# Scientific Advancements in the Hellenistic Period: Divergence from Philosophy, Royal Patronage, and the Emergence of Applied Science

ALEXANDRA BILHETE

The evolution of science reflects a history of innovations traceable throughout civilization. Science is currently defined as a discipline of knowledge based on observation, experiment, and examination. All aspects of science aim at understanding the natural and political world through analytical means.[1] In the ancient world, an unprecedented period of extensive scientific development arose in the Hellenistic era. This essay will address how and why this particular period became a watershed moment for scientific development. It will begin by investigating how the transition from the Classical to the Hellenistic period impacted science. The focus will be on Ptolemaic Egypt and particularly the Mouseion, Library and empirical scientific activity of Alexandria. Overall, the superior nature of Hellenistic science was a direct result of three main factors: the divergence of science from philosophy, royal patronage and the emergence of applied science.

In the Classical period, science was founded on philosophy, as Greek thinkers focused on achieving a theoretical understanding of the world based on observation over experimentation.[2] This deductive approach was inspired by the Ionians, who brought science into the western Mediterranean world.[3] Ionian scientists, such as Thales of Miletus (c.624-565 B.C.) tied science with philosophy by making observations and engaging in deliberations to draw conclusions on the natural world.[4] By the fifth century, Athens had become the scientific centre of the ancient world.[5] The city's intellectuals maintained an approach to science that was embedded in philosophical discourse. Intellectual practices emerged through philosophical debates between prominent intellectuals on morality and politics.[6] This is exemplified by the development of academic schools, whose structure and curriculum were founded on theory and philosophy. Socrates founded the first permanent school in Athens in 445 B.C. and attributed greatest importance to the written word and discussion.[7] Similarly, Plato's

[1] G. Shipley, *The Greek World After Alexander: 323-30 BC.* (London: Routledge, 2000), 326.
[2] Ibid., 379.
[3] Charles Singer, *A Short History of Scientific Ideas to 1900* (Oxford: Clarendon Press, 1959), 12-19. The primary inspiration of Greek science is attributed to the Ionians. Ionia's geographic location, participation in sea trade and warfare resulted in communication networks with the East, bringing science into Greece and the West.
[4] Ibid., 18. Thales of Miletus' achievements include major developments in astronomical observation and astronomy. His pupils included prominent scientists is such as Anaximander (611-547 BC), Anaximenes (c.570 BC) and Hecataeus (c. 540 BC).
[5] Singer, *A Short History of Scientific Ideas to 1900*, 37-61.
[6] Ibid.
[7] M. Ostwald and John P. Lynch, "The Growth of Schools and The Advance of Knowledge," in *The Cambridge Ancient History* ed. David M. Lewis, 2nd ed., (Cambridge: Cambridge University Press, 2008), 594-595.

Academy centered on philosophical discussion of political life and moral principles. Aristotle's Peripatetic school, founded in 335 B.C. also reflected a philosophical community.[8] Ultimately, the schools of Classical Greece relied on philosophical deductive logic in order to draw conclusions about the material world.

Hellenistic science primarily developed in the three large cities of Alexandria, Rhodes, and Pergamum, which all competed to become the dominant centre of science.[9] Fourth-century Hellenestic kings viewed science as a tool to political self-advancement. They monopolized scientific inquiry in order to display superior wealth, reputation and power, and to consolidate their reign over new territories and populations. Ultimately, the city of Alexandria emerged victorious, and became the centre for leading intellectuals of the Hellenistic world. It quickly became a "great magnet," attracting engineers, mathematicians, doctors, and scientists who sought to pursue scientific practices and, by extension, increase their wealth and reputation.[10]

The transition from the Classical to Hellenistic period is marked by a distinct shift from theory to practice in the sciences, as scientists began to apply their work for the purpose of technological, medical and geographic innovation. In the late fourth century, new disciplines including astronomy, medicine and mathematics emerged.[11] Further, academic instruction in Hellenistic schools was now based on practical experiments.[12] The shift from theoretical to practical is epitomized by Hippocrates and the "Hippocratic method," which was adopted by Hellenistic scholars and involved practical procedures founded on experience, experimentation and testing.[13] This shows that science was developing based on facts and proofs, rather than philosophical discussion. Furthermore, the major fields of scientific study became centred on three new themes, all of which emphasized direct observation of the material world: numbers and their relation to material objects; the formation and function of the universe; and the nature of man.[14] This shows an evident break away from Classical Greek science, which focused by contrast on philosophical deductions on the immaterial world in order to draw conclusions about the material world.

Much of this shift in the scientific landscape from the theoretical to the practical is owed to the Ptolemies, who revamped the fifth-century scientific model. They monopolized intellectual theories and applied them in order to gain even greater power. They recognized the value of science as a tool for advancing political and social goals. As such, the Ptolemies were the main patrons of both the arts and sciences in this period. They encouraged inductive over deductive approaches to science, and the application of science in military, medical, and geographic fields. This shift away from traditional Greek thought impacted society, with Greek immigrants becoming dissociated from their

[8] Ibid., 594-612.
[9] Singer, *A Short History of Scientific Ideas to 1900,* 61.
[10] J. V. Luce, "Greek Science in Its Hellenistic Phase," *Hermathena* 145 (1988): 23-38, 36.
[11] Singer, *A Short History of Scientific Ideas to 1900*, 32.
[12] Ibid., 32.
[13] Ibid., 33.
[14] Ibid., 66.

past and disconnected "spiritually from their ancient folk-ways."[15] This marked a watershed moment and a clear break from Classical Greece, which did not distinguish thought from application. This is supported by Pappus, who noted that the Heron school was divided between theoretical (*logikon*) and manual (*cheirourgikon*) activity.[16] Hellenistic science developed through this break from philosophy and the new use of knowledge toward applied science.

Aristocratic patronage in fourth-century science was motivated by the fierce competition amongst the successor kings who fought to seize land from Alexander's dissolved Empire.[17] Hellenistic politics reflect a "struggle by those who achieved royal status" to maintain their power and territorial claims.[18] To gain the upper hand in this political chess game, the kings needed to exhaust all avenues to enhance power. By extension, science was exploited to maintain auras of economic success and intellectual superiority.

The Ptolemies were most successful in monopolizing Egypt's wealth to advance their reputation as the supreme, all-powerful dynasty. They embodied Hellenistic kingship; they used Egypt's immense wealth to engage in gift-giving and benefaction to an unprecedented degree. They were champions of self-representation and victorious in the competitive philanthropy that categorized the era. They attracted the most prominent Greek writers and scholars to the Alexandrian court.[19] This greatly increased the amount of literature and research produced in Alexandria, which embraced a "new style [of] research institute" and became the central location of scientific activity.[20]

The use of royal patronage in advancing scientific pursuits marks a revolutionary change and explains why science was so advanced in the third century B.C. Preceding centuries reveal no evidence to suggest that state funds were granted to intellectual or scientific pursuits.[21] Indeed, fifth-century academic centres received no state funding or subsidization.[22] This stresses a distinction between a Classical and Hellenistic perspectives on science; whereas the fifth-century philosophers simply sought to understand nature, the third-century kings saw knowledge as a tool to propagate notions of self-superiority.

The Ptolemies remodelled the pre-existing conventional ruler patronage, insofar as that "science as well as literature was now taken under the royal wing."[23] This revolution explains why science had more opportunity to develop in the Hellenistic period, as the kings funded entire scholarly institutions, rather than exclusively financing

[15] Shipley, *The Greek World After Alexander*, 67.
[16] Pappus Alexandrinus, *Mathematical Collection*, GMW *ii* 615. Translated by D. Jackson.
[17] Shipley, *The Greek World After Alexander*, 328.
[18] M. M. Austin, "Hellenistic Kings, War and the Economy," *The Classical Quarterly* 36, no. 2 (1986): 457.
[19] Shipley, *The Greek World After Alexander*, 329. This was done by offering privileged employment as scientists, architects, tax collectors, judges, and professional mercenaries called *kleruchs*.
[20] Luce, *Greek Science in Its Hellenistic Phase*, 23.
[21] T. E. Rihll, *Greek Science* (Oxford: Oxford University Press, 1999), 16-17.
[22] Rihll, *Greek Science*, 3. The main fifth-century academic institutions include the famous Academy and Lyceum in Athens.
[23] Luce, *Greek Science in Its Hellenistic Phase*, 24.

particular individuals.[24] Furthermore, by re-directing financing to stimulate the multiple fields of science, Ptolemy was able to reap a vast amount of power and prestige. The intensification of royal patronage and new usage of public funding were why science developed so much in Hellenistic Alexandria. The Ptolemies quickly realized that scientific discoveries and innovations made in Egypt would, in turn, bring glory and popularity to the king himself.

In the third century, libraries and museums were royally commissioned as tools of political propaganda throughout the Hellenistic world.[25] They stood as physical testaments to the wealth, status and power of the city and king himself.[26] In Alexandria, the Mouseion and Library were established in order for Ptolemy II to achieve political advancement in light of the competition between Alexander the Great's successors.[27] The Mouseion was strategically constructed to reflect Aristotle's Academy in Athens. Aristotle had been employed by Philip II as Alexander the Great's private tutor, so through the Mouseion, Ptolemy II emphasized his connection to Aristotle and, by extension, Alexander. This would have increased Ptolemy II's legitimacy as king in Egypt and as the most powerful successor of Alexander.[28] Strabo's description of the Mouseion revealed that the elite scientists worked, lived, ate and enjoyed luxurious pleasures at the king's expense.[29] The fact that the most prominent minds came together in close quarters increased the quantity and quality of work disseminating from Alexandria.[30] Royal funding was being employed in a new way by the Ptolemies that resulted in reciprocal political benefits.

A key explanation for powerful advancements in Hellenistic science was the creation of applied science. During this period for the first time science began to be practically used in an effort to accomplish social, political and cultural objectives. The kings and aristocrats began to realize that scientific theories, if realized, could be used to their advantage and had the potential to yield high degrees of power and prestige. The early Ptolemies applied theoretical scientific knowledge in practical ways to benefit themselves. This is apparent in the construction of immense war machines, technological innovations, revolutionary medical and geographic activity, all of which in turn engendered more scientific developments.

[24] Andrew Erskine, "Culture and Power in Ptolemaic Egypt: The Museum and Library of Alexandra," *Greece & Rome, Second Series* 42, no. 1 (1995): 40.
[25] S. P. Johnstone, "A New History of Libraries and Books in the Hellenistic Period," *Classical Antiquity* 33, no. 2 (2014): 349.
[26] Ibid., 362. Many institutions developed across the Hellenistic world, in Cos, Jerusalem, Babylonia, Pergamum, Rhodes, and Athens.
[27] Erskine, *Culture and Power in Ptolemaic Egypt*, 38.
[28] M. Ostwald and John P. Lynch, "The Growth of Schools and The Advance of Knowledge," In *The Cambridge Ancient History Vol. 6*, ed. David M. Lewis, (Cambridge: Cambridge University Press, 2008), 622.
[29] Strab. 17.793-4. Translated by H.C. Hamilton and W. Falconer.
[30] Erskine, *Culture and Power in Ptolemaic Egypt*, 41-42.

From the fifth to the third century, a distinct change in warfare ideology occurred.[31] Military technology developed in terms of quantity rather than quality. In the Classical period, military victories belonged to the entire citizen body, highlighting the communal nature of the polis. Contrarily, Hellenistic warfare emphasized the individual successes of the king and army, concentrating on advanced weapons and tactical equipment.[32] Competition between the successor kings developed into "something like a naval arms-race" and from this the Ptolemies arose triumphant.[33] The late fourth century marked the transition from field combat to siege-warfare.[34] Mechanized warfare was underpinned by applied science and the new use of state finances, as kings invested significant amounts of money toward the engineering of weapons such as catapults and missile-throwing machines.

The Hellenistic period saw the practical application of scientific information to construct gigantic battle machines.[35] The new emphasis on gigantism and colossal weaponry had important political ramifications, and was used by the kings as undeniable visual evidence of power, wealth, and the material and intellectual richness of their society. The most famous Hellenistic siege machine was the *Helepolis*, a wheeled tower.[36] Diodorus notes that it was funded by King Demetrios Poliorketes and was used to successfully besiege Salamis, Cyprus and Rhodes.[37] These creations demonstrate that Hellenistic scientists made active efforts to transform scientific theory in pragmatic ways, as a means to achieve tangible results on the battlefield.

Notably, Plutarch states that many of these enormous machines were never used in battle.[38] This further stresses that the Hellenistic kings were monopolizing scientific knowledge for self-advancement. The mere existence of massive siege weapons served as a tool to visually propagate the king's power, authority and wealth to the public. Motivated by internal competition, the successor kings would mount their colossal artillery which publically promoted the king's omnipotence and superior military, intellectual, and leadership capabilities.

The schism between science and philosophy and the emergence of applied science are highly evident in the field of medicine. Prior to the Hellenistic era, it was both socially and politically unacceptable to perform human dissections, as it defied the traditional philosophy that the body was sacred.[39] It was Socrates who first rejected the traditional taboo on human dissection, thus triggering the dissolution of philosophical and spiritual ideologies on anatomy. This provoked the rise of practical, hands-on anatomical

[31] Giogrio Santillana, *The Origins of Scientific Thought from Anaximander to Proclus 600 B.C-500 A.D.* (Chicago: University of Chicago Press, 1961), 237-240.
[32] Austin, *Hellenistic Kings, War and the Economy*, 453-458.
[33] Luce, *Greek Science in Its Hellenistic Phase*, 30.
[34] Singer, *A Short History of Scientific Ideas to 1900*, 37-61
[35] Ibid., 31.
[36] Shipley, *The Greek World After Alexander*, 338.
[37] Diod. 20.48.2-3 and 20.91.2-6. Translated by Immanel Bekker. Ludwig Dindorf. Friedrich Vogel.
[38] Luce, *Greek Science in Its Hellenistic Phase*, 31.
[39] Santillana, *The Origins of Scientific Thought*,129-131.

investigation in the third century B.C.[40] It was this vital "disregard of the body […] a hundred years later" which "made human dissection possible […] in Greek circles at Alexandria".[41]

Backed by royal patronage, Herophilos of Chalkedon (c.330-260 B.C.) and Erasistratos (c.315-240 B.C.) performed the first systematic human dissections in Alexandria.[42] This highlights a scientific watershed, as dissection had now become socially and culturally accepted.[43] Taking it a step further, Celsus wrote "It is necessary to cut open the bodies of dead persons and inspect … Herophilos and Erasistratos [received] from the kings wicked men brought from prison and cut them open when alive," which was done to examine first hand the inner workings of the body.[44] This confirms that Hellenistic practices included scientific dissections and vivisections.

These physicians made huge strides in our understanding of the human body, with Herophilos connecting the functions of the brain, spinal cord and nervous system; additionally, both physicians believed illnesses to have natural causes at a time when it was common to believe illnesses were sent from the gods.[45] Thus the development of applied science, triggered by a divergence away from philosophy, caused scientific intensification in the Hellenistic era.

The new trend of using scientific theories in practical ways is highlighted by royal patronage toward geography and exploration. Kings sought to expand their empires and wanted to know the exact amount of land they conquered.[46] Alexander the Great commissioned prominent scholars to accompany him on military conquests and measure the distances his army travelled and amount of territory he seized.[47] Similarly, the early Ptolemies sponsored geographers to study the earth in an effort to determine just how much land, and by extension, power, they controlled. New mathematical advancements allowed for these men to make calculations regarding the earth's longitude, latitude and meridian lines.[48]

The Ptolemies realized economic investment in territorial sciences would lead to positive political repercussions. The increase in exploration promoted communication and trade networks. By extension, the king enhanced his public reputation and increased the potential to acquire larger commercial markets to fuel his kingdom's economy. The Ptolemies also applied scientific theories of the Earth toward practical military purposes. For instance, Eratosthenes made practical use of official maps to establish a north-south

[40] Singer, *A Short History of Scientific Ideas to 1900*, 36.
[41] Singer, *A Short History of Scientific Ideas to 1900*, 36.
[42] Luce, *Greek Science in Its Hellenistic Phase*, 29-30.
[43] Rihll, *Greek Science*, 118-122. Heroplilos' hands-on tests on the body led to the discovery of the pulse and distinction between sensory and motor nerves. Further, Erasistratos dissected the heart and discovered of veins and blood circulation.
[44] Cels. 23-4, 26. Translated by Walter Geroge Spencer.
[45] Justin Pollard and Howard Reid, *The Rise and Fall of Alexandria: Birthplace of the Modern World* (London: Penguin Books ltd., 2006), 68-69.
[46] Shipley, *The Greek World After Alexander*, 359.
[47] Ibid,, 360.
[48] Ibid,, 361.

base line across Egypt.[49] The mathematical calculation of geographical landscapes enhanced the king's military power. It gave the king and army a better understanding of territories, which could augment the efficiency and success of campaigns.

Ptolemaic investment in the sciences was not founded on the value of knowledge, but rather as tied to their desire for political and social advancement. Royal patronage increased the prestige of the king, which was the strongest driving factor that encouraged spending state money on science.[50] Science became highly advanced because it diverged from the philosophical sphere and was practically applied in society. Science was applied even in the domain of entertainment. For example, hydraulic innovations were used in making musical instruments.[51] This highlights a "typical Hellenistic mix of theory and the manufacture of amusements [for] the elite."[52] This had reciprocal benefits, as avant-garde objects would have sparked the curiosity of other kings and their elite courts. The Ptolemies owned new unique objects of wonder, which would have increased the king's prestige and the number of visitors into Alexandria, fuelling Egypt's economy.

However, Alexandrian science was not without limitations. The common people were denied access to any benefits that new technology could offer. Many new tools and mechanisms had large potentials to cause communal benefits, but were exclusively employed in elite social spheres. For instance, Archimedes' invention of "snail screw" could have been used to drain farmlands flooded by the Nile.[53] Water-mills, pulley systems and the creation of iron presented significant potential in improving the efficiency of agricultural work. However, the Ptolemies made no attempts at any widespread adoption of this knowledge to assist the population. They governed with the underlying stipulation that everything done in society should have positive benefits for the state and for the king himself.[54] This stresses that royal patronage of scientific pursuit was motivated by the king's desire for political advancement rather than social or educational reform.

To conclude, the Hellenistic period marks a watershed moment where science became focused on experiment and technical innovation. It was practically applied to benefit the king's political ambitions. This diverged from Classical science, which was founded upon philosophical theories rather than practical experimental processes. However, scientific inquiry was not used to benefit the entire population, but was rather monopolized by the kings to enhance their public reputations as powerful rulers. Science became particularly advanced in Alexandria, where the Ptolemies revolutionized the use of royal patronage and redirected state funds toward scientific, medical and technological advancements to bolster their individual power. Science represented a means to an end in achieving political advancement above the other successor kings. Hellenistic science set

[49] Luce, *Greek Science in Its Hellenistic Phase*, 28.
[50] Ibid,, 329.
[51] Shipley, *The Greek World After Alexander*, 331.
[52] Ibid.
[53] Ibid,, 332.
[54] William Linn Westermann, "The Ptolemies and the Welfare of Their Subjects," *The American Historical Review* 43, no. 2 (1938): 275.

the standard for systematic developments on evidence, proof, and practical purpose, thus laying the foundations for empirical science.

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