Earth 101
Introduction to Astronomy

Slide Presentation by Jatila van der Veen

OpenStax Ch 2
Arab / Islamic
Astronoy

Photo/Material Credit:

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- Erin O'Connor + others

The Butterfly Nebula

After the fall of Rome, all of western science and math were carried on by Arabic scholars.

This is not mentioned in most western textbooks. The question is, *WHY?*

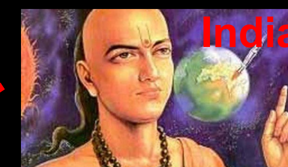
Astronomy developed along many paths in the ancient world. Indigenous people saw the skies as we, in the modern world, rarely get to see them: completely dark, and filled with stars. Ancient people appear to have used astronomy to predict seasons, to keep time and date, often building structures that aligned with the solstices and equinoxes, and to monitor the skies.

The pathway along which modern western astronomy developed seems to have begun in India, China, and Greece simultaneously. In the ancient world there was little trade between the Far East and the Middle East, until 130 BC, when the Silk Road trade routes opened between China and the West. Knowledge of math and science followed the textile and spice trade along the Silk Road, until the mid 15th Century.

After the fall of the Greco/Roman Empire in 476 AD, the knowledge developed by the ancient Greeks was kept alive AND ADVANCED in the great learning centers of the Islamic Empire for more than 1,000 years.

It was from the scientists and mathematicians of the Islamic Empire that Copernicus, in the early 16th Century, was able to develop his heliocentric model of the Solar System, which began what is known as the Copernican Revolution in science.

Greece

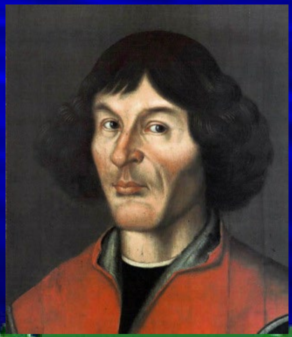


China

Islamic Empire

Western Europe

Indigenous Astronomy
of the Western Hemisphere

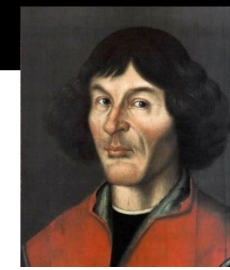


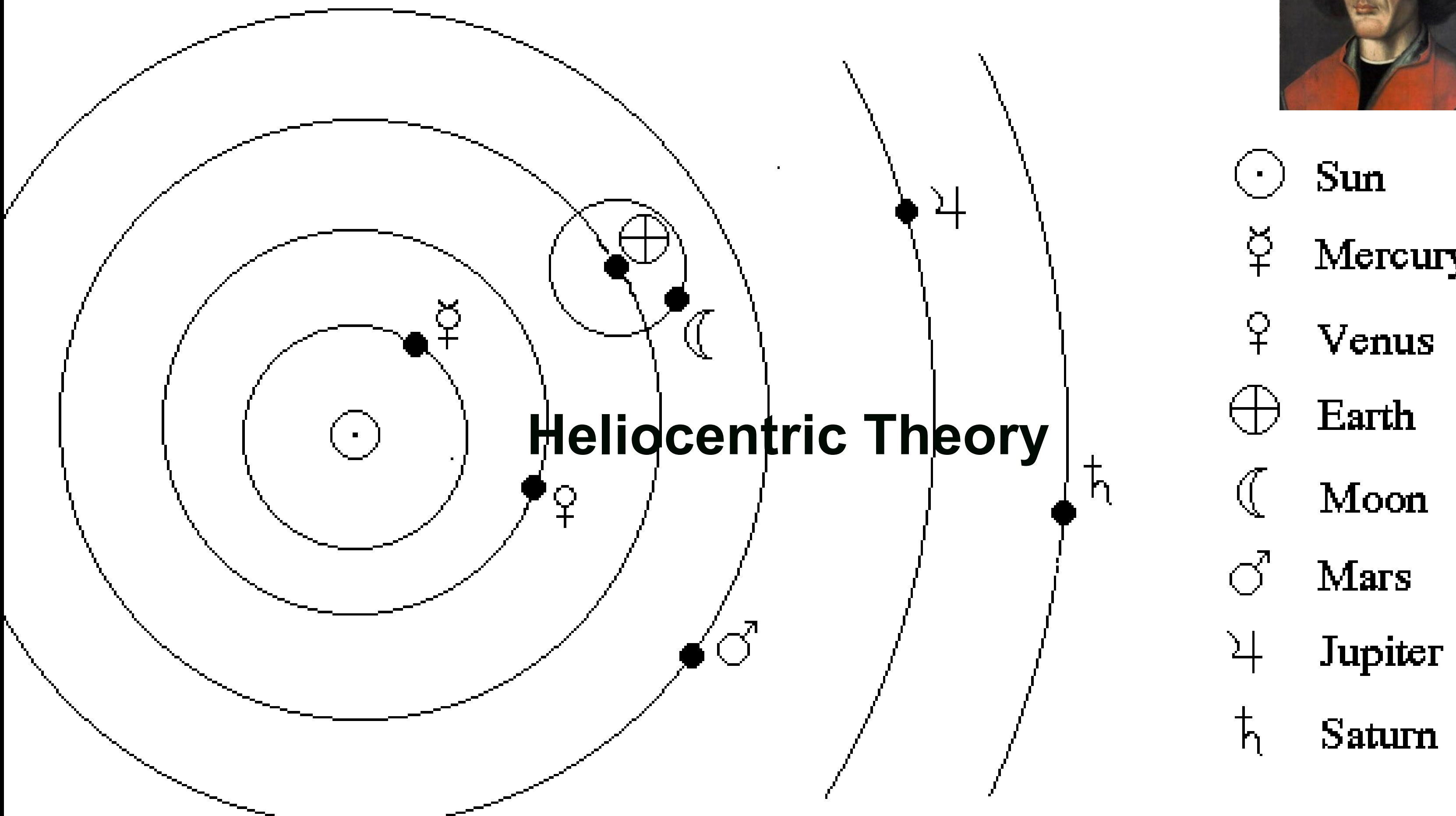
Niklaus Copernicus
1473 - 1543

Poland

The Copernican Revolution in the 16^{th} Century *depended* on the mathematics and astronomy from the Arabic empire.

Although most western scholars do not acknowledge the Arabic origins of Copernicus' heliocentric model of the known solar system, namely that the Sun is in center of solar system and all planets revolve around the Sun, scholars of the history of science conclude that Copernicus could not have produced this model without knowing the hundreds of years of observations and mathematical theory that came from the great centers of learning in the Islamic Empire.





The so-called Dark Ages and Middle Ages in Europe were the Golden Age for Islam, in which knowledge and learning flourished in the Muslim Empire. *It is evident, even to modern western scholars, that the so-called Copernican Revolution began in the Islamic centers of learning.*

From Copernicus and his Islamic Predecessors: Some Historical Remarks
F. Jamil Ragep, McGill Univ., *in History of Science, xiv (2007).*

Beginning in the first half of the thirteenth century, a number of works appeared that proposed alternatives to Ptolemy's planetary models. This was the start of an extremely fruitful period in the history of science in Islam in which a series of creative mathematical models were produced that dealt with the problems of Ptolemaic astronomy. Among the most important of these new models were those of Naṣīr al-Dīn al-Ṭūsī (1201–74), Mu'ayyad al-Dīn al-ᶜUrḍī (d. *c.* 1266), Quṭb al-Dīn al-Shīrāzī (1236–1311), ᶜAlā' al-Dīn Ibn al-Shāṭir (d. *c.* 1375), and Shams al-Dīn al-Khafrī (*fl.* 1525).

The earliest systematic attempt in Islam to criticize Ptolemy's methods and devices occurred in *al-Shukūk ᶜalā Baṭlamyūs* (*Doubts against Ptolemy*) by Ibn al-Haytham (d. *c.* 1040), who was better known in Europe for his great work on optics. In addition to his blistering critique of Ptolemy, Ibn al-Haytham also wrote a treatise in which he attempted to deal with some of the problems of Ptolemy's planetary latitude models.[6]

On the next few slides are a few of the prominent mathematicians of the Islamic Empire, upon whose work western mathematics and astronomy preceded the Renaissance in western Europe.

Think about this: Why do our modern, western textbooks completely skip this step? Why do basically all our textbooks in physical sciences of physics, chemistry, and astronomy, jump 1500 years from the Ancient Greek scholars to the 1500s?

It's not because the Arabic scholars did not leave written records!

Muḥammad ibn Mūsā al-Khwārizmī c. 780 – c. 850),

“The father of algebra”

First mathematician to solve quadratic equations

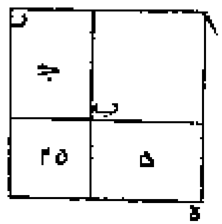
Invented algebra

Astronomer

Geographer

Calculated values of trigonometry functions, producing tables of sines, cosines, and the first table of tangents.

علي تسعة وثلثين ليتم السطح الاعظم الذي هو سطح ره فبلغ
ذلك كله اربعة وستين فاخذنا جذرها وهو ثمانية وهو احد
اضلاع السطح الاعظم فاذا نقصنا منه مثل ما زدنا عليه وهو
خمسة بقي ثلثة وهو ضلع سطح اب الذي هو المال وهو جذره
والمال تسعة وهذه صورته



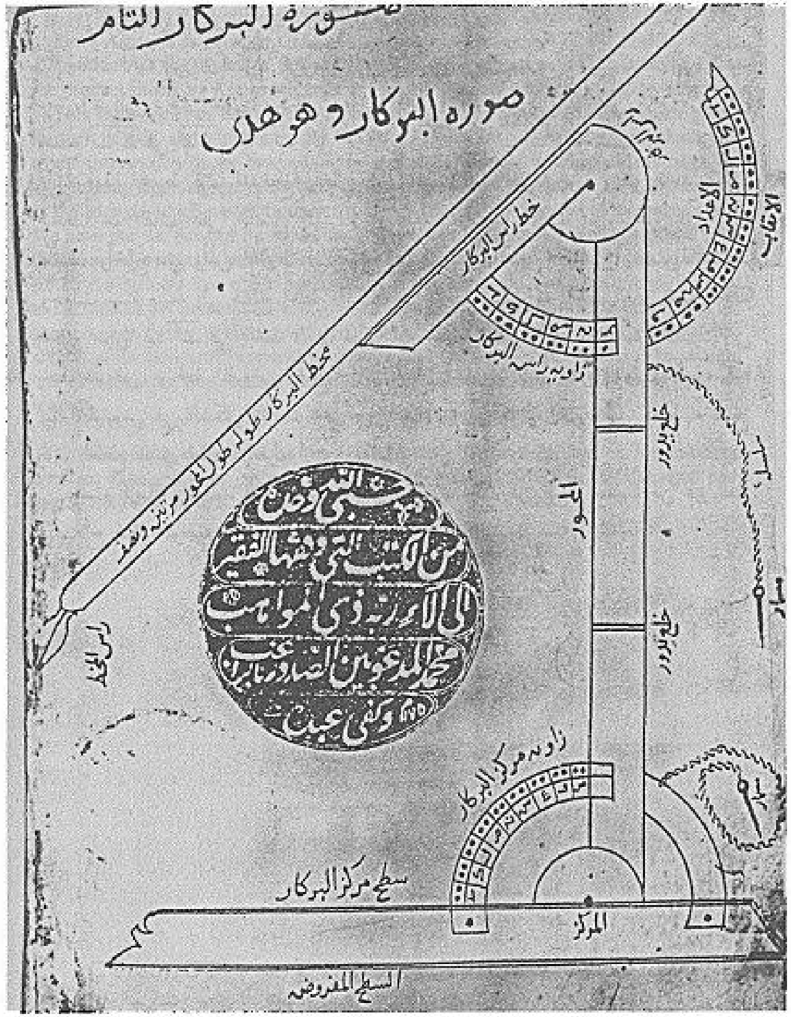
واما مال واحد وعشرون درهما يعدل عشرة اجذاره فانا
نجعل المال سطحا مربعا مجهول الاضلاع وهو سطح اد ثم نضم
اليه سطحا متوازي الاضلاع عرضه مثل احد اضلاع سطح اد وهو
ضلع هن والسطح هب فصار طول السطحين جميعا ضلع جه
وقد علمنا ان طوله عشرة من العدد لان كل سطح مربع
متساوي الاضلاع والزوايا فان احد اضلاعه مضروبا في واحد جذر
ذلك السطح وفي اثنين جذراه فلما قال مال واحد وعشرون
يعدل عشرة اجذاره علمنا ان طول ضلع هج عشرة اعداد لان
ضلع جد جذر المال فقسمنا ضلع جه بنصفين على نقطة

The original Arabic print manuscript of the *Book of Algebra* by Al-Khwārizmī

Al-Khwārizmī's *Zīj al-Sindhind*[(Arabic: "astronomical tables of Sind and Hind") is a work consisting of approximately 37 chapters on calendrical and astronomical calculations and 116 tables with calendrical, astronomical and astrological data, as well as a table of sine values.

Abū Sahl Wayjan ibn Rustam al-Qūhī (al-Kūhī; Persian: ابوسهل بیژن کوهی *Abusahl Bijan-e Koohi*) was a Persian mathematician, physicist and astronomer in Baghdad, in the 10th century.

Al-Qūhī is considered one of the greatest Muslim geometers, with many mathematical and astronomical writings ascribed to him.



Kitāb al-Qūhī fī al-birkār al-tāmm, MS Istanbul, Raghib Pasha 569, fol. 235v.

Engraving of al-Quhi's perfect compass to draw conic sections

Mu’ayyad al-Din al-’Urdi (b. ~ 1200) is known for being the first of the Maragheh astronomers to develop a non-geocentric model of planetary motion.

In particular, the *Urdi lemma* he developed was later used in the heliocentric Copernican model of Nicolaus Copernicus in the 16th century.

Khawaja Muhammad ibn Muhammad ibn Hasan Tūsī (1201 -1274) better known as

Nasīr al-Dīn Tūsī

For his planetary models, Tusi invented a geometrical technique called a Tusi couple, which generates linear motion from the sum of two circular motions.

He also determined the precise value of 51 arc seconds for the annual precession of the equinoxes and contributed to the construction and usage of some astronomical instruments including the astrolabe.

Central Asia

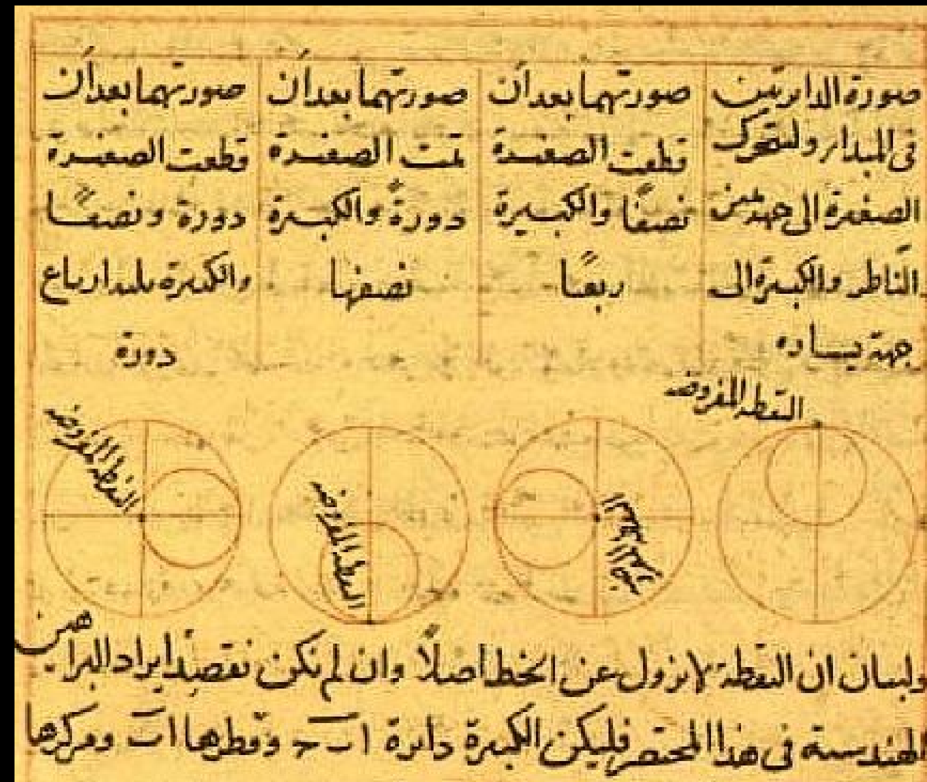
Ulugh Beg (1394–1449), ruler in Samarkand, Uzbekistan, built a famous observatory between 1424 and 1429, considered the finest observatory in the world at that time. It was destroyed after his death (by assassination), and uncovered in the early 1900s by archaeologists.

He built the Maragheh Observatory in Samarkand in 1259, which had the largest sextant at that time, predating Tycho Brahe's observatory and instruments by more than 300 years.

(https://mathshistory.st-andrews.ac.uk/Biographies/Ulugh_Beg/)
(https://en.wikipedia.org/wiki/Ulugh_Beg_Observatory)
(https://en.wikipedia.org/wiki/Maragheh_observatory)

Two modern views of the Maragheh Observatory

Painting of Al-Tusi and colleagues working at the Maragheh Observatory



Tusi Couple - Original source: Biblioteca Apostolica Vaticana, Vat. Arabic ms 319, fol. 28 verso, http://digi.vatlib.it/view/MSS_Vat.ar.319/0062Library of Congress Vatican Exhibit, Rome Reborn, https://www.loc.gov/exhibits/vatican/images/math19.jpg, Public Domain, https://commons.wikimedia.org/w/index.php?curid=877168

The spread of astronomy, mathematics, and other natural sciences appears to have followed the Silk Road trade routes from Asia through the Arabic Empire, and eventually to Europe from around 130 BC to 1453 AD.

Read more about Astronomy along the Silk Road trade routes at https://en.unesco.org/silkroad/content/did-you-know-astronomy-along-silk-roads

Some quotes from the following article:
How Islamic scholarship birthed modern astronomy

“There were so many contributions over a millennium that it’s impossible to pick just a few.”

By Shannon Stirone , Astronomy Magazine, February 14, 2017

https://astronomy.com/news/2017/02/muslim-contributions-to-astronomy

Astronomers like Ibn Yunus from Egypt found faults in Ptolemy’s calculations about the movements of the planets and their eccentricities. Ptolemy calculated that the wobble of the Earth, or precession as we now know it, varied 1 degree every 100 years.

Later, astronomer Ibn Yunus found that Ptolemy was quite wrong and that in fact it was 1 degree every 70 years. However, they didn’t know that it was the Earth’s wobble causing this change because in the 10th century it was still believed that Earth was at the center of the universe. This discovery by Ibn Yunus and others like Ibn al-Shatir changed the landscape of astronomy forever. ***The heliocentric model eventually proposed by Copernicus in the 16th century was built on this body of work.***

In the 8th century under Caliph al-Mamun al-Rashid, the first observatory was built in Baghdad and subsequent observatories were built around Iraq and Iran. ***Since this was before the telescope had been developed, the astronomers of the time invented observational sextants.***

Around this same time in 964, after more and more observations took place, one of Iran's most famous astronomers Abd al-Rahman al-Sufi published The Book of Fixed Stars, one of the most comprehensive texts on constellations in the sky. Abd al-Rahman al-Sufi was also the first astronomer to observe the Andromeda galaxy and the Large Magellanic Cloud. These observations would have been made purely with the naked eye since the telescope hadn't yet been created. Of course he didn't know it was a galaxy at the time, he marked it down as a "cloud" in his notes. ***This work would later prove to be useful to famed Danish astronomer Tycho Brahe.***

What do we understand today, from archeological excavations of ancient civilizations from the Neolithic through early Bronze ages, and written records in India, China, and the Islamic Empire?

* **There was quite a lot of advanced astronomy in the ancient cultures of the Western Hemisphere, but they left no written records. There was no trade between developing countries in Asia and the Middle East and cultures of the western hemisphere, which is most likely why their work was not incorporated into the work of the East, which was brought to Europe via trade routes from the East.**

* **There was quite a lot of advanced astronomy in Asia, which was written down. There was ample exchange of ideas between India and China starting with the spread of Buddhism from India to China, and from there to the centers of learning in Baghdad and the Islamic Empire via the Silk Road trade routes.**

So the question is WHY, in our western textbooks of astronomy and physics, are the critical contributions from the Islamic world not mentioned? Why are western students taught that the progression of science skipped 1,000 years from Ancient Greece to Copernicus, Kepler, Galileo, and Newton?

I hope you have gained a small insight into the thousands of years that preceded the rise of astronomy, physics, and mathematics in Europe.

We don’t have time to go into more detail because we have SOOO much to discover about our current understanding of the universe! But I want you to take away the following ideas from this lecture, which I hope you will keep in mind throughout this course, as well as in future science courses you take:

1. Science is NOT a static body of knowledge, but is constantly evolving.

2. Science is deeply connected to politics and cultural prejudice.

3. Science is really a global endeavor.

4. In every scientific ‘revolution,’ advancements have been made because of two things:

i. Someone asked the right question which began a revolution in thought;

ii. Someone invented a new instrument which allowed more detailed observations than were previously possible.

Additional references:

The Missing Link? The Maragha Observatory, Khan Academy

Ptolemaic Astronomy, Islamic Planetary Theory, And Copernicus's Debt To The Maragha School

The Confluence of Some Ideas Used by Copernicus in De Revolutionibus