Tannery, whose dream was to do this great work, but he unfortunately died in 1904.[3]

Once the order of study of the sciences and part of the method had been determined, the next point was how to present the sciences. According to Comte, there were two paths: historical and dogmatic. According to the former, all human knowledge should be presented in the same order in which it was obtained, which meant approaching "a chronological arrangement of the various original works that have contributed to the progress of science". In contrast, the dogmatic method could only be applied to highly developed sciences, since it consisted of presenting "the system of ideas such as can be conceived at the present time with a single fundamental idea, which, if it were in the right place and had the required knowledge, would engage in the reconstitution of the science [in question] as a whole". This meant that the dogmatic method did not aim at presenting details, which increased and accumulated day by day. For this reason,

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[2] جورج كانتغيلام، دراسات في تاريخ العلوم وفلسفتها، تر: محمد بن ساسي، المنظمة العربية للترجمة، 2007. ص. 108

[3] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. pp. 330,331.

dogmatism was advantageous over the historical method, which proved increasingly impractical compared to ancient times, when the number of works to be studied was small.[1]

However, Comte noted that "it is easy to see that there is only a clear connection between the study of a science according to the historical method and the possession of a true knowledge of the effective history of such a science." The progress of the sciences and the arts was interdependent, that is, the sciences developed through their mutual relations and were thus linked to the general development of human society. As a result, an accurate knowledge of the history of the various sciences was of the utmost importance, since one could learn a science fully only by knowing its history. Given such a connection and interrelationship between all sciences, including the social sciences, in the second part of the *Cours de Philosophie Positive*, Comte gave more emphasis to the history of their progress.[2]

In contrast, William Whewell's History of the Inductive Sciences of 1837 and his Philosophy of Inductive Sciences of 1840 were deliberately written in contrast to the Comtean treatise. It was Whewell who coined the term "scientist" in 1833, and he covered an exceptionally wide range of subjects, including mathematics, mineralogy, and archaeology, but his rich and original works on the history and philosophy of science were the most influential. In The History of Inductive Sciences, Whewell proposed a general three-stage history of science followed by a period of fact-gathering (the "Introduction") in which disparate facts were brought together through major discoveries (the "Inductive Era"). Finally, these discoveries were evaluated and accepted by the wider community (the "Continuum"). If this resembled Baconian induction, his philosophy emphasized the ways in which scientists used organizing principles or "ideas" that served to "bring together" disparate facts. Unlike Comte, Whewell argued that science did not advance by avoiding the search for causes, but in fact its forward progress was linked to the creation of more precise ways of discovering new kinds of causes.[3]

In his article "The Philosophy of the History of Science" (2009), Nicholas Jardine addresses the view that philosophical reflections are what create the fundamental patterns and interpretations, and thus the models for the advancement of science. He sees this embodied in several philosophies, beginning with the writings of the rationalist William Whewell (1794-1866), the empiricist Ernst Mach (1838-1916), and then the conventionalist Pierre Duhem (1861-1916). On the other hand, he moves on to discuss the rational reconstruction of the history of science by Imre Lakatos (1922-1974) and its sharply opposing relationship to the views of Thomas Kuhn (1922-1996) and Karl Popper (1902-1994). In a subsequent section, he addresses the relationship between philosophy and the history of sciences, where it is considered in a simpler manner, not

[1] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[2] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[3] Rob Iliffe, History of Science, p.5.

as a contributor or founding engineer of major narrative structures, but as a source of insights into specific historical interpretative problems, interpretation, and narration.[1]

In his monumental book prominent in the history of science, titled "The History of Inductive Sciences" (1837), Whewell organized each science based on a dramatic system of periods, where he brought together the distinctive frameworks of facts in clear ideas to infer new general truths. In doing so, he began each period with a historical narrative where events converged, attempting to clarify the ideas and their interrelations, and how those relationships were established. He then followed each time period with analytical summaries and conclusions that illustrated how they bore the fruits of subsequent new theories, how these opinions conflicted, and how the contents of the theories spread and competed in the practical community. Whewell also demonstrated that the succession of these periods and their outcomes follows a pattern of stability, particularly in the Middle Ages, which was characterized by ambiguity in ideas and dogmatism.[2]

Whewell also commented on the great difference in the development of the sciences, starting with astronomy and mechanics, which had acquired a huge body of knowledge - certainty - then to the organic sciences such as physiology and comparative anatomy, and then comes geology, which, according to him, is still waiting for names like Kepler and Newton to emerge for a new decade. Then in his later book of similar importance, entitled The Philosophy of Inductive Sciences (1840), Whewell presented a fundamental dialectical issue between subjective ideas and objective things, and thus distinguished theories and ideas in the science of thought from facts or events, which are nevertheless inevitably burdened and laden with concepts and perceptions very close to the world of things.

In this book, Whewell tried to show the importance of the conceptual network of each science in each era in which it developed, as it expressed basic ideas that define that science, such as space or place in geometry or matter and force in the case of mechanics. In this, he sought to explain and interpret these basic ideas and link them to facts and events, as he made these relationships a source of truth in the subsequent theory based on deduction and induction. In this inductive escalation, laws are derived by linking those ideas and facts that can be used in the subsequent inductive step. In the same context, he also discussed the possibility of realizing certainty in the natural sciences, and the method, creativity, intuition, and scientific textual criticism in the inductive sciences. Accordingly, the attempt to deduce the general conditions for discovery in a certain era and the ability to understand and comprehend the facts that were achieved as a result of that, as there is no principle or general truth given in such a way that leads to discovery in an inevitable and necessary way. Therefore, Whewell saw that scientific progress is historical and

[1] Nicholas Jardine, “Philosophy of History of Science”, Blackwell Companion to the Philosophy of History and Historiography, ed: Aveizer Tucker, Blackwell Publishing Ltd, 2009: United Kingdom. pp.287-296.
[2] Nicholas Jardine, “Philosophy of History of Science”, Blackwell Companion to the Philosophy of History and Historiography, ed: Aveizer Tucker, Blackwell Publishing Ltd, 2009: United Kingdom. pp.287-296.

that the basic ideas that led to its clarification and use in understanding scientific progress are, for him, merely a means created by man in certain circumstances and not absolute ideas.[1]

Nineteenth-century historians of science similarly treated scientific progress as inevitable and necessary, transcending the particular circumstances of the production of hypotheses and theories. In stark contrast to these predictive histories of science, Mach sees scientific progress as the result of contingent human innovations as responses to particular local needs and problems, while for Whewell history reveals the ways in which most scientific advances have become permanent structures of certain knowledge. For Mach, his function is not to praise and commend certainties but to discover and disguise them as historical events that can be replaced by different principles of equal effectiveness in organizing the phenomenon. That is, the study of history is, for him, essential at every level of understanding of science. It provides the only way to understand and grasp the fundamental problems and from which the status of scientific principles can be critically evaluated. It is also the most effective way to teach scientific methods and the content of science itself.[2]

[1] Nicholas Jardine, "Philosophy of History of Science", Blackwell Companion to the Philosophy of History and Historiography, ed: Aveizer Tucker, Blackwell Publishing Ltd, 2009: United Kingdom. pp.287-296.
[2] Nicholas Jardine, "Philosophy of History of Science", Blackwell Companion to the Philosophy of History and Historiography, ed: Aveizer Tucker, Blackwell Publishing Ltd, 2009: United Kingdom. pp.287-296.

Contemporary History of Science

The history of science in Britain was the preserve of a few scholars committed to their disciplines, many of them at Trinity College Cambridge. The mathematician W. W. Rouse Ball wrote his Short History of Mathematics (1888), and Thomas Heath chronicled Greek mathematics in History of Greek Mathematics (1921). The physicist William Watham (after Dampier 1931) wrote a bestseller, Recent Developments in Physical Science (1904), and his History of Science and its relations with Philosophy and Religion (1929) went through many editions, becoming a strong advocate for the introduction of the history of science to Cambridge in the 1930s. Otherwise, there were few examples of work that met the standards of European historical scholarship, such as the astronomer Louis Emil Dreyer's History of Planetary Systems from Thales to Kepler (1906), a seminal work in astronomy.[1]

In Europe, a number of scientists turned to history to support their theories of the scientific method (what we call the philosophy of science). The tradition of providing comprehensive accounts of scientific progress using historical examples was continued at the turn of the century by Ernst Mach, Pierre-Henri Poincaré, and Pierre Duhem, writing at a time of extraordinary innovation in physics, each of whom used historical examples to illuminate original philosophical positions. Ernst Mach, in his writings on the history of mechanics and the philosophy of science, especially in his 1893 book Mechanics, argued that the assumption of the existence of real theoretical entities such as atoms was an unwarranted leap of inductive faith, that only scientific experiments, or rather physical sense, were real, and that the aim of science was to formulate the simplest laws that accounted for known facts, that is, the controlled sense experiences that consisted of experiments and observations. Pierre Henri Poincaré and Pierre Duhem can also be mentioned in the same context with their books, respectively, Science and Hypothesis 1902, The Aim and Structure of Physical Theory 1914.

According to Sarton, "It seems that some people believe it is impossible to write the history of science as a whole, and that the subject is too vast; I would rather say that the impossibility itself lies in selecting from this inseparable network to develop one branch of human knowledge. Furthermore, it is indeed impossible to write the history of any significant discovery without writing a chapter of the history of science, willingly or not, I mean the history of science as a whole. How can we explain, for example, the discovery of blood circulation if we do not explain the development of anatomy, comparative zoology, general biology, natural philosophy, chemistry, and mechanics? In short, the purpose of the history of science, as I understand it, is to determine the origin and development of scientific facts and ideas, taking into account all intellectual exchanges and all the influences brought about by the progress of civilization itself. This definition implies that the only rational way to divide this history is not by cutting it

[1] Rob Iliffe, History of Science, p.5.

according to countries or sciences, but only according to time. For each time period, we must look simultaneously at the entirety of its scientific and intellectual development."[1]

In order to develop our historical work, we must, of course, use the same methods that ordinary historians use to evaluate and critique the materials available to them. However, the historian of science must independently employ some other methods of a more specific nature. I cannot explain them here, but it is easy to understand that, for example, to determine the date when a discovery became a real part of science and enriched human experience, the historical interpretation must be complemented by a scientific interpretation based on evidence from the positive sciences.[2]

Let us now turn to some of Canguilhem's views on the history of science, in which epistemology plays a crucial role. Interestingly, Canguilhem (1904-1995) admitted that it would be absurd to blame the historians of the eighteenth and nineteenth centuries "for not having taken into account any of the concepts that epistemologists are currently trying to establish as rules of writing or composition for all those who practice or produce the history of science", because the history of science also has a history of its own.[3]

In fact, Canguilhem criticized the history of science written impersonally within the doctrine of the infinite perfection of the human spirit, which was legitimized by a continuous series of revolutions only to anticipate the progress of science within the exclusive aspect of continuity. Instead of a neat description of a science resulting from the reading of all the works that seem to be related to it in the past, Canguilhem called for a history of science based on epistemology. Only in this way can science be distinguished from other cultural manifestations. In this context, Canguilhem distinguished between the past of science and how this science was in the past. A history in which epistemology plays the main role allows for the selection from the past of the ideas that have shaped the subject of science within an “ideal” temporal framework. Thus historians “select” from the past some ideas, that is, the history they will write, referring to the (epistemological) discontinuities in their temporal development. They thus invent a specific past for science, instead of a succession of ideas, and they no longer ask theories formulated in the past about the reasons for their lack of logical maturity.[4]

Canguilhem's history is certainly a history of ruptures, but not in the style of Thomas Kuhn (1922-1996) whose proposals did not spring from philosophical criticism, but from social psychology. As is well known, Canguilhem's source was Bachelard and his concept of ruptures, and more specifically, Canguilhem emphasized Bachelard's agreement with Jean Cavaillès (1903-1944) on the idea of progress, one of the fundamental problems of the doctrine of science

[1] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. pp.332-333.
[2] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.334.
[3] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[4] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.

being precisely that progress should not mean an increase in volume by juxtaposition, the older lives on with the new, but permanent revision of contents through in-depth study and erasure. What comes later is more than what existed before, not because the former contains or prolongs the latter, but because it necessarily comes from it and always includes the unique mark of its superiority in its understanding.[1]

History of Science as a Field of Academic Research

History of Science: The Beginnings of Formation

The founding father of the history of science as a field of academic research was the Belgian scholar Georges Sarton, who founded the journal Isis in 1912 while at Ghent, and edited it for four decades. At the outbreak of World War I, he went to England, but, unable to find work as a teacher or independent scholar in the history of science, he traveled to the United States. After the war he was funded by the Carnegie Corporation, and succeeded in reviving Isis, which had ceased publication when he left Belgium. Sarton devoted most of his research to producing his monumental Introduction to the History of Science, which was to survey the place of science and science alone in the great civilizations from ancient Greece onward. However, when the third volume of the expected 26 volumes appeared in 1948, he had only reached the end of the fourteenth century. He believed that the sciences represented human greatness in its broadest and deepest forms, and that each contained certain unifying features that made it possible to speak of science as a whole (rather than as a set of sciences).[2]

Accordingly, Sarton focused his study of past achievements in science on the positive, accepted scientific achievements that served as building blocks for the discoveries of later generations. His collection of bibliographies, a major function of Isis, was explicitly designed to serve the same supporting role for the future development of the field. Sarton believed that science provided a way to erase the differences that existed between different nations and cultures. His commitment to the unity of science was closely linked to his belief in the unity of the human race, and the titles of his works show how closely he linked the practice of science to the achievement of civilization. Indeed, with exemplary force, and in times that were hardly auspicious, he attempted to establish an Institute for the History of Science and Civilization as early as 1917. By promoting the history of science as an ideal and as a fact—particularly at Harvard, where he took up a lectureship in 1916—he aimed to establish a new, synthetic discipline that would span the gap between the sciences and the humanities.[3]

The first institution to formally teach the history of science in Britain was University College London, the rationale for its creation being that it should be aimed at science education. Abraham Wolf, the first head of the Department of History and Philosophy of Science when it

[1] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[2] Rob Iliffe, History of Science, p.8.
[3] Rob Iliffe, History of Science, p.8.

was established in 1921, had a distinguished career. In 1919–20 Wolf delivered lectures in the history of science covering the ancient period to the mid-nineteenth century, and invited a number of other scholars from a wide range of departments to lecture on various topics in the history of science, and the success of this lecture series led to the formation of the new department. Then came Charles Singer, who, after the success of his first two volumes of Studies in the History and Methods of Science (1917–21), taught the history of medicine and biology at UCLA throughout the 1920s and remained exceptionally productive, publishing a number of works including Evolution of Anatomy 1925, and Short History of Biology in 1931. He was president of the International Academy for the History of Science from 1928 to 1931, and chairman of the famous Second International Congress on the History of Science and Technology which met in London in the summer of 1931. Elliot Smith is also a remarkable scholar in his own right, for outside his medical work he was an exceptionally successful author on all things Egyptological, arguing in a number of works that ancient civilization originated in Egypt and then spread outward in a series of migrations. He had long been interested in mummification, and was not slow to capitalize on the public fascination with the discovery of Tutankhamun's tomb in November 1922 and published a book on the subject the following year.[1]

At its inception as a subject of academic research at the University of London, the close institutional links between the history of science and the philosophy of science were based on the idea that science was a unique form of human rationality, and what interested philosophers of science was how science was distinct from other forms of human activity, that is, how it progressed through processes that lifted it up and freed it from the mundane concerns and imperfections of the wider culture. From a similar perspective, the task of most historians of science was to understand how pure science had come to distinguish itself from the morass of metaphysical, astrological and religious superstitions (or 'obstacles') that had impeded scientific progress. Inevitably, interest was focused on a handful of great men, selfless geniuses whose attitudes to science were abstracted from their other concerns and taken as models of scientific practice. The history of science and the philosophy of science were thus in harmony as long as these basic assumptions remained at the heart of the work of research on the subject. The philosophy of science gained a new lease of life after the Second World War and became a central element of the HPS program at Cambridge. The scientific community was committed to the idea that historians of science should be able to do philosophy of science and vice versa, and the journal Studies in the History and Philosophy of Science was founded in 1970.[2]

A major presence at Cambridge for two and a half decades was Mary Hesse, who began her career in 1951 as a lecturer in mathematics at Leeds before turning her attention to HPS in the mid-1950s. After lecturing in the history and philosophy of science at UCL for five years, she moved to Cambridge in 1960, where she remained until her retirement in 1985. Much of her work at HPS aimed to demonstrate the overwhelming influence of clear and intuitive models that

[1] Rob Iliffe, History of Science, p.9.
[2] Rob Iliffe, History of Science, p.24.

scientists have adopted in the development and acceptance of theories. These views were set out in Forces and Fields (1961) and Models and Analogies in Science (1963). Along with The Structure of Scientific Inference (1974), this work was based on a belief in the greater need to integrate the history of science and the philosophy of science. In the second half of her career, she moved away from traditional HPS and ventured more widely to write influential articles on the work of Jurgen Habermas and the sociology of scientific knowledge.[1]

By the 1950s, the main centre for the study of the philosophy of science in Britain was at the London School of Economics (the LSE), which was dominated by the presence and philosophy of Karl Popper. Popper had been associated with (but by his own admission never a member of) the logical positivist Vienna Circle of the 1930s, but his philosophy of falsification was at odds with the prevailing views of prominent logical positivists. In his 1934 book Logik der Forschung (translated and expanded in 1959 as The Logic of Scientific Discovery), he argued that science had advanced in the past through the brilliant and improbable conjectures of a small number of great thinkers whose theories had survived a series of tests.[2]

The history of science then became an academic subject with a global character, best represented in America by Thomas Kuhn, whose ideas appeared in his book "The Structure of Scientific Revolutions" in 1962, in which he presented an interpretive model for the progress of science that differed from that of the logical positivists and Popper. In France, Bachelard, through a valuable collection of writings, was another model for interpreting and philosophizing about the history of science, which will be studied in the next section of this publication.

[1] Rob Iliffe, History of Science, p.24.
[2] Rob Iliffe, History of Science, p.24.

Trends in Historiography of Science

Internalism and Externalism

Another distinction at the epistemological-methodological level is between **internal** history of science and **external** history of science. The internal focuses on the development of scientific ideas in their relations to each other, such as how Copernican astronomy contributed to Newtonian physics. The external looks at scientific developments in their political, social and economic contexts, such as the question of the impact of science on government policies and vice versa, or the interactive relationship between science and belief, and so on. These topics are classified within the external history of science. However, most philosophers of science do not emphasize the existence of a dividing line between the internal and external history of science.

As technology began to enter the scope of studies in the history of science, science came to be seen as belonging to specific historical contexts, rather than as separate from spatial and temporal determinants. Here we should draw attention to Boris Hessen (1893-1936), who surprised the audience at the Second International Congress on the History of Science, in London, in 1931, with a groundbreaking paper on the social determinants of Newton's scientific activity. This was the impetus for a view known as "externalism," especially influential in Britain during the Cold War. Over time, like any polar position, externalism was also leveled with its opposite, "internalism," that is, the purely cognitive focus on the history of science, which had traditionally represented the main approach to writing the history of science. According to Canguilhem, "Without reference to epistemology, epistemology would be an empty speculation. Without a relationship to the history of science, epistemology would be an entirely unnecessary duplication of the science it is supposed to discuss," and in the same vein, Imre Lakatos (1922-1974) observed that "epistemology without the history of science is empty, and the history of science without epistemology is blind."[1]

Sarton says that one can understand the history of science in different ways, but these different concepts are not incompatible with each other; they are simply more or less comprehensive, and that his own conception is not very different from Tannery's, except that he give greater importance to the logical-psychological-social viewpoint, that is, as the external contexts for the development of science.[2]

However, Walter Pagel (1898-1983) had already set a major milestone, holding that the past of science should not be judged by current standards, but should be understood on its own terms, requiring a sound analysis of both the socio-historical and the epistemological aspects together.[3]

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[1] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[2] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.331.
[3] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.

We believe that we are in a position to attempt a working definition of the subject of the history of science, which we place at the intersection of three areas of analysis. The first area concerns the essential features of scientific theories or practices through a common textual criticism (derived from the linguistic tradition) and an internal theoretical contextual analysis (i.e. the cognitive analysis of key concepts and arguments). The second is the historiographical area proper, which targets the main approaches to the analysis of a given problem, document, etc., and the third area focuses on the general historical context, with an emphasis on the conditions under which the documents under analysis were produced.[1]

In the early 1930s, a seminal paper presented by the Soviet historian Boris Hessen catalyzed a significant shift in the field, prompting scholars to investigate the intricate alliances between scientific practices and their specific socioeconomic contexts. Hessen's research emphasized the socio-political determinants that dictate both the direction and the methodology of scientific inquiry. This historiographical approach, which came to be known as externalism, analyzes the ways in which science and its practitioners are influenced and directed by the external world and the contemporary milieu in which they operate.[2]

This perspective stands in direct opposition to internalism, as it rejects the conceptualization of the history of science as merely the chronological evolution of "pure thought." By deconstructing the idea that scientific ideas develop within a contextual vacuum—where one discovery leads to another solely through the efforts of isolated "geniuses"—externalism asserts that scientific progress is inextricably linked to the specific historical and geographical conditions of its time.[3]

Preceding the rise of externalist methodology, the internalist approach to the history of science focused primarily on the rational reconstruction of scientific concepts, treating their development as an autonomous process occurring entirely within the intellectual confines of the scientific community. This perspective emphasizes the internal logic and cumulative progression of theories, often applying the norms and rigorous standards of modern science to past discoveries. However, internalism is not limited to contemporary frameworks; it is equally utilized to analyze the cohesive systems of thought underlying pre-modern inquiries, such as the mathematical structures of Babylonian astronomy or the conceptual foundations of Medieval impetus theory.[4]

In practice, the demarcation between internalist and externalist methodologies is frequently ambiguous, as few contemporary historians maintain that either extreme provides a comprehensive account of scientific evolution. While it is methodologically difficult to adhere strictly to one approach at the exclusion of the other, the tension between them centers on a

[1] Márcia H. M. Ferraz, Ana M. Alfonso-Goldfarb, Silvia Waisse, Science and History of Science: between Comte and Canguilhem, Transversal: International Journal for the Historiography of Science, 4 (2018) 108-117.
[2] Hessen, B. "The Social and Economic Roots of Newton's 'Principia'." In Science at the Cross Roads: Papers Presented to the International Congress of the History of Science and Technology by the Delegates of the U.S.S.R. London: Kniga, 1931.
[3] Shapin, S. "Disciplining History: Units of Historical Analysis." History of Science 30, no. 4 (1992): 333-369.
[4] Bowler, P. J., & Morus, I. R. (2005). Making Modern Science: A Historical Survey. University of Chicago Press.

fundamental inquiry regarding the relationship between the producers and consumers of scientific knowledge. The resolution of this inquiry necessarily shapes the methodology of the history of science and technology; conversely, the conclusions drawn from such historical research can refine the initial theoretical framework. This central problem further encompasses a complex array of philosophical concerns, including the nature of scientific truth, the definition of objectivity within a scientific context, and the mechanisms governing shifts in scientific theory.[1]

Building upon the foundational thesis established by Boris Hessen, the historian and sociologist Robert K. Merton produced an influential body of work that functioned as both a reaction to and a sophisticated refinement of Hessen's socioeconomic arguments. In his seminal study, Science, Technology and Society in Seventeenth-Century England, Merton introduced the specific religious and cultural ethos of Puritanism as a primary catalyst for the accelerated growth of scientific inquiry during that era. While Hessen's framework relied on broad economic categories, Merton systematically disaggregated these into more precise subcategories of influence—such as transportation, mining, and military technique—to demonstrate their specific impact on scientific priorities. Furthermore, Merton pioneered the use of empirical and quantitative methodologies to substantiate the influence of these external factors, shifting the study of scientific development toward a more data-driven sociological analysis.[2]

Despite his emphasis on external determinants, Merton's interpretation diverged significantly from Hessen's strictly materialist framework. Merton contended that while extra-scientific factors—such as economic or religious pressures—might direct a researcher's attention toward specific problems, the ultimate trajectory of inquiry remained governed by the "internal history of the science in question" (Merton, 1938). In an attempt to resolve the tension between these two perspectives, Merton proposed a disciplinary demarcation: he argued that the sociologist of science should analyze the external context and institutional conditions of discovery, whereas the historian of science should remain focused on the conceptual and technical content of the discipline.[3]

Science Studies

The history of science has long focused on the internal development of theories and representations of nature. "Science studies" has attempted to address the dynamics of science by taking into account the contexts, environments, actors and tools that produce knowledge.

Science studies constitutes an interdisciplinary field of inquiry dedicated to situating scientific expertise within expansive social, historical, and philosophical frameworks. Utilizing a diverse array of methodological tools, the discipline analyzes the production, representation, and

[1] Kragh, H. (1987). An Introduction to the Historiography of Science. Cambridge University Press.
[2] **Merton, R. K.** (1938). "Science, Technology and Society in Seventeenth-Century England." *Osiris* 4: 360-632. See Also: **Shapin, S.** (1988). "Understanding the Merton Thesis." *Isis* 79, no. 4: 594-605.
[3] **Merton, R. K.** (1938). *Science, Technology and Society in Seventeenth-Century England*. Osiris 4.

reception of scientific knowledge, as well as its specific epistemic and semiotic functions within society.[1]

In her 1998 assessment of the field's evolution, Lorraine Daston identifies the "philosophical school" as a foundational approach to the history of science, characterized by its emphasis on the succession of metaphysical systems and epistemological frameworks. This school posits that the history of science is essentially a "history of ideas" that have fundamentally altered human perception of the world, driven by the conviction that ideas serve as the primary engines of historical change and that rigorous arguments provide the mechanism for their impact. Exemplified by the scholarship of Alexandre Koyré, Gaston Bachelard, Karl Popper, and Thomas Kuhn, this tradition treats science as a predominantly theoretical enterprise where progress is determined by the dialectical conflict of competing arguments. In this view, science remains an autonomous discipline defined by the history of scientific thought. However, the expansion of the interdisciplinary field of science studies has significantly reshaped this concept. This shift introduces a sociological perspective that prioritizes questions regarding the social structures inherent within scientific activity, moving beyond the internal development of ideas to examine science as a socially embedded practice.[2]

These different approaches have highlighted the complexity of the factors involved in scientific construction: categories of thought, tools, actors' games, the rules and norms of the scientific community, institutions and economic, financial and political factors or the politics of science in the process of formation. This concern with complexity will lead to the fragmentation and fragmentation of studies and thus the collapse of the analytical system. In order to counter this fragmentation, historian Lauren Daston proposes a new research program that aims to provide a universal and comprehensive vision of scientific activity.

The convergence of these diverse methodologies has illuminated the multifaceted nature of scientific construction, acknowledging the interplay between cognitive patterns, material instruments, sociopolitical norms, and institutional frameworks. In response to this complexity, Lorraine Daston advocates for a revised research agenda that seeks a comprehensive and integrated synthesis of scientific activity. This approach is best exemplified by the historical evolution of "objectivity"—a foundational pillar of scientific inquiry. Daston observes that in the eighteenth century, objectivity was tied to the "truth-to-nature" ideal, where scientists sought to depict the essential forms of nature through curated illustrations. By the early nineteenth century, however, a shift toward "mechanical objectivity" occurred; during this era of heightened positivism, the scientific community sought to eliminate human subjectivity and personal

[1] **Hess, D. J.** (1997). *Science Studies: An Advanced Introduction*. New York University Press.
[2] **Daston, L.** (1998). "The Nature of Nature in Early Modern Europe." *Configurations* 6, no. 2: 149-172.

interpretation by relying on mechanical instruments, which were perceived as impartial and inherently more objective.[1]

The conceptualization of science as a mere "clash of knowledges" remained the dominant historiographical paradigm for a significant duration, a trend critically examined by Dominique Pestre. In the seminal three-volume series A History of Science and Knowledge (2015), Pestre rejects the traditional portrayal of science as an autonomous, hermetically sealed field defined solely by methods and theories distinct from philosophical or technical expertise. He argues against the isolation of scientific inquiry from its practical catalysts and broader applications. For instance, the theoretical development of thermodynamics is fundamentally linked to the industrial emergence of the steam engine as a power source, just as the expansion of the natural sciences in the eighteenth century is inextricably tied to the logistics and ambitions of imperial maritime and commercial expeditions.[2]

The impact of social conditions and determinants

The conceptual framework of "knowledge systems" is predicated on the principle that scientific activity and its subsequent discoveries cannot be understood in isolation from the material and spatial means of their production. This approach necessitates a close analysis of the "sites of knowledge"—ranging from laboratories and academic institutions to religious communities—where inquiry is situated. In this view, science is defined not merely by abstract ideas but by its instrumental mediation through technologies such as the microscope, the telescope, and the cyclotron. This perspective was pioneered by sociologists of science Bruno Latour and Steve Woolgar in their seminal work, Laboratory Life: The Social Construction of Scientific Facts (1979). Adopting an anthropological methodology, the researchers observed a neuroscience laboratory to document the mundane daily interactions and discursive practices of the research team. Their findings suggest that the "scientific fact" is an end-product of social negotiation and material constraints rather than a pre-existing truth discovered in a vacuum. Ultimately, the scientific world is shown to be inextricably linked to the same social determinants and lived conditions that characterize all human endeavors.[3]

Science studies constitutes an interdisciplinary field of inquiry dedicated to situating scientific expertise within expansive social, historical, and philosophical frameworks. Utilizing a diverse array of methodological tools, the discipline analyzes the production, representation, and reception of scientific knowledge, as well as its specific epistemic and semiotic functions within society.[4]

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[1] Daston, L., & Galison, P. (2007). Objectivity. Zone Books. Or: Daston, L. (1992). "Objectivity and the Escape from Perspective." Social Studies of Science 22, no. 4: 597-618.

[2] Pestre, D. (Ed.). (2015). Histoire des sciences et des savoirs (Vols. 1-3). Éditions du Seuil.

[3] **Latour, B., & Woolgar, S.** (1979). *Laboratory Life: The Social Construction of Scientific Facts*. Sage Publications.

[4] **Hess, D. J.** (1997). *Science Studies: An Advanced Introduction*. New York University Press.

In 1935, in a celebrated paper, the Polish sociologist couple Maria Ossowska and Stanisław Ossowski proposed the founding of a "science of science" to study the scientific institutions, its practitioners, and the factors influencing their work. [1]

Thomas Kuhn's The Structure of Scientific Revolutions (1962) acted as a catalyst for renewed scholarly engagement with both the history of science and its foundational philosophical principles. Kuhn challenged the traditional teleological view of scientific progress, arguing that the history of science is not a linear accumulation of discoveries, but rather a series of discontinuous paradigm shifts. In this framework, a paradigm serves as a comprehensive socio-intellectual construct that defines the shared beliefs, methodologies, and standards of a scientific community. These paradigms are authoritative; they function as the regulatory frameworks that determine which questions are worth asking and which types of truth claims are recognized as permissible within a given era.[2]

The Sociology of Scientific Knowledge (SSK) originated at the University of Edinburgh, where David Bloor and his associates articulated the "Strong Programme." This methodological framework posits that both "true" and "false" scientific theories must be subjected to the same level of sociological scrutiny—a principle known as symmetry. According to this view, all scientific claims, regardless of their eventual success or failure, are shaped by social determinants such as cultural milieu and professional self-interest. Because human knowledge resides within the structures of human cognition, it is viewed as ineluctably influenced by the social context in which it is produced. [3]

The sociology of scientific knowledge "(SSK) is the study of science as a social activity, especially dealing with "the social conditions and effects of science, and with the social structures and processes of scientific activity."[4] The sociology of knowledge studies the impact of human knowledge and the prevailing ideas on societies and relations between knowledge and the social context within which it arises. "Sociologists of scientific knowledge study the development of a scientific field and attempt to identify points of contingency or interpretative flexibility where ambiguities are present. Such variations may be linked to a variety of political, historical, cultural or economic factors".[5]

[1] Maria Ossowska and Stanisław Ossowski, "The Science of Science" [originally published 1935], reprinted in Bohdan Walentynowicz, ed., Polish Contributions to the Science of Science, Dordrecht, D. Reidel Publishing Company, 1982, pp. 82–95.

[2] **Kuhn, T. S.** (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.

[3] David Bloor, "The strengths of the strong programme", Scientific Rationality: The Sociological Turn, Springer Netherlands, 1984, pp. 75-94.

[4] Ben-David, Joseph; Teresa A. Sullivan (1975). Sociology of Science. Annual Review of Sociology. 1 (1) 203–222.

[5] Baber, Zaheer (1992). Ashmore, Malcolm; Bhaskar, Roy; Mukerji, Chandra; Woolgar, Steve; Yearley, Steven (eds.). "Sociology of Scientific Knowledge: Lost in the Reflexive Funhouse?". Theory and Society. 21 (1): 105–119.

Into practice

The foundations of scientific inquiry originated in Ancient Egypt and Mesopotamia between 3000 and 1200 BCE, where early advancements in mathematics, astronomy, and medicine laid the groundwork for subsequent Greek natural philosophy. In Classical Antiquity, Greek thinkers moved toward formalizing explanations of the physical world through natural rather than supernatural causes.[1] Following the collapse of the Western Roman Empire, this Greek intellectual heritage declined in Latin-speaking Western Europe during the early Middle Ages (400–1000 CE), though it remained vibrant within the Byzantine Empire.

Through the translation of key texts, the Hellenistic worldview was preserved and expanded upon during the Islamic Golden Age. The eventual recovery and assimilation of these Greek and Islamic inquiries into Western Europe between the 10th and 13th centuries served to revive the study of natural philosophy in the West.[2] Parallel to these developments, sophisticated scientific traditions emerged independently in ancient India and China—the latter of which deeply influenced the intellectual landscapes of Vietnam, Korea, and Japan.[3] Similarly, in Pre-Columbian Mesoamerica, civilizations such as the Zapotec and Maya established rigorous traditions in astronomy and mathematics to facilitate the creation of complex calendrical systems.[4]

The Scientific Revolution of the sixteenth and seventeenth centuries fundamentally transformed natural philosophy, as emergent discoveries catalyzed a departure from traditional Greek conceptions. This "New Science" championed a mechanistic worldview, characterized by a rigorous integration with mathematics and a reliance on a formalized scientific method that prioritized empirical reliability and transparency.[5]

This transformative period set the stage for subsequent "revolutions" across diverse disciplines. The eighteenth-century Chemical Revolution introduced precise quantitative methodologies and standardized measurements to the study of matter. By the nineteenth century, scientific focus shifted toward revolutionary perspectives on the conservation of energy, the geological age of the Earth, and the theory of evolution.[6]

In the twentieth century, breakthroughs in genetics and physics established the groundwork for specialized sub-disciplines such as molecular biology and particle physics. Furthermore, the convergence of industrial interests, military requirements, and the burgeoning complexity of

[1] Lindberg, D. C. (2007). The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450. University of Chicago Press.
[2] Saliba, G. (2007). Islamic Science and the Making of the European Renaissance. MIT Press.
[3] Needham, J. (1954). Science and Civilisation in China. Cambridge University Press.
[4] Grant, E. (1996). The Foundations of Modern Science in the Middle Ages: Their Religious, Institutional and Intellectual Contexts. Cambridge University Press.
[5] Shapin, S. (1996). The Scientific Revolution. University of Chicago Press.
[6] **Galison, P., & Hevly, B. W.** (1992). *Big Science: The Growth of Large-Scale Research*. Stanford University Press.

research projects ushered in the era of "Big Science" following World War II, shifting the scale of scientific endeavor from individual inquiry to massive, state-funded collaborations.[1]

Schools of History of Science

The problem of the development of scientific knowledge and research into its logic began, and is it a single historical process for all sciences? Since awareness of science began as a civilizational motive and human knowledge began with scientific control over nature and harnessing cognitive power in its service and subjugating nature, then as a result of those shocks, revolutions and societal changes in this field, awareness expanded and opinions fermented, and with self-reflection on cognitive identity, scientific crises and the development of knowledge raised important questions about the history of this scientific knowledge and its method, and does the history of science have a meaning or logic that can be exploited? Is it cumulative and linear? Or are they revolutions and subjective positional transformations subject to circumstances such that they can be used as models?

Although the interest in researching the subject of knowledge in general, and scientific knowledge in particular - as a historically evolving phenomenon - is not new; what is new is the diversity of viewpoints and research methods, as well as the intense activity to study the problem of the development of knowledge, the cultural and social conditions of scientific knowledge, the possibility of a realistic interpretation of scientific knowledge, and the feasibility of this interpretation; since there is no generally agreed upon idea in scientific research methods about the standard units of knowledge. This topic constitutes a fundamental obstacle to critical comparison between the various concepts of research methods; since researchers use many different concepts and terms: theory, planned concept, model, research, intellectual framework or guiding model, research program, scientific problem, prevailing theory, problem area, etc. Many classification studies have emerged that distinguish and compare these concepts because each term is loaded with different content according to each researcher individually. We find that every researcher in the history of science talks to us about what he calls the preconditions or predispositions, which he sees changing from one theory to another, and they see that what distinguishes one theory from another is ultimately the sum of the conditions and predispositions that represent the basis for it. Thinkers call these preconditions by various names; Koyre, the philosophical background that has influenced science; Tolman, the natural order of an age; ideals of the natural order, which provide us with basic patterns of expectation through which we see the world, so that we do not know what the world would be like without them; they determine the questions we will ask; they give meaning to facts; they determine what facts are to us. The content of specific scientific views must be examined and studied; and as we study the development of scientific ideas, we must look for the ideals and models that people resort to in order to make nature seem reasonable and intelligible to them, a view that in many ways

[1] Bowler, P. J., & Morus, I. R. (2005). Making Modern Science: A Historical Survey. University of Chicago Press.

resembles that of Thomas Kuhn, as he presents it in The Structure of Scientific Revolutions (1962).[1]

Dudley Shapere argues that the view of the history of science has changed, following the pioneering historical research written by Pierre Duhem, and that the type of change in the history of science is that it is no longer a mere process of knowledge accumulation; knowledge is composed and structured into more and more comprehensive theories; but contemporary historians of science see that the transition from Aristotle's dynamics to the dynamics of the seventeenth century did not require a greater attention to facts as the old historians had shown; rather, as Herbert said, it required taking the same set of data but after placing them in a new system of relations between each other, and giving them a different framework; which ultimately means thinking about them differently. Shapere also sees that the transition from prevailing and dominant preconditions to other preconditions and dispositions is the focus of the changes in the history of science, and that this view, in his opinion, is the essential characteristic of the new revolution in the philosophy of science. According to him, preconditions mean the basic principles on which science is built, and they are more comprehensive than law and theory.[2]

A- The positivist school:

The historical development of science is a series of events, not subject to a consistent rule that can be described, nor can it be explained. All modern schools of history and philosophy of science are efforts to deny this trend and constitute a rebellion against the positivist view of science, its development and structure, and even in terms of their perceptions of the appropriate methods for solving the problems of the philosophy of science, and explaining the nature of these problems themselves. It is noteworthy that the legacy of logical empiricism tended to ignore the history of science as irrelevant to the philosophy of science, based on the belief that "there is no logic to discovery", and that the processes of adapting scientific discovery and scientific progress are the subject of study for psychology and sociology, and not the work of the logician. In addition, the philosophers of logical empiricism used to view the history of science as a record of gradual displacement of superstition and passion, and other obstacles to progress, then steadily increasing additions; this is the familiar interpretation of the history of science, which Thomas Kuhn called "the concept of development by accumulation", while H. Feigl (one of the figures of the positivist school) believes that the philosophy of science aims to clarify the nature of knowledge in terms of logical form, and to analyze scientific terms and expressions; that is, the language of science. Feigl denies other schools that recognize the history of science the right to belong to the philosophy of science, and says that the social-psychological study of science (that is, the study of science as an activity and social phenomenon) is like other activities, and the effect of the results of scientific activity on other stages of society, and the effect of the social structure on the scientific project and on the choice of problems and the conditions in which it is carried out (which is called the sociology of knowledge or the history of ideas); all of this is a

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

kind of engagement with scientific activity, and not a discussion of this activity; therefore, it is not part of the philosophy of science, which is the logic of science, and a treatment of the logical form without the content of scientific issues, and the optimal logical structure of any scientific theory without specification.[1]

Many objections have been raised against the positivist approach:

Firstly, since the philosophy of science, according to this conception, does not deal with scientific theories themselves, it becomes immune to the fluctuations of science (the emergence and disappearance of specific scientific theories), because these transformations are focused on the content of science, while the philosopher of science is concerned with the structure or structure, which is an apparent form, and he is not concerned with specific theories, but rather with the general characteristics of any possible theory, and he is concerned with the indicative meaning, that is, the meaning of the word theory itself.

Secondly, the philosopher of science in this sense is limited to providing us with a final analysis of the expressions he analyzes, and defining for us the characteristics of all possible interpretations; that is, he rather provides us with the formal characteristics of all possible interpretations in the future.

Thirdly, logical empiricism attempts to solve the problems of the philosophy of science by applying the techniques of formal logic and adhering to its method; thus, logical empiricism has lost all close connection with science in its true sense in living reality.

B - Pluralism and open options:

The second trend sees the historical development of science as a series of qualitative shifts or revolutions, without any connection between them. The most important figures in this trend are Sir Karl Raymond Popper, Paul Feyerabend, Amery Lakatos, and others. Perhaps Popper (1902-1994) is the most prominent and influential in this field. He published his first book (which was translated into English) in 1959, and chose a title that clearly expresses his rejection of the positivist position: "The Logic of Scientific Discovery." It is worth noting that Karl Popper had a close relationship with many of the logical positivist philosophers who were members of the Vienna Circle; however, he disagreed with them in most of their opinions, especially those related to the nature of the scientific issue and the possibility of verifying it, although he had his own approach in that regard. He also rejected the theory of meanings proposed by the positivists, and asserts that scientific hypotheses are not reached through induction; rather, they are formulated through creative imagination. The scientific researcher tests the scientific hypothesis by seeking evidence that proves its falsehood. But after the greatest number of these tests the hypothesis cannot be considered more than conditionally or provisionally true. Popper asserts that all that science can do is prove the falsehood of propositions; therefore, the search for

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

scientific truth consists in the gradual elimination of error, but without the hope of arriving at absolutely true knowledge that cannot be challenged.[1]

Popper does not deny that scientists establish general laws, nor that they test these laws in the light of observational data, but what he says is that when a scientific researcher "confirms a general law, he does not confirm that the law is true, or even probable. The phrase: "I have confirmed this law to a high degree" means only that I have subjected this law to severe tests or tests and it has withstood them." The laws of science are falsifiable not verifiable, and scientific knowledge, for Popper, is a project that expresses a desire to approach the truth, and it is not generated or created in a vacuum.[2]

Karl Popper says: "I believe that there is no such thing as 'instructions from outside the structure', or the passive reception of the flood of information that imprints itself on our senses; all observations are marked by the mark of theory. If Francis Bacon felt a great concern about the fact that our theories might harm our observations, and lead them to bias, and this led him to call on scientists to avoid bias and passion by purging their minds of all previous theories and judgments... However, in order to achieve objectivity, we cannot rely on an empty mind; objectivity is based on criticism, on critical discussion, and on the critical study of experiments... Theories are like the sense organs."[3]

Popper believes that scientific knowledge takes the form of a theory to describe the universe, its system, its harmony and its laws. Whenever a researcher reveals the falsity of a theory, this is evidence that he has touched the side of truth. One of the characteristics of Popper's logic of scientific discovery is that it allows for the existence of several competing theories at the same time, while stopping at judging them; since they are only subject to refutation and can never be proven correct; therefore, many of them could exist, and this is exactly what explains to us the possibility of scientific progress in Popper's opinion. Knowledge is not infallible in any way, whether it is derived from the senses or from the mind. It grows and develops through strict criticism of competing theories, and constantly exposing them to decisive tests.[4]

For a new theory to be a discovery or a step forward, it must conflict with its predecessor, or at least lead to some degree of conflicting results. But this logically means that it contradicts its predecessor; that is, it overthrows it. In this sense, progress is revolutionary. With the multiplicity of theories and the continuation of conflict and contradiction, science remains in a state of permanent revolution, contrary to what Thomas Kuhn argued that science is in a state of stability and constancy that leads to revolution, then stability and constancy, and so on. If progress in science is revolutionary and not cumulative, it is - in a sense - conservative; any new theory, no matter how revolutionary, must be able to fully explain the success of its predecessor, and provide better results. Thomas Kuhn agrees with Popper on this; he sees that the old

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[3] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[4] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

paradigm is represented by the scientists who believe in it, and does not surrender easily and smoothly to the new paradigm; Rather, the conflict between them takes place, a conflict fueled by the urgent problems of science that are on the table for discussion, until the new triumphs thanks to a new vision that resolves many of the problems causing the crisis, so that the movement of science flows easily and normally after that. However, Thomas Kuhn does not describe the movement as progress, while Popper sees the history of science as a history of steadily advancing movement, and says that science seems to be the only field in human behavior that we can describe as such, but this means that we have some standard for judging the type of any theory in comparison to its predecessor; it is a standard of progress, and this also means that progress in science can be evaluated rationally; scientific revolutions are rational in the sense that it is possible to decide their matter in principle, and to determine whether any new theory is better than its predecessor or not.[1]

Karl Popper identifies a social dimension to this progress, explaining that among the fundamental obstacles to scientific progress are those of a social nature, and he believes that they can be divided into two groups: economic obstacles and ideological obstacles. In his opinion, it is not enough to keep alternative theories alive; rather, we are deeply concerned when we do not find alternatives before us when a theory prevails and is the only one that dominates; the danger that threatens scientific progress increases if one theory has a monopoly position. We find this feature more clearly in Feyerabend, who asserts that the multiplicity of theories opens the door to the spread and prosperity of conflicting theories; an expression of the richness and wealth of scientific research in all ages, and that anarchy is the best medicine for epistemology and the philosophy of science. He says in this regard: “The history of science ultimately consists not only of facts and results derived from previous facts; it also includes ideas and interpretations of facts, problems resulting from contradictory interpretations, errors, and so on.” A careful analysis shows that science does not know "abstract facts"; our knowledge enters it, but we look at it in a special way, and therefore it is necessarily intellectual; that is, colored by our ideas. In this case, the history of science becomes complex, full of errors, and as interesting as the ideas it contains, and these ideas in turn will be complex, full of errors, and as interesting as the minds that created them. On the contrary, a little brainwashing goes a long way towards making the history of science more crude, simpler, and more smiling, as well as more "objective" and easier to control and process in the light of fixed, strict, unchanging rules; and this is what "science education" in schools as we know it today does. It simplifies science by simplifying its participants. In this way, we prefer the field of research to the rest of history. It is worth mentioning here what Thomas Kuhn said in his criticism of the method of teaching natural science in schools, which molds the ideas of students and obliges them to drawn and traditional intellectual frameworks.[2]

It is possible to create a tradition whose construction is governed by rigid rules, and which is more or less successful, but the question is: Is it right to support such a tradition to the exclusion

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

of all others? Should we make it the sole and exclusive right to treat knowledge, so that any result we reach by another method we completely exclude?... Feyerabend says in response to this question: My answer is no. He adds: I have two reasons for this answer: First, the world we seek to discover is a great entity unknown to us; therefore, we must leave our options open and not limit ourselves in advance; and second, scientific education as practiced in our schools cannot be reconciled with the humanistic attitude. It is incompatible with the cultivation of individualism, which alone can produce developed human beings.[1]

Here, Feyerabend made the construction of theory a completely free and unfettered matter, contrary to what is required by the principle of the stability and consistency of theories by the empiricists, and he also rejected the principle of the stability of meaning, and decided that any meaning of any term is subject to the theoretical context in which it appears; words do not mean something that has its own independent existence; rather, they derive their meaning from being part of a theoretical system, and thus he stripped the issues of observation of any meaning independent of the phenomenon, and also stripped them of any authority to judge theories, but rather we must interpret them by reading the meaning contained in them, and then read the theory in them. But it is worth noting that when he gave interpretation unlimited authority and unlimited possibilities, he thereby destroyed - as Dudley Shapere says - the possibility of comparing theories, on the basis of referring to experience and judging them in light of experience. Likewise, when he decided that all meanings differ according to the theoretical context and there is no way to measure them against each other, he destroyed every possibility of comparing them on another basis; Here he is similar to Thomas Kuhn in his talk about the incommensurability and the interruption of the means of translation or dialogue between the supporters of each paradigm.[2]

Feyerabend sees every epistemological or theoretical issue as a structure with its own distinct historical entity, and that this historical-structural distinction makes it impossible to compare them with each other. He says that the prevailing tendency in methodological discussions is to approach problems of knowledge as if they were eternal types; we compare issues with each other without regard to their history, and to the possibility that they may belong to different historical segments, and we consider them atemporal entities independent of the events that produced them. This approach ignores the fact that science is a complex and heterogeneous historical process. The material at the scientist's disposal: his laws and the results of his experiments, his mathematical techniques, his cognitive whims and biases, and his attitude toward the false results of the theories he accepts; all of these are infinite and ambiguous, and are never separated from the historical background. The language of observation may be linked to ancient aspects of philosophical speculation that influence the most recent methods of research.[3]

C - Cumulative development:

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[3] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

The third trend is that its proponents believe in the continuity and continuity of scientific knowledge in the form of cumulative development, and it is the most common opinion among historians of science and scientists. It can be said that this trend is the root or the first seed of the history of modern science, which began in the thirties of the last century by Whewell (1794-1866), who wrote a huge book comprising several volumes entitled: "The History of Inductive Sciences and the Philosophy of Inductive Sciences". Then there is George Sarton, who published a magazine specialized in the history and philosophy of science called "Isis", which was published in 1913, and became the mouthpiece of the Society for the History of Science in 1924. Then there is the French physicist, philosopher and historian of science, Pierre Maurice Duhem (1861-1916), who has two pioneering studies in the field of the history of science, entitled: "Leonardo da Vinci", and "The System of the World", which were published at the beginning of this century, and in which he opposes the opinion of the logical positivist school; as he confirms that scientific theory does not only explain; Rather, it links and describes empirical laws, and that science is a continuous process through the slow accumulation of empirical laws and the development of theory.[1]

There is also Werner Heisenberg (1801-1976), who sees the development of science as a succession of brilliant discoveries whose connections the mind can discover. The progress of science or the progress of scientific knowledge is achieved at the expense of previous formulations that had great significance and were replaced by other new formulations that involve an increase in knowledge and understanding; meaning that the development of science is a development of concepts thanks to the increase in the field of perception and the displacement of the new by the old. Heisenberg believed that science, if we look at it historically, will be very useful in pushing the movement of scientific development, and his opinion included a belief that science advances through leaps or mutations within the framework of thought; as he says in his book "Philosophical Problems" referred to: "The progress from the parts that have been completed to those that have been recently discovered or will be newly constructed requires each time an intellectual leap that cannot be achieved through the simple growth of existing knowledge."[2]

D - From tradition to revolution:

This school includes different trends, but they all agree on a basic idea; namely, that the historical development of science proceeds in a gradual development, leading to a qualitative leap to be the starting point for a new phase of quantitative accumulation. Here we are concerned with pointing out a school with a distinct approach, which has adopted a special expressive title for its research in the field of philosophy and history of science; which is “the science of science”. But before we talk about it, we see it necessary to point out the imam and leader of the history of science in the modern era; for his distinguished effort and profound impact that extends to the present day, and we mean by him the French philosopher of the history of science

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

Gaston Bachelard 1884-1962, who realized the nature of the crisis of the new positivism and the logical formalist tendency; and then tried to create a new philosophy consistent with the “new scientific spirit”; and he called his new doctrine “applied rationalism”, “dialectical rationalism”, and “technical rationalism”. His works are distinguished by their great value in analyzing modern science and its role in society. Bachelard believes that the new scientific spirit arose with the birth of the two modern scientific revolutions; They are Einstein's relativity and Max Planck's quantum mechanics.[1]

Bachelard rejected the positivism that Comte had adopted, starting with his view of the three stages of development; this is the view that Comte tried to use to explain the history of the emergence and development of knowledge. He based his rejection on the fact that the basic characteristic of Comte's doctrine is continuity, while the history of science, in his view, develops according to the characteristic of continuity, in addition to being subject between the stages to the principle of discontinuity or separation between these stages. For this reason, Bachelard criticized the view that the history of thought in general, and the history of science in particular, is characterized by continuity; as this means that the mind remains the same throughout all stages of its development; and thus history becomes a sterile repetition. Bachelard sets two basic concepts to explain the emergence and development of scientific knowledge; they are the concept of "epistemological discontinuity" and the concept of "epistemological obstacle". Together, the two concepts form the dialectic of the history of science according to Bachelard. By epistemological obstacle, he means "effective repressions", and he compares them to Freud's unconscious, which affects human behavior and the choices and orientations of the researcher. Bachelard argued that the history of scientific knowledge advances by overcoming obstacles, such as ignorance and errors, which increase the obscurity of the problems that reason strives to overcome.[2]

[1] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.
[2] شوقي جلال، على طريق توماس كون: رؤية نقدية لفلسفة تاريخ العلم في ضوء نظرية توماس كون، القاهرة، ص 70-93.

The Importance of The History of Science

From an Epistemological Perspective

The history of science has a great heuristic value, especially if it has been arrived at by someone who is as familiar with modern scientific tendencies as with ancient ones. The sequence of ancient discoveries points out similar sequences to the scientist, and thus enables him to make new discoveries. Unused methods, intelligently modified, may become effective again. When understood in this way, the history of science really becomes a method of inquiry.[1] This is what makes the history of science so scientifically important. On the one hand, it is a laboratory for the philosophy of science and for scientific progress as such.

In any case, new and old sciences continually complement and help each other to advance and reduce the unknown that surrounds us everywhere. Does this idea not throw light on our concept of universal scientific cooperation? Death itself does not interrupt the work of the scientist, and theories once revealed live on in their effectiveness forever. To give our history all its evidential value, it is not enough to trace the progress of the human mind, but it is also necessary to remember the declines, the sudden stops, and the accidents of all kinds that interrupted its course. The history of errors is very useful; for one thing, because it helps us to appreciate better the development of truth; also because it enables us to avoid the same errors in the future; finally, because the errors of science are of a relative nature. Today's truths may be regarded tomorrow, if not as complete errors, at least as imperfect truths; and who knows whether yesterday's errors will not be the approximate truths of tomorrow? Rehabilitations occur frequently, and the results of historical research often oblige us to admire and honor people who were misunderstood and despised in their time. This proves to us incidentally that the study of the history of science also has certain moral advantages.[2]

But the history of superstitions and errors must not make us forget that it is the history of truth? the most complete and highest truths? that interests us in the first place. Moreover, one may aim to restore the history of truth in its entirety, for it is naturally limited, but the history of errors is infinite. It is therefore necessary to set some artificial limits to the latter and to choose wisely between errors and superstitions. A great simplification is obtained by classifying errors into groups. In fact, the same errors and superstitions appear again and again in different forms, and it is useful to know the different types of errors in order to understand the mechanisms of reason.[3]

The history of science constitutes a laboratory and scientific material for the philosophy of science to direct criticism at it, thus opening new horizons for research or rehabilitating theories or vice versa. Therefore, the history of science is the history of errors that can later become theories, because science takes on a relative nature, as all contemporary scientific histories and philosophies of science have proven.

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[1] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.344.
[2] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.344.
[3] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.345.

From a Pedagogical Perspective

The scientific revolution in the seventeenth century proved the effectiveness of science as a human activity in society and civilization and as a dominant force later in the twentieth century. This made many thinkers and philosophers of education realize that understanding the development of science and its impact on societies is a vital subject and an essential part of education programs, because studying the history of science provides an understanding of the relationship of science to various aspects of human life, especially development and civilization.

In addition to the importance of building a scientific knowledge background that helps in understanding the history of science, it helps in the critical comparative view, and understanding the scientific material more in its historical context with its social and other dimensions, and it also provides a deeper understanding and knowledge of the educational process and scientific research methodology and enhances the student's skills in dealing with scientific ideas.

Social factors are important in influencing social and educational culture, because knowing how science developed in its social context not only gives us valuable insight into our own culture but also provides insight into changing the way we organize and use science. The formation of historical awareness from this perspective suggests creative ways of solving problems and develops expertise in dealing with scientific ideas. The history of civilizations and their achievements cannot be studied or discussed in isolation from science, which is the vital engine of civilizational development and the determinant of political history and the course of conflicts in contemporary centuries. Scientific progress has always been a decisive factor in the victory of world wars.

Knowing the history of science and the development of ideas within educational curricula enhances identity and belonging to society, and thus understanding the social, political, economic and civilizational impact of science and scientists in writing general history, with the aim of stimulating enthusiasm and stimulating the spirit of creativity in the student, through calling for the preservation of this heritage in society through pride in belonging.

In many countries one cannot become a teacher, at least in secondary schools, if one has not studied the history of pedagogy. But is it any less important to know the history of what is taught? Would not anyone who knows this history be better equipped to distinguish what is essential and truly interesting from what is not, and to teach his pupils the best of each science? Moreover, would not the history of science illuminate the history of pedagogy?[1] Sarton asked himself this question when he began his discussion of the educational and pedagogical importance of the history of science.

Nothing, adds Sarton, is more useful from this point of view than to make some textbooks in which science will be explained in historical chronological order; this is indeed a very important task, for which Ernst Mach has given us some excellent models, because such historical

[1] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.351.

textbooks will put teachers in a particularly good position, by enabling them to make their lessons clearer and more accessible. Nothing is better for developing the critical sense of the pupil and testing his profession than to retrace the whole history, to see in detail all the obstacles which continually arise in the path of the inventor, to see also how the man of science overcomes or evades them, and finally how he approaches more and more the goal without ever reaching it. Besides, this historical education will cure young pupils of the unfortunate habit of thinking that science began with them.[1]

Good scientific biographies have great educational value; they lead the adolescent's imagination in the best direction. Critical and honest biographies make excellent contributions to the history of mankind. Would students not work with a better heart and greater enthusiasm? Would they not have a deeper respect for science, if they knew a little about the heroes who built it stone by stone with so much suffering, struggle, and perseverance? Would they not be more eager to do some honest research work? Or would they not at least appreciate the greatness and beauty of the world better if they shared, in some measure, in the joy and vigilance of seeing it realized amidst constant difficulties?[2]

Finally, the history of science—more than ordinary history—is a general education in itself, which introduces us to the ideas of the continuous evolution and transformation of human ideas, techniques, and discoveries; it surprises us with an understanding of the relative and unstable nature of all our knowledge; it sharpens our spirits, it shows us that if the achievements of humanity as a whole are truly great, the contribution of each of us to them is not small, and that the greatest must be modest; it helps to form scientists who are not just scientists but also men and citizens.[3]

[1] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.352.
[2] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.353.
[3] George Sarton, The History of Science, The Monist, Volume 26, Issue 3, 1 July 1916, 2014. p.353.

History of Science in Mesopotamia

Mesopotamia, a historical region in Western Asia, is situated within the Tigris–Euphrates River system, in the northern part of the Fertile Crescent. In contemporary terms, it largely corresponds to most of Iraq, Kuwait, eastern Syria, southeastern Turkey, and areas along the Turkish–Syrian and Iranian–Iraqi borders. The Sumerians and Akkadians, including the Assyrians and Babylonians, governed Mesopotamia from the dawn of written history (circa 3100 BC) until the fall of Babylon in 539 BC, when it was conquered by the Achaemenid Empire. It subsequently fell to Alexander the Great in 332 BC, after whose death it became part of the Greek Seleucid Empire. This collection of states was established in the valley of the Tigris and Euphrates rivers. The Greeks referred to this land as Mesopotamia, as much of it was situated between the two rivers. The inhabitants were of Semitic origin, thus sharing ethnic ties with the ancient Hebrews and Phoenicians, as well as the Arameans and Arabs.[1]

The relationship between the study of physical phenomena in ancient Mesopotamia and the history of science is a matter of significant importance to both fields. It explores the nature of knowledge within one of the earliest literate cultures and examines the historical scope of what we define as science. If the essence of science lies in its methodological approach to understanding phenomena and the diverse practices linked to these knowledge systems—such as astronomical observation, prediction, and interpretation—then science was indeed a fundamental component of cuneiform intellectual culture.[2]

Science and technology flourished in Mesopotamia during the Uruk period (4100-2900 BC) and the Early Dynastic period (2900-1750 BC) of the Sumerian culture in southern Mesopotamia. The Sumerians established the groundwork for subsequent advancements in scientific and technological progress, pioneering the practice of scientific hypothesis, engaging in technological innovation, inventing writing, and developing mathematics, astronomy, astrology, and the very concept of time. Among the most significant inventions attributed to the Sumerians are the wheel, the sail, writing, maps, mathematics, timekeeping devices, astronomy and astrology, medicinal drugs, and surgical techniques.[3]

Mathematics in Ancient Mesopotamia

Mathematics may have originated from commerce as a necessity for accounting, yet it is evident that it played a significant role in architecture, particularly in the planning and construction of cities and their temples. During the development of these remarkable cities and monumental structures, the Sumerians seemingly devised the mathematical model of the Pythagorean theorem

[1] Smith Williams, A History of science Henry, vol.1, The Beginnings of Science, Harper & Brothers, London: 1904, pp.56, 57.
[2] Francesca Rochberg, The Cambridge History of Science, Vol 1: Ancient Science, Cambridge University Press, 2018, pp 7-28.
[3] Joshua J. Mark, Mesopotamian Science and Technology, published on 11 October 2019. [https://www.ancient.eu/Mesopotamian_Science/]. 28/02/2026. 20:46.

centuries prior to Pythagoras's existence. This is unsurprising, as the cities of Mesopotamia were renowned as prominent centers of learning and culture—most notably Babylon, which thrived from 1792 to 600 BC, where the Greek philosopher Thales of Miletus is believed to have studied. In the historical records of science, this is referred to as Babylonian mathematics or Assyro-Babylonian mathematics, encompassing any mathematical practices or developments by the inhabitants of Mesopotamia, from the era of the early Sumerians to the centuries following the fall of Babylon in 539 BC. The Babylonian mathematical texts are plentiful and well-crafted.[1]

While Egyptian mathematical records are relatively rare, our understanding of Babylonian mathematics comes from clay tablets discovered since the 1850s [2]. These records were created by pressing cuneiform script into soft clay, which was then hardened by the sun or in ovens to ensure durability. Most of these tablets were produced between 1800 and 1600 BC and demonstrate that Babylonian scholars studied complex topics, including algebra, fractions, and cubic equations [3]. Notably, the tablet known as **YBC 7289** shows that they could calculate the square root of two with a high degree of precision, reaching an accuracy of about six decimal places.[4]

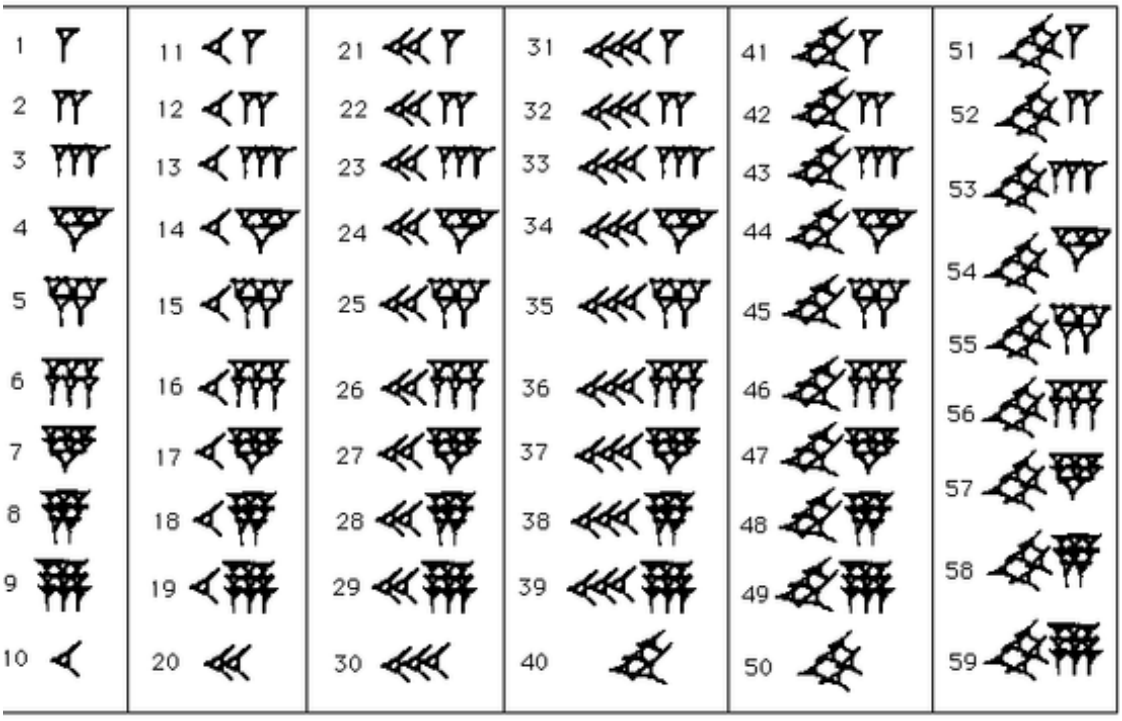
In the history of science, ancient Mesopotamia is recognized as one of the earliest centers of mathematical and scientific knowledge. Mesopotamian scholars developed a sexagesimal (base-60) number system, which still influences modern science through the division of time into 60 minutes per hour, 24 hours per day, and the circle into 360 degrees. The Sumerians also organized time using a seven-day week, showing an early attempt to systematize natural cycles. Babylonian mathematicians created practical methods to calculate areas and volumes of geometric shapes, including cylinders, cones, and pyramids, although some formulas were not fully accurate by modern standards. They commonly approximated the value of π as 3, but clay tablets reveal that more precise values such as 25/8 (3.125) were also used. These mathematical advances supported early astronomy, cartography, and measurement systems, such as the Babylonian mile, which linked distance with the movement of the sun. Together, these achievements demonstrate how early scientific thinking emerged from practical needs and laid foundations for later developments in mathematics and science (Neugebauer, 1957; Robson, 2008).[5]

The Babylonian mathematical system was based on the sexagesimal (base 60) number system, which facilitated significant advancements in mathematics for two primary reasons. Firstly, the number 60 is a highly composite number, possessing factors of 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30,

[1] Joshua J. Mark, Mesopotamian Science and Technology, published on 11 October 2019. [https://www.ancient.eu/Mesopotamian_Science/]. 13/12/2020. 20:46.
[2] Neugebauer, O. (1969). The Exact Sciences in Antiquity. Dover Publications.
[3] Robson, E. (2008). Mathematics in Ancient Iraq: A Social History. Princeton University Press.
[4] Fowler, D. H., & Robson, E. (1998). Square Root Approximations in Old Babylonian Mathematics: YBC 7289 in Context. Historia Mathematica, 25(4), 366–378.
[5] Eves, Howard, An Introduction to the History of Mathematics. Holt, Rinehart and Winston, 1969. p. 31.

and 60 (including those that are composite), thereby simplifying calculations involving fractions. In contrast to the Egyptians and Romans, the Babylonians employed a true place value system, where the numbers in the left column denoted larger values (similar to our base 10 system, where $734 = 7 \times 100 + 3 \times 10 + 4 \times 1$).[1]

Only two symbols (Babylonian for counting ones and Babylonian for counting tens) were employed to denote the 59 non-zero digits, as illustrated in the image below:



Babylonian Cuneiform Numerals Utilize Merely Two Symbols for Expression.

The Babylonians did not possess a number or concept of zero. While they grasped the notion of nothingness, it was not regarded as a number but merely as an absence of quantity. Subsequent Babylonian texts employed a placeholder (the Babylonian numeral) to signify zero, but this was limited to the middle positions, not the right side of the number, as is done in modern numerals such as 100.

The ancient Sumerians of Mesopotamia established a sophisticated system of measurement around 3000 BC. Beginning in 2600 BC, the Sumerians recorded multiplication tables on clay

[1] Lucas N. H. Bunt, Phillip S. Jones, Jack D. Bedient (2001). The Historical Roots of Elementary Mathematics (reprint ed.). Courier Corporation. p. 44.

tablets and engaged in geometric exercises and division problems. The earliest evidence of Babylonian numerals also originates from this period.[1]

Most clay tablets detailing Babylonian mathematics originate from ancient Babylon, which is why Mesopotamian mathematics is commonly referred to as Babylonian mathematics. Some tablets feature mathematical lists and tables, while others present practical problems and their solutions.

The Babylonians employed pre-calculated tables to facilitate calculations. For instance, two tablets discovered at Sinkara on the Euphrates in 1854, dating back to 2000 BC, provide lists of squares of numbers up to 59 and cubes of numbers up to 32. The Babylonians utilized these lists of squares along with the formulas below to streamline multiplication.[2]

$$ab = \frac{(a+b)^2 - a^2 - b^2}{2}$$

$$ab = \frac{(a+b)^2 - (a-b)^2}{4}$$

This demonstrates that a table of squares suffices for multiplying numbers by calculating the difference between the two squares referenced in the table and subsequently taking a quarter of the result.

Division presents greater challenges, as the Babylonians lacked an algorithm for long division. Instead, their method relied on the principle that only the reciprocal of the number is required. $\frac{a}{b} = a \times \frac{1}{b}$

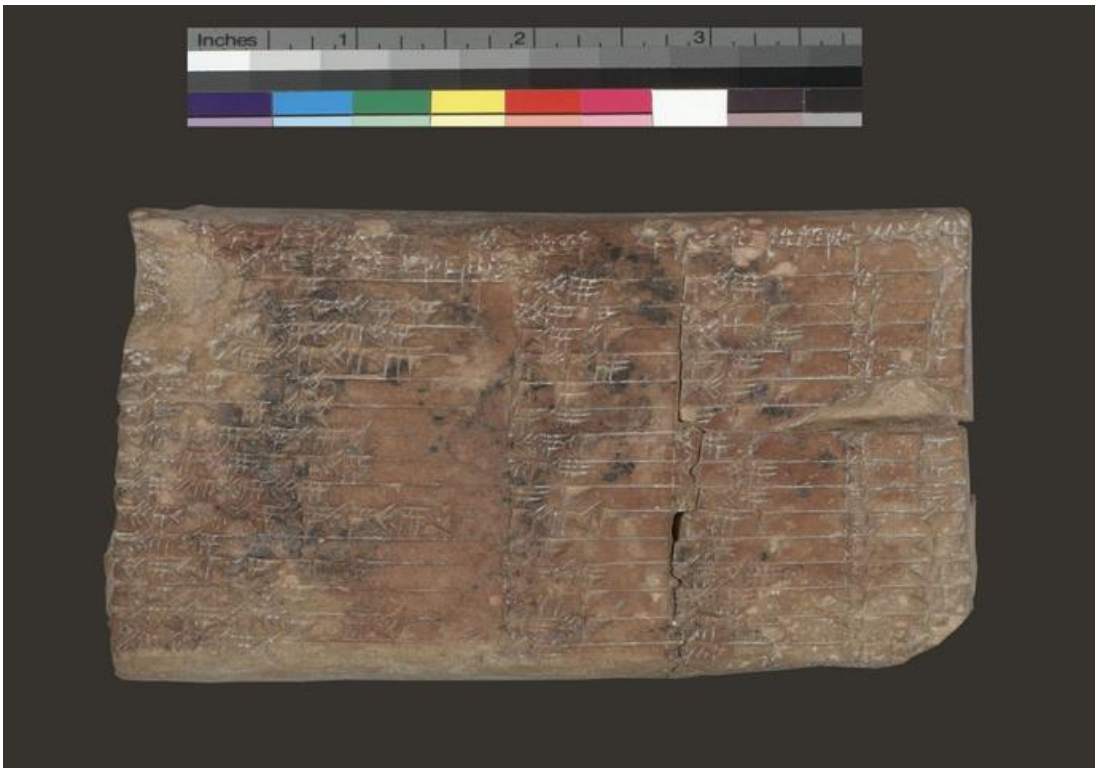
Since $\frac{1}{13}$ ، $\frac{1}{11}$ ، $\frac{1}{7}$. are not precise fractions based on 60. This does not imply that the Babylonians were incapable of calculations; for instance, they would express: $\frac{1}{13} = \frac{7}{91} = 7 \times \frac{1}{91} \approx 7 \times \frac{1}{90}$

It was previously mentioned that the Babylonians were renowned for constructing tables that facilitated the resolution of equations. For instance, they developed tables $n^2 + n^3$ to assist in solving certain third-degree equations. Similarly, $ax^3 + bx^2 = c$ they were capable of solving second-degree equations using this method, although they established a singular model for these equations. [3]

Plimpton 322 is a Babylonian clay tablet, distinguished for its representation of Babylonian mathematics, designated as 322 in the GA, Plimpton Collection at Columbia University. The

[1] Duncan J. Melville (2003). Third Millennium Chronology, Third Millennium Mathematics. St. Lawrence University.
[2] J O'Connor and E F Robertson, An overview of Babylonian mathematics, School of Mathematics and Statistics University of St Andrews, Scotland, 200. [https://mathshistory.st-andrews.ac.uk/HistTopics/Babylonian_mathematics/].
[3] J O'Connor and E F Robertson, An overview of Babylonian mathematics.

tablet is believed to have been inscribed around 1800 BC and features a table comprising four columns and 15 rows of numbers in the cuneiform script of the era. The table enumerates two of the three numbers in what are now referred to as Pythagorean triples, specifically the integers a, b, and c that fulfill the equation $a^2 + b^2 = c^2$. From a contemporary viewpoint, the methodology for constructing such triples constitutes a significant early accomplishment, recognized long before Greek and Indian mathematicians identified solutions to the problem. It is also essential to acknowledge that the tablet's author was a scribe rather than a professional mathematician; it has been posited that one of his objectives may have been to furnish examples for educational mathematics exercises.[1]



"Plimpton Cuneiform 322, Cuneiform Tablet," Columbia University Libraries Online Exhibitions, accessed December 15, 2020, https://exhibitions.library.columbia.edu/exhibits/show/jewels/item/10987.

Boyer, in his History of Mathematics, regards the algebraic accomplishments of the Babylonians as remarkable, yet the underlying motivations for this work remain elusive. It is often presumed that all pre-Hellenic science and mathematics were strictly utilitarian; however, what genuine circumstances in ancient Babylon might have prompted inquiries into the sum and reciprocal of a

[1] [https://exhibitions.library.columbia.edu/exhibits/show/jewels/themes/science] 02/28/2026, 17:27.

number or the disparity between area and length? The direct connections between intention and application in Babylonian mathematics are not as straightforward as they seem. Tablet 322 in the Plimpton Collection at Columbia University indicates that mathematics pursued for its own sake may have been not only tolerated but possibly encouraged. This tablet, dating from the Old Babylonian period (c. 1900–1600 BCE), contains tables that could readily be interpreted as records of business transactions. Nevertheless, analysis reveals that it possesses significant mathematical implications in number theory and may have been associated with an early form of trigonometry. [1]

The Babylonians possessed a fundamental understanding of the principles governing the measurement of volumes and areas. They calculated the circumference of a circle as three times the diameter and determined the area as one-twelfth of the square of the circumference, which would be accurate if π were approximated as 3. They recognized this as an estimation. An ancient Babylonian tablet, unearthed near Susa in 1936 and dating from the 19th to the 17th centuries BC, provides a more precise approximation of π as 25/8, equating to 3.125, which is approximately 0.5 percent less than the true value. The volume of a cylinder was regarded as the product of its base and height; however, the volume of a cone or square pyramid was inaccurately calculated as the product of the height and half the sum of the bases. Additionally, the Babylonians were aware of the Pythagorean theorem.[2]

The ancient Babylonians possessed knowledge of theories concerning the proportions of the sides of similar triangles; however, they did not have the concept of measuring angles and thus focused on the sides of triangles instead. Babylonian astronomers meticulously documented the rising and setting of stars, the motion of planets, and solar and lunar eclipses, all of which necessitated an understanding of measured angular distances on the celestial sphere.[3] They also employed a form of Fourier analysis to compute the ephemeris (tables of astronomical positions), a discovery made by Otto Neugebauer in the 1950s. To determine the movements of celestial bodies, the Babylonians utilized basic arithmetic and a coordinate system based on the ecliptic, the region of the sky traversed by the sun and planets. Tablets housed in the British Museum provide evidence that the Babylonians conceptualized objects in abstract mathematical space. These tablets, dating from 350 to 50 BC, indicate that the Babylonians comprehended and utilized geometry even earlier than previously believed.[4]

The ancient Babylonians possessed knowledge of significant geometric relationships. Similar to the Egyptians, they understood that the altitude of an isosceles triangle bisects the base, allowing them to determine the perpendicular to a regular polygon from the length of the hypotenuse of a circle with a known radius. In contrast to the Egyptians, they recognized that the angle subtended by a semicircle is a right angle, a principle commonly referred to as Thales's theorem, despite

[1] Carl B Boyer and Uta C Merzbach , History Mathematics, 3rd Edition, p.32.
[2] Carl B Boyer and Uta C Merzbach , History Mathematics, 3rd Edition, p.37.
[3] Maor, Eli (1998). Trigonometric Delights. Princeton University Press. p. 20.
[4] Emspak, Jesse. "Babylonians Were Using Geometry Centuries Earlier Than Thought". Smithsonian.

Thales having lived over a millennium after the Babylonians first employed it. Boyer contends that cuneiform tablets possess a durability unmatched by documents from other civilizations, as papyrus and parchment are less resilient to the passage of time. Moreover, cuneiform texts continued to be produced until the advent of the Christian era; however, it remains uncertain whether they were comprehended by neighboring civilizations, particularly the Greeks. The epicenter of mathematical development had shifted from the Mesopotamian valley to the Greek world six centuries prior to the commencement of our era, yet the reconstruction of early Greek mathematics is rendered perilously challenging due to the scarcity of extant mathematical documents from before the Hellenistic period. Thus, it is crucial to consider these overarching characteristics of Egyptian and Babylonian mathematics to formulate reasonable hypotheses regarding potential parallels between pre-Hellenic contributions and the endeavors and perspectives of subsequent cultures.[1]

Astronomy in Mesopotamia

Babylonian astronomy encompasses the study and documentation of celestial bodies during the formative period of Mesopotamia. These records are preserved on Sumerian clay tablets, inscribed in cuneiform, and date back to approximately 1000 BC. In conjunction with their mythology, the Sumerians cultivated a distinctive form of astronomy and astrology that significantly influenced Babylonian culture, wherein planetary deities held a prominent position. Babylonian astronomy appears to have concentrated on a select group of stars and constellations referred to as the Ziqpu stars.[2] These constellations may have been synthesized from various earlier sources. The earliest record references the Three Stars Each, the stars of the Akkadian Empire, the stars of Amurru and Elam, among others.[3]

The sexagesimal numbering system was employed, facilitating the calculation and documentation of both large and small numbers. The contemporary convention of dividing a circle into 360 degrees, each comprising 60 minutes, originates from the Sumerians.

During the 8th and 7th centuries BC, Babylonian astronomers pioneered a novel empirical methodology in astronomy. They commenced the study and documentation of their belief systems and philosophies concerning the ideal nature of the universe, employing internal logic within their predictive planetary models. This marked a significant advancement in both astronomy and the philosophy of science, leading some contemporary scholars to designate this innovative approach as the First Scientific Revolution.[4] This methodology was subsequently embraced and further refined in Greek and Hellenistic astrology. Classical Greek and Latin texts frequently refer to Mesopotamian astronomers as Chaldeans, who were regarded as scribes and writers with expertise in astrology and various forms of divination.

[1] Carl B Boyer and Uta C Merzbach , History Mathematics, 3rd Edition, p.38.
[2] Hunger, Herman (1999). "Ziqpu Star Texts". Astral Sciences in Mesopotamia. Brill. pp. 84–90.
[3] History of the Constellations and Star Names — D.4: Sumerian constellations and star names? Archived 2015-09-07 at the Wayback Machine, by Gary D. Thompson
[4] D. Brown (2000), Mesopotamian Planetary Astronomy-Astrology, Styx Publications,

Only fragments of Babylonian astronomy endure, primarily comprising contemporary clay tablets that contain astronomical notes, records of events, and procedural texts. Consequently, our understanding of Babylonian planetary theory remains incomplete. Nevertheless, the extant fragments indicate that Babylonian astronomy represented the first successful endeavor to provide an accurate mathematical description of astronomical phenomena, and that all subsequent forms of scientific astronomy—whether in the Hellenistic world, India, Islam, or the West—are fundamentally reliant on Babylonian astronomy in critical and essential ways.[1]

The roots of Western astronomy trace back to Mesopotamia, with all Western endeavors in the exact sciences being direct descendants of the contributions made by late Babylonian astronomers. Contemporary understanding of Sumerian astronomy is derived indirectly from the earliest Babylonian star catalogues, which date to approximately 1200 BC. The presence of numerous star names in Sumerian indicates a continuity extending back to the Early Bronze Age.[2]

"Old" Babylonian astronomy was practiced during and after the First Babylonian dynasty (circa 1830 BCE) and prior to the Neo-Babylonian Empire (circa 626 BCE). The Babylonians were pioneers in recognizing the cyclical nature of astronomical phenomena and in applying mathematics to their predictions. Tablets from the Old Babylonian period document the use of mathematics to analyze variations in daylight length throughout the solar year. Babylonian observations of celestial events were meticulously recorded over centuries in a series of cuneiform tablets known as the Enûma Anu Enlil. Our earliest significant astronomical text is Tablet 63 of the Enûma Anu Enlil, the Venus Tablet of Ammisaduqa, which details the first and last visible risings of Venus over approximately 21 years. This represents the earliest evidence of the recognition of planetary phenomena as cyclical.[3]

Our primary interest lies in astronomy, which, much like in Egypt, is regarded as the foremost and most significant of the sciences. The renown of the Chaldean astronomer indeed captivated the Greeks, and through the outcomes of astronomical observations, Babylonia imparted its most profound influences to the Western world. "Our division of time is of Babylonian origin," states Hornmel; "to Babylon we owe the seven-day week, along with the planetary names assigned to the days of the week, as well as the divisions into hours and months." Thus, we should feel a nearly personal connection to the endeavors of the Babylonian stargazer today.[4]

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[1] A. Aaboe (May 2, 1974). "Scientific Astronomy in Antiquity". Philosophical Transactions of the Royal Society. 276 (1257): 21–42.

[2] Aaboe, Asger (1991), "The culture of Babylonia: Babylonian mathematics, astrology, and astronomy", in Boardman, John; Edwards, I. E. S.; Hammond, N. G. L.; Sollberger, E.; Walker, C. B. F (eds.), The Assyrian and Babylonian Empires and other States of the Near East, from the Eighth to the Sixth Centuries B.C., The Cambridge Ancient History, 3, Cambridge: Cambridge University Press, pp. 276–292,

[3] Holden, James H. (2006). A History of Horoscopic Astrology. American Federation of Astrologers, Inc.

[4] Williams H.S. A history of science, p.26.

An artifact known as the ivory prism was discovered in the ruins of Nineveh. Initially believed to outline the rules for a game, it was subsequently interpreted as a unit converter for calculating the movements of celestial bodies and constellations.[1]

The Babylonians were the first civilization recognized for developing a functional theory of the planets, and the oldest extant planetary astronomical text is the Babylonian Venus Tablet of Amsadoka, a 7th-century BC copy of a compilation of observations regarding the motions of the planet Venus, likely originating in the 2nd millennium BC. Additionally, Babylonian astrologers established the foundational principles that would ultimately evolve into Western astrology. The Enuma anu enlil, composed during the Neo-Assyrian period in the 7th century BC, encompasses a catalog of omens and their correlations with various celestial phenomena, including planetary movements.[2]

In contrast to the worldview articulated in Mesopotamian and Assyro-Babylonian literature, particularly within Mesopotamian and Babylonian mythology, our understanding of ancient Babylonian cosmology and astronomy remains limited, primarily due to the fragmentary nature of Babylonian planetary theory and the autonomy of Babylonian astronomy from cosmological considerations during that period. Nevertheless, remnants of cosmological thought can be discerned in Babylonian literature and mythology. Babylonian cosmology portrayed the Earth and heavens as "a spatial unit, even one of circular shape," referencing "the circumference of heaven and earth" and "the totality of heaven and earth." Their perspective was not geocentric; rather, Babylonian cosmology posited that the universe revolved in a circular manner, with the heavens and earth perceived as equal and interconnected, mirroring the beliefs of the Babylonians and their predecessors, the Sumerians, regarding the plurality of heavens and earth. This concept can be traced back to Sumerian spells from the 2nd millennium BC, which allude to the existence of seven heavens and seven earths, potentially linked chronologically to the creation of seven generations of deities.[3]

The Astrolabe (not to be confused with the later astronomical measuring instrument of the same name) is among the earliest documented cuneiform tablets addressing astronomy, originating from the Old Babylonian Kingdom. It comprises a list of thirty-six stars linked to the months of the year. It is generally believed to have been composed between 1800 and 1100 BC. Although no complete texts have been discovered, a recent compilation by Pinches, derived from texts in

[1] Van der Waerden, B. L. (1951). "Babylonian Astronomy. III. The Earliest Astronomical Computations". Journal of Near Eastern Studies. 10 (1): 20–34.
[2] Lambert, W. G.; Reiner, Erica (1987). "Babylonian Planetary Omens. Part One. Enuma Anu Enlil, Tablet 63: The Venus Tablet of Ammisaduqa". Journal of the American Oriental Society. 107 (1): 93.
[3] Norriss S. Hetherington (1993). Cosmology: historical, literary, philosophical, religious, and scientific perspectives. Taylor & Francis. p. 44

the British Museum, is regarded as excellent by historians specializing in Babylonian astronomy. Additionally, two other texts pertinent to the Astrolabe are the Brussels and Berlin compilations.[1]

The thirty-six stars comprising the astrolabe are believed to have originated from the astronomical traditions of three Mesopotamian states: Elam, Akkad, and Amurru. The stars delineated and possibly depicted by these city-states are identical to those represented on the astrolabe. Each region was associated with a set of twelve stars, collectively totaling thirty-six stars on the astrolabe. The twelve stars from each region also corresponded to the months of the year. The two cuneiform texts that substantiate this assertion are the extensive star list "K 250" and "K 8067." Both texts were translated and reproduced by Widener. During Hammurabi's reign, these three distinct traditions were amalgamated, resulting in a more scientific approach to astronomy as the connections to the original three traditions diminished. The growing application of science in astronomy is evident in the arrangement of traditions from these three regions according to the paths of the stars Ea, Anu, and Enlil, an astronomical system included and discussed in Mul.apin.[2]

MUL.APIN comprises a pair of cuneiform tablets (Tablet 1 and Tablet 2) that document various aspects of Babylonian astronomy, including the motion of celestial bodies and records of solstices and eclipses. Each tablet is further subdivided into smaller sections known as lists. It is situated within the broader timeline of the Astrolabe and Enuma Anu Enlil, as indicated by overlapping topics, mathematical principles, and events. Tablet 1 contains information that closely aligns with that found in Astrolabe B. The parallels between Tablet 1 and Astrolabe B imply that the authors may have drawn from a common source for at least some of their data. This tablet features six lists of stars corresponding to sixty constellations within the designated paths for the three groups of Babylonian star paths: Ea, Anu, and Enlil. Additionally, there are modifications to the paths of both Anu and Enlil that are absent in Astrolabe B.[3]

The exploration of the sun, moon, and other celestial bodies significantly influenced the evolution of Mesopotamian culture. The study of the heavens facilitated the creation of sophisticated calendars and mathematical systems within these societies. While the Babylonians were not the first complex civilization to establish a universal calendar, as the Egyptians had developed their own, the two systems differed fundamentally. The Egyptian calendar was solar-based, whereas the Babylonian calendar was lunar-based. Some historians note a potential amalgamation between the two, particularly in the Babylonians' adoption of a rudimentary leap year following the Egyptians' innovation. However, the Babylonian leap year bears no resemblance to the contemporary leap year; it entailed the addition of a thirteenth month to realign the calendar with the agricultural season. Babylonian priests played a crucial role in the

[1] Van der Waerden, B. L. (1949). "Babylonian Astronomy. II. The Thirty-Six Stars". Journal of Near Eastern Studies. 8 (1): 6–26.
[2] Van der Waerden, B. L. (1949). "Babylonian Astronomy. II. The Thirty-Six Stars". Journal of Near Eastern Studies. 8 (1): 6–26.
[3] Hunger, Herman (1999). "MUL.APIN". Astral Sciences in Mesopotamia. Brill. pp. 57–65.

advancement of new mathematical forms, which were essential for accurately tracking the movements of celestial bodies. Among these priests, Nabu-Rumanni stands out as the first documented Babylonian astronomer. A priest of the moon god, he is credited with creating tables for calculating lunar phases and eclipses, as well as other intricate mathematical computations. His calculation tables were systematically organized into seventeen or eighteen records detailing the orbital velocities of the planets and the Moon. His contributions were later referenced by astronomers during the Seleucid dynasty.[1]

Medicine in Mesopotamia

There is no doubt that medicine is among the earliest sciences and bodies of knowledge that humanity has recognized or practiced since ancient times, driven by instinct and a desire to alleviate suffering. Consequently, individuals diligently sought out methods to maintain their health and well-being, motivated by the fear of succumbing to illness. Through chance discoveries and repeated experimentation, as well as by observing animal behavior, they arrived at various effective treatments. In those earlier times, medicine was often intertwined with quackery and sorcery.

The civilizations of Mesopotamia were renowned for their advancements in medical sciences, as Iraqi pharmacists were pioneers in the preparation of medicines and drugs, including novel compound formulations. They were the first to develop and document a pharmacopoeia, which continued to serve as a reference in hospitals and pharmacies. Additionally, they established the first pharmacy shops, a fact evidenced by the drug names adopted by Western civilization, many of which still retain their Arabic, Persian, and Indian origins. Consequently, it is unsurprising that the field of medicine owes a significant debt to the pharmacists of Mesopotamian civilization for the art of pharmacy, encompassing numerous preparations still in use today, such as beverages, lozenges, plasters, ointments, and distilled water, along with various drugs like tamarind, cochineal, camphor, and alcohol.[2]

The Mesopotamian civilization coexisted with the ancient Egyptian civilization, and medicine constituted a significant facet of this society. Herodotus noted that the ancient Babylonians and Assyrians would position their patients in public squares outside the cities to showcase them to passersby, allowing individuals to approach and inquire about their ailments. Those who had suffered from a particular disease and subsequently recovered would advise the afflicted individuals to employ the same medicinal methods that facilitated their own recovery.[3]

Medical assessment and admission to a healthcare facility

[1] Olmstead, A. T. (1938). "Babylonian Astronomy: Historical Sketch". The American Journal of Semitic Languages and Literatures. 55 (2): 113–129.

[2] تاريخ الصيدلة في بلاد الرافدين، [https://learning.aljazeera.net/en/languageofmedia].

[3] سليم نحلة، المعارف الطبية ما بين النهرين، علوم وتكنولوجيا آذار 27, 2015، [https://kassioun.org/more-categories/science-and-technology/item/38851-12446].

The earliest Babylonian (i.e., Akkadian) texts concerning medicine can be traced back to the First Babylonian Dynasty in the initial half of the second millennium BC, although the oldest medical prescriptions in the Sumerian language emerged during the Third Dynasty of Ur. Notably, the most comprehensive Babylonian medical text is the Diagnostic Manual, authored by the chief scholar, Esagil-kin-apli of Borsippa, during the reign of King Adad-apla-iddina (1069-1046 BC).[1] Some sources assert that the oldest medical writings date to the third millennium BC, with the Code of Hammurabi recognized as the earliest legal document pertaining to Babylonian medicine. Regarding treatment methods, cuneiform texts indicate that the inhabitants of Mesopotamia utilized oil in various medical applications, employed tar to treat ulcers and alleviate inflammations and tumors when mixed with sulfur, and used oil to address certain skin diseases in both humans and animals. Additionally, oil was applied in the treatment of joint diseases, paralysis, and conditions affecting the eyes, such as cataracts. The Assyrians utilized tar for disinfecting wounds. The Babylonians exhibited a keen interest in anatomy, particularly concerning heart and liver ailments. Physicians employed intoxicants in their treatments, alongside practices involving possession. They possessed knowledge of surgical techniques and utilized hashish and opium as anesthetics during operations. The tablets unearthed by Sir Harry LaPard in 1849 AD from the Ashurbanipal Library in the ruins of Nineveh revealed numerous medical prescriptions that were prevalent at that time. Furthermore, the Code of Hammurabi includes a provision stating that doctors and employees who neglect their duties should be held accountable. The Hammurabi Tablet outlines six clauses related to the medical profession's constitution, regulating its practice and imposing responsibility on physicians for errors made in patient care. It also mandated a punishment of blindness for wet nurses who failed to adequately care for the infants entrusted to them, underscoring the awareness of these societies regarding the physician's ethical responsibility toward patients and the necessity of diligent care and treatment.[2]

The cuneiform texts discovered in Iraq at the onset of the second millennium BC reference various medical practitioners, including doctors, surgeons, bone setters, veterinarians, and ophthalmologists, some of whom are noted in the Code of Hammurabi. Physicians held different ranks, with the chief doctor overseeing the others. They donned distinctive garments that set them apart and possessed specialized tools and instruments. The ophthalmologist held a significant position, utilizing a specific eye ointment for treating conjunctivitis, which was prevalent in the region. This ointment was composed of plants cooked in fat or raw copper extract mixed with beer. For individuals suffering from constipation, a concoction of the cooked plant mixture was consumed with beer. A wide array of elements, whether mineral, plant, or animal in origin, was employed in the formulation of medicines. Deer dung was not considered the most repugnant substance, and certain physicians enjoyed a high level of esteem.[3]

[1] Leo Oppenheim (1977). Ancient Mesopotamia: Portrait of a Dead Civilization. University of Chicago Press. p. 290.

[2] سليم نحلة، المعارف الطبية ما بين النهرين، علوم وتكنولوجيا.

[3] سليم نحلة، المعارف الطبية ما بين النهرين، علوم وتكنولوجيا.

Alongside contemporary ancient Egyptian medicine, the Babylonians contributed the principles of diagnosis, prognosis, physical examination, and prescriptions. Furthermore, the diagnostic manual presented treatment methodologies, etiology, and the application of empiricism, logic, and rationality in diagnosis, prognosis, and treatment. The text encompasses a compilation of medical symptoms and frequently includes detailed empirical observations, as well as logical rules employed to correlate the symptoms observed on the patient's body for the purposes of diagnosis and prognostication.[1]

By the end of the third millennium BC, an anonymous Sumerian physician compiled and documented his most esteemed medical prescriptions in the world's inaugural pharmacopoeia, intended for the benefit of his students and colleagues. To achieve this, he crafted a clay tablet upon which he inscribed twelve prescriptions of his preferred medicines in cuneiform script. This clay artifact is regarded as the oldest concise medical text known to humanity. It remained interred in the ruins of Nippur for over four millennia until it was unearthed by an American excavation team and subsequently transported to the University Museum in Philadelphia. These prescriptions were based on plant, animal, and mineral sources for the preparation of medicinal drugs. The methods for compounding medicines and their formulations had reached an advanced level of sophistication during the Sumerian era, reflecting a profound understanding of chemical techniques for drug preparation, as several prescriptions included instructions emphasizing the necessity of purifying foreign materials before grinding. Notably, these medical prescriptions did not specify the quantities to be utilized in the formulation of the medicinal drugs. This omission may have been a deliberate choice by the Sumerian physician to safeguard his secrets from being exploited by anyone other than medical practitioners, as the quantities could be discerned during the experimental process of preparing the medicines. Furthermore, these prescriptions did not identify the diseases for which they were intended, rendering it challenging to assess their efficacy.[2]

Scientific concepts that emerged during the Babylonian era are evidenced by the discovery of numerous medical documents inscribed on clay tablets and composed in cuneiform. These documents encompassed three distinct sections of data:[3]

First: Catalogs of medicinal herbs. This compilation encompasses texts of significant relevance in the examination of Babylonian medicine. The information is organized into three columns. The first column lists the name of the herb, the second identifies the patient receiving treatment with this herb, and the third describes the method of application. A crucial observation in this text is that the diseases were understood as clinical physiological conditions rather than magical occurrences.

[1] H. F. J. Horstmanshoff, Marten Stol, Cornelis Tilburg (2004), Magic and Rationality in Ancient Near Eastern and Graeco-Roman Medicine, Brill Publishers, p. 97–98.

[2] تاريخ الصيدلة في بلاد الرافدين، [https://learning.aljazeera.net/en/languageofmedia].

[3] تاريخ الصيدلة في بلاد الرافدين، [https://learning.aljazeera.net/en/languageofmedia].

Second: A collection of diverse therapeutic prescriptions, organized by the affected area of the body, and categorized into three fundamental sections:

• Enumerate the symptoms of the disease and, at times, its diagnosis.

• The medications to be utilized, along with their preparation and administration to the patient.

• Treatment outcome.

Third: Engaging in the diagnosis of diseases and forecasting their progression.

The patient's symptoms and ailments were addressed through therapeutic interventions such as bandages, creams, and medications. In instances where physical healing was unattainable, Babylonian physicians frequently resorted to exorcism to liberate the patient from any malevolent curses. Esagil-kin-apli's diagnostic manual was founded on a systematic framework of axioms and assumptions, aligning with the contemporary perspective that thorough examination and inspection of the patient's symptoms can reveal the nature of the illness, its etiology and progression, as well as the likelihood of recovery. Esagil-kin-apli also identified a range of diseases and meticulously documented their symptoms in his diagnostic manual. These encompassed symptoms associated with various forms of epilepsy and related disorders, along with their diagnosis and treatment. Subsequent Babylonian medicine exhibits notable similarities to early Greek medicine in numerous respects. Notably, the early writings of Hippocrates reflect the influence of later Babylonian medical practices in both substance and structure.[1]

[1] M. J. Geller (2004). H. F. J. Horstmanshoff; Marten Stol; Cornelis Tilburg (eds.). West Meets East: Early Greek and Babylonian Diagnosis. Magic and rationality in ancient Near Eastern and Graeco-Roman medicine. 27. Brill Publishers. pp. 11–186.

History of Science in Ancient Egyptian Civilization (Pharaonic)

Astronomy in Ancient Egypt

Egyptian astronomy originated in prehistory, predating the era of the ruling pharaonic dynasties, approximately around 3100 BC, with some sources suggesting an even earlier inception around 5000 BC. Consequently, the era of the ruling dynasties commences with the reign of the first pharaoh, Nikhmer and Menes, who unified Upper and Lower Egypt.[1]

The 365 days of the Egyptian calendar continue to be utilized today, representing an independent development from the Babylonians, albeit with a more distant origin. This calendar divided the year into 12 months of thirty days, supplemented by an additional five days. Each month was further segmented into three weeks, or decans, comprising ten days each. Due to the ancient Egyptian year being slightly less than a solar year—by approximately a quarter of a day—events within the calendar shifted, leading to its designation as the shifting year.[2] H. S. Williams posits that there is reason to believe that the Egyptians initially established the year at only 360 days, as the division into twelve months of thirty days supports this notion. Nevertheless, the error was eventually recognized, and a partial remedy was implemented by intercalating a "little month" of five days between the conclusion of the twelfth month and the onset of the new year. This adjustment nearly, but not entirely, resolved the issue. Notably, it failed to account for the additional quarter of a day necessary to complete the actual year. Additionally, the observation of stars played a crucial role in predicting the annual flooding of the Nile River.[3]

It is essential to consider these stages of practical civilization, as much of our understanding of the purely scientific accomplishments of the Egyptians relies on contemporary observations of their pyramids and temples. For instance, it was noted early on that the pyramids are distinctly oriented according to the direction they face, adhering strictly to specific astronomical principles. In the early nineteenth century, the French scholar Biot conducted intriguing studies related to this topic, and a century later, in our own era, Sir Joseph Norman Lockyer, building upon the work of numerous preceding observers, devoted significant attention to this subject, making it the focal point of his exploration into the origins of astronomy. Lockyer's investigations reveal that the temples of Egypt were primarily oriented in relation to the point of sunrise on the day of the summer solstice. This time was of particular significance to the Egyptians, as it closely coincided with the annual rising of the Nile. The river's floods occur with remarkable regularity, reaching the regions of Heliopolis and Memphis almost precisely on the day of the summer solstice. While the timing varies at different points along the river's course, observations

[1] Parker R. A. 1974Ancient Egyptian astronomyPhilosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences27651–65. See also: Eglash, Ron (1995). "Fractal Geometry in African Material Culture". Symmetry: Culture and Science. 6–1: 174–177.

[2] Parker R. A. 1974Ancient Egyptian astronomyPhilosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences27651–65.

[3] Williams H.S. A history of science, p.15.

conducted at Memphis were particularly prevalent due to the concentration of Early Dynastic civilization in that area.[1]

A clay tablet from the First Dynasty of King Khent-Djer, dating to 3000 BC, has been examined by specialists in Egyptian civilization and reveals that the Egyptians recognized the correlation between the brightness of the star Sirius and the commencement of the year. The Egyptian calendar was divided into three seasons: akhet, the month of flooding; peret, the month of emergence or growth; and shemu, the month of harvest, with each season comprising four months. The observation and contemplation of stars and celestial bodies were crucial in predicting the flooding of the Nile, significantly influencing the establishment of religious festivals and celebrations, as well as the determination of nighttime hours. Notably, the pyramids were meticulously aligned with the North Star, and the worship of Amun-Ra at Karnak was oriented towards the sun at its winter rising, marking the onset of the flood season and coinciding with the actual flooding period. The most precise identification of New Year's Day was achieved by observing the solar rise of the dog star Sirius, known in Egyptian as Sothis. It is likely that, as viewed from Heliopolis, the sun during the summer solstice occupies a prominent position in the sky near the Dog Star. The Egyptians, who perceived divinity in nearly every aspect of nature, naturally bestowed particular reverence upon such a profoundly influential entity as the sun-god.[2]

Lockyer posits that, while the evidence remains inconclusive, the astronomical observations of the Egyptians can be traced to a time when Sothis, the dog star, was not in close proximity to the sun on the morning of the summer solstice. However, Biot's calculations indicate that the heliacal rising of Sothis on the solstice was recorded as early as 3285 BC, and it is evident that in the subsequent centuries, this star consistently retained its prominent position. Consequently, Sothis became linked with Isis, one of the most significant goddesses in Egypt, and the day marking Sothis's first appearance in the morning sky signified the commencement of the new year; this day coincided, as previously noted, with the summer solstice and the onset of the Nile's inundation.[3]

The Ptolemaic period (322-30) was notably fruitful for astronomy, as Alexandria emerged as a cultural capital and commercial hub, fostering a blend of Egyptian, Greek, and Babylonian influences. The most renowned contribution to this field is the Almagest, authored by Ptolemy, the Greek scholar residing in Alexandria.

Conversely, the existence of stone circles in Nabtaplaya, located 100 km from Abu Simbel in the Egyptian desert, dates back to 5000 BC, underscoring the significance of astronomy in the religious life of the ancient Egyptians during the pre-dynastic period. The precise alignment of the Egyptian pyramids further illustrates the advanced skill and technique employed in observing

[1] Williams H.S. A history of science, p.15.
[2] Williams H.S. A history of science, p.15.
[3] Williams H.S. A history of science, p.15.

and contemplating the sky in the third millennium BC. This alignment indicates that the pyramids are oriented towards the North Star. [1] As previously mentioned, astronomical knowledge was crucial in determining religious festivals, celebrations, and the timing of nocturnal hours, as evidenced by various inscriptions in temples that document the movements and phases of the sun, moon, and stars.

The luminosity or visibility of Sirius at the onset of the inundation is depicted in significant detail on the ceilings of the tombs of Ramses VI and Ramses IX, which mark crucial points in the Egyptian annual calendar. According to astronomers and ancient historians, the Egyptians also formulated a conception of the solar system or a planetary theory in which the Earth rotates on its axis, while the inner planets, Mercury and Venus, orbit the Sun and the Earth in the worldview of the ancient Egyptians.[2]

Regarding the conception of the universe, the Egyptians envisioned the heavens as a material roof over the world, supported at each of its four corners by pillars, which were later depicted as great mountains. The earth was illustrated as an oblong box, elongated from north to south rather than from east to west; the upper surface of this box, where humanity resided, was slightly concave, with the valley of the Nile situated at its center. The supporting pillars were positioned at the cardinal points; the northern section extended beyond the Mediterranean, the southern part lay far from habitable areas towards the Nile's source, while the eastern and western regions were equally inaccessible. The world revolved around the southern hemisphere, resembling a vast river suspended in the air, akin to mountain slopes; upon this river, the sun-god traversed daily in a boat, engaging in an ongoing struggle against Set, the demon of darkness. The expansive channel of this river allowed the sun-god to alter its course periodically, as has been noted. In winter, it directed its vessel towards the far bank of the canal; in summer, it glided closer to the nearer bank. The stars are akin to lights suspended from the sky's vault, yet the explanation for their observed motion across the sky remains unclear.[3]

Medicine in ancient Egypt

Medicine in ancient Egypt is notable for its extensive documentation and sources, dating back to the 33rd century BC. From the emergence of civilization in the late fourth millennium BC until the Persian invasion in 525 BC, Egyptian medical practices remained relatively consistent, yet they were highly sophisticated for their time. This medical knowledge subsequently influenced later civilizations, particularly the Greeks. [4] The ancient Egyptians made significant advancements in this field, demonstrating remarkable proficiency for their era, which

[1] Ruggles, C.L.N. (2005), Ancient Astronomy, pages 354-355.
[2] Faulkner, R.O. (1969). The Ancient Egyptian Pyramid Texts. Oxford: The Clarendon Press. pp. 154, 155.
[3] Williams H.S. A history of science, p.18.
[4] Metwaly AM, Ghoneim MM, Eissa IH, Elsehemy IA, Mostafa AE, Hegazy MM, et al. (October 2021). "Traditional ancient Egyptian medicine: A review". Saudi Journal of Biological Sciences. 28 (10): 5823–5832.

encompassed basic surgical procedures, fracture setting, and dentistry, alongside their development of medicinal and healing substances.[1]

Until the 19th century, the principal source on ancient Egyptian medicine was the writings of Homer (c. 800 BC) in the Odyssey, in which he asserts that "the men of ancient Egypt were more skilled in medicine than any other human society, and were more adept in the art of medicine than in any other art." The Greek historian Herodotus visited Egypt around 440 BC and documented his extensive observations of medical practices, while Hippocrates (c. 370 BC) and others studied at the temples of Amenhotep, acknowledging in their writings the significant contributions of ancient Egyptian medicine to Greek practices.[2]

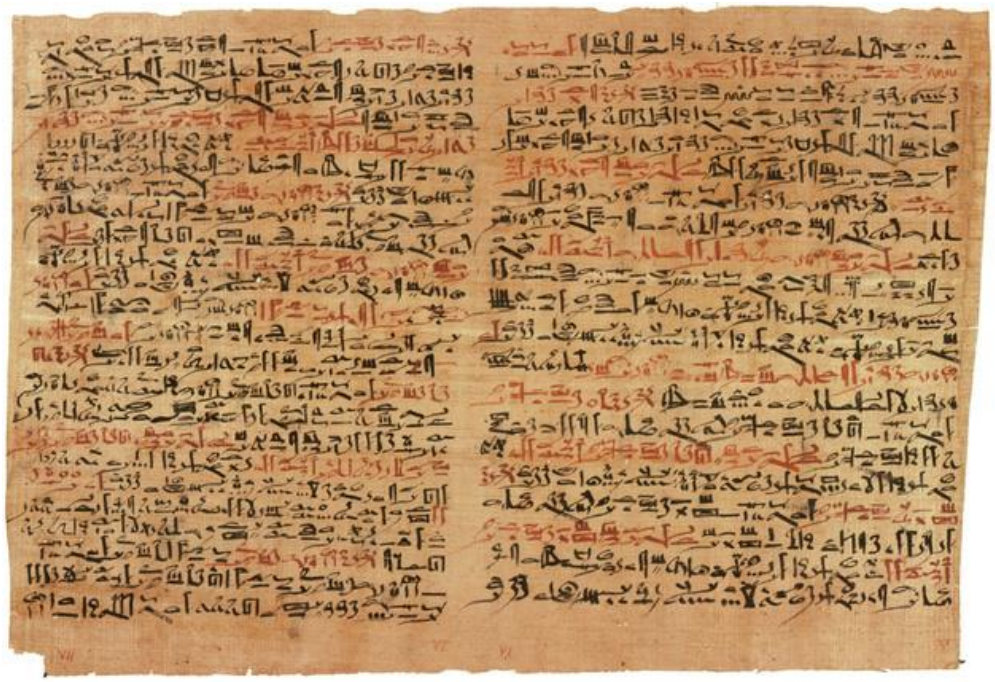
From 1799 to 1824, the discovery and translation of the Rosetta Stone served as a pivotal source and gateway to understanding the history of science within Pharaonic civilization. This was achieved through the decoding of the ancient Egyptians' hieroglyphic writing found on papyrus, as well as the walls and ceilings of temples and tombs. Consequently, the cognitive advancements attained across various fields became comprehensible. This transformation was primarily facilitated by the study of Egyptian hieroglyphics, which, as we now recognize, represent a highly sophisticated writing system. This system had been in use for millennia but became entirely obsolete during the later Roman period, with its knowledge fading from human consciousness for approximately two thousand years. During this time, no one could decipher even a single letter of this enigmatic text with any clarity, leading to the prevailing belief that it was not a legitimate writing system but rather a crude form of religious symbolism. The fallacy of this notion was dispelled in the early nineteenth century when Dr. Thomas Young, through his examination of the renowned inscription in three languages on the Rosetta Stone, achieved the first successful attempt to unveil the mysteries of hieroglyphic writing.[3]

The decipherment of the hieroglyphic code sparked a significant interest in Egyptology during the nineteenth century, resulting in the discovery of numerous extensive collections of ancient medical documents, including the Ebers Papyrus, the Edwin Smith Papyrus, the Hearst Papyrus, the London Medical Papyrus, and others that date back to 2900 BC.

The Edwin Smith Papyrus serves as a comprehensive textbook on surgery, encompassing anatomical observations and the "examination, diagnosis, treatment, and cure" of various ailments. Likely composed around 1600 BC, it is regarded as a compilation of several earlier works. The medical knowledge contained within dates back to 3000 BC, positioning it as an educational resource. Treatments include ointments derived from animal, vegetable, or fruit

[1] Steinbock RT (1990). "The Medical Skills of Ancient Egypt". JAMA. 264 (23): 3074.
[2] Jouanna, Jacques; Allies, Neil (2012), "Egyptian Medicine and Greek Medicine", Greek Medicine from Hippocrates to Galen, Brill, pp. 3–20.
[3] Williams H.S. A history of science, p.12.

substances, as well as minerals, and there is evidence of oral surgery being conducted as early as the Fourth Dynasty (2900–2750 BC).[1]



Edwin Smith Papyrus

https://en.wikipedia.org/wiki/Edwin_Smith_Papyrus#/media/File:Edwin_Smith_Papyrus_v2.jpg

Although sorcery was extensively utilized for healing, H. S. Williams contends that it is essential to recognize that the ancient Egyptian physician did not solely depend on incantations; rather, he equipped himself with an extensive array of medicines. He particularly favored what contemporary physicians would refer to as a prescription comprising a diverse assortment of ingredients. This included not only various herbs but also substances such as lizard's blood, pigs' teeth, decomposed meat, moisture from pigs' ears, boiled horn, and numerous other unpalatable components. Those familiar with the formulas employed by European physicians as recently as the eighteenth century will observe a remarkable similarity. Erman notes that modern Egyptians continue to adhere closely to many practices of their ancient predecessors; notably, the efficacy of the beetle as a medicinal agent has endured through centuries of application. An ancient formula states: "Against all forms of magic, a large scarab beetle; sever its head and wings, and boil it; place it in oil and set it aside; then cook its head and wings, and incorporate them into

[1] "Edwin Smith papyrus (Egyptian medical book)". Encyclopedia Britannica (Online ed.). Retrieved 1 January 2016.

snake fat, boil, and allow the patient to consume the mixture." Erman indicates that modern Egyptians utilize a nearly identical recipe, substituting snake fat with contemporary oil.[1]

The Ebers Papyrus (circa 1550 BC) comprises 877 prescriptions, as categorized by a contemporary editor, addressing a range of ailments, some of which incorporate magical remedies, reflecting the intertwined nature of Egyptian beliefs regarding magic and medicine. Additionally, it includes texts that demonstrate an understanding of tumors, accompanied by guidelines for their removal.[2]

The Hearst Papyrus was presented to the Hearst Expedition in Egypt in 1901. It is believed to date back to approximately 2000 BC, although its authenticity has been subject to scrutiny. The text addresses treatments for urinary tract issues, blood disorders, hair conditions, and bites. Since its publication in 1905, it has been extensively studied. The London Medical Papyrus, housed in the British Museum, originates from the era of Tutankhamun. Despite its deteriorated state, research has revealed that it emphasizes magical spells as remedies for ailments.[3]

The Kahun Gynecological Papyrus addresses women's health issues, including complications related to pregnancy. Thirty-four cases remain, outlining diagnoses and treatments, though some are merely fragments. Dating back to 1800 BC, it stands as the oldest extant medical text of its kind. Additional documents, such as the Berlin Papyrus (1200 BC), also offer significant insights into ancient Egyptian medicine.[4]

The medical knowledge of ancient Egypt was highly esteemed, with rulers from other empires requesting that the Egyptian pharaoh dispatch their most skilled physicians to care for their loved ones. The Egyptians possessed a rudimentary understanding of human anatomy; during the traditional mummification process, they employed a long, curved instrument inserted through the nostril to fracture the delicate bone of the brain and extract the organ. They also had a general awareness of the internal organs situated within the body cavity, removing them through a small incision in the left thigh. It remains uncertain whether this knowledge was transmitted to practitioners, yet it appears to have had little impact on their medical theories. Egyptian physicians recognized the pulse and its relationship to the heart; even the author of the Smith Papyrus had a rudimentary comprehension of the heart's function, although he lacked awareness of the circulatory system and did not find it significant to differentiate between blood vessels, tendons, and nerves. They also formulated a theory of "channels" that transported air, water, and blood throughout the body, drawing an analogy to the Nile River; when blocked, crops would

[1] Williams H.S. A history of science, p.12.

[2] Dawson, W. (1927). The Beginnings of Medicine: Medicine and Surgery In Ancient Egypt. Science Progress in the Twentieth Century (1919–1933), 22(86), 275–284.

[3] Marry, Austin (January 21, 2004). "Ancient Egyptian Medical Papyri". Ancient Egypt Fan. Eircom Limited. Retrieved 2007-10-24.

[4] Bynum, W. F.; Hardy, Anne; Jacyna, Stephen; Lawrence, Christopher; Tansey, E.M. (2006). "The Rise of Science in Medicine, 1850–1913". The Western Medical Tradition: 1800–2000. Cambridge University Press. pp. 198–199.

suffer, and they applied this principle to human health: if an individual was ill, they would administer laxatives to clear the "channels."[1]

Numerous medical practices were effective, including the surgical procedures outlined in the Edwin Smith Papyrus. Physicians often recommended maintaining health by washing and shaving the body, particularly under the arms, to avert infections. They also counseled patients to be mindful of their diet and to avoid consuming foods such as raw fish or other animals deemed unclean.[2]

The oldest known metal surgical instruments, made of bronze or copper, were unearthed from the tomb of Qar. Surgery was a prevalent practice among physicians for addressing physical injuries. Egyptian physicians classified injuries into three categories: treatable, debatable, and untreatable. Treatable conditions were those that surgeons could promptly rectify. Debatable conditions were those in which the patient might survive without intervention; thus, individuals in this category were monitored, and if they survived, surgical attempts could be made to address the issue. Instruments such as knives, hooks, drills, forceps, tongs, scales, spoons, saws, and vases containing burning incense were employed.[3]

Ancient Egyptian Mathematics

The unique climate and location of Egypt have preserved mathematical records spanning over three thousand years, within a civilization that lasted more than two millennia. This rich history has captivated scholars for nearly two centuries, driven by curiosity about the mathematical underpinnings of Egypt's monumental architecture and a broader fascination with the origins of mathematics itself, as Egypt and Mesopotamia pioneered advanced mathematical systems.[4] Ancient Egyptian mathematics encompasses the mathematical systems and techniques utilized in Egypt from approximately 3000 to 300 BC, a period extending from the Old Kingdom to the beginning of Hellenistic influence. Primarily documented through a limited number of surviving papyrus texts, this mathematical tradition included a numeral system adept at handling calculations involving multiplication and fractions. Furthermore, the Egyptians demonstrated a practical understanding of geometry, enabling them to compute surface areas and volumes for architectural purposes, and employed algebraic methods such as the false position method and the solution of quadratic equations.

Our understanding of ancient Egyptian mathematics is primarily based on mathematical texts preserved on papyri, ostraca, and leather. These documents, dating from approximately 1800 to

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[1] Loukas M, Hanna M, Alsaiegh N, Shoja MM, Tubbs RS. Clinical anatomy as practiced by ancient Egyptians. Clin Anat. 2011 May;24(4):409-15.

[2] Stiefel, Marc; Shaner, Arlene; Schaefer, Steven D. (February 2006). "The Edwin Smith Papyrus: The Birth of Analytical Thinking in Medicine and Otolaryngology". The Laryngoscope. 116 (2): 182–188.

[3] Greiner, Ryan (2001). "Ancient Egyptian Medicine". Creighton University Virtual Museums. Creighton University. https://web.archive.org/web/20011223061304/http://puffin.creighton.edu/museums/greiner/

[4] Imhausen, A. (2016). Mathematics in Ancient Egypt: A Contextual History. Princeton University Press.

1600 BC (the Middle Kingdom and Second Intermediate Period), include key sources like the Rhind Mathematical Papyrus, the Moscow Mathematical Papyrus, the Kahun Papyri, and the Egyptian Mathematical Leather Roll.[1]

Pharaonic surveyors employed body-part measurements—specifically, the palm as the width of the hand and the arm from the elbow to the fingertips—to assess land and structures in the early stages of Egyptian history. Additionally, a decimal number system was established based on ten fingers. Nevertheless, the oldest known mathematical text from ancient Egypt is the Moscow Papyrus, which dates back to the Middle Kingdom of Egypt, approximately 2000–1800 BC.[2]

Written evidence of mathematical usage can be traced back to at least 3200 BC, with ivory labels discovered in the U-j tomb at Abydos. These labels seem to have served as identifiers for grave goods, and several are inscribed with numerical values. Additional evidence of the base 10 number system is found in the Narmer Macehead, which illustrates offerings of 400,000 bulls, 1,422,000 goats, and 120,000 prisoners.[3]

Evidence of mathematical application in the Old Kingdom (circa 2690–2180 BC) is limited, yet can be deduced from inscriptions on a wall adjacent to an ancient Egyptian tomb at Meidum, which provide guidance on the tomb's slope. The lines depicted in the drawing are spaced one arm's length apart, demonstrating the utilization of this unit of measurement.[4]

The earliest known mathematical documents originate from the Twelfth Dynasty (circa 1990 - 1800 BC). This period includes the Moscow Mathematical Papyrus, the Egyptian Mathematical Leather Roll, the Lahun Mathematical Papyri, which is part of the more extensive Kahun Papyri, and the Berlin Papyrus 6619. Additionally, the Rhind Mathematical Papyrus, dating from the Second Intermediate Period (circa 1650 BC), is believed to be derived from an earlier mathematical text from the Twelfth Dynasty.[5]

The Moscow Mathematical Papyrus and the Rhind Mathematical Papyrus are classified as mathematical problem texts. They comprise a collection of problems accompanied by their solutions. These texts may have been authored by a teacher or a student involved in the resolution of standard mathematical challenges.[6]

An intriguing aspect of ancient Egyptian mathematics is the utilization of unit fractions. The Egyptians employed specific symbols for fractions such as ½, 1/3, 2/3, and, in certain texts, ¾. However, all other fractions were represented as fractional units in the form 1/n or as sums of

[1] Corinna Rossi 2003, Architecture and Mathematics in Ancient Egypt, Cambridge University Press
[2] Egyptian Mathematics – Numbers & Numerals, [https://www.storyofmathematics.com/egyptian.html].
[3] Imhausen, Annette (2006). "Ancient Egyptian Mathematics: New Perspectives on Old Sources". The Mathematical Intelligencer. 28 (1): 19–27.
[4] Rossi, Corinna (2007). Architecture and Mathematics in Ancient Egypt. Cambridge University Press.
[5] Katz V, Imhasen A, Robson E, Dauben JW, Plofker K, Berggren JL (2007). The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook. Princeton University Press.
[6] Imhausen, Annette (2006). "Ancient Egyptian Mathematics: New Perspectives on Old Sources". The Mathematical Intelligencer. 28 (1): 19–27.

these fractions. Scribes also utilized tables to facilitate their calculations with these fractions. For instance, the Egyptian Mathematical Leather Roll features a table of unit fractions expressed as sums of other unit fractions, while the Rhind Mathematical Papyrus and several other texts include tables of the form 2/n. These tables enabled scribes to express any fraction as 1/n in the form of a sum of unit fractions.[1]

During the New Kingdom (1550-1070 BC), mathematical problems are referenced in the Papyrus Anastasi I, while the Papyrus Wilbour, dating from the era of Ramesses III, documents land measurements.[2]

Ancient Egyptian texts were composed in either hieroglyphs or hieratic script. In both forms, the numerical system consistently utilized a base 10 framework. The numeral 1 was depicted as a single stick, while the numeral 2 was represented by two sticks, and so forth. Distinct hieroglyphs were assigned to the numbers 10, 100, 1,000, 10,000, 100,000, and 1,000,000. Specifically, the numeral 10 is symbolized by a hobble, 100 by a coiled rope, 1,000 by a lotus flower, 10,000 by a finger, 100,000 by a frog, and 1,000,000 by a deity with raised hands in reverence.[3] It is believed that the Egyptians developed the earliest fully realized base 10 numbering system as early as 2700 BC, and potentially even earlier. However, the absence of a place value concept rendered larger numbers cumbersome; for instance, while a million was denoted by a single character, the numeral for a million minus one required fifty-four characters.[4] This can be exemplified as follows:

1	10	100	1000	10,000	100,000	1,000,000

Hieroglyphics for Egyptian Numerals

The Egyptian numeral system was predicated on addition, wherein large numbers were denoted by clusters of glyphs, and the total value was derived by summing the individual components. The Egyptians predominantly employed fractions of the form 1/n, with the notable exception of the fraction 2/3, which appears frequently in mathematical texts. A specific glyph was seldom utilized to signify 3/4. The fraction 1/2 was represented by a glyph that may illustrate a piece of

[1] Imhausen, Annette (2006). "Ancient Egyptian Mathematics: New Perspectives on Old Sources". The Mathematical Intelligencer. 28 (1): 19–27.
[2] Imhausen, Annette (2006). "Ancient Egyptian Mathematics: New Perspectives on Old Sources". The Mathematical Intelligencer. 28 (1): 19–27.
[3] Clagett, Marshall Ancient Egyptian Science, A Source Book. Volume Three: Ancient Egyptian Mathematics (Memoirs of the American Philosophical Society) American Philosophical Society. 1999.
[4] Egyptian Mathematics – Numbers & Numerals, [https://www.storyofmathematics.com/egyptian.html].

linen folded in half. The fraction 2/3 was depicted by a glyph resembling a mouth accompanied by two sticks of varying sizes. The remaining fractions were consistently represented by a mouth positioned above the numeral.[1]

Hieroglyphic notation of certain fractions

The Rhind Papyrus, an instructional manual in arithmetic and geometry, offers clear elucidations of the methods employed for multiplication and division during that era. It also presents evidence of additional mathematical knowledge, encompassing unit fractions, complex and prime numbers, as well as arithmetic, geometric, and harmonic techniques, alongside solutions for first-degree linear equations and arithmetic and geometric series. The Berlin Papyrus, originating around 1300 BC, demonstrates that the ancient Egyptians possessed the capability to solve quadratic algebraic equations.[2]

Egyptian multiplication involved the repeated doubling of the number to be multiplied (the multiplier) and the selection of specific multipliers to sum, representing a form of binary arithmetic akin to that utilized in contemporary computing, a technique linked to the Old Kingdom. The multiplier was inscribed adjacent to the numeral 1; subsequently, the multiplier was added to itself, with the outcome recorded next to the numeral 2. This process persisted until the multiplications yielded a figure exceeding half the multiplier. The multiplier values (1, 2, etc.) were then systematically subtracted from the multiplier to ascertain which results from the current calculations should be combined to yield the final answer. This method effectively harnessed the concept of binary numbers over 3,000 years prior to Leibniz's introduction of it to the West, and many years before the advent of computers was anticipated to fully realize its potential.[3]

Egyptian algebraic problems are documented in both the Rhind Mathematical Papyrus and the Moscow Mathematical Papyrus, along with numerous other sources. The Aha problem entails determining unknown quantities (designated as Aha) when the sum of the quantity and its respective parts is provided. The Rhind Mathematical Papyrus features four such problems.

[1] Imhausen, Annette (2006). "Ancient Egyptian Mathematics: New Perspectives on Old Sources". The Mathematical Intelligencer. 28 (1): 19–27.
[2] Egyptian Mathematics – Numbers & Numerals, [https://www.storyofmathematics.com/egyptian.html]. See also: Moore, Deborah Lela (1994). The African roots of mathematics (2nd ed.). Detroit, Mich.: Professional Educational Services.
[3] Egyptian Mathematics – Numbers & Numerals, [https://www.storyofmathematics.com/egyptian.html].

Additionally, Problems 1, 19, and 25 of the Moscow Papyrus also pertain to Aha. For instance, Problem 19 requires the calculation of a quantity that, when multiplied by 1 and 1⁄2 and added to 4, results in 10.[1] In contemporary mathematical notation, this translates to solving the linear equation: $\frac{2}{3} + x + 4 = 10$

The resolution of this Aha problem employs a technique known as the method of false position or false assumption. In this approach, the scribe substitutes an initial estimate for the solution into the problem; the outcome derived from this false assumption will be proportional to the actual answer, enabling the scribe to determine the correct solution using this ratio. Mathematical texts indicate that scribes utilized (at least) common multipliers to convert fractional problems into integer problems. In this context, auxiliary numbers are inscribed alongside the fractions. The application of the Eye of Horus fractions demonstrates a degree of (rudimentary) understanding of geometric progression.[2]

A limited number of geometric problems from ancient Egypt are documented in both the Moscow Mathematical Papyrus (MMP) and the Rhind Mathematical Papyrus (RMP). These examples indicate that the ancient Egyptians possessed the knowledge to calculate the area of various geometric shapes, as well as the volumes of cylinders and pyramids. The RMP and MMP include recorded problems for determining the area of a triangle, alongside issues related to the area of a rectangular plot of land. A similar problem is found in the Lahun Mathematical Papyrus in London. Regarding circles, RMP problem 48 compares the area of a circle (approximated by an octagon) to its enclosing square. The outcome of this problem is utilized in problem 50, where the scribe calculates the area of a circular field with a diameter of 9 khet. MMP problem 10 determines the area of a hemisphere.[3]

The volumes of cylindrical granaries are addressed in several problems within RMP 41-43, while problem 60 of RMP appears to pertain to a column or cone rather than a pyramid. This structure is notably small and steep, featuring an inverted slope on each of its four sides. In section IV.3 of the Lahun Mathematical Papyrus, the volume of a circular-based granary is determined using the same methodology as outlined in RMP 43. For rectangular granaries, multiple problems in the Moscow Mathematical Papyrus (14) and the Rhind Mathematical Papyrus (Nos. 44, 45, 46) focus on calculating their volumes. The volume of a truncated pyramid is computed in MMP 14.[4]

History of Science in Ancient Chinese Civilization

The history of science in China is extensive and marked by significant contributions from ancient times. Ancient Chinese philosophers achieved remarkable advancements in science, technology,

[1] Clagett, Marshall Ancient Egyptian Science, A Source Book. Volume Three: Ancient Egyptian Mathematics (Memoirs of the American Philosophical Society) American Philosophical Society. 1999. pp.49-55.
[2] Clagett, Marshall Ancient Egyptian Science, A Source Book. Volume Three: Ancient Egyptian Mathematics (Memoirs of the American Philosophical Society) American Philosophical Society. 1999. pp.49-55.
[3] Clagett, Marshall Ancient Egyptian Science, A Source Book, pp.68-80.
[4] Clagett, Marshall Ancient Egyptian Science, A Source Book, pp.68-80.

mathematics, and astronomy, independently of their Greek counterparts and other civilizations. The earliest documented observations of comets, solar eclipses, and supernovae originated in China, alongside the practice of traditional Chinese medicine, acupuncture, and herbal remedies. Among the initial inventions were the abacus, sundial, and Kunming lantern. The Four Great Inventions of compass, gunpowder, papermaking, and printing rank among the most pivotal technological advancements, which were only introduced to Europe a millennium later, by the end of the Middle Ages. The Tang Dynasty (618-906 AD) was particularly notable for its remarkable innovation. Substantial exchanges between Western and Chinese discoveries transpired until the Qing Dynasty.[1]

Ancient Chinese Mathematics

Geographical isolation and cultural assimilation fostered an independent mathematical tradition in China from around 1000 BC. Natural barriers limited external influence, and foreign conquerors were absorbed into Chinese culture. This led to a fluctuating history of mathematical development, with periods of growth, stability, and decline. The Chinese developed a comprehensive real number system that encompassed significantly large and negative numbers, multiple number systems (base 2 and base 10), as well as algebra, geometry, number theory, and trigonometry. Characterized by its conciseness, akin to the Chinese language, Chinese mathematics was deeply rooted in practical applications. Driven by real-world problems related to calendrical calculations, commerce, land surveying, architecture, official records, and taxation, it thrived on problem-solving. By the 4th century BC, the Chinese employed counting boards, a unique innovation not found in other civilizations, effectively utilizing a decimal place value system for calculations.[2]

During the Han Dynasty, significant advancements were made in the determination of the ninth root of positive numbers and the resolution of linear congruence equations. The principal texts from this era, the Nine Chapters on the Mathematical Art and the Book of Numbers and Arithmetic, outlined comprehensive procedures for addressing various mathematical challenges encountered in daily life. All calculations were performed using a counting board in both texts, incorporating inverse elements and Euclidean sections. The methodologies presented were akin to those of Gauss's elimination, Horner's method for linear algebra, and the modular approach for the Diophantine equation, respectively. The pinnacle of Chinese algebra was achieved in the 13th century with the invention of the Tianyuanshu by Li Jingzhai.[3]

[1] History of science and technology in China, [https://www.newworldencyclopedia.org/entry/History_of_science_and_technology_in_China]. Hao, Q. A History of Chinese Science and Technology, Volume 1. pp.19-34.

[2] J O'Connor and E F Robertson, 2003, Overview of Chinese mathematics, https://mathshistory.st-andrews.ac.uk/HistTopics/Chinese_overview/

[3] Needham, Joseph (1955). "Horner's Method in Chinese Mathematics". T'oung Pao. Second Series. 43 (5): 345–401.

Due to the evident linguistic and geographical barriers, along with content differences, Chinese mathematics and the mathematics of the ancient Mediterranean world are believed to have evolved largely independently until the Nine Chapters on the Mathematical Art reached its final form. Meanwhile, the Book of Numbers and Arithmetic and the Huainanzi are approximately contemporaneous with classical Greek mathematics. It is likely that some ideas were exchanged across Asia through cultural interactions known since at least the Roman era. Frequently, mathematical elements in early societies align with foundational results later identified in modern branches of mathematics, such as geometry or number theory. For instance, the Pythagorean theorem was established by the time of the Duke of Zhou. Additionally, knowledge of Pascal's triangle has been demonstrated to have existed in China centuries prior to Pascal, as evidenced by the multicultural contributions of the Song dynasty scholar Shen Kuo.[1]

Chen Jiushao (c. 1202–1261) was the pioneer in introducing the zero symbol into Chinese mathematics. Before this advancement, blanks were utilized in place of zeros within the counting rod system. Pascal's triangle was initially articulated in China by Yang Hui in his Xiangjie Jiuzhang Suanfa, although it had been previously described around 1100 by Jia Xian. While Zhu Shijie's introduction to arithmetic studies, written in 1299 AD, did not present any novel concepts in Chinese algebra, it significantly influenced the evolution of Japanese mathematics.[2]

Simple mathematics inscribed in oracle bone script can be traced back to the Shang Dynasty (1600–1050 BC). Among the earliest extant mathematical texts is the I Ching, which significantly influenced literature during the Zhou Dynasty (1050–256 BC). This work incorporated advanced applications of hexagrams in mathematics. Leibniz observed that the I Ching (Yi Jing) encompassed elements of binary numbers. By the Shang period, the Chinese had already established a comprehensive decimal system. Since antiquity, the Chinese had grasped fundamental arithmetic (which predominated the history of the Far East), algebra, equations, and negative numbers utilizing counting rods. While the Chinese primarily concentrated on advanced arithmetic and algebra for astronomical applications, they were also pioneers in the development of negative numbers, algebraic geometry (specific to Chinese geometry), and the implementation of decimal fractions.[3]

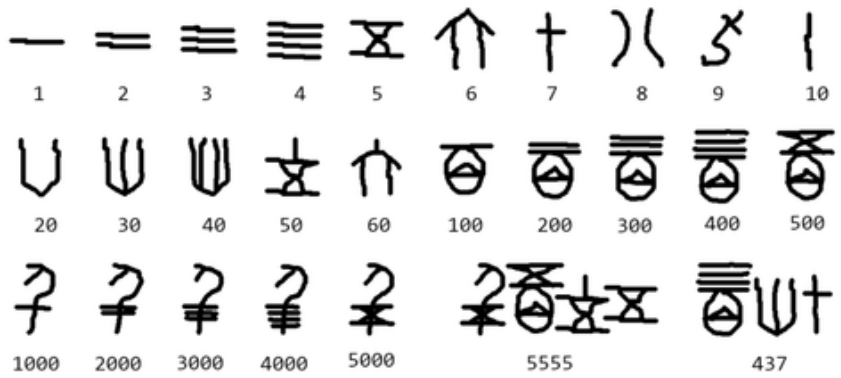
Mathematics was one of the Liu Yu (六艺) or Six Arts that students were required to master during the Zhou Dynasty (1122–256 BC). Mastery of all these disciplines was considered essential for achieving the ideal of a "perfect man," akin to the concept of a "renaissance man" in Western thought. The origins of the Six Arts are deeply rooted in Confucian philosophy. The earliest surviving work on geometry in China is attributed to the Mohist Philosophy of 330 BC,

[1] Frank J. Swetz and T. I. Kao: Was Pythagoras Chinese? [https://www.psupress.org/books/titles/0-271-01238-2.html].

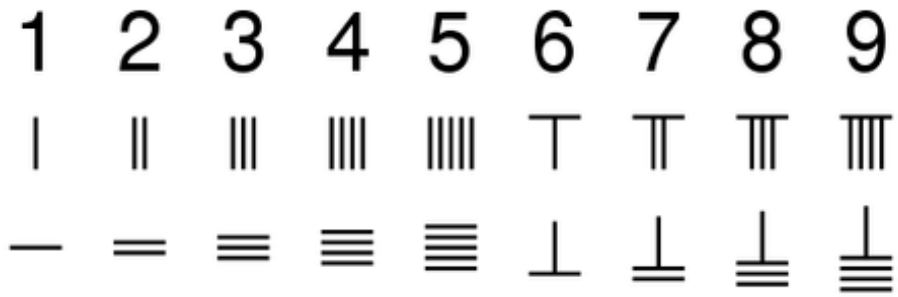
[2] Joseph Needham, Science and Civilization in China: Volume 3, Mathematics and the Sciences of the Heavens and the Earth (Taipei: Caves Books, Ltd., 1986) pp. 46.

[3] The history of Chinese Mathematics, [https://warwick.ac.uk/fac/sci/maths/general/outreach/diversity/mao/] 28/02/2026.

compiled by adherents of the Mohist school (470–390 BC). Mo Jing explored various aspects of numerous fields related to the physical sciences and offered a substantial amount of information on mathematics as well. He provided an atomic definition of the geometric point, asserting that a line is divided into segments, and the segment that possesses no further subdivisions (i.e., cannot be divided into smaller parts) constitutes the extreme end of the line, which is identified as a point. Similar to Democritus, Mo Jing posited that a point is the smallest unit and cannot be bisected, as "nothing" cannot be divided. He asserted that two lines of equal length will invariably terminate at the same point, offering definitions for comparing lengths and parallels, as well as principles concerning area and bounded area. The text also introduced definitions for perimeter, diameter, radius, and volume.[1]



Ancient Chinese numeral system inscribed on bones



Counting rods for decimal notation

Archaeological discoveries from the Shang dynasty (14th to 11th century BC) reveal the earliest numeral symbols inscribed on bones and tortoise shells. By this period, various decimal and

[1] Joseph Needham, Science and Civilization in China: Volume 3, Mathematics and the Sciences of the Heavens and the Earth (Taipei: Caves Books, Ltd., 1986)

sexagesimal systems were already in operation. The use of rod numbers on coins has also been documented since the Wang Mang era (9-23 AD). These are associated with the tools employed for calculations. Numbers were represented on the calculation surface using counting rods. This representation adhered to a decimal positional notation, featuring nine distinct signs for the numbers from 1 to 10, which included vertical or horizontal bars to denote units, hundreds, large numbers, and so forth, as well as tens, thousands, and other powers of ten. For instance, three hundred and twenty-six was indicated as follows: III = T. Negative numbers were represented with black counting rods instead of red. In printed records (from the 11th century onward), they were denoted with a diagonal bar.[1]

The history of ancient Chinese mathematical development is marked by a lack of conclusive evidence, leading to ongoing debates regarding certain mathematical classics. For instance, the Zhoubi Suanjing is believed to date back to approximately 1200-1000 BC; however, many scholars contend that it was composed between 300 and 250 BC. The Zhoubi Suanjing provides substantial evidence of Gougu's theorem (a specific instance of the Pythagorean theorem) but primarily emphasizes astronomical calculations. Recent archaeological findings, particularly the Tsinghua Bamboo Slips from 305 BC, have illuminated aspects of pre-Qin or Ch'in dynasty mathematics, including the earliest known decimal multiplication table.[2]

Little is known about the mathematics of the Qin Dynasty, or the preceding era, due to the destruction of texts and the entombment of scholars around 213-210 BC. Insights into this period can be derived from civil projects and historical documentation. The Qin Dynasty instituted a standardized system of weights. The civil projects of the Qin Dynasty represented remarkable accomplishments in human engineering. Emperor Qin Shihuang (秦始皇) commissioned numerous individuals to construct large-scale statues for the palace tomb, in addition to other temples and shrines, with the tomb's design reflecting advanced architectural engineering skills. Among the most significant achievements in human history, the Great Wall of China undoubtedly necessitated various mathematical techniques. All constructions and major undertakings of the Qin Dynasty employed sophisticated mathematical equations pertaining to volume, area, and proportion.[3]

During the Han Dynasty, numbers evolved into a decimal place-value system and were utilized on a counting board with a set of counting rods known as a chousuan, comprising only nine symbols, with a blank space on the counting board denoting zero. Negative numbers and fractions were also integrated into the solutions of the prominent mathematical texts of the era. The mathematical works of the time, the Suàn shù shū and the Jiuzhang suanshu, addressed fundamental arithmetic problems such as addition, subtraction, multiplication, and division.

[1] Helaine Selin-Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures - Second Edition (2006) Mathematics in China

[2] Jane Qiu (7 January 2014). "Ancient times table hidden in Chinese bamboo strips" [https://www.nature.com/news/ancient-times-table-hidden-in-chinese-bamboo-strips-1.14482].

[3] Yongxiang lu, A History of Chinese Science and Technology Volume 1. pp.210-214.

Additionally, they provided methods for extracting square and cube roots, which were ultimately applied to solving quadratic equations up to the third degree.[1] Both texts also achieved notable advancements in linear algebra, specifically in solving systems of equations with multiple unknowns. The value of pi is approximated as three in both texts. However, mathematicians Liu Xin and Zhang Heng offered more precise approximations of pi than those previously employed by the Chinese. Mathematics was developed to address practical issues of the time, such as land division and payment distribution. The Chinese did not emphasize theoretical proofs based on geometry or algebra in the contemporary sense of validating equations to determine area or volume. The Book of Calculations and the Nine Chapters on the Mathematical Art present numerous practical examples applicable to everyday life.[2]

The Suàn shù shū, or Book of Accounting, is an ancient Chinese mathematical text comprising approximately seven thousand characters, inscribed on 190 bamboo strips. It was unearthed alongside other writings in 1984 when archaeologists excavated a tomb in Zhangjiashan, Hubei Province. Documentary evidence indicates that this tomb was sealed in 186 BC, during the early Western Han Dynasty. Although scholars continue to debate its relationship with the Nine Chapters, it is evident that certain contents exhibit parallels. Nevertheless, the text of the Suàn shù shū is considerably less systematic than that of the Nine Chapters, consisting of several short, relatively independent sections derived from various sources. The Book of Accounts addresses numerous problems that are further elaborated upon in the Nine Chapters of mathematical art. An instance of elementary mathematics in the Suàn shù shū is the approximation of a square root utilizing the false position method, and the Book of Accounts also resolves systems of two equations with two unknowns employing the same technique.[3]

The Nine Chapters on the Mathematical Art is a Chinese mathematical textbook, with the earliest archaeological evidence dating to 179 AD (traditionally ascribed to 1000 BC), but likely originating from 300–200 BC. While the authors remain unidentified, their contributions to the Eastern world are substantial. The text presents problems in a format where questions are followed directly by answers and procedures. It lacks formal mathematical proofs, instead offering step-by-step methodologies. Liu Hui's commentary supplies geometric and algebraic proofs for the problems addressed in the text.[4]

The Nine Chapters on the Mathematical Art stands as one of the most significant Chinese mathematical texts, comprising 246 problems. It was subsequently integrated into the Ten Arithmetic Rules, which became foundational to mathematical education in subsequent centuries. This work encompasses 246 problems related to surveying, agriculture, partnerships,

[1] Needham, Joseph (1959). Science and Civilization in China. England: Cambridge University Press. p. 886.
[2] Yongxiang lu, A History of Chinese Science and Technology Volume 1. pp.210-214. See also: Siu, Man-Keung (1993). "Proof and Pedagogy in Ancient China". Educational Studies in Mathematics. 24 (4): 345–357.
[3] Dauben, Joseph W. (2008). "算数書 Suan Shu Shu A Book on Numbers and Computations: English Translation with Commentary". Archive for History of Exact Sciences. 62 (2): 91–178.
[4] Chemla, Karine. "East Asian Mathematics". Britannica Online Encyclopedia.

geometry, taxation, arithmetic, equation solving, and the properties of right triangles. The Nine Chapters introduced crucial advancements in solving quadratic equations, employing techniques akin to Horner's method. Furthermore, it made notable contributions to "fangcheng," now recognized as linear algebra. Chapter 7 addresses a system of linear equations with two unknowns through the wrong position method, reminiscent of the Book of Calculations. Chapter 8 focuses on simultaneously solving definite and indefinite linear equations using both positive and negative numbers, with one problem involving the resolution of four equations in five unknowns. The Nine Chapters employ methods for solving systems of equations that parallel modern Gaussian elimination and back substitution techniques.[1]

In the 3rd century, Liu Hui authored his commentary on the Nine Chapters and composed the Haidao Suanjing, which addressed the application of the Pythagorean theorem (already recognized in the Nine Chapters) and the trigonometric triangle for surveying; his contributions to mathematical surveying eclipsed those of the West by a millennium. He was the first Chinese mathematician to compute $\pi = 3.1416$ utilizing the π algorithm. He identified the application of Cavalieri's principle to derive an exact formula for the volume of a cylinder and developed elements of infinitesimal calculus during the 3rd century AD. In the 4th century, another prominent mathematician, Zu Chongzhi, created the Da Ming Li calendar. This calendar was meticulously calculated to forecast various cosmic cycles over a specified duration. Very little is known about his life, with the Sui Book serving as the sole source of information, revealing that Zu Chongzhi was part of a remarkable generation of mathematicians. He employed Liu Hui's pi algorithm on the 12288-gon, achieving the value of pi to seven decimal places (between 3.1415926 and 3.1415927), which would remain the most precise approximation of pi for the subsequent 900 years. He also utilized He Chengtian's interpolation to approximate irrational numbers with fractions in astronomical and mathematical contexts, arriving at 355/13 as an excellent fractional approximation of pi; Yoshio Mikami noted that neither the Greeks, Hindus, nor Arabs were aware of this fractional approximation of pi until the Dutch mathematician Adrian Anthoniszoom rediscovered it in 1585, "thus the Chinese possessed this most extraordinary of all fractional values a full millennium before Europe."[2]

Zu Chongzhi and his son Zu Geng employed Cavalieri's principle to derive an exact solution for calculating the volume of a sphere. His book also encompassed formulas for cubic equations and the precise value of pi described by a lengthy calculation involved and Zu's value of pi is precise to six decimal places and for almost nine hundred years thereafter no subsequent mathematician computed a value this precise.[3] This work of Zhui Shu, was omitted from the mathematics curriculum during the Song Dynasty and subsequently lost. Many scholars believe that Zhui Shu contains equations and methodologies pertinent to linear algebra, as well as an algorithm for

[1] Hart, Roger. The Chinese Roots of Linear Alegbra. Johns Hopkins University. pp. 11–85.
[2] Yoshio Mikami, The Development of Mathematics in China and Japan, chap 7, p. 50, reprint of 1913 edition Chelsea, NY, Library of Congress catalog 61–13497
[3] Du Shiran (杜石然); He Shaogeng (何紹庚) (2000). "Zu Chongzhi". Encyclopedia of China (Mathematics Edition) (1st ed.).

determining the value of π and an equation for the volume of a sphere. The text is also associated with his astronomical methods of interpolation, which may encompass knowledge akin to contemporary mathematics.[1]

The Sunzi mathematical classic, a seminal work dated between 200 and 400 CE, provides the most comprehensive step-by-step description of algorithms for multiplication and division utilizing counting rods. Notably, Sunzi may have played a role in the evolution of place-value systems and the corresponding kitchen-board division in the West. European scholars became acquainted with place-value techniques in the 13th century through a Latin translation of an early 9th-century text by al-Khwarizmi. The presentation by al-Khwarizmi closely mirrors Sunzi's division algorithm, despite certain stylistic discrepancies (e.g., the use of blank spaces to denote trailing zeros); this resemblance implies that the findings may not have been an independent innovation. Islamic commentators on al-Khwarizmi's work contend that he effectively encapsulates Hindu knowledge. Al-Khwarizmi's omission of source citations complicates the determination of whether those sources, in turn, acquired the procedure from China.[2]

By the Tang Dynasty, the study of mathematics had become well-established in prominent educational institutions. The Ten Arithmetic Laws comprised a compilation of ten Chinese mathematical texts, assembled by the Tang Dynasty mathematician Li Chunfeng (李淳风 602–670), serving as the official mathematical references for the imperial examinations. Both the Sui and Tang Dynasties maintained the "School of Arithmetic." Wang Xiaotong emerged as a notable mathematician at the onset of the Tang Dynasty, authoring the work Jigu Suanjing (Continuation of Ancient Mathematics), which first presented numerical solutions to general cubic equations. The sine table was translated by the Indian mathematician Aryabhata into the Chinese mathematical textbook Kaiyuan Zhanjing, compiled in 718 AD during the Tang Dynasty. While the Chinese excelled in various mathematical domains such as solid geometry, the binomial theorem, and complex algebraic formulas, early forms of trigonometry did not receive the same level of recognition as they did in contemporary Indian and Islamic mathematics.[3]

Four distinguished mathematicians emerged during the Song and Yuan dynasties, particularly in the 12th and 13th centuries: Yang Hui, Qin Jiushao, Li Ji (Li Yi), and Zhu Shijie. Yang Hui, Qin Jiushao, and Zhu Shijie employed the Horner-Ruffini method six centuries ago to address specific types of simultaneous equations, as well as quadratic, cubic, and quartic equations. Yang Hui was notably the first individual in history to discover and prove "Pascal's triangle," along with his binomial proof, although the earliest reference to Pascal's triangle in China predates the

[1] Ho Peng Yoke (1987) [1985]. Li, Qi & Shu: An Introduction to Science & Civilization in China (University of Washington Press ed.). Hong Kong University Press. p. 76.

[2] [2] Lam Lay Yong (1996). "The Development of Hindu Arabic and Traditional Chinese Arithmetic". Chinese Science. 13: 35–54.

[3] Needham, Joseph (1959). Science and Civilization in China. England: Cambridge University Press. Volume 3, 108-109.

11th century AD. Conversely, Li Zhi explored a form of algebraic geometry based on the tiān yuán sh. His work, Ceyuan haijing, revolutionized the concept of inscribing a circle within triangles by transforming this geometric problem through algebra rather than the traditional Pythagorean theorem. Guo Shoujing also contributed to spherical trigonometry during this period to facilitate precise astronomical calculations. At this juncture in mathematical history, Chinese mathematicians had uncovered much of what constitutes modern Western mathematics. A period of relative quiet ensued until the resurgence of Chinese mathematics in the 13th century, which enabled Chinese mathematicians to solve equations using methods that remained unknown in Europe until the 18th century. The pinnacle of this era was marked by Zhu Shijie's works, Suanxue qimeng and Siyuan yujian. In one instance, he is credited with providing a method equivalent to Gauss's axial condensation. Qin Jiushao (c. 1202–1261) was the first to introduce the zero symbol into Chinese mathematics; prior to this innovation, blanks had been utilized in place of zeros within the counting rod system. One of Qin Jiushao's most significant contributions was his method for solving advanced numerical equations.[1]

Astronomy in ancient China

Astronomy was a science of cardinal importance for the Chinese, thus it boasts a rich and extensive history. Correspondingly, astronomy and calendrical science were always 'orthodox', Confucian, sciences. Along with Babylonian records, many of which are presumed to have been completely lost, Chinese records demonstrate that they were the most consistent and accurate observers of celestial phenomena in the pre-Arab world. Even today, as will become clear, there is a long period (from about the 5th century AD to the 10th century AD) in which almost all Chinese records are available. In many cases (such as the frequent appearances of comets, especially Helle's) contemporary astronomers have turned to these records and obtained valuable results. A notable example is the appearance of supernovae and hypernovae, which is important in current cosmological theory. The Chinese records cover the entire period between Hipparchus and Tycho Brahe, during which the rest of the world remained almost completely ignorant of the fact that "new stars" occasionally appeared in the sky. In other cases (such as sunspots), the Chinese observed phenomena regularly for centuries, which Europeans not only ignored but would have found unacceptable based on their cosmological preconceptions. All this constitutes no small contribution to the history of human knowledge of celestial events, nor is it spoiled by the fact that the observations of previous centuries were often due to the belief in the importance of predicting state affairs.[2]

Oracle bones from the Shang dynasty (2nd millennium BC) document eclipses and supernovae. While ancient China utilized stars from the Shang dynasty (Chinese Bronze Age), Chinese star names, later categorized into twenty-eight mansions, have been identified on oracle bones unearthed in Anyang, dating back to the mid-Shang dynasty. The foundation of the mansion

[1] Needham, Joseph (1959). Science and Civilization in China. England: Cambridge University Press. Volume 3, p.43.
[2] Needham, Joseph (1959). Science and Civilization in China. Volume 3. England: Cambridge University Press. p.171-172.

system (xiù: 宿) appears to have been established during the reign of the ruler Wu Ding (1339–1281 BC). Comprehensive records of astronomical observations commenced during the Warring States period (4th century BC) and flourished from the Han period onward. Chinese astronomy was tropical, emphasizing meticulous observation of the polar stars, and was predicated on principles distinct from those of traditional Western astronomy, where stellar risings and zodiacal constellations constituted the fundamental framework of the ecliptic. Needham characterized the ancient Chinese as the most accurate and precise observers of celestial phenomena globally prior to the era of Muslim astronomers.[1]

The early Chinese sages were captivated by the act of gazing upward and contemplating the celestial signs. “They examined the myriad variations beneath the heavens and pondered how all movements within this realm converged and became interconnected, following eternal laws. This inquiry can be traced back to the fourth century B.C. The Chinese endeavored to depict the celestial sphere, as exemplified by the eminent astronomer Zhang Heng in the first century A.D. in his work, Spiritual Constitution of the Universe: “In ancient times, the wise kings, seeking to understand the pathways of the heavens, to delineate the lofty trajectories (the paths of celestial bodies), and to ascertain the origins of phenomena, first constructed a celestial sphere. This allowed them to refine their instruments and establish a degree, thereby fixing the imperial pole. All celestial bodies rotated around the celestial axis in a manner that could be systematically studied. Once this framework was established and observed, it became evident that the heavens exhibited a natural regularity.”[2]

In the early 1980s, a tomb was discovered at Xi Shui Po (西水坡) in Bo Yang, Henan Province. Within the tomb, shells and bones depicted images of the blue dragon, the white tiger, and the northern cotton. This tomb is believed to date back to the Neolithic period, approximately 6,000 years ago. The names of the stars associated with the 28 Lunar Mansions were inscribed on oracle bones from the Wuding period, around 3,200 years ago. In 1978, a lacquer box was unearthed from the Zeng Hou Yin tomb in Suixian, Hubei Province. The names of the 28 Lunar Mansions were found on the box's cover, indicating that this classification system was in use prior to 433 BC. Given the ancient origins of the Lunar Mansions, the meanings of most of their names have become obscure. Compounding this issue, each Lunar Mansion's name consists of a single Chinese word, with meanings that can vary throughout history. Consequently, the interpretation of these names remains a topic of debate. In addition to the 28 Lunar Mansions, much of the zodiac is derived from the works of Shi Shenfu and Gan Di, who were astrologers during the Warring States Period (481 BC - 221 BC) in China.[3]

Before the Greek astronomer Hipparchus compiled the first star catalog for the Western world in the 2nd century BC, the 4th century BC astronomers Shi Xin and Gan Di were the pioneers in

[1] Needham, Joseph (1959). Science and Civilization in China. Volume 3. England: Cambridge University Press. p.171-177.
[2] Chinese astronomy, [https://www.newworldencyclopedia.org/entry/chinese_astronomy], 28/02/2026.
[3] Chinese astronomy, [https://www.newworldencyclopedia.org/entry/chinese_astronomy], 28/02/2026.

creating a star catalog in history. Their works are collectively known as the Star Manual of Masters Gan and Shi (甘石星經), recognized as the world's first star catalog. Although this catalog was ultimately lost over the centuries, some of its content was referenced and utilized by subsequent Chinese texts, such as the Treatise on Astrology of the Kaiyuan Reign (開元占經) during the reign of Emperor Xuanzong of Tang (712-756 AD). After analyzing and summarizing the contributions of Gan Di and Shi Xin, Tang astronomers documented the names of over 800 stars, 121 of which were identified by their locations.[1]

Another classic Chinese text is the Star Manual of Master Wuxian (巫咸星經). Its authorship remains contentious due to its mention of twelve countries that did not exist during the Shang Dynasty, the period in which it is believed to have been composed. The Han Dynasty astronomer and inventor Zhang Heng (78–139 AD) catalogued approximately 2,500 distinct stars and identified over 100 different constellations. He also published his work Ling Xian, which serves as a summary of the various astronomical theories prevalent in China at that time. During the later Three Kingdoms period (220–280 AD), Qin Zhu (陳卓) compiled the works of his predecessors, resulting in another star catalogue that listed 283 constellations and 1,464 stars. The ancient Chinese astronomer Shi Xin (4th century BC) recognized the relationship between the moon and solar eclipses, providing instructions in his writings for predicting them based on the relative positions of the moon and sun. The Chinese philosopher Wang Chong (27–97 AD) challenged the "radiating effect" theory of solar eclipses but acknowledged in his writings that this concept was not novel. Zhang Heng (78–139 AD) also addressed both solar and lunar eclipses in his publication Ling Xian (靈憲), dated 120 AD.[2]

Medicine in ancient China

Chinese medicine represents a traditional healing approach and philosophy of physical balance originating in China. With a history spanning over thousands of years, it remains significant and has even gained global recognition. The origins of Chinese medicine can be traced back to the 2nd century BC, although clear records of the earliest medical practices are lacking. Written accounts of diseases from the Shang Dynasty (1600-1046 BC) exist, yet there is no documentation of their medical techniques.[3]

The Chinese medical system is regarded as an ancient and autonomous tradition, largely uninfluenced by external factors. According to tradition, Huangdi Neijing (“Yellow Emperor”), one of the mythical founders of Chinese civilization, authored a foundational text on internal medicine known as the Yellow Emperor’s Inner Classic in the third millennium BCE; however, evidence suggests that its current form dates no earlier than the third century BCE, detailing the application of moxibustion and acupuncture to balance yin and yang in ways akin to contemporary practices. This text, along with subsequent writings, encompasses a range of

[1] Chinese astronomy, [https://www.newworldencyclopedia.org/entry/chinese_astronomy], 28/02/2026.
[2] Chinese astronomy, [https://www.newworldencyclopedia.org/entry/chinese_astronomy], 28/02/2026.
[3] The History of Chinese Medicine [https://www.chinahighlights.com/travelguide/chinese-medicine/history.htm]

techniques rooted in traditional physical concepts. Most Chinese medical literature is derived from the Huangdi Neijing, which remains a significant authority. Other notable works include the Mojing (referred to in the West as the "Pulse Classic"), composed around 300 AD, and the Yuzhuan Yizong Jinjian ("The Golden Mirror of the Orthodox Medical Dynasty, commissioned by the Emperor"), commonly known in English as the Golden Mirror, a 1742 compilation of medical texts from the Han dynasty (202 BC - 220 AD). European medicine began to be introduced in China in the early 19th century, yet the original system continues to be widely practiced.[1]

The Yellow Emperor's Inner Canon (Huángdì Nèijīng) has been the most influential treatise for over two millennia. This multi-volume work articulates perspectives on the functions of the human body and the physical world, which continue to underpin the foundational concepts embraced by practitioners of traditional medicine. The text elaborates on the principles of yin and yang, the five phases of nature (wood, fire, earth, metal, water), and Qi. The origins of these concepts remain uncertain. The Treatise on Cold Injuries (伤寒 Shānghán Lùn) and the Bencao Gangmu (本草纲目 Běncǎo Gāngmù) are two additional seminal texts for traditional medicine practitioners, both focusing on medicines and herbs. The Treatise on Cold Injuries is attributed to Zhang Zhongjing and was published around 220 at the conclusion of the Han Dynasty (206 BC - 220 AD). It is recognized as the earliest known treatise on medicines and medicinal herbs.[2]

The foundation of traditional Chinese medicine rests on the dualistic cosmic theory of yin and yang. Yang, representing the male principle, is characterized by activity and light, symbolized by heaven. Conversely, yin, the female principle, embodies passivity and darkness, represented by earth. The human body, akin to matter in general, comprises five elements: wood, fire, earth, metal, and water. These elements are associated with various other groups, including the five planets, five atmospheric conditions, five colors, and five tones. Health, character, and the success of both political and private endeavors are influenced by the prevailing balance of yin and yang at any given time, with the primary objective of ancient Chinese medicine being the regulation of their proportions within the body.[3]

In these paragraphs, we concentrate on the history of science in ancient civilizations, noting the subsequent additions and advancements in various scientific fields among their later populations, particularly following the birth of Christ.

History of Science in Ancient Greek Civilization

Ancient Greek science is a modern term for the application of systematic inquiry into the individual, the world, and the universe, which began in Ionia in the 6th century BCE with Thales of Miletus (l. c. 585 BCE) and continued through the work of the astronomer Ptolemy (l. 100-

[1] [Https://www.britannica.com/science/history-of-medicine/China]
[2] The History of Chinese Medicine [https://www.chinahighlights.com/travelguide/chinese-medicine/history.htm]
[3] [Https://www.britannica.com/science/history-of-medicine/China]

170 CE) to form the foundation of modern scientific method. The history of science in classical antiquity encompasses both practical investigations into the workings of the universe, such as the establishment of a reliable calendar and the treatment of various diseases, as well as the abstract inquiries known as natural philosophy. Individuals in ancient times who identified as early scientists may have regarded themselves as natural philosophers, skilled practitioners (e.g., physicians), or adherents of a religious tradition (e.g., temple healers). The encyclopedic contributions of Aristotle, Archimedes, Hippocrates, Galen, Ptolemy, Euclid, and others are widely disseminated across the globe. These works, along with significant commentaries, served as the foundation of scientific inquiry.

The History of Mathematics in Ancient Greece

The accomplishments of ancient Greek science rank among the most significant of antiquity. Drawing upon Egyptian and Babylonian knowledge, luminaries such as Thales of Miletus, Pythagoras, and Aristotle formulated concepts in mathematics, astronomy, and logic that would profoundly shape Western thought, science, and philosophy for centuries. Aristotle pioneered a systematic approach to the study of logic, while early developments were imparted by philosophers like Anaximander and Empedocles. Additionally, the mathematical theorem attributed to Pythagoras remains relevant in contemporary applications.

Greek contributions to mathematics and astronomy rank among the most significant of antiquity. The foundations of mathematics were initially established through the influence of Egyptian mathematical practices. Subsequently, astronomy thrived during the Hellenistic period, following Alexander the Great's (356 BC - 323 BC) conquests in the East, which were further enhanced by Babylonian insights.[1]

Greek mathematics encompasses mathematical texts produced and ideas developed during antiquity, particularly throughout the Hellenistic periods, from the 7th century BC to the 4th century AD, along the eastern Mediterranean. Greek mathematicians resided in cities scattered across the eastern Mediterranean, from Italy to North Africa, yet they were unified by a shared Greek culture and language. The term "mathematics" itself originates from Ancient Greek: μάθημα, romanized: máthēma Attic Greek: [má.tʰɛː.ma] Koine Greek: [ˈma.θi.ma], signifying "subject of instruction." A significant distinction between Greek mathematics and that of preceding civilizations is the pursuit of mathematics for its own sake, alongside the application of generalized mathematical theorems and proofs.[2]

One of the strengths of science lies in its pursuit to distinguish itself from concepts of specific utility and to seek general principles with extensive applications. As science becomes more generalized, it also becomes increasingly abstract, leading to a wider range of applications. The Greeks derived from Egyptian mathematics primarily practical rules with specific uses. For instance, the Egyptians recognized that a triangle with sides in the ratio of 3:4:5 constitutes a

[1] Cristian Violatti, Ancient Greek Science, 2013: [https://www.ancient.eu/Greek_Science/].
[2] Boyer, C.B. (1991), A History of Mathematics (2nd ed.), New York: Wiley, p. 48

right triangle. Pythagoras expanded upon this idea, formulating a mathematical theorem that bears his name: in a right triangle, the square of the length of the side opposite the right angle (the hypotenuse) is equal to the sum of the squares of the lengths of the other two sides. This principle is not only applicable to the 3:4:5 triangle but also holds true for any right triangle, irrespective of its dimensions.[1]

Through the discovery of mathematical theorems, the Greeks encountered the art of deductive reasoning. To construct their mathematical knowledge, they derived conclusions through deductive reasoning from what appeared self-evident. This method proved effective, and its success in mathematics fostered its application across various other disciplines. The Greeks ultimately came to believe that the sole acceptable means of acquiring knowledge was through deduction.

Historians typically mark the inception of Greek mathematics with Thales (c. 624–548 BC). Limited information exists regarding Thales's life and contributions, with scant details about his birth and death, aside from the eclipse of 585 BC, which likely occurred during his prime. Nonetheless, it is widely accepted that Thales was the inaugural member of the Seven Sages of Greece. The two earliest mathematical theorems are attributed to him: the Thalesian theorem and the intersection theorem. The former, which asserts that an angle inscribed in a semicircle is a right angle, was likely acquired by Thales during his time in Babylon, although tradition attributes its presentation to him. Consequently, he is frequently recognized as the progenitor of the deductive systematization of mathematics and the first true mathematician. Thales is believed to be the earliest individual in history to whom specific mathematical discoveries are ascribed. While it remains uncertain whether Thales introduced the logical structure prevalent in contemporary mathematics, it is established that within two centuries of his time, the Greeks incorporated logical structure and the concept of proof into the discipline.[2]

Another significant figure in the evolution of Greek mathematics was Pythagoras of Samos (c. 580–500 BC). Similar to Thales, Pythagoras journeyed to Egypt and Babylon, then under Nebuchadnezzar, before establishing himself in Croton, Magna Graecia. He founded a system known as the Pythagorean order, which collectively held knowledge and property, attributing all discoveries made by individual Pythagoreans to the order itself. Although Pythagoras claimed credit for the findings of his order, Aristotle, for instance, refrained from attributing any specific contributions to Pythagoras as an individual, instead discussing the work of the Pythagoreans as a collective. A defining characteristic of the Pythagorean order was its assertion that the pursuit of philosophical and mathematical studies served as an ethical foundation for living. Indeed, the terms philosophy (love of wisdom) and mathematics (what you have learned) are believed to have been coined by Pythagoras. This passion for knowledge led to numerous accomplishments.

[1] Cristian Violatti, Ancient Greek Science, 2013: [https://www.ancient.eu/Greek_Science/].
[2] Boyer & Merzbach (1991) pp. 43–61.

It is commonly stated that the Pythagoreans uncovered most of the content in the first two books of Euclid's Elements.[1]

The contributions of Thales and Pythagoras are challenging to differentiate from those of both preceding and subsequent mathematicians, as none of their original works have endured, with the possible exception of the disputed "Fragments of Thales." Nevertheless, several historians, including Hans-Joachim Waschkies and Carl Boyer, contend that much of the mathematical knowledge ascribed to Thales was developed in later periods, particularly elements that depend on the concept of angles, while the application of general statements emerged earlier, as evidenced in Greek legal texts inscribed on tablets. The ambiguity surrounding the precise contributions of Thales and Pythagoras stems from the scarcity of contemporary documentation. The sole evidence available derives from traditions recorded in later works, such as Proclus' commentary on Euclid, composed centuries afterward. Some of these subsequent texts, including Aristotle's commentary on Pythagoras, are known only through a limited number of surviving fragments.[2]

Thales is believed to have employed geometry to address problems such as determining the height of the pyramids by measuring the length of shadows and the distance of ships from the shore. He is also traditionally recognized for providing the first proofs of two geometric theorems—the "Thales' theorem" and the "intersection theorem" mentioned earlier. Pythagoras is widely acknowledged for identifying the mathematical foundation of musical harmony and, according to Proclus' commentary on Euclid, for discovering the theory of proportions and constructing regular solids. Some contemporary historians have raised doubts regarding whether he actually constructed all five regular solids, proposing instead that it is more plausible he constructed only three. Various ancient sources attribute the discovery of the Pythagorean theorem to Pythagoras, while others assert that it was a proof of the theorem he uncovered. Modern historians contend that the principle itself was known to the Babylonians and was likely derived from them. The Pythagoreans regarded numerology and geometry as essential for comprehending the nature of the universe, thereby forming the basis of their philosophical and religious beliefs. They are credited with numerous mathematical advancements, including the discovery of irrational numbers. Historians acknowledge their significant contribution to the evolution of Greek mathematics (particularly in number theory and geometry) into a coherent, logical system founded on clear definitions and proven theorems, which was deemed a discipline worthy of study in its own right, independent of the practical applications that primarily concerned the Egyptians and Babylonians.[3]

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[1] Boyer & Merzbach (1991) pp. 43–61.

[2] Hans-Joachim Waschkies, "Introduction" to "Part 1: The Beginning of Greek Mathematics" in Classics in the History of Greek Mathematics, pp. 11–12

[3] Hans-Joachim Waschkies, "Introduction" to "Part 1: The Beginning of Greek Mathematics" in Classics in the History of Greek Mathematics, pp. 43–61

The Hellenistic period commenced in the 4th century BC with Alexander the Great's conquest of the eastern Mediterranean, Egypt, Mesopotamia, the Iranian Plateau, Central Asia, and parts of India, resulting in the dissemination of Greek language and culture across these territories. Greek emerged as the predominant language of scholarship throughout the Hellenistic world, while Greek mathematics integrated with Egyptian and Babylonian mathematics to form Hellenistic mathematics. During the Hellenistic and Roman periods, Greek mathematics and astronomy attained remarkable advancements, exemplified by scholars such as Hipparchus, Apollonius, and Ptolemy. The foremost center of learning during this era was Alexandria in Egypt, which drew scholars from across the Hellenistic world.[1]

Archimedes' work foreshadowed modern calculus through his skillful use of infinitesimals. He employed a technique known as the method of exhaustion, a form of proof by contradiction, to determine solutions with arbitrary precision. This method allowed him to establish upper and lower bounds for the answers he sought. Notably, he used this approach to approximate the value of π. In his work "Squaring the Parabola," Archimedes demonstrated that the area enclosed by a parabola and a straight line is exactly 34 times the area of a triangle sharing the same base and height. He elegantly expressed this solution as the sum of an infinite geometric series, which converges to 34. Furthermore, in "The Sand Reckoner," Archimedes challenged the prevailing belief that the number of sand grains in the universe was too large to quantify. To accomplish this, he developed an innovative counting system. He introduced the concept of a 'myriad myriad,' representing 108, and used powers of this number to express extremely large quantities. This work demonstrated his ability to handle numbers far exceeding the conventional limits of his time.[2]

Medicine in ancient Greece

Ancient Greek medicine comprised a dynamic array of theories and practices that evolved through innovative ideologies and experimentation. Various factors were considered within this medical framework, leading to a synthesis of the spiritual and the physical. The ancient Greeks posited that health was affected by humors, geography, social class, diet, trauma, beliefs, and mental state. Early Greeks viewed diseases as “divine punishments” and regarded healing as a “gift from the gods.” As experimentation progressed, with theories being tested against symptoms and outcomes, the strictly spiritual notions of “punishments” and “gifts” were supplanted by a foundation rooted in the physical, emphasizing cause and effect.[3]

Humorism, encompassing the four humors—blood, phlegm, yellow bile, and black bile—was a foundational concept in ancient medicine. Gender was believed to influence medical practices, as certain diseases and treatments varied between females and males. Additionally, geographic

[1] Russo, L. (2004), "Hellenistic Mathematics", The Forgotten Revolution: How Science Was Born in 300 BC and Why It Had to Be Reborn, Berlin, Heidelberg: Springer, pp. 31–55.
[2] Reviel Netz (2003), "The Goal of Archimedes' Sand Reckoner", Apeiron, 36 (4): 251–290.
[3] Cartwright, Mark (2013). "Greek Medicine". Ancient History Encyclopedia Limited. UK. Retrieved November 9, 2013.

location and social class significantly impacted individuals' living conditions, exposing them to diverse environmental challenges, including mosquitoes, rats, and the availability of clean drinking water. Diet was also considered a critical factor, often compromised by inadequate access to proper nutrition. Trauma, particularly that experienced by wrestlers due to dog bites or other injuries, contributed to the understanding of anatomy and inflammation. Moreover, considerable emphasis was placed on the beliefs and mindset of the patient within diagnostic and treatment theories, acknowledging the mind's role in healing and its potential as the sole determinant of disease.[1]

Ancient Greek medicine originated with the humoral theory, which posits that optimal health arises from a precise equilibrium of the four humors: blood, phlegm, yellow bile, and black bile. Consequently, poor health is attributed to an imbalance among these humors. Hippocrates, often referred to as the "father of modern medicine," founded a medical school in Kos and is regarded as the most significant figure in ancient Greek medicine. He and his students meticulously documented numerous diseases in the Hippocratic Corpus and formulated the Hippocratic Oath for physicians, which remains in practice today. The contributions of Hippocrates, Socrates, and others to ancient Greek medicine exerted a profound influence on Islamic and medieval European medicine, although many of their findings became outdated by the 14th century.[2]

Despite their acknowledged reverence for Egyptian medicine, efforts to identify any specific influence on Greek practices during this early period have largely proven futile, primarily due to a scarcity of sources and the complexities of interpreting ancient medical terminology. Nevertheless, it is evident that the Greeks incorporated Egyptian substances into their pharmacopoeia, with the influence becoming increasingly pronounced following the establishment of a Greek medical school in Alexandria.[3]

Asclepius is revered as the first physician, and mythology designates him as the son of Apollo. Temples dedicated to the healing god Asclepius, known as Asclepios (Greek: Ἀσκληπιεῖα; sing. Ἀσκληπιεῖον Asclepieion), served as centers for medical guidance, diagnosis, and healing. Within these sanctuaries, patients would enter a dream-like state of induced sleep referred to as "Enkoimesis" (Greek: ησιςμησις), akin to anesthesia, during which they either received divine guidance in dreams or underwent surgical procedures. Asclepias provided meticulously controlled environments conducive to healing, fulfilling many of the criteria established for medical institutions. The temple of Asclepius at Pergamum featured a spring that flowed into an underground chamber within the structure. Visitors came to drink from and bathe in the waters, believed to possess medicinal properties. Mud baths and herbal teas, such as chamomile for relaxation or peppermint for headache relief, were utilized, with peppermint tea remaining a popular home remedy today. Patients were also encouraged to rest within the facilities, where

[1] Bendick, Jeanne. "Galen – And the Gateway to Medicine." Ignatius Press, San Francisco, CA, 2002.
[2] http://www.medicinaantiqua.org.uk/sa_hippint.html
[3] Heinrich von Staden, Herophilus: The Art of Medicine in Early Alexandria (Cambridge: Cambridge University Press, 1989), pp. 1-26.

their dreams were interpreted by physicians, followed by a review of their symptoms. Dogs were occasionally brought in to lick open wounds to facilitate healing. In the Asclepieion of Epidaurus, three large marble tablets dating to 350 BC preserve the names, case histories, complaints, and treatments of approximately 70 patients who sought assistance at the temple. Some of the surgical procedures documented, such as the incision of an abdominal abscess or the removal of painful foreign objects, are plausible enough to have been performed, albeit with the patient in a state of enkoimesis induced by narcotic substances like opium. The Rod of Asclepius remains a universal symbol of medicine today; however, it is frequently confused with the Caduceus, a staff associated with the god Hermes. The Rod of Asclepius is characterized by a single wingless serpent, while the Caduceus features a serpent entwined around a staff with a pair of wings, symbolizing the swiftness of Hermes.[1]

The Hippocratic Corpus challenges ancient beliefs by presenting biologically grounded approaches to disease rather than relying on magical interventions. This collection comprises approximately seventy early medical texts from ancient Greece, attributed to Hippocrates and his disciples. While it was once assumed that Hippocrates authored these works, contemporary scholars contend that they were produced by various authors over several decades. Among these texts is the treatise The Sacred Disease, which posits that if all diseases originated from supernatural causes, biological remedies would be ineffective. The foundation of humoral theory in medicine emphasized the equilibrium among blood, yellow bile, black bile, and phlegm within the human body. Disruptions in this balance due to extreme heat, cold, dryness, or humidity resulted in illness and disease. Patients were not perceived as being punished by deities or demons, but rather by detrimental air (miasma theory). Physicians practicing humoral medicine concentrated on reestablishing the balance of the humors. This transition from supernatural to biological explanations for disease did not entirely eliminate Greek religious beliefs, but it did foster a novel approach for physicians in their interactions with patients. Ancient Greek physicians adhering to humoral principles recognized the significance of the environment. They believed that patients' susceptibility to various diseases was influenced by their living conditions. Local water sources and wind patterns were thought to impact the health of the community. Patients were considered integral to their own treatment. The treatise Proverbs asserts, "[I]t is not enough for the physician to do what is necessary, but the patient and attendant must do their part as well."[2]

Patient compliance was fundamentally rooted in the respect afforded to the physician. According to the treatise "Prognostication," the physician could enhance his reputation and esteem by accurately predicting the outcomes of diseases. Physicians played an active role in the lives of their patients, considering their place of residence. The differentiation between fatal and curable diseases was crucial for fostering the patient's trust and respect, which in turn positively

[1] Risse, G. B. Mending bodies, saving souls: a history of hospitals. Oxford University Press, 1990. p. 56

[2] Hippocratic writings, Chadwick, edited with an introduction by G.E.R. Lloyd; translated from the Greek by J.W.N. Mann et.al. (1983). in Penguin classics, Harmondsworth: Penguin. p. 206

influenced patient compliance. As patient compliance increased in Greek medicine, consent emerged as a significant element in the physician-patient relationship. With all pertinent information regarding the patient's health disclosed, the patient made an informed decision to accept treatment. The responsibilities of both the physician and the patient are articulated in the treatise "Epidemiology," which asserts that "there are three factors in the practice of medicine: the disease, the patient, and the physician. The physician is the servant of science, and the patient must do what he can to combat the disease with the assistance of the physician." [1]

It was not until the era of Alexandria under the Ptolemies that significant advancements in biology reemerged. Herophilus of Chalcedon was the first medical educator in Alexandria, distinguishing himself from Aristotle by attributing intelligence to the brain and associating the nervous system with movement and sensation. He differentiated between veins and arteries, noting that the latter exhibited a pulse while the former did not. This distinction was achieved through an experiment involving the incision of specific veins and arteries in the neck of a pig until the squealing ceased. Similarly, he developed a diagnostic method based on the differentiation of various pulse types. Alongside his contemporary Erasistratus of Chios, he explored the functions of veins and nerves, mapping their trajectories throughout the body. Erasistratus correlated the increased complexity of the human brain's surface with superior intelligence compared to other animals. He occasionally employed experiments to advance his research, notably weighing a bird in a cage repeatedly and documenting its weight loss between feedings. Building on his mentor's studies in pneumatics, he posited that the human vascular system was regulated by a vacuum, facilitating the movement of blood throughout the body. In Erasistratus's physiological framework, air enters the body, is drawn by the lungs into the heart, where it is transformed into a vital spirit, and subsequently pumped by the arteries throughout the body. A portion of this vital spirit reaches the brain, where it is converted into an animal spirit, which is then disseminated by the nerves. Herophilus and Erasistratus conducted their experiments on criminals provided to them by the Ptolemaic kings. They performed dissections on these individuals while still alive, observing parts that nature had previously concealed, and examining their position, color, shape, size, arrangement, hardness, smoothness, and connections.[2]

Aelius Galen was a distinguished Greek physician, surgeon, and philosopher of the Roman Empire. Considered the most accomplished medical researcher of antiquity, Galen significantly influenced the evolution of various scientific fields, including anatomy, physiology, pathology, pharmacology, and neurology, as well as philosophy and logic. The son of Aelius Nicon, a prosperous architect with scientific interests, Galen received an extensive education that equipped him for a successful career as a physician and philosopher. Born in Pergamon (modern-day Bergama, Turkey), Galen traveled extensively, immersing himself in diverse medical

[1] Chadwick (1983). Hippocratic Writings. p. 94
[2] Mason, A History of the Sciences, p 57

theories and discoveries before establishing himself in Rome, where he attended to prominent members of Roman society and ultimately became the personal physician to several emperors.[1]

Galen's comprehension of anatomy and medicine was profoundly shaped by the prevailing theory of humors, as articulated by ancient Greek physicians such as Hippocrates. His theories dominated and influenced Western medical science for over 1,300 years. His anatomical reports, primarily derived from the dissection of monkeys, particularly the Barbary macaque, and pigs, remained unchallenged until 1543, when descriptions and illustrations of human anatomy were published in the seminal work De humani corporis fabrica by Andreas Vesalius. Galen's physiological theory was required to accommodate these new observations. His theory of circulatory physiology persisted until 1628, when William Harvey published his treatise De motu cordis, in which he demonstrated that blood circulates and the heart functions as a pump. Medical students continued to study Galen's writings until the 19th century. Galen conducted numerous nerve-ligation experiments that supported the theory, still accepted today, that the brain governs all muscle movements through the cranial and peripheral nervous systems.[2]

Through their prolonged engagement with Greek culture and the eventual conquest of Greece, the Romans developed a favorable perspective on Hippocratic medicine. This acceptance facilitated the dissemination of Greek medical theories throughout the Roman Empire and, consequently, much of the Western world.[3] The most prominent Roman scholar to perpetuate and expand the Hippocratic tradition was Galen. However, the study of Hippocratic and Galenic texts waned in the Latin West during the early Middle Ages, following the fall of the Western Empire, although the examination and tradition of Greek medicine by Hippocratic-Galenic philosophers persisted in the Eastern Roman Empire (Byzantium). After 750 AD, Arab, Persian, and Andalusian scholars translated the works of Galen and Dioscorides, in particular. The Hippocratic-Galenic medical tradition was subsequently assimilated and ultimately expanded, with Ibn Sina emerging as the most influential Muslim physician and scholar. Beginning in the late 11th century, the Hippocratic-Galenic tradition re-emerged in the Latin West through a series of translations of classical texts, primarily derived from Arabic translations but occasionally from the original Greek. During the Renaissance, additional translations of Galen and Hippocrates were made directly from the Greek, utilizing newly accessible Byzantine manuscripts.[4]

Astronomy in Ancient Greece

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[1] Nutton, Vivian (2012). *Galen and Roman Medicine: or can a Greek become a Latin?*. European Review. pp. 534–542.

[2] Frampton, M, 2008, Embodiments of Will: Anatomical and Physiological Theories of Voluntary Animal Motion from Greek Antiquity to the Latin Middle Ages, 400 B.C.–A.D. 1300, Saarbrücken: Verlag. pp. 180 – 323

[3] Heinrich von Staden, "Liminal Perils: Early Roman Receptions of Greek Medicine", in *Tradition, Transmission, Transformation*, ed. F. Jamil Ragep and Sally P. Ragep with Steven Livesey (Leiden: Brill, 1996), pp. 369-418.

[4] Nutton, Vivian (2012). *Galen and Roman Medicine: or can a Greek become a Latin?*. European Review. pp. 534–542.

Greek astronomy refers to the astronomical knowledge documented in Greek during classical antiquity, encompassing the Archaic, Hellenistic, Greco-Roman, and Late Antiquity periods. Its influence extends beyond geographical and ethnic boundaries, as Greek emerged as the language of scholarship throughout the Hellenistic world following Alexander's colonization campaigns. This era of Greek astronomy is often termed Hellenistic astronomy, while the preceding phase is recognized as Classical Greek astronomy. Throughout the Hellenistic and Roman periods, numerous Greek and non-Greek astronomers, adhering to the Greek tradition, conducted their studies at the Musaeum and Library of Alexandria in Ptolemaic Egypt. The Greek contribution is pivotal to the broader history of astronomy, marked by the initiation of inquiries into mental-physical explanations of celestial phenomena. Most names of stars, planets, and constellations in the Northern Hemisphere derive from Greek astronomical terminology, which was largely translated from empirical insights in Babylonian astronomy, noted for its theoretical framework involving algebra and numerical relationships, alongside a lesser influence from Egyptian astronomy. Subsequently, the scientific endeavors of astronomers and mathematicians within the Arab Muslim Empire, representing a variety of backgrounds and faiths, to translate, comment on, and refine Ptolemy's Almagest, significantly impacted both Indian and Western European astronomy.[1]

We possess no tangible evidence regarding the actions or assertions of certain Greek philosophers from 600 BC to 300 BC. Nevertheless, speculation endures that Anaximander (c. 610 BC – 546 BC) posited a rotating Earth positioned at the center of the universe, encircled by rings of fire, while Philolaus (c. 480 BC – 405 BC) and Pythagoras envisioned a cosmos comprising stars, planets, the sun, the moon, the Earth, and an anti-Earth (Antichthon)—numerous celestial bodies in total—revolving around an unseen central fire. Thus, it remains purely conjectural that the Greeks of the 6th and 5th centuries BC possessed knowledge of the planets and contemplated the universe's structure. Furthermore, a more comprehensive depiction of the universe, including stars, the sun, the moon, and the Earth, is found in Orphism, which originates from the late 5th century BC. Within the verses of Orphic poems, one can uncover intriguing insights, such as the Earth being spherical, possessing an axis and completing a rotation in one day, featuring three climatic zones, and the sun's role in magnetizing the stars and planets.[2]

The term "planet" is derived from the Greek word πλανήτης (Planētēs), which translates to "wanderer." Ancient astronomers noted the movement of certain celestial bodies across the sky in relation to fixed stars. Five planets can be observed with the naked eye: Mercury, Venus, Mars, Jupiter, and Saturn, known in Greek as Hermes, Aphrodite, Ares, Zeus, and Cronus. Occasionally, the stars, the Sun, and the Moon are included in the category of naked-eye planets, resulting in a total of seven. Identifying all five planets requires careful observation, as they can

[1] Thurston, H., Early Astronomy. Springer, 1994. p.2

[2] *Kirk, G.S., Raven, J.E., & Schofield, M.B. (1957). The Presocratic Philosophers a Critical History with a Selection of Texts /by G.S. Kirk, J.E. Raven, M. Schofield.*

sometimes vanish when they approach the Sun. Observations of Venus present particular challenges. The early Greeks mistakenly believed that the evening and morning appearances of Venus were two distinct entities, referring to it as Hesperus ("evening star") in the western evening sky and Phosphorus ("shining bringer") in the eastern morning sky. They ultimately recognized that both appearances were manifestations of the same planet, a realization attributed to Pythagoras.[1]

Regarding the calendar, as previously noted, ancient calendars were predominantly lunar or solar. The Hellenic calendar integrated elements of both systems, and certain Greek astronomers even devised a calendar based on the eclipse cycle. Astronomy was intrinsically linked to mathematics, as astronomers endeavored to develop geometric models that could replicate the observed movements of celestial bodies. This tradition originated with the Pythagoreans, who categorized astronomy as one of the four mathematical arts, alongside arithmetic, geometry, and music. The exploration of numbers, encompassing these four disciplines, later became known as the Quadrivium.[2]

Although not an exceptional mathematician, Plato (427–347 BC) incorporated the Tetrarchy as a foundation for philosophical education in the Republic. The mathematician Eudoxus of Cnidus (c. 410–347 BC) promoted the advancement of the Greek astronomical system, and according to contemporary science historian David Lindberg: "In their work we find (1) a shift from stellar to planetary concerns, (2) the creation of a geometric model, the 'two-sphere model', to represent stellar and planetary phenomena, and (3) the establishment of criteria governing theories designed to account for planetary observations."[3] The dual-sphere model is a geocentric framework that categorizes the universe into two distinct regions: a spherical, central, stationary Earth (the sublunar sphere) and a spherical celestial sphere centered on the Earth, which may encompass several rotating spheres composed of aether.[4]

Eudoxus met the challenge by assigning a series of concentric spheres to each planet. By tilting the axes of these spheres and designating distinct periods of revolution for each, he successfully approximated the celestial "appearance." He was, therefore, the first to endeavor to mathematically describe planetary motion. A general understanding of the content of his work, On the Speeds of the Planets, can be inferred from Aristotle's Metaphysics. As all of his original work has been lost, our knowledge of Eudoxus is derived from secondary sources.[5]

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[1] Ross, Micah T. (2020). "Hellenistic Egyptian Planetary Theory". In Bowen, Alan C.; Rochberg, Francesca (eds.). *Hellenistic Astronomy: The Science in Its Contexts*. Brill. pp. 160–165.

[2] Lindberg, D. C. (2007). *The beginnings of Western science: The European scientific tradition in philosophical, religious, and institutional context, prehistory to A.D. 1450* (2nd ed.). University of Chicago Press.

[3] David C. Lindberg (2010). The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450 (2nd.). University of Chicago Press. p. 86.

[4] David C. Lindberg (2010). The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to A.D. 1450 (2nd.). University of Chicago Press. p. 86.

[5] Neugebauer, O. (1975). A History of Ancient Mathematical Astronomy. Journal for the History of Astronomy.

Callippus, a 4th-century Greek astronomer, introduced seven spheres to the model proposed by Eudoxus. Aristotle documented both systems but insisted on incorporating "open" spheres between each set to neutralize the motions of the outer spheres. His focus was on the physical nature of the system. The Eudoxan model had several limitations, including its inability to accurately predict motions, and Callippus's contributions may have aimed to address these shortcomings. Additionally, his models fail to account for the variations in planetary speed. Another limitation is their inability to explain fluctuations in the brightness of planets as observed from Earth. Due to the concentric arrangement of the spheres, the planets maintain a constant distance from Earth. This issue was highlighted in antiquity by Autolycus of Pitanes (c. 310 BC).[1]

In the 2nd century BC, Hipparchus, recognizing the remarkable precision with which Babylonian astronomers predicted planetary motion, asserted that Greek astronomers could achieve comparable accuracy. He somehow accessed Babylonian observations and predictions, utilizing them to develop improved geometric models. For the Sun, he employed a straightforward eccentric model based on equinox observations, which accounted for variations in the Sun's speed and discrepancies in seasonal lengths. For the Moon, he adopted an epicycle model. However, he was unable to formulate accurate models for the other planets and criticized fellow Greek astronomers for their inaccuracies. Hipparchus also compiled a star catalog and observed novae (new stars). To ensure that future generations could ascertain whether stars had dimmed, shifted, or altered in brightness, he meticulously recorded their positions and luminosity. Ptolemy referenced this catalog in relation to Hipparchus's discoveries. In the 3rd century BC, Aristarchus of Samos proposed an alternative cosmology: the heliocentric model of the solar system, positioning the Sun, rather than the Earth, at the center of the known universe, earning him the moniker "Greek Copernicus." Nevertheless, his astronomical theories were largely dismissed, with only scant references surviving. One known follower of Aristarchus was Seleucus of Seleucia. Aristarchus also authored a treatise on the sizes and distances of the Sun and Moon, which remains his only extant work. In this treatise, he calculated the dimensions of the Sun and Moon, as well as their distances from the Earth in terms of Earth's radius. Shortly thereafter, Eratosthenes determined the size of the Earth, providing a radius value that could be correlated with Aristarchus's calculations. Hipparchus wrote an additional work on the sizes and distances of the Sun and Moon, which has not survived. Both Aristarchus and Hipparchus significantly underestimated the distance from the Earth to the Sun.[2]

Claudius Ptolemy, a mathematician active in Alexandria, Roman Egypt, during the 2nd century, made significant contributions to astronomy and astrology. His notable works include the Almagest, planetary hypotheses, hand tables, the Canopic Inscription, and various minor writings. The Almagest is regarded as one of the most influential texts in the history of Western astronomy. In this work, Ptolemy elucidated methods for predicting planetary behavior,

[1] Neugebauer, O. (1975). A History of Ancient Mathematical Astronomy. Journal for the History of Astronomy.
[2] Netz, R. (2022). A New History of Greek Mathematics. Cambridge: Cambridge University Press. p. 328–329.

surpassing the capabilities of Hipparchus, through the introduction of a novel mathematical concept, the equant. The Almagest offered a thorough examination of astronomy, integrating theories, models, and observations from numerous earlier mathematicians. This comprehensive nature may account for its enduring legacy, in contrast to more specialized texts that were overlooked and ultimately lost. Ptolemy established the order of the planets, a standard that persisted until the advent of the heliocentric model.[1]

Almagest, an astronomical manual authored by Ptolemy circa 150 AD, served as the principal reference for Muslim and European astronomers until the early 17th century. Originally titled Mathematike Syntaxis ("Mathematical Arrangement"), the term Almagest emerged as an Arabic adaptation of the Greek word megiste. It was translated into Arabic around 827 and subsequently from Arabic into Latin in the latter half of the 12th century. The Greek text later gained widespread circulation in Europe, although Latin translations from Arabic remained more influential.[2] The work is divided into 13 books. Book I presents arguments for a geocentric, spherical universe and introduces essential trigonometry, along with a trigonometric table, enabling Ptolemy to elucidate and predict the motions of the Sun, Moon, planets, and stars in subsequent books. Book II employs spherical trigonometry to elucidate cartography and astronomical phenomena, such as the duration of the longest day, that characterize various locations. Book III addresses the motion of the Sun and methods for predicting its position in the zodiac at any given time, while Books IV and V tackle the more complex issue of the Moon's motion. Book V also outlines the construction of instruments to facilitate these investigations. The theories developed thus far are applied to solar and lunar eclipses in Book VI. Books VII and VIII primarily focus on the fixed stars, providing the coordinates and magnitudes of the ecliptic for 1,022 stars. This star catalogue is largely derived from that of Hipparchus (129 BC), with Ptolemy typically converting Hipparchus' descriptions of each star's position into ecliptic coordinates and adjusting these values by a constant to account for the deceleration over the intervening centuries. These two books also discuss the construction of a stellar sphere adapted to precession. The remaining five books, the most original, detail geometrical models of the motion of the five planets visible to the naked eye, accompanied by tables for predicting their positions at any given time.[3]

[1] Netz, R. (2022). A New History of Greek Mathematics. Cambridge: Cambridge University Press. p. 360–366.
[2] Netz, R. (2022). A New History of Greek Mathematics. Cambridge: Cambridge University Press. p. 366–368.
[3] Netz, R. (2022). A New History of Greek Mathematics. Cambridge: Cambridge University Press. p. 366–368.

Conclusion

This series of lectures seeks to furnish scholarly material on the topic of "History of Science" as an academic discipline from two perspectives. First, the theoretical perspective focuses on defining the concept of the history of science, its foundational principles, and its relationship with the philosophy of science, distinguishing it from the narrative accounts found in numerous texts titled "History of Science." This section will also explore its origins and evolution into a recognized field of academic research on an international scale, along with its scientific, pedagogical, and societal significance. Second, the applied perspective endeavors to compile informational resources on the history of science across various ancient civilizations, serving as a historical repository for students engaged in the study of the history of science.

Upon engaging with these lectures, the student will recognize that the history of philosophical science transcends a mere chronological account of scientific events; it embodies a critical process both internally and externally, as well as a logical and rational reconstruction of scientific occurrences within their social contexts, encompassing all relevant aspects and influences. Subsequently, the student should examine the various interpretive schools of the history of science and compare them to broaden the understanding of the logic underlying the progression of science, thereby illuminating the efforts of contemporary philosophers of science to articulate this framework.

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