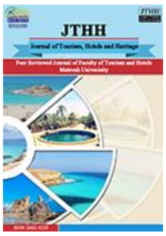

Journal of Tourism, Hotels and Heritage (JTHH)

Vol. 4 No. 1, (2022) pp 55-78.

Journal Homepage: https://sjs.journals.ekb.eg

The Influential Impact and Contributions of the Scientific Heritage of Mouseion's Scholars Towards Renaissance and Present-day Technologies

Wessam Fekry Ibrahim

Assistant Professor, Faculty of Tourism and Hotels, Matrouh University.

ARTICLE INFO

Keywords:

Scientific Heritage

the Mouseion

Scientists of Alexandria

Ancient Technology

(JTHH)

Vol. 4 No. 1, (2022)

pp 55-78.

Abstract

The Mouseion of Alexandria and its library were considered as one of the great archetypes for modern civilization. During antiquity, vast numbers of scientists, scholars, philosophers, writers, artists and students have dreamed to join this blessed spot where all human knowledge, wisdom and books had been collected. In this place, the learned men of the Mouseion became able to conquest every field of culture. During the third and second centuries B.C. Alexandria became the residence of some of the brightest scientists and the center for the development of practical technology. Among the generations of scientists who succeeded in the Mouseion and its Library and worked there for long hours to study and scrutinize, some examples have emerged and their researches formed the basis for many of the inventions and theories that are in use nowadays. Unfortunately, though their remarkable heritage materials, they are less well known. Therefore, the study will shed light on that forgotten heritage represented in devices, inventions and theories conceived by scientists and engineers of ancient Alexandria which, in some cases, can be considered precursors of contemporary sciences and technologies, demonstrating how the concept of science has been presented in the minds of ancient scientists and engineers since the 3rd century B.C. Findings revealed the remarkable impact of Alexandrian scholars' knowledge in terms of machine design and construction, thinking about the outside world, solving problems, and founding new curriculums. The chosen samples are presented and classified according to the significant of their inventors.

1. Introduction

The study focuses on the period between the third century B.C. and the early fifth century A.D., when there was a boom in objective knowledge about the outside world. While the ancient Egyptian civilization, followed by the Greek culture, reached great heights in different fields such as architecture, art, astronomy, literature and philosophy in previous eras, it is during the Hellenistic period that one sees the first appearance of science as it is known today, especially in the international pole of attraction for science and scientists at that time, Alexandria. Alexandria was a significant city and a source of inspiration in the history of science since the 3rd century B.C. Its fertile cultural and scientific atmosphere produced innovative and creative thinking and understanding across a wide range of fields. Ptolemy I (323− 285 BC) founded the Mouseion and the Great Library of Alexandria that were praised throughout Antiquity for their intellectual resources. In addition, the complicated interaction between Egyptians and Greeks prior to and throughout the reign of the Ptolemies provided scientistswith an exceptional opportunity to live and operate under royal patronage.

With the arrival of the brightest minds of the day, scientific work in this metropolis was revitalized. Scholars were motivated to participate in scientific researches, particularly in astronomy, medicine, and mathematics, they even developed new areas and curricula as a result. Moreover, brilliant Scholars, such as Archimedes, were students in Alexandria who returned back to their home with fresh ideas and knowledge, each with specific understanding of the disciplines (Berti & Costa, 2009). The Ptolemaic capital caught numerous tendencies in the 3rd century BC and became the site of several independent schools (Rosso, 2021).

It is well known that Alexandria was a world-famous metropolis, especially for its intellectual excellence, which resulted in the establishment of the Mouseion and its a library, by Ptolemy I, with nearly 700,000 books. (Otto, 2018) At its peak, the Mouseion employed 100 professors, whose salaries were paid by the state. The Great Library, floral gardens, an astronomical observatory, a zoo, and dissecting rooms were all part of the Mouseion complex. Alexandria had overtaken Athens as the hub of Greek science in a few of years, not only as a significant center of trade for the Greek and Arab worlds. The scholarly climate and liberal funds drew philosophers, physicists, and intellectuals to Alexandria (Rothschild, 1982). During those days, there was a concerted effort to model nature and apply such models, or scientific theories to the solution of practical problems and a developing comprehension of nature. We owe this new perspective to scientists of the Mouseion like Eukleides, Ctesibius, Eratosthenes, Heron, and some others who are, unfortunately, less well-known today but no less remarkable.

2. Objectives of the Study

The study aims to reveal some new evidence that was less addressed in previous studies which were concerned with shedding light on the contributions of the library of Alexandria in various fields of science in general, without giving a deeper study on the achievements and most important inventions of its scientists. Therefore, their innovations will be studied through this research paper, especially with the need that contemporary generations must learn about the origin of modern technologies to increase their understanding of the value of the Museum and Library of Alexandria, not only historically, but also scientifically, technologically and appreciate its scholars. This can be summarized as follow:

1. Reviewing our knowledge about some pioneer scientists of the Mouseion of Alexandria.
2. Investigating what was accomplished in the field of astronomy, geography, automata and mathematics during antiquity, millennium before renaissance and the industrial revolution.
3. Shedding light on their innovations and contribution that became the base for some modern technologies.
4. Describing some of those scientists' devices and ideas from a current perspective, not only to convey a mental image of the artifact's physical shape to us, but also to interpret the item and provide cultural context by revealing the various types of knowledge it holds.
5. Demonstrating evidences that feedback control is a discipline that dates back to the 3rd century B.C.

3. Methodology

To fulfil the objective of this paper, the approach is to analyze the achievements of eight selected scientists during the period from 300 B.C until 415 A.D (fig. 1). This period is characterized by the conception, inventions and writings which will be framed within this research in the historical context of the evolutional way of thinking about physical phenomena, within which science, in its modern sense, was developed and the scientific method was formed. The primary impact of this development, given by those scientists and scholars of Alexandria, will be described, with particular attention to those of Heron of Alexandria, who is universally regarded as the greatest scientist of the ancient world. Their writings, books, notable works, inventions and legacies have all been grouped and tabulated in Table 1 in order to facilitate the inventory and compilation of their works to achieve the objectives of the study. The selection based on the qualifying theoretical contributions that for the first time appeared in the history of science. Examples of technical devices or inventions that were made during that period that known to us at the present time will be cited too.

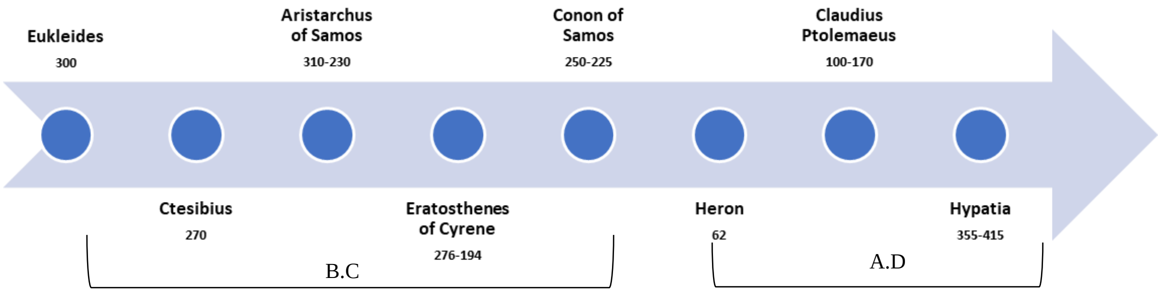

Fig. 1: Timeline of the selected ancient scientists of the Mouseion, by the Author.

4. The Sampling Technique

4.1 Eukleides (flourished c. 300 B.C)

Euclid, Eukleides, is considered the most influential mathematician of Greco-Roman antiquity, best remembered for his treatise on geometry, the Elements. He is popularly known as the "Father of Geometry" or "Founder of Geometry" (Bruno, 1999). Nothing is known about his life other than what Proclus (c. 410–485 CE) relates in his "*summary*" of notable Greek mathematicians. Euclid, according to Proclus, was a scholar at Alexandria during the reign of Ptolemy I Soter (Taylor, 1961), within a period after Plato and before Archimedes. He was among the first scholars appointed to the Museum of Alexandria, where he had the opportunity to establish his mathematics school (Bruno, 1999).

His Elements, Στοιχεῖον, Stoikheîon, is one of the most significant books in mathematics history, serving as the primary curriculum for teaching mathematics (particularly geometry) from its release until the late nineteenth or early twentieth century (macardle, 2021). Euclid's instructions appeared in commentaries of Heron of Alexandria and Pappus of Alexandria. Theon of Alexandria, Hypatia's father, updated the Elements with textual alterations and additions; his version rapidly displaced other editions (Hosch, 2010). Most subsequent Arabic and Latin translations were based on this Greek source (Hosch, 2010).

According to Bruno, it is the most widely reproduced book in the Western world, after the Bible. More than 1000 editions of the Elements have emerged since the introduction of mechanical printing in 1455 (Bruno, 1999). Wilson stated that, Euclid's Elements formed the foundation of all mathematics instruction, not only within the Roman and Byzantine eras, but right up until the mid of the 20th century, he also adds, it may be claimed that it is the most successful textbook ever produced (Wilson, 2013).

4.2 Ctesibius (flourished: c. 270 B.C.)

Greek inventor, physicist and mathematician. The earliest great figure in the ancient engineering legacy in Alexandria. Ctesibius was a son of a barber, he primarily studied the properties of air, and is recognized as the "Father of Pneumatics" (from pneuma = air), it means here the transfer of power through air (Rogers et al., 2013). He probably produced at least two books about his studies, one on theory and the other on his practical inventions. Unfortunately, all of Ctesibius' works have been lost, including those that are thought to have explained the theoretical foundations of pneumatics (Vullo, 2020). Later authors, on the other hand, collected sections from his treatises. Therefore, Ctesibius' teachings can not only be reconstructed, but his innovations can also be found in usage during the Renaissance and modern periods (Irby, 2019).

Ctesibius is credited with discovering the elasticity of air and inventing many compressed-air devices, including force pumps which could produce a water jet or raise water from wells. He is also credited for inventing the syphon principle (Keyser, 2018). This invention was widely utilized in practice; its description survives in the accounts of Vitruvius and Heron, and as a result, the pump of Heron is known to generations (Fényes, 2015). The fact that it was employed not just in Antiquity and the Middle Ages demonstrates how clever the idea was; fire pumps used the same technique into the nineteenth century. Additionally, piston pumps and compressors are still used in a variety of industries today (Fényes, 2015). His main improvement was on the **clepsydra** (fig. 2), or water clock, in which water dripping at a constant rate lifted a float that support a pointer to show the progress of the hours. In ancient Egypt and Greece, water clocks were well known. But Ctesibius' water clock was a more advanced version of prior water clocks which didn't give the user any feedback. Ctesibius' clock, clepsydra, employed a system of gears, movable figures and a water wheel to measure the flow of time using an arrow on a scale that indicated the current time to the user (Ferguson, 2015). As Ferguson sated, Ctesibius' clepsydra with its provided feedback to the user could be considered one of "*the first control systems of the ancient world to do so"*. With the introduction of that system*, "the era of automation could begin*" (Ferguson, 2015). In middle ages mechanical clocks were developed but they weren't as accurate as Ctesibius' clepsydra. It was the most accurate clock until 1656 when the Dutch physicist Christiaan Huygens invented the pendulum clock (Coleman, 2005).

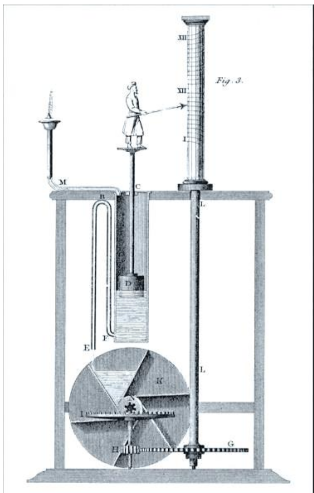

Fig.2: Illustration of the Hydraulic Clock of *Ctesibius. Source,* (Ferguson, 2015, fig.5).

A hydraulis, or water organ, was another notable invention, in which air was driven through the organ pipes by the weight of water rather than falling heavy objects (Cort maclean Johns, 2021). He is indeed put the roots of the Industrial Revolution in 270 B.C. Cort maclean Johns reported that Ctesibius had all of the components and parts required to form the first Steam Hydraulis or Calliope. He also stated that during the Renaissance, Vitruvius' literature introduced the Hydraulis to the Abbey of St. Gall in 1414. It then took its path through Italy, Germany, and Paris (Cort maclean Johns, 2021). In another word, Ctesibius invention reignited the Industrial Revolution in 1690 (Cort maclean Johns, 2021).

4.3 Aristarchus of Samos (c. 310 B.C - 230 B.C)

Greek astronomer and mathematician. He proposed the first recorded heliocentric theory, which put the Sun at the center of the known cosmos, with the Earth rotating once a day around its axis and orbiting around the Sun once a year (Heath, 2013). Gregersen announced that, in his Sand-Reckoner, Archimedes reported that Aristarchus had suggested a new theory that, if true, would make the universe substantially larger than previously thought (Gregersen, 2009). His astronomical hypotheses were dismissed in favor of Aristotle's and Claudius Ptolemaeus 's geocentric theories, as will be mentioned later. However, his theories, expressed by the great mathematician, Archimedes, include the essence of the heliocentric system later proposed by the Renaissance astronomer and the founder of modern astronomy, Nicholas Copernicus during the 16th century A.D. Indeed, because of the startling similarities between ancient and modern notions, Aristarchus was labeled "The Ancient Copernicus", as Heath (2013) proposed. Unfortunately, Aristarchus' only extant work is "*On the Sizes and Distances of the Sun and Moon*" which assumes the typical geocentric viewpoint in its presentation of arithmetic and geometrical measures for astronomical entities (Gutzwiller, 2008).

According to NASA (2019), he is commemorated by the lunar crater Aristarchus, telescope Aristarchus, and the minor planet 3999 Aristarchus.

4.4 Eratosthenes of Cyrene (c. 276 B.C – c. 195/194 B.C)

Eratosthenes was a Greek geographer, astronomer and mathematician who compiled the first geography book and accurately measured the Earth's circumference.

He was the director of the Library of Alexandria. Due to his effort, the geography was accepted as a legitimate scientific field, moreover, it was Eratosthenes who introduced the word *Geographia* and its related other terminologies which are still used nowadays (Roller, 2010). Eratosthenes produced his three-volume Geographika, the first scholarly books on the subject, sometime about 245 B.C (Lasky, 2008). In this work, which is equivalent to what is known today as geography, he introduced some of the terminologies that are still used today. (Roller, 2010).

Catasterisms, a book on the constellations that includes a description and explanation for each constellation as well as a calculation of the number of stars contained in it, is Eratosthenes' only surviving work, however the attribution of this work has been questioned by certain scholars, as Evan who elaborated on his study about the Constellation Myths (Evans, 2018). On the other hand, his mathematical work is traced in the work of Pappus of Alexandria. His geographical researches can be found too in the first two books of the Greek geographer Strabo (Hosch, 2010).

Eratosthenes did the first known perimeter measurement of the Earth. He, certainly, as Fraser confirms didn't use neither lasers or satellites nor precise surveying equipment (Fraser, 2011). Instead, he read in the Library of Alexandria that one day a year, the bottom of a certain deep well in Syene – Aswan- would be completely lit by the noon sun. This indicated that the sun had to be directly overhead at the moment. Moreover, he noticed that vertical items in Alexandria (almost directly north of Syene) cast a shadow at the same moment. Alexandria, as a result, received light from a slightly different angle at the same moment (Fraser, 2011). Eratosthenes realized he could use this information to calculate Earth's curvature (Dutka, 1993). As Albrecht described in his lecture, Eratosthenes' methods were simple and easy (fig.3). Eratosthenes' observations and calculations resulted in precise estimates of the earth's size. By analyzing the Sun's relative position at two separate sites on the earth's surface, he calculated the earth's diameter to be 40,250 to 45,900 kilometers. The circumference of the earth is now commonly recognized to be 40,096 kilometers. As a result, his error was less than 1%, "*an incredible calculation*" as Albrecht said (ALBRECHT, 2005).

.

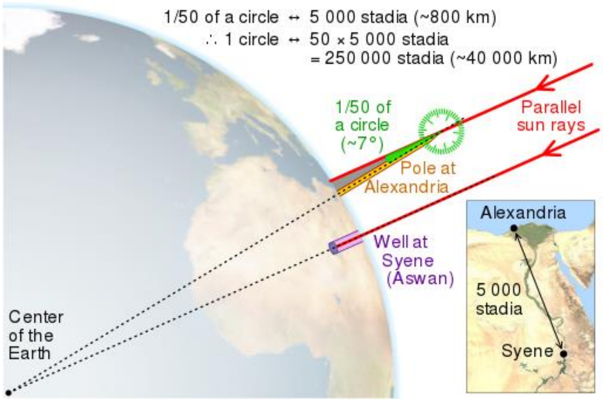

Fig.3: Eratosthenes' methods to determine size of the earth (ALBRECHT, 2005)

4.5 Conon of Samos (flourished c. 245 B.C.)

He lived at the time of Archimedes. The work of Conon, the astronomer and mathematician, on conic sections formed the basis for Apollonius of Perga's (c. 262–190 B.C.) fourth book of the Conics (Hosch, 2010).

Conon is best known for writing seven books in astronomy, ***De Astrologia*** (de Ruiter, 2015), they were partly based on the Egyptian observations. Sarton (Sarton, 1993) suggests that he could be the man who transmitted the Egyptian observations to Hipparchus, one of the greatest astronomers of antiquity (Willard, 1856). Conon also introduced a new calendar (parapégma) which is an astronomical table recording his observations of lunar phases, solar eclipses, seasonal indications, the rising and setting of the stars along with weather forecasts (Keim, 2006). This parapégma was developed based on his meteorological and astronomical observations not only in Alexandria, but also in Sicily and Italy (Sarton, 1993).

He is reputed by describing the Coma Berenices. The Coma Berenices, a separate constellation, is named after the Egyptian Queen Berenice II who devoted her long hair to the goddess Aphrodite to assure her husband Ptolemy III safe return from a battel during the Third Syrian War (Hartnett, 2011). After the return of Ptolemy III and during the victory celebrations, her hair vanished from the temple. At this time Conon, who was the court astronomer, stated that God Zeus had taken the Queen's hair and placed it among the stars to honor its donor (Garfinkle, 1997). Conon mainly observed this constellation among the stars in the region of Bootes, Leo, and Vigro, giving this constellation the name Coma Berenices

(Berenice's Hair), immortalized queen Berenice and at same time ensured Cono's position in the court (Faulkner & Hosch, 2018). It is now considered to be the only modern constellation named after a historic figure (de Ruiter, 2015; Faulkner & Hosch, 2018).

While Archimedes was studying in Alexandria, Conon became his close friend and later sent him many of his mathematical discoveries (Strathern, 1998). According to the Greek mathematicians Pappus of Alexandria (flourished *c.* 320 A.D), Conon is supposed to be the real inventor of the Archimedean **Spiral** (Collectio, Vol. I, IV), a curve that Archimedes used extensively in several of his mathematical works (Cuomo, 2000; Britannica, 2017).

4.6 Heron (flourished c. 62 A.D)

In ancient times, Heron of Alexandria was possibly the most well-known designer of automatic devices. Although little is known about his life, he is well-known for a variety of inventions in several sectors; one of the most key fields of his innovations is possibly automation (Rossi, 2016).

Heron/Hero of Alexandria (Ηρων ο Αλεξανδρευς), was a Greek engineer, physicist and mathematician who lived in Alexandria during the Roman periods, in the middle of the 1st century A.D (Lazaris, 2017). Although the authorship of some of Heron's works is debated, a vast number of his works have survived. In the section below, the study will go over some of Heron's technical, mechanical and mathematical works.

Heron is the author of 11 treatises (WALLACE, 2021), most of which deal with the practical applications of mechanics and mathematics. They appear to have been updated and partially rewritten over time to satisfy the needs of later users as practical handbooks. Speake (2021) has summarized them as follow:

1. Metrica (Μετρικά), 3 books; explain how to calculate the surface and volume of a variety of items
2. Pneumatica (Πνευματικά), two books; describe machines that operate under the influence of air, steam, or water pressure, such as the hydraulis or water organ and the aeolipile, his most famous invention which is considered the first steam-powered engine (Oakes, 2014, Cort maclean Johns, 2021).
3. *Automata* (Περὶ αὐτοματοποιητικῆς); descriptions of machines that, through mechanical or hydraulic means, enable wonders in banquets and potentially theatrical scenarios for instance: automated opening or closing of temple portals, sculptures that pour wine and milk, etc.
4. Mechanica (Μηχανικά), three books - extant only in Arabic, translated by Qusṭā b. Lūqā the Syrian translator and mathematician (Hall & Smith, 2016; Iqbal, 2017; Hill, 2020) -; designed for architects, it includes tools for lifting heavy objects.
5. Dioptra (Περὶ διόπτρας); a collection of techniques for measuring lengths, a work describing the odometer and the dioptra, that resembles the theodolite.
6. Catoptrica (Κατοπτικά) about mirrors and light, reflection - extant only in Latin translation (Faulkner & Hosch, 2018).
7. Belopoeica (Βελοποιικά), explained war machines.
8. Geometrica (Γεωμετρικά); it appears to be a variant version of the Metrica's first chapter, based exclusively on instances. Despite the fact that it is based on Heron's work, it is unlikely that it was made by him.
9. Stereometrica (Στερεομετρικά); based on the second chapter of the Metrica and measures 3 dimensional objects.
10. Cheiroballistra, explains the construction of various types of a powerful 9catapult (WALLACE, 2021).

11. Definitiones (Ὅροι); includes 133 definitions of geometrical concepts starting with points, lines, etc. (Van den Belt, 2007), it also defines the art of how to draw buildings (Haselberger, 1999).

Some scholars (Guillaum, 1997; O'Connor & Robertson, 2001; Van den Belt, 2007) assumed that the last four works are based on Heron's work, but they were written by others.

During Renaissance, two of his surviving works were essential, Pneumatics and Automata. Pneumatics was translated from Greek and printed in the late 16th century. Federico Commandino published the whole text of the Pneumatics in Latin translation in 1575 (Herón & Commandino, 1575). After Commandino, Renaissance designers and thinkers, particularly Aleòtti, whose book was cited by Leonardo, and Bernardino Baldi, studied the Pneumatics with great interest (Steadman, 2021). As for the Automata, published in Italy in 1589, Steadman argued that its contents have strong traces in late Renaissance stage engineering (Steadman, 2021). Since the purpose of this paper is to reveal the legacy of specific scholars whose impact can be echoed during the Renaissance, examples of Heron's notable contributions will be presented as follow:

4.6.1 Mathematics and Geometry

Due to its presence in his book "*Metrica*,", a widely known formula for determining the area of triangles retains his name, Heron's Formula (Vodolazhskaya, 2008; Bianchini & Fantini, 2015). In his effective practical geometry book, "*Metrica*", he also stated and proofed the area and volume of other objects, that are very close to the ones used today (WALLACE, 2021), for instance the area of the circle which continued to exist in other mathematical works for centuries including Muhammad ibn Musa al-Khwarizmi's work in the 9th century A.D who was one of the earliest outstanding Arabs (Katz & Michalowiz, 2020).

Although some of Heron's writings include mathematical content in the same form and purposes as traditional Euclidean geometry, what's significant is that that he demonstrates how Greek mathematics may be applied to practical use (WALLACE, 2021).

Heron frequently used real-world examples to illustrate his processes. Evans & Berggren considered him an expert in estimating the number of jars that might be packed in containers or ships, as well as estimating seating capacity of a theatre (Evans & Berggren, 2018). He also developed a number of terminologies in the field of geometry, including "geodesy," which is currently used to describe the geometric shape of the Earth (Evans & Berggren, 2018).

4.6.2 Machines and Devices (figs, 4-8)

In addition to his practical contributions to mathematics and geometry, Heron is best renowned, however, for his descriptions of machines, devices, and automata, which conserve some of the rare remaining forms of evidence of Egyptians, Babylonian, and Greek science application to practical technology (WALLACE, 2021). According to historians (Lloyd, 1973; Valavanis, 1999; Papadopoulos, 2007), his book on automation is the first known record that explains mechanical automatic systems able to conduct programmed movements.

Heron depended on water, fire, steam and compressed air, to operate his automatic devices, therefore, it will be interesting here to investigate some of these devices from a current perspective. Focusing in particular on a number of distinguishing examples that are of importance due to the integrated mechanics and/or their design.

4.6.2.1 Aeolipile (fig.4)

The aeolipile is attributed to Heron as the earliest documented steam engine (Robinson & Clark, 2017). The word aeolipile derived from Aeolos (Αἴολος, the Greek deity of the winds) and ***pilos*** (sphere) (Heilman, 2019). So, it literally means the sphere of Aeolos "wind ball" (Papadopoulos, 2007). In his Pneumatics Heron describes his aeolipile (Pneumatics 2.11). It consists of a hollow spherical fixed on a boiler by two pipes. The sphere can rotate due to the mounting, and as water boils, steam rises via the pipes into the sphere, eventually leaving through two bent outlet tubes. The rotating motion is caused by the flowing steam (Riznic, 2017). Robinson & Clark stated that this design was used in part to create the steam engines of the 18th century (Robinson &Clark, 2017).

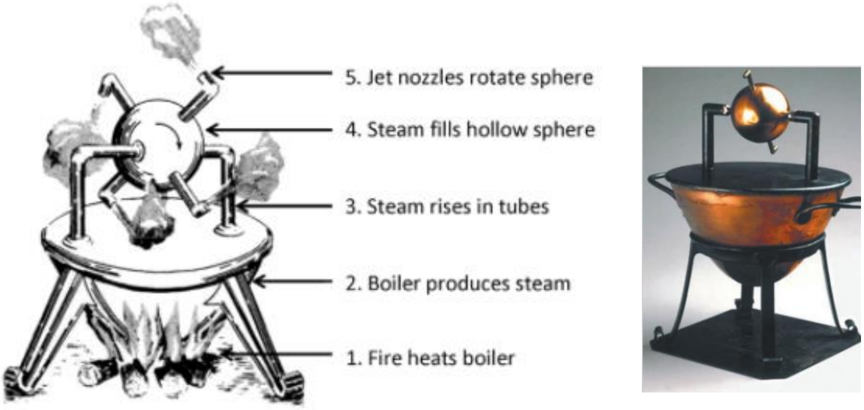

Fig.4: left) Heron's Aeolipile, the steam engine, source: (Robinson & Clark, 2017, fig, 11). Right) modern replica after Whipps (2008)

4.6.2.2 Coin-Operated Machine, Vending Machine (fig.5)

Coin-Operated Machine is a holy water dispenser. It is considered the oldest known vending machine (Žmolek, 2013). As been described in his books *Mechanics and Optics,* once a coin of 5 drachms was inserted into the slot, the mechanism provided a certain amount of water. The weight of the coin worked on the plate R of the rocker arm N, which, when rotated, opened the valve S, allowing water to flow outside from the hole M. The coin felt down as a result of the revolution, and the rocker arm rotated in the other direction, closing the mouth (Rossi, 2016). It's worth noting that this water wasn't for drinking; rather, it was for washing hands before heading to the temple to pray (Robinson, 2017).

Fig.5: Drawing of Heron's holy water dispenser, vending machine. Source: (Rossi, 2016, fig. 6).

4.6.2.3 Automatic Temple Doors (fig.6)

Heron's most famous automatic invention is likely the mechanism that opens and closes temple doors.

Rossi, depending on the Heron's description, explained the mechanism of the door. The altar was lighted, and the hot air heated the water in the pressure tank. The water in the container was pushed via a U-shaped conduit by the pressure in this tank. Ropes or chains coiled in coils on the temple door hinges were used to link the mobile water container to the temple doors. Because of the weight of the adjacent water container, the ropes were unrolled and the doors were opened as it was filled with water. When the fire was put out, the steam in the pressure tank condensed, lowering the pressure in the tank and sucking the water out of the water container (Rossi, 2016).

Unfortunately, literatures don't indicate where or for whom this automatic door was used? The researcher believed that Heron mainly built such hydraulic system to move the doors of a remarkable temple in ancient Alexandria during specific religiose ceremonies. May future excavations and studies reveal that.

Heron was particularly fascinating since his passion in applied mathematics and science led to interesting innovations like the world's first vending machine, which was a coin-operated water dispenser, and, of course, the first automatic doors.

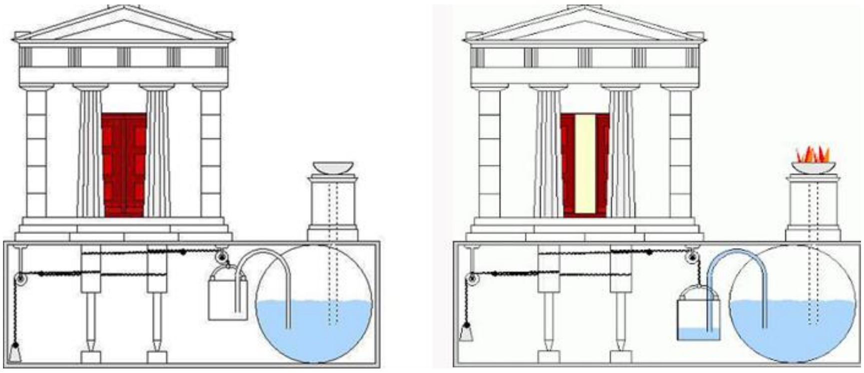

Fig.6: Reconstruction drawing of Heron's automatic temple door, when a fire is lighted at the altar, the temple doors automatically opened. Source: (Exarchopoulos, 2020).

4.6.2.4 Programmable Self-Moving Automata (figs. 7,8)

Hero described in his Automata-Making two automatic theatres, the first one, presents the Legend of Nauplios who seeks revenge on the Achaeans for his son's death at Troy, is a fixed in place theater. The other one is a moving theatre presenting The Apotheosis of Dionysos (Mcdonald & Walton, 2007).

In the fixed theater he developed a 10-minute mechanical play that was controlled by a complicated system of ropes and drums that might be regarded a method of determining which sections of the mechanism executed which movements and when (Pathak, 2021). Pathak stated that this is what programmability is all about (Pathak, 2021).

Fig.7: 3D digital reconstruction model of Hero's fixed theatre. Source: (Steadman, 2021, Fig. 3.2).

The mobile theater rolls into position on wheels, pauses, performs a show, and then rolls away all without human intervention (Steadman, 2021). The building of the mobile theatre is made up of a podium with four huge columns on top. These hold up a platform that houses a small circular temple (Steadman, 2021). Baldi (Baldi, 1589), who translated Hero's book into Italian in 1589, commissioned diagrams depicting the mobile theatre as shown in figure 8.

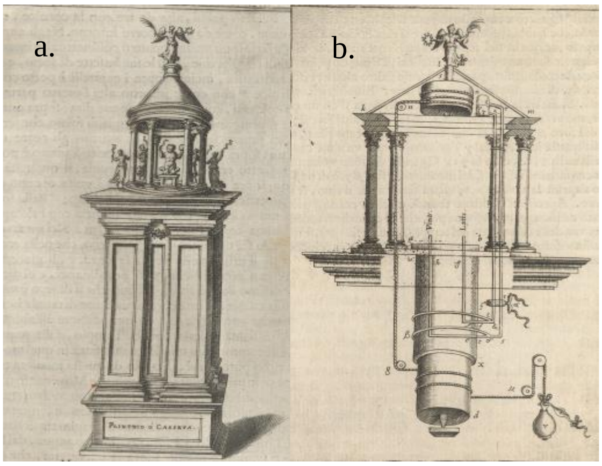

Fig.8: Hero’s mobile theater, a) overview b) cross section. Source: (Baldi, 1589)

On the theatre stage, all of the performances were excuted by automata, they were designed as "actors" in a puppet theatre, as described by Baldi (Baldi, 1589).

The mechanisms of both mobile and static theatres are exceedingly sophisticated. In practice, there are very few machines of this complexity known from antiquity, and these are the only ones that have complete documented technical descriptions. Ren fun

The devices of the Pneumatics may appear uncomplicated to modern views (since Hero explains how they function), yet they were unfamiliar to ancient and Renaissance audiences. Steadman suggested that this was almost certainly due to the fact that most ordinary machines during those periods consisted of only one or a few moving elements — levers, balances, and wheels – that performed simple, repetitive operations. Furthermore, their driving force, depending on animals, human muscle, and the weight of water, was visible. Heroic devices, on the other hand, performed complex actions and concealed both the mechanisms and the internal sources of power (Steadman, 2021).

5. Claudius Ptolemaeus (c. 100 – 170 A.D)

Claudius Ptolemaeus, an Egyptian-Greek geographer, astronomer and mathematician of Greek descent who lived in Alexandria during the 2nd century A.D (born *c.* 100 A.D, died *c.* 170 A.D) (Ball, 2016). His writings are considered the pinnacle of Greco-Roman science in various fields, primarily his *geocentric* (Earth-centered) explanation of the universe, currently known as the Ptolemaic system (Senior, 2009).

What is known about Ptolemy is based primarily on his three prominent books, the Almagest, a book on Greek astronomy; the Geography, on the geography of the Persian and Roman empires; and the Tetrabiblos, on astrology (Cavin, 2012). The first two books were the last of their kind in the disciplines of astronomy and geography, and they were the only ones that had survived intact. Ptolemy's approach of these issues was so "*revolutionary*" that it had an impact that lasted for generations and could be detected by any researcher interested in the study of the sky and earth (Aujac, 2015). As late as the time of the great explorations, Ptolemy's computational methods were accurate enough to serve the needs of mathematicians, astrologers, and navigators (Lasater, 2008).

Ptolemy's Almagest is rightly recognized, as Burnett stated, as Antiquity's greatest treatise on mathematical astronomy. Until the beginning of the 17th century, Almagest was the standard reference for Islamic and European astronomers with its mathematics, paradigms for the sun, moon, and planets, and descriptions of around 1022 fixed stars (BURNETT, 2010). Ptolemy called it *Μαθηματική Σύνταξις*, Mathematike *Syntaxis* which means “The Mathematical Arrangement” (Cavin, 2012). Almagest came from an Arabic version of the Greek term for greatest (Μεγίστη, Megiste). Almagest, which was divided into 13 books, was translated into Arabic as late as the 8th century A.D, and then into Latin in the second half of the 12th century (Saliba, 1995). The Greek text was widely transmitted in Europe after that, though Latin versions from Arabic remained more prominent (Haskins & Lockwood, 1910).

The *Geographike Hyphegesis*, more common *Geographia*, in eight books, is the second influential writings of Ptolemy. It is a comprehensive overview of the Greco-Roman world's geographic knowledge (Berggren & Jones, 2020). This is a collection of what was known about the world's geography during his time in the Roman Empire. He mostly relied on the work of an earlier geographer, Marinos of Tyre (120 A.D), as well as guidebooks of the Roman and ancient Persian empires (Bagrow, 2017), but most of his sources outside the Roman Empire's border were questionable

In his first book he analyzed the quantity of knowledge passed down and described his own thoughts regarding the size of the inhabited world (οἰκουμένη, *oikoumenè*) and the best means to draw maps (Bagrow, 2017). The next second to seven books were devoted to a comprehensive list of all the cities or features that were to be engraved on the map including their coordinates. The final volume serves as a summation, outlining 26 regional maps to be constructed following the world map (Aujac, 2015).

The *oikoumenè* of Ptolemy, of only three continents (Africa, Europe and Asia), stretched 180 degrees longitude from the Canary Islands in the Atlantic Ocean to the center of China, and around 80 degrees latitude from the Arctic to the East Indies and deep into Africa. Ptolemy was well aware that he only understood roughly a fourth of the world and that the world's land mass extends beyond the knowledge of his time. (Efthymiou & Dohrn-van Rossum, 2021).

In comparison to modern maps, Ptolemy's map is severely warped in size and orientation, a reflection of the sparse and erroneous descriptions of road systems and trade routes at his hand. (Gregersen, 2009).

Ptolemy's geographical work was almost unknown in Europe until around 1300, when Byzantine scholars began producing a large number of manuscript copies, many of which were illustrated with skilled reconstructions of Ptolemy's maps. In 1406 the text was translated into Latin by Jacopo d'Angelo. The numerous Latin manuscripts and early print copies of Ptolemy's Guide to Geography, most of which include maps, demonstrate to the work's great impact on Renaissance humanists upon its rediscovery (Gregersen, 2009).

Despite its mistakes, Ptolemy's depiction of the inhabited globe remained unchangeable for ages (Aujac, 2015).

His work is considered to be the final and essential step in the development of Eratosthenes' Geography, which had been developed some five centuries before. As Aujac stated (2015), it aspired not only to inscribe the newest advances in knowledge of the inhabited world on a map, but also to provide everyone with the ability to draw a map of the world or of any selected country.

Ptolemy's most significant geographical contribution was the recording of longitudes and latitudes in degrees for around 8000 places in Europe and Africa, with 6400 of them recorded with their coordinates inside a standard grid of vertical longitudes and horizontal latitudes allowing an identical replica to be made (Efthymiou & Dohrn-van Rossum, 2021).

6. Hypatia (c. 370 – March, 415 A.D)

The earliest Greek female mathematician, astronomer, and Neoplatonist philosopher who lived throughout an unstable period of Alexandria's history (Watts, 2017).

She was the daughter of Theon of Alexandria, a mathematician and astronomer who was the last prominent member of the Alexandrian Museum (Barrow-Green et al., 2019). Theon is best known for his contribution to the preservation of Euclid's Elements, he, in addition, wrote and commented on Ptolemy's Almagest. Hypatia pursued her father program, which was essentially a deliberate endeavor to conserve the Greek mathematical and astronomical heritage (Mohsen et al., 2021).

She has come to symbolize the misery of the female researcher to feminists, and she has come to signify the end of ancient science to historians. With her terrible death, as the last pagan scholar, which corresponded with the Roman Empire’s latter years, no significant developments in mathematics, astronomy, or physics appeared in the Western world for another 1000 years following Hypatia (Alic, 1981).

When Hypatia was born in 370, Alexandria's intellectual culture had already been in a dangerous state of chaos. The Roman Empire was changing; for Christians, mathematics and science frequently represent heresy and evil magic. The Great Library was destroyed by the Romans. The Serapeum Library was sacked in a Christian riot in 389, when Hypatia was nineteen, by command of Theophilos, Bishop of Alexandria. Generally, as Arnault referred, it was not an ideal time to be a scientist (Arnault, 1989).

She was fascinated with mechanics and practical technology; it is suggested that she developed scientific instruments (Rowbotham, 1995; Ramsden, 2015) such as a planispheric astrolabe, a device most likely created by Hipparchus ca. 150 B.C, for calculating the heights of stars and planets. She also invented a water distillation device, a graduated hydrometer for calculating liquid specific gravity, and a hydroscope for observing objects far beneath the water's surface (Deakin, 1994; Dzielska, 2013). This aspect of her career is documented in the writings of Synesius of Cyrene, her student and friend, who became the rich and privileged Bishop of Ptolemais. These letters include Hypatia's designs for numerous scientific devices (Ramsden, 2015). Although the basics of astrolabe projection have been known since 150 B.C as mentioned above, Hypatia's astrolabes must have been among the early operational models, according to Alic's explanation (1989). Astrolabes were further improved in the Islamic world in the year 800 A.D, but they did not reach Europe until the early 12th century, when they were transmitted through Islamic Spain (Andalusia). As Harrsch explained, if the murdering monks had spared Hypatia, Europe's astronomical knowledge would have advanced by 800 years (Harrsch, 2010). The assassination of Hypatia signaled the end of Platonic ideas in Alexandria and across the Roman Empire. According to the decree of the Council of Macon, the church claimed in 585 A.D that “women had no soul” (Nolan, 1993). Through the time astrology and mysticism became popular as a substitute for scientific study and the Dark Ages had started in Europe.

The crime committed in her murder made Hypatia a powerful feminist symbol and an influential figure who expresses the power of thought in the face of ignorance. Her intellectual accomplishments alone were entirely sufficient to merit the preservation and respect of her name, however, the manner of her tragic death added further focus.

Table. 1: Scientists of the Mouseion, their innovations, contributions and legacy

Scientist/ Scholar	Date	Interests	Writings/ Books	Notable Works/ Significant Innovations	Influence/ Contributions	Legacy
Eukleides	Flourished c. 300 B.C	Greek mathematician, astronomer, poet, and scientific writer. He was among the first scholars appointed to the Museum of Alexandria, where he had the opportunity to establish his mathematics school	The Elements	Father of Geometry	The Elements, is one of the most significant books in mathematics history, serving as the primary curriculum for teaching mathematics (particularly geometry) from its release until the late nineteenth or early twentieth century.	The Euclid spacecraft of the European Space Agency (ESA) and the minor planet Euclides are named after him (NASA, 2017)
Ctesibius	Flourished: c. 270 B.C.	Greek inventor, physicist and mathematician. The earliest great figure in the ancient engineering legacy in Alexandria		The father of pneumatics, the founder of Alexandrian mechanical school. The force pump, water lifting device, The hydraulic clock, the hydraulis (a hydraulic musical instrument)	Ctesibius' water clock, with its direct feedback, was the prototype of current pendulum clocks	
Aristarchus of Samos	Born *c.* 310 B.C - died *c.* 230 B.C	Greek astronomer and mathematician		On the Sizes and Distances of the Sun and Moon. The founder of the heliocentric theory.	Aristarchus preceded the Renaissance astronomer Copernicus with his heliocentric theory	He is commemorated by the lunar crater Aristarchus, telescope Aristarchus, and the minor planet 3999 Aristarchus.

Eratosthenes of Cyrene	Born c. 273 B.C, Cyrene, Libya Died c. 192 B.C, in Alexandria	Greek geographer, astronomer and mathematician, the fourth director of the Library of Alexandria	*Geographia*, Catasterisms?	The first academic to apply mathematics to geography and mapmaking, created a map of the entire known world. The first accurate measurement of the circumference of earth	Introduced the word *Geographia* and its related other terminologies	
Conon of Samos	Flourished *c.250 B.C - c.225 B.C* Born on the Greek island of Samos, Ionia, and probably died in Alexandria	Greek astronomer and mathematician	"De astrologia", in Astronomy "Pros Thrasydaion", in Reply to Thrasydaeus - addressing the points where conics meet other conics and circles, his work formed the basis for Conics.	The Spiral, Coma Berenices	Under his guidance, Archimedes grew up	The lunar crater Canon, Main-belt asteroid 12153, were named after him (Garfinkle, 2020)
Heron of Alexandria	Flourished c. 62 A.D	Greek engineer, physicist and mathematician	Metrica, Pneumatica, Automata, Mechania, Dioptra, Catoptrica, Belopoeica Geometrica? Stereometrica? Cheiroballistra? Definitiones?	Heron's formula, Machines and Devices (figs, 4-8) (i.e., Aeolipile, Coin-Operated Machine, Automatic Temple Doors, Programmable Self-Moving Automata, Dioptra, Hydraulis)	The first known record that explains mechanical automatic systems able to conduct programmed movements. The Aeolipile design was used in part to create the steam engines of the 18th century.	Heron's formula

Claudius Ptolemaeus	Born *c.* 100 A.D, died *c.* 170 A.D.	Egyptian-Greek geographer, astronomer, and mathematician.	Almagest (13 books), Geographia (8 books), Planetary Hypotheses (2 books), Optics (5 books)	Recording longitudes and latitudes in degrees for around 8000 places in Europe and Africa	Until the beginning of the 17th century, Almagest was the standard reference for Islamic and European astronomers with its mathematics, paradigms for the sun, moon, and planets, and descriptions of around 1022 fixed stars	The crater Ptolemaeus on the Moon and another On Mars, Ptolemy Cluster were named after him
Hypatia	Born c. 355 A.D; died March 415 A.D.	Greek astronomer, mathematician, and philosopher. .	Comment or edit previous works	An operational astrolabe, hydrometer, hydroscope. A highly respected professor, commentator on mathematics, and head of her own science school. The most famous woman scientist in antiquity	Concept of conics, conserve the Greek mathematical and astronomical heritage especially Almagest of Claudius Ptolemaeus	From antiquity up to the twenty-first century, literatures have fictionalized Hypatia's legend and her tragic death in a variety of countries and languages.

7. Results and discussions

Data shown in table. 1 explores theories, innovations, technologies and mechanisms that emerged in Ancient Alexandria. Indeed, some clues revealed modern opinions and actions taken to commemorate the inherited science of Alexandria that served as the base for the development of contemporary science and technology, this can be summarized as follow:

- Aristarchus of Samos, Eratosthenes of Cyrene and Conon of Samos; testify that there were some Hellenistic cities that enjoyed fruitful exchange relations with Alexandria, on top of them, Samos and Cyrene, which sent to the museum the greatest mathematicians, geographers and astronomers of the time.
- The presented scholars are founders/fathers of modern theories and present-day technologies as follow:
    - Eukleides, father of Geometry, his Elements served as the primary curriculum for teaching mathematics until the twentieth century.
    - Ctesibius, father of pneumatics and the founder mechanics. His water clock, with its direct feedback, is the prototype of our current pendulum clocks.
    - **Aristarchus, founder of the heliocentric theory. He preceded the Renaissance astronomer Copernicus with his heliocentric theory.**
    - **Eratosthenes, introduced *Geographia* and its related other terminologies. He presented the first accurate measurement of the circumference of Earth by applying math to geography. He is, also, widely credited with inventing an earliest geographic coordinate system.**
    - Conon of Samos, his work formed the basis for Conics, discovered the separate constellation of Coma Berenices. Conon is supposed to be the real inventor of the Spiral which is globally known as Archimedean Spiral.
    - Heron, presented the first known record that explains mechanical automatic systems able to conduct programmed movements without human intervention. His Aeolipile design was used in part to create the steam engines of the 18^{th} century.
    - Claudius Ptolemaeus, his book Almagest, until the beginning of the 17^{th} century, was the standard reference for Islamic and European astronomers with its mathematics, paradigms for the sun, moon, and planets, and descriptions of around 1022 fixed stars.
- The most prominent engineers of Hellenistic Alexandria were Ctesibius and Heron, whose research marked a considerable advance in hydraulics. According to Koutsoyiannis & Angelakis (2003) this advancement enabled for the building of elaborate water delivery systems, such as the one at Pergamon's citadel, which included pressure pipes.
- The automation of our modern world is based on the designs of the engineers of Alexandria who devoted their time on improving control systems and introducing automation. Where ancient devices depended on water, air, steam or fire, modern ones use electricity but their mechanism capabilities remain relatively unchanged over the ages. Even the digital control systems can trace the forms of their software back to the control systems of ancient Alexandria.
- The 3^{rd} century B.C. is unquestionably the golden age of science. Thanks to the policies and foresight of Ptolemy I Soter and his successor, Ptolemy II Philadelphus. However, it is clear that during the second century B.C., the scientific age is devoured, and innovative achievements in Alexandria declined substantially. The common

assumption is that this dramatically ceased is linked to the fall of the Lagid Dynasty. Yet, the investigation revealed that this historical fact was owing to the dispersion of the Museum's scientists, who abandoned Alexandria in 145 and 144 B.C. to avoid Ptolemy VIII' brutal persecution (Afrontamento, 2021).

- It appears that Hero, Claudius Ptolemaeus, and Hypatia do not belong to a scientific school that has survived or was founded by their predecessors; rather, they acquired their knowledge through reading the literature and manuscripts from the 3rd and 2nd century B.C.
- Hero's use of pneumatics, fluid mechanics, and mechanical technologies is based on pneumatics, hydrostatics and mechanics theories that dated back to the 3rd and 2nd centuries B.C., especially those of Ctesibius.
- By time researchers, academics, and highly qualified engineers, who marked Alexandria's golden age, eventually diminished. After the first century A.D., the ability to do science and produce new knowledge decreased rapidly, and the scientific method was permanently and irreversibly lost especially after the tragic death of Hypatia in the fifth century A.D.
- NASA, named some craters and minor planets after some specific astronomers to commemorate their legacy as, Eukleides, **Aristarchus,** Conon and Claudius Ptolemaeus.

8. Conclusions

The study presented significant historical evidence of scientific, technological, and mechanical advancements of ancient Alexandria. Pumps, compressed-air engines, wind and hydraulic instruments, feedback control, and programmed movements were among the brilliant mechanical tools invented by Alexandrian engineers such as Ctesibius and Hero. They also developed toys and devices, including the aeolipile, which is said to be the world's first successful steam turbine. These inventions had little practical application, but the Alexandrian school marks a significant step from very rudimentary mechanisms to more complicated systems that qualify to be called "machines." In other words, it served as a platform for current mechanical technique.

In addition, Heliocentrism and coordinate systems should be attributed to the original scholars who introduced them more than a thousand years before the Renaissance.

Archimedes was a student in the Mouseion, some of his inventions were based on the studies of Eratosthenes and Conon of Samos, his Spiral which is widely known as Archimedean Spiral is actually of Conon.

The study presented their inventions and contributions that are in use in present-day technology. A brief history is given of the improvement and studies of each scientist during antiquity.

Inventions of the ancient scientists of Alexandria were based around the exploiting of the natural forces, i.e., air, water and fire, to manage the activities and devices of everyday life as well as to automate and measure their surrounding environment. From the sophisticated water clocks that paved the way for contemporary time measuring, to the earliest known steam engine which was intended to entertain, their contributions had a profound impact on the modern world. They even founded the startup of other new sciences such as Pneumatics, Geography and Mechanics.

References

Afrontamento, E. (2021). Alexandrea ad Aegyptvm The legacy of multiculturalism in antiquity (English Edition). Edições Afrontamento.

ALBRECHT, J. (2005). Determining the earth's size. Hunter College. Http://www.geo.hunter.cuny.edu/%7Ejochen/gtech201/lectures/lec6concepts/Datums/Determining%20the%20earths%20size.htm

Alic, M. (1981). Women and Technology in ancient Alexandria: Maria and Hypatia. Women's Studies International Quarterly, 4(3), 305-312.

Arnault, L. S. (1989). Hypatia's Heritage: A History of Women in Science from Antiquity through the Nineteenth Century.

Aujac, G. (2015). The "Revolution" of Ptolemy. Brill's Companion to Ancient Geography: the Inhabited World in Greek and Roman Tradition, edited by: Bianchetti, S., Cataudella, MR, and Gehrke, H.-J., EH Brill, New-York/Leiden, 313-334.

Bagrow, L. (2017). History of cartography. Routledge.

Baldi, B. (1589). Di Herone Alessandrino De Gli Avtomati, ouero Machine Se Moventi, Libri due. Girolamo Porro.

Ball, R. S. (2016). Claudius Ptolemy: Great Astronomers (1st ed.). DIAMOND PUBLISHERS.

Barrow-Green, J., Gray, J., & Wilson, R. (2019). The History of Mathematics: A Source-based Approach (AMS/MAA Textbooks). American Mathematical Society.

Beacham, R. (2013). Heron of Alexandria's 'toy theatre'automaton: Reality, Allusion and llusion. In *Theatre, Performance and Analogue Technology* (pp. 15-39). Palgrave Macmillan, London.

Berti, M., & Costa, V. (2009, March). The Ancient Library of Alexandria: a Model for Classical Scholarship in the Age of Million Book Libraries. In CLIR Proceedings of the International Symposium on the Scaife Digital Library.

Bianchini, C., & Fantini, F. (2015). Dimensioning of Ancient Buildings for Spectacles through Stereometrica and De mensuris by Heron of Alexandria. Nexus Network Journal, 17(1), 23-54.

Britannica, T. Editors of Encyclopaedia (2017, January 27). Conon of Samos. Encyclopedia Britannica. Https://www.britannica.com/biography/Conon-of-Samos

Bruno, L. C. (1999). Math and Mathematicians: The History of Math Discoveries Around the World. U*X*L.

BURNETT, C. (2010). ›Ptolemaeus in Almagesto dixit‹: The Transformation of Ptolemy's Almagest in its Transmission via Arabic into Latin. In G. Toepfer & H. Böhme (Ed.), Transformationen antiker Wissenschaften (pp. 115-140). Berlin, New York: De Gruyter. Https://doi.org/10.1515/9783110228229.115

Cavin J.D. (2012) Claudius Ptolemy and the Almagest. In: The Amateur Astronomer's Guide to the Deep-Sky Catalogs. Patrick Moore's Practical Astronomy Series. Springer, New York, NY. Https://doi.org/10.1007/978-1-4614-0656-3_1

Coleman, M. (2005). Demystifying Electricity. Xlibris Corp.

Cort maclean Johns, P. D. H. (2021). The Industrial Revolution-Lost in Antiquity-Found in the Renaissance. Cort maclean Johns Ph. D.-HSG.

Cort maclean Johns, P. D. H. (2021). The Industrial Revolution-Lost in Antiquity-Found in the Renaissance. Cort maclean Johns Ph. D.-HSG.

Cuomo, S. (2000). Pappus of Alexandria and the mathematics of late antiquity. Cambridge University Press.

De Ruiter, B. F. V. O. (2015). Astronomy and Ideology in the Coma Berenices. In Berenice II Euergetis (pp. 71-115). Palgrave Macmillan, New York.

Deakin, M. A. (1994). Hypatia and her mathematics. The American Mathematical Monthly, 101(3), 234-243.

Dutka, J. (1993). Eratosthenes' measurement of the Earth reconsidered. Archive for History of Exact Sciences, 46(1), 55-66.

Dzielska, M. (2013). Once more on Hypatia's death.

Efthymiou, M., & Dohrn-van Rossum, G. (2021). Ptolemy: Mapping the Globe. In World and Global History. Research and teaching. (pp. 183-186). Cliohworld.

Evans, J. (2018). CONSTELLATION MYTHS IN ENGLISH-(R.) Hard (trans.) Eratosthenes and Hyginus: Constellation Myths. With Aratus's Phaenomena. Pp. Xlvi+ 210, ills. Oxford: Oxford University Press, 2015. Paper, £ 8.99, US $15.95. ISBN: 978-0-19-871698-3. The Classical Review, 68(2), 393-395.

Evans, J., & Berggren, L. J. (2018). Geminos's Introduction to the Phenomena: A Translation and Study of a Hellenistic Survey of Astronomy. Princeton University Press.

Exarchopoulos, S. (2020, January 31). First Automatic Door Invented in Ancient Greece (3D Video Presentation) - The History of the World's First Automatic Door. GHD. Https://www.greecehighdefinition.com/blog/2019/10/5/first-automatic-door-invented-in-ancient-greece-3d-video-presentation-the-history-of-the-worlds-first-automatic-door

Faulkner, N., & Hosch, W. L. (2018). Geometry (Foundations of Math). Rosen Education Service.

Fényes, G. (2015). Ctesibius: The barber of Alexandria – the father of pneumatics. Aquincum Museum. Retrieved November 11, 2021, from http://www.aquincum.hu/en/blog/ktesibios/

Ferguson, L. (2015). Control Systems as Used by the Ancient World.

Fraser, M. (2011). How to Measure Anything: Finding the Value of" Intangibles" in Business. People & Strategy, 34(2), 58-60.

Garfinkle, R. A. (1997). Star-hopping: your visa to viewing the universe. Cambridge University Press.

Garfinkle, R. A. (2020). Crater-Hopping: Observing the Moon on Day 7: First Quarter. In Luna Cognita (pp. 495-528). Springer, New York, NY.

Gregersen, E. (Ed.). (2009). The Universe: A Historical Survey of Beliefs, Theories, and Laws. Britannica Educational Publishing.

Gregersen, E. (Ed.). (2009). The Universe: A Historical Survey of Beliefs, Theories, and Laws. Britannica Educational Publishing.

Guillaum, A. (1997). Les Pneumatiques D Heron D Alexandrie (Antiquité) (French Edition). Pu Saint Etienn.

Gutzwiller, K. (2008). A guide to Hellenistic Literature. John Wiley & Sons.

Hall, R. A., & Smith, N. (2016). History of Technology Volume 2 (Reissue ed.). Bloomsbury Academic.

Harrsch, M. (2010). Were Hypatia's Astrolabes among the first working models? Roman Times. Https://ancientimes.blogspot.com/2010/04/were-hypatias-astrolabes-among-first.html

Hartnett, K. (2011). The Heavens: Intimate Moments with Your Majestic God (Gift ed.). Thomas Nelson.

Haselberger, L. (1999). Appearance and Essence: Refinements of Classical Architecture--Curvature (Vol. 107). Upenn Museum of Archaeology.

Haskins, C. H., & Lockwood, D. P. (1910). The Sicilian Translators of the Twelfth Century and the First Latin Version of Ptolemy's Almagest. Harvard Studies in Classical Philology, 21, 75-102.

Heath, T. (2013). Aristarchus of Samos, the Ancient Copernicus: A History of Greek Astronomy to Aristarchus, Together with Aristarchus's Treatise on the Sizes and Distances of the Sun and Moon. Cambridge University Press.

Heilman, R. (2019). An Engineering View of the Universe Vol I (First Edition). Lulu.com.

Herón, & Commandino, F. (1575). Heronis Alexandrini Spiritalium liber. Domenico Frisolino.

Hill, D. R. (2020). Studies in Medieval Islamic Technology: From Philo to al-Jazari–from Alexandria to Diyar Bakr. Routledge.

Hosch, W. (Ed.). (2010). The Britannica guide to geometry. Britannica Educational Publishing.

Iqbal, M. (2017). Studies in the Making of Islamic Science: Knowledge in Motion: Volume 4 (Islam and Science: Historic and Contemporary Perspectives) (1st ed.). Routledge.

Irby, G. L. (Ed.). (2019). A Companion to Science, Technology, and Medicine in Ancient Greece and Rome, 2 Volume Set. John Wiley & Sons.

Katz, V. J., & Michalowiz, K. D. (Eds.). (2020). Historical modules for the teaching and learning of mathematics (Vol. 26). American Mathematical Soc.

Keim, F. (2006). Copernicus in der" Schule von Athen"(1508-11): eine Studie zum Bildnis des Nicolaus Copernicus und zur Gruppe um Aristarch von Samos in Raphaels Fresko.

Keyser, P. (Ed.). (2018). The Oxford Handbook of Science and Medicine in the Classical World. Oxford University Press.

Koutsoyiannis, D., & Angelakis, A. N. (2003). Hydrologic and hydraulic science and technology in ancient Greece. The encyclopedia of water science, 415-417.

Lasater, B. (2008). The Dream of the West, PT II (null ed.). Lulu.com.

Lasky, K. (2008). The librarian who measured the earth. Little, Brown Books for Young Readers.

Lazaris, S. (2017). 4 Scientific, Medical and Technical Manuscripts. In A Companion to Byzantine Illustrated Manuscripts (pp. 55-113). Brill.

Lister, M., Dovey, J., Giddings, S., Grant, I., & Kelly, K. (2008). New Media: A Critical Introduction (2nd ed.). Routledge.

Lloyd, G. E. R. (1973). Greek science after Aristotle (p. 138). New York: Norton.

Macardle, M. (2021). Scientists: Extraordinary People Who Altered the Course of History (1st ed.). Metro Boks.

Mcdonald, M., & Walton, M. (2007). The Cambridge Companion to Greek and Roman Theatre (Cambridge Companions to Literature) (1st ed.). Cambridge University Press.

Mohsen, J. P., Ismail, M. Y., Parsaei, H. R., & Karwowski, W. (2021). Global Advances in Engineering Education (Industrial and Systems Engineering) (1st ed.). CRC Press.

NASA. (2017, May 9). NASA Delivers Detectors for ESA's Euclid Spacecraft. JPL. Retrieved November 25, 2021, from https://www.jpl.nasa.gov/news/nasa-delivers-detectors-for-esas-euclid-spacecraft

NASA. (2019, June 17). Aristarchus Crater. NASA Solar System Exploration. Retrieved November 25, 2021, from https://solarsystem.nasa.gov/resources/2465/aristarchus-crater/

Nolan, M. (1993). The Mysterious Affair at Mâcon: The Bishops and the Souls of Women. New Blackfriars, 74(876), 501-507.

O'Connor, J. J., & Robertson, E. F. (2001). The Mactutor History of Mathematics archive. University of St. Andrews, Scotland, www-gap. Dcs. St-and. Ac. Uk/~ history/or www-history. Mcs. St-and. Ac. Uk/~ history/index. Html.

Oakes, E. H. (2014). A to Z of STS Scientists. Infobase Publishing.

Otto, J. (2018). Philo of Alexandria and the Construction of Jewishness in Early Christian Writings. Oxford University Press.

P., Berggren, L. J., & Jones, A. (2020). Ptolemy's Geography: An Annotated Translation of the Theoretical Chapters (New Ed). Princeton University Press.
Partington, J. R. (1970). *A History of Chemistry. Vol. 1. Pt. 1*. Macmillan.
Pathak, R. (2021). Science & Technology for UPSC & State PSC Civil Services Prelim & Main Exams. Disha Publication.
Ramsden, J. (2015). HYPATIA OF ALEXANDRIA. Mathematics in School, 44(3), 31.
Riznic, J. (Ed.). (2017). Steam generators for nuclear power plants. Woodhead Publishing.
Robinson, E. A., & Clark, D. (2017). Basic Geophysics (Geophysical Monographs). Society of Exploration Geophysicists.
Robinson, E. A., & Clark, D. (2017). Basic geophysics. Society of Exploration Geophysicists.
Robinson, T. (2017). Sir Tony Robinson's Weird World of Wonders Joke Book (Main Market ed.). Macmillan Children's Books.
Rogers, G. E., Wright, M. D., & Yates, B. (2013). Gateway to engineering. Cengage Learning.
Roller, D. W. (Ed.). (2010). Eratosthenes'" Geography". Princeton University Press.
Rossi, C.. (2016). Precursors of the automation in the Hellenistic Age. 17. 31-36.
Rosso, A. M. (2021). From Iology to Toxicology: A new specialization in Ancient Alexandrian School. Toxicology Reports.
Rothschild, J. (Ed.). (1982). Women, technology, and innovation. Pergamon.
Rowbotham, S. (1995). Feminist approaches to technology. Women encounter technology: changing patterns of employment in the third world, 1, 44.
Saliba, G. (1995). A history of Arabic astronomy: Planetary theories during the golden age of Islam (Vol. 2). NYU Press.
Sarton, G. (1993). Hellenistic science and culture in the last three centuries BC. Courier Corporation.
Science, Industry and Business Library: General Collection , The New York Public Library. (1801). Bootes et Mons Mænalus, Corona Borealis, Coma Berenices, Canes Venatici, Quadrans Muralis. Retrieved from https://digitalcollections.nypl.org/items/510d47dc-897b-a3d9-e040-e00a18064a99
Senior, K. R. (Ed.). (2009). The 100 most influential scientists of all time. The Rosen Publishing Group, Inc.
Speake, G. (Ed.). (2021). Encyclopedia of Greece and the Hellenic Tradition. Routledge.
Steadman, P. (2021). The automata of Hero of Alexandria. In Renaissance Fun: The machines behind the scenes (pp. 111–132). UCL Press. Https://doi.org/10.2307/j.ctv18msqmt.10
Strathern, P. (1998). Archimedes and the Fulcrum. Random House.
Taylor, T. (1961). The Philosophical and Mathematical Commentaries of Proclus on the first book of Euclid's Elements.
Valavanis, K. P., Vachtsevanos, G. J., & Antsaklis, P. J. (2007, July). Technology and Autonomous Mechanisms in the Mediterranean: From Ancient Greece to Byzantium. In 2007 European Control Conference (ECC) (pp. 263-270). IEEE.
Valavanis, P. (1999). Hysplex: the Starting mechanism in Ancient Stadia: a Contribution to Ancient Greek technology (Vol. 36). Univ of California Press.
Van den Belt, H. (2007). The Authority of Scripture in Reformed Theology: Truth and Trust. Brill.
Vodolazhskaya, L. (2008). Reconstruction of Heron's Formulas for Calculating the Volume of Vessels.
Vullo, V. (2020). The First Scientific Age and Birth of the Science: From the Beginning of Hellenism to the Diaspora of Scientists of the Museum of Alexandria. In Gears (pp. 21-56). Springer, Cham.

WALLACE, R. (Ed.). (2021). Heron. In Encyclopedia of Greece and the Hellenic Tradition (pp. 744–745). Routledge.
Watts, EJ (2017). Hypatia: the life and legend of an ancient philosopher . Oxford University Press.
Whipps, H. (2008). How the steam engine changed the world. Live Science, 7, 16.
Willard, E. (1856). Astronography; Or, Astronomical Geography.(Vol. 2).
Wilson, N. (Ed.). (2013). Encyclopedia of ancient Greece. Routledge.
Žmolek, M. A. (2013). Rethinking the Industrial Revolution: Five Centuries of Transition from Agrarian to Industrial Capitalism in England. Brill.

Journal of Tourism, Hotels and Heritage (JTHH)

Vol. 4 No. 1, (2022) pp 55-78.

Journal Homepage: https://sjs.journals.ekb.eg

أهمية التراث العلمي لعلماء الموسيون وإسهاماته في عصر النهضة والتقنيات الحالية

معلومات المقال

الكلمات الدالة:

التراث العلمي

الموسيون

علماء الإسكندرية

التكنولوجيا القديمة

ملخص البحث

يعتبر موسيون الإسكندرية ومكتبتها من أعظم النماذج الاولية للحضارة الحديثة. خلال العصور القديمة ، حلم عدد كبير من العلماء والفلاسفة والكتاب والفنانين والطلاب بالانضمام إلى هذا الصرح العلمي حيث تم جمع كل المعارف الإنسانية والحكمة والكتب. في هذا المكان ، أصبح رجال الموسيون المتعلمون قادرين على احتلال كل مجال من مجالات الثقافة. خلال القرنين الثالث والثاني قبل الميلاد أصبحت الإسكندرية موطنًا لبعض أعظم العلماء ومركزًا لتطوير التكنولوجيا العملية. من بين أجيال العلماء الذين نجحوا في الموسيون ومكتبته وعملوا هناك لساعات طويلة للدراسة والتدقيق ، ظهرت بعض الأمثلة وشكلت أبحاثهم الأساس للعديد من الاختراعات والنظريات التي نستخدمها اليوم. على الرغم من موادهم التراثية رائعة ، إلا أنهم لم يلقوا الشهرة التي يستحقونها. لذلک ، ستلقي الدراسة الضوء على هذا التراث المنسي المتمثل في الأجهزة والاختراعات والنظريات التي تصورها علماء ومهندسو الإسكندرية القديمة والتي ، في بعض الحالات ، يمكن اعتبارها سلائف للعلوم والتقنيات المعاصرة ، مما يوضح كيف تم مفهوم العلم قديما في أذهان العلماء والمهندسين منذ القرن الثالث قبل الميلاد. كشفت النتائج عن اهمية معرفة وعلم علماء الإسكندرية من حيث تصميم الآلات والبناء ، والتفكير في العالم الخارجي ، وحل المشكلات ، وتأسيس مناهج جديدة. تم تقديم العينة المختارة وتصنيفها حسب أهمية مخترعها.