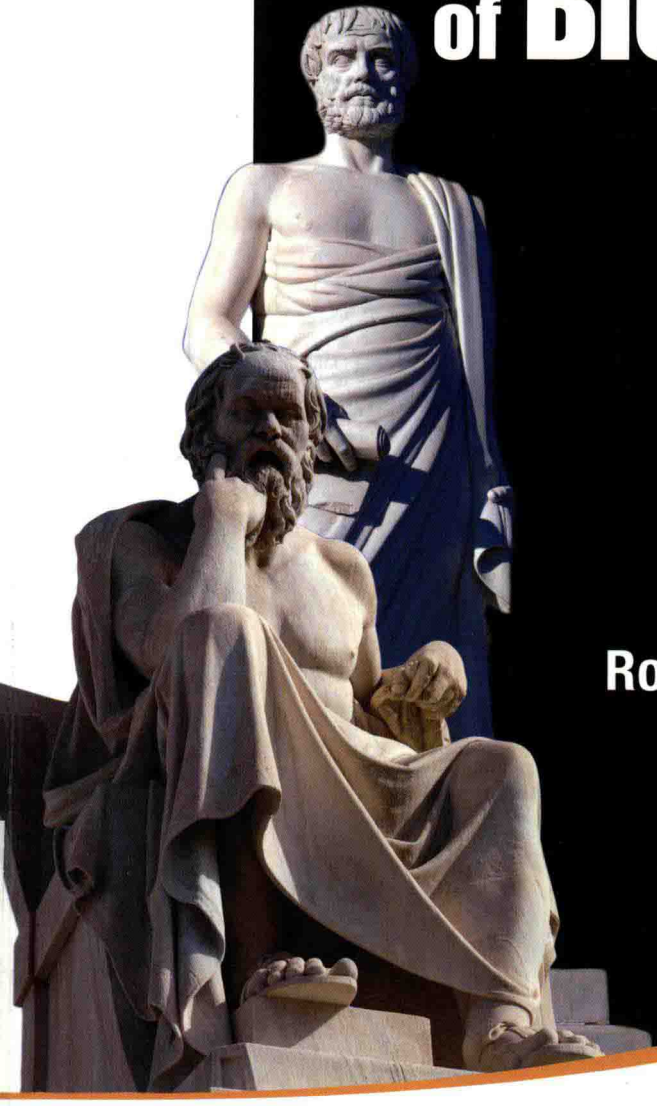
History and Philosophy of Biology



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NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.

5 Toh Tuck Link, Singapore 596224

USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601

UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

Library of Congress Cataloging-in-Publication Data

Kretsinger, Robert H.

History and philosophy of biology / Robert Kretsinger, University of Virginia, USA.

pages cm

ISBN 978-9814635035 (hardcover : alk. paper) -- ISBN 9814635030 (hardcover : alk. paper) --

ISBN 978-9814635042 (pbk. : alk. paper) -- ISBN 9814635049 (pbk. : alk. paper)

1. Biology--Philosophy. 2. Biology--History. I. Title.

QH331.K727 2015

570.1--dc23

2014050204

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Printed in Singapore

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Acknowledgments

Ms Sine Harris, Glasgow, provided the figure for "genes or environment" (Chapter 46). Carter Ransom suggested many changes to make the discussions more accessible to the general reader. Many scholars, only a few of whom are explicitly cited, did the fundamental research that provided the foundation for HPB; thank you.

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Section A

History and Philosophy: Overview

How has one thought about science in times past and in various cultures? What are the more meaningful and rewarding ways to think about science today? Most definitions or characterizations of science fall into two categories:

The first says that science is the study of the natural world. If one includes applications of science, then immediately one is dealing with an un-natural world — one that reflects human activities, especially engineering and medicine. More difficult is the concept of the natural world. Surely investigating the blood circulation of a mouse is science, as is the study of its mating behavior. One then asks whether studying the circulatory system of a human is science. How about the study of his mating behavior? Of his art?

The second definition emphasizes procedure or technique. Does science involve the formulation of a theory and its subsequent testing? If so, how does one go about testing a theory in a historical science such as geology or biology? What distinguishes generalizations from hypotheses, from theories, from laws? Is there a scientific method(s); and if so, should it be applied to the study of human activities such as economics, governance, and art?

The following chapters address these questions: What is science? How have various cultures thought about science? What are contemporary perspectives on science and how have they evolved in recent centuries?

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A1

Pre-Hellenic Science

A contemporary map of Iraq and the surrounding region showing Mesopotamia (literally, "between rivers").

As will be discussed in the next chapter, most historians, especially those in the West, appropriately turn to Greece to understand the origins of science, as well as many other intellectual endeavors. However, there are strong arguments for including engineering, informatics, medicine, and agriculture in the definition of science. If so, we should consider our first tools, garments, dwellings, and herbal remedies.

It requires reasonable talent to flake a stone and attach it to a handle to make an axe. It is hardly trivial to cure a hide and sew pieces together to make a cape or shoes or to bind branches and leaves to make a sturdy shelter. Chimpanzees use digging sticks to access termite nests. Other mammals and birds use tools and make complex nests and burrows. Macaws intuitively ingest clay, apparently to absorb toxins in some seeds that they eat. These skills are to some extent transmitted by imitation, but most are inherent. It seems reasonable to infer that some ability to do simple science is innate in our own species, as well as in others. There is overwhelming evidence that other complex behaviors are genetically encoded — so much for tabla rasa.

One can only speculate about the development of human language and the urges to do art and to do science. These intellectual abilities are probably inter-related. In any case, several fundamental achievements occurred independently several times in human evolution. These include the concepts of counting and adding, identification of stellar constellations, codification of medical practices, as well as the naming and grouping plants and animals. The assignment of names, stories, and powers to these constellations, animals, and practices reflects abstract thinking. These basic achievements of applied science occurred independently in Egypt, India, Mesopotamia, China, and Meso-America.

The earliest astronomer for whom we have records is Thales of Miletus (~600 B.C.). We are left to marvel as to why the Greeks extended these speculations and analyses to new levels of sophistication and abstraction. Did their achievements reflect unique environmental circumstances or the convergence of yet to be identified historical currents? Or were the circumstances that led to the appreciation of questioning purely stochastic? This is hardly a popular interpretation. However, the antecedents, if any, of Greek philosophy have yet to be established.

This chapter summarizes some of the early achievements of the Egyptians, Indians, Assyrians, and Babylonians — peoples of the Bronze Age in the Middle East. Subsequent chapters survey Chinese and Islamic science.

One refers to Egypt, after the unification of the upper and lower kingdoms about 3000 B.C., without exploring the subtleties of different dynasties. Lunar and solar calendars were merged; their calendar consisted of 12 months each of 30 days plus five special days committed to religious holidays. Sundials gave a precise definition of the solstices.

Much of their knowledge of anatomy came from mummifiers, who inserted a long hook through a nostril, broke the thin ethmoid and removed the brain. They removed viscera through an incision in the left groin. These procedures seemed not to have laid the foundation for further exploration of anatomy. Why were they not more curious?

The Ebers Papyrus (~1550 B.C.) listed some 877 "prescriptions" and noted a "... tumor against the god Xenus ... do nothing there against." Homer (~700 B.C.) in the Odyssey noted that "... the Egyptians were skilled in medicine more than any other art." Herodotus (484–425) visited Egypt ~440 B.C. and wrote of their advanced medical practices. Pliny the Elder (23–79) praised their medicine. However, they failed to distinguish arteries from veins or nerves from tendons. The heart was assigned spirit and thought. Hippocrates, Herophilos, Erasistratus, and Galen studied at the temple to Amenhotep III across the Nile from Luxor. Peseshet (~2400 B.C.), mother of Akhethotep, was the first female doctor on record.

The Egyptians made potions or amulets with animal or plant parts that resembled afflicted regions — "*simila similibus*" (similar with similar), a concept not unknown to modern homeopathy. They distinguished phylactic, protection against demons, from theophoric procedures that invoked the help of a deity.

Herodotus in his *Histories* noted that circumcision was the norm and that the Egyptian military brought back uncircumcised phalli of Libyans as souvenirs. How might one evaluate the effectiveness,

physiologically or psychologically, of their medicine? Or is effectiveness the right question?

The Edwin Smith papyrus (~1550 B.C.), Hearst papyrus (~1450 B.C.), and Berlin papyrus (~1200 B.C.) noted a range of foods and a sophisticated agriculture that reflected the importation of plants and animals from thousands of kilometers — "... milk, three kinds of beer, five kinds of wine, ten loaves, four of bread, ten of cakes, four meats, different cuts, joints, roast, spleen, limb, breast, quail, goose, pigeon, figs, ten other fruits, three kinds of corn, barley, spelt, five kinds of oil, and fresh plants ..."

After the annual flood of the Nile, fields had to be re-surveyed; they made right angles using 3, 4, 5 triangles. We still marvel at their feats of civil engineering — pyramids, obelisks, the fabled light tower at Alexandria, and complex irrigation systems. Their ships could sail 90° to the wind. They made jars from molten glass. They made quality papyrus (paper) from reeds and developed hieroglyphs with phonetic symbols. Egyptians mastered a lot of engineering and agriculture. Many of these practices seemed to have remained unchanged from ~3400 B.C. until the Persian invasion of 525 B.C.

The people of the Indus valley, prior to 500 B.C., developed a calendar of 12 months, 30 days per month, with an intercalary month as needed about every sixth year. Their math incorporated zero and a base 10 number system; it included sine and cosine tabulations. Their metallurgy produced large cast iron pillars. They made stainless steel (wootz, with particles of Fe_3C) sword blades, later called Damascus steel in the West. Mercury and sulfur were used in metallurgy and as medicines. Several medical texts or vedas were compiled.

Just as Egypt developed beside the Nile and India on the banks of the Indus, so Mesopotamia developed between the Tigris and the Euphrates rivers in present day Iraq and southeast Turkey. The succession of peoples, languages, and rulers is complex. The important point is that by ~500 B.C. they had made significant

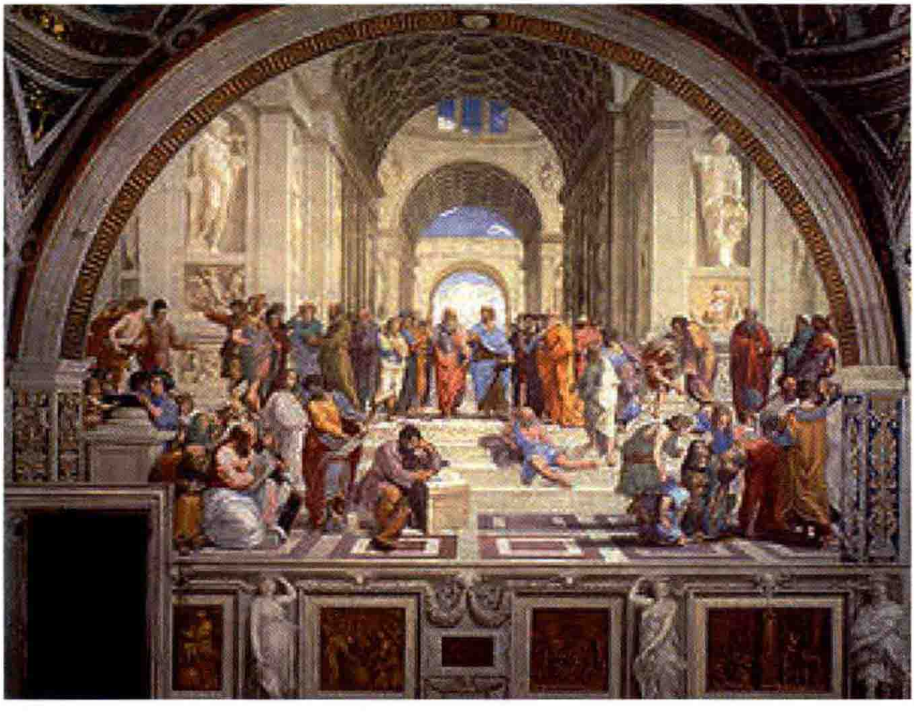
advances. They developed a base 60 numeral system — hence our 60 minute hour, 24 hour day, and 360° circle. Al-Batani reckoned the precession of the earth's axis of rotation to be 54.5 arc-seconds per year; this compares well to the current value of 49.8 (see Chapter B3).

They were among the first to make quality bronze, cloth woven of wool and flax, and complex irrigation systems. Esagil-kin-apli of Borsippa wrote one of several *Diagnostic Handbooks* about 1050 B.C.

Egypt, India, Mesopotamia, and China (to be discussed in Chapter A3) all reached reasonable levels of sophistication with limited inter-communication. The details of their sciences varied. However, one can see that given a bit of political stability and economic self-sufficiency the pursuit of science and its applications seems inherent. These advances occurred before Thales (~624–~546 B.C., see Chapter A2) and a millennium of Greek leadership in inquiry. Islamic science (Chapter A4) built on the heritage of Egypt and Mesopotamia. One might then ponder why the Greeks tolerated all sorts of contentious speculations and why only in post-renaissance Europe did science proceed to higher levels of abstraction and sophistication.

A2

Hellenic Science



The School of Athens (1509).

The term "Hellenic" refers to both Greek language and Greek culture. Their civilization extended from Macedonia to southern Italy including Sicily, to Egypt, and to cities near the Mediterranean coast of present Turkey and Syria. Significant insights and innovations were made in mathematics, astronomy, physics, anatomy,