3 The Islamic Contribution

3.1 Historical Background

Hellenistic Greece

- The conquests of Philip II of Macedonia and his son, Alexander (356-323 BCE), extended the Greek empire over most of the ancient world, from Egypt through Mesopotamia to India.
- This brought enormous dissemination of Greek culture and the advent of the Hellenistic, or “Golden Age” of Greece.
- Following the death of Alexander in 323 BCE the empire was partitioned among three of Alexander's generals: Ptolemy in Egypt, Seleucus in Mesopotamia, and Antigonus in the Greek peninsula, Syria and Asia Minor.

Alexander’s empire

Rome

- By about 275 BCE the Romans had established supremacy over most of Italy.
- From ca. 168 BCE they made Greece and Macedonia protectorates, with Roman governors, but otherwise left traditional politics alone.
- The Romans were in awe of Greek culture and took much of it over wholesale, producing copies and imitations of Greek architecture, sculpture, & literature.
- But they had little interest in Greek science, and very little was translated into Latin; the Romans were more interested in technology and engineering.
- However, there was the revision of the calendar under Julius Caesar in 45 BCE (a leap-year every 4 years).

Rome 2

- After the death of Marcus Aurelius in 180 CE, peace and stability gave way to turmoil.
- Understanding of the content and style of Greek science declined in the Roman empire.
- In 285 the Emperor Diocletian divided the Roman Empire in two, East and West.
- In 323 Constantine became the sole emperor.
- In 330 CE Constantine moved his capital from Rome to Byzantium, renamed Constantinople (now Istanbul) and he re-built the old city of Byzantium.
- The eastern part of the Roman empire became the Byzantine empire, and it held together until Constantinople was conquered in 1453.
Decline of the West

- Meanwhile, Rome was over-run repeatedly by German tribes from the north, and sacked with finality in 476 CE.
- The western division went into decline: intellectually, demographically, & economically.
- Europe became a hard-scrable subsistence economy.
- The population declined, there was little literacy, and the high civilization of Greece was lost.
- Europe entered the “Dark Ages.”

Byzantine empire

- In contrast, the Greek-speaking eastern division of the empire flourished.
- It inherited and maintained the culture of the Graeco-Roman civilization.
- Constantine had converted to Christianity and had made Christianity the official state religion of his empire.
- Hence the Byzantine empire became a Christian empire.
- Greek science and philosophy were seen by many as “pagan,” but the Byzantine empire played a critical role in preserving and diffusing Greek learning, and indeed, many of the Christian theologians used Greek philosophy in their apologetic writings.

Mesopotamia

- In Mesopotamia the Persian Sassanid dynasty (ca. 226-637) co-existed with the Byzantine empire.
- It continued with the old-style Babylonian agricultural economy & irrigation.
- However, monasteries in eastern Mesopotamia became centers of Greek scholarship, and Greek philosophy and science were translated into Syriac.
- Example: Nestorian (heretical) Christians fleeing Byzantium, brought Greek culture to Syria, became influential, and established several centers of learning in western Persia.
- In this way Greek science was preserved in the East.

3.2 The Decline of Greek Science

- In the period following the death of Aristotle, Greek cosmologists began to lose interest in what we would call scientific theories.
- Instead, the interest changed to purely mathematical constructions to fit the Aristotelean model more precisely to observations (“saving the appearances”).
- We have seen examples of this in the introduction of epicycles, eccentric motion, and the equant, none of which are consistent with Aristotle’s theory of dynamics and celestial natural motion.
- Ptolemy is not interested in the actual nature of things in the heavens, but only finding mathematical methods to show how things might be expected to change.
Accurate celestial forecasting

- However, as has been noted, these mathematical patches were quite clever, and enabled the later Greek astronomers to make very accurate calculations of future celestial events.
- For example, using Ptolemy's geometrical constructions one could forecast planetary positions to better than 2 deg accuracy over several centuries.
- Thus we see something of a return to the mentality of the Babylonians: accurate celestial forecasting was the aim, rather than to find a deeper understanding of the underlying reality of celestial objects and their motion.

Loss of Greek vision

- Toulmin & Goodfield adduce several reasons for this deterioration in the Greek vision of an underlying theory of Nature:
  - The loss of centers of learning, such as the Academy and the Lyceum in Athens
  - Gifted individuals are often working alone, e.g. Hipparchus (Rhodes) & Archimedes (Syracuse).
  - Modest ambitions, and a resulting tendency to work on making small improvements rather than to consider moving in significantly new directions with new ideas.

“Saving the appearances”

- There was increasing skepticism about the value of natural philosophy and its ambitions (cf. quotation from Ptolemy).
- The goal of a theory about underlying reality seemed to be more the province of theology.
- In contrast, astronomers saw their aims to be geometrical constructions which are in good agreement with astronomical observations: “saving the appearances.”
- N.B. this is an “instrumentalist” philosophy of science.
- We shall see that tension between these two views of the aims of science continues through history and into the 21st C.

3.3 The Islamic Contribution

Islamic expansion

From ca. 670 Muslims began over-running the Middle East, conquering Egypt, Persia, North Africa, and Spain.

The Abbasid caliphate

- First caliphate after Muhammad's death were the Umayyads, who ruled from Damascus (644-749).
- Hellenization of Islam began with educated Syrians and Persians who became civil servants.
- In 749 the Abbasid caliphate came to power with the idea that power should be shared among all muslims and not just Arabs.
- In 762 Al Mansur built a new capital city, Baghdad.
- The Abbasids transformed the empire into a centralized state, requiring an enormous increase in civil servants, and therefore hiring large numbers of educated Persians and some Christians.
- The Abbasid Court was intellectual, secularized, tolerant.
Translation projects

• The Abbasids established major translation centers, sending emissaries to various parts of the empire to bring back manuscripts for translation into Arabic.
• Most famous of these was the “House of Wisdom,” set up by the son of Harun al Rashid in Baghdad in 832. (Many of the translators were Syrian Christians.)
• Baghdad became the intellectual center of the Islamic empire, although there were several other major intellectual centers, including Basra.
• Most of the known Greek scientific texts were translated into Arabic—e.g. at least 5 translations of the Almagest.
• An estimated 10,000 Arabic astronomical manuscripts & 1,000 Arabic astronomical instruments survive.

Rationale for translation

• There is no agreement among scholars about the rationale for these large translation projects.
• The pursuit of knowledge for its own sake was not part of Islamic religious ideology.
• It is likely that Greek science was considered important for its practical applications.
• Medicine, astronomy, astrology, mathematics, alchemy, and natural history do have obvious utilitarian applications.
• There are many examples to show that Greek science was assimilated into Islamic culture: e.g. mathematics and astronomy were taught in several of the legal colleges, or madrasas.

Libraries & observatories

• Many 100s of libraries were created, some with collections in the 100,000s of volumes.
• Copies of translated Greek texts were circulated to these libraries.
• They were often attached to mosques & madrassas.
• The concept of an astronomical observatory seems to have been invented in the Abbasid caliphate.
• Al-Mansur established an observatory in Baghdad in 829, and others were built throughout the empire.
• Observatories were sometimes attached to mosques so that the correct times for religious observances could be established reliably.

Islamic astronomers at work

• Islamic astronomers not only assimilated Greek science; they developed it further. In particular, Islamic astronomers:
  ◦ thought that the precession of the equinoxes varies and developed a theory to account for it,
  ◦ calculated new values for solar and lunar motions and the inclination of the ecliptic—e.g. Al-Battini, whose astronomical tables were used & admired by Copernicus,
  ◦ discovered the variation in the location of closest approach between Sun & Earth,
  ◦ developed improved and corrected star catalogues (N.B. the names of most of the bright stars are Arabic),
  ◦ made improvements in the calendar.

Islamic astronomy

• Islamic astronomers constructed superior instruments for making astronomical measurements.
• They improved quadrants & invented the Equatorium (a device for finding positions of the Sun, Moon, & planets).
• They made improvements in the theory and construction of sundials.
• They built celestial globes for solving problems in spherical trigonometry that arise in positional astronomy.
• Although the astrolabe was a Greek invention it was further developed and many treatises on its use for astrology, astronomy, and timekeeping were written.

Astronomical instruments
Islamic astrolabe

- They made improvements in the astrolabe, a two-dimensional projection of the heavens for computing positions of celestial objects.
- Astrolabes could be used not only to find stars, but also the time Ramadan begins, and the hours of prayer.

More on the astrolabe

- Excellent discussion of the astrolabe, including how to make and use one, in James Evans, *The History and Practice of Ancient Astronomy*, Section 3.5, p. 141.

Reminder: Ptolemaic Model

- Apollonius & Hipparchos added the epicycle & deferent, and the eccentric point.
- Ptolemy added uniform motion about the equant.
- There were different constructions for each problem one wanted to solve.

Critiques of Ptolemy

- A number of Islamic astronomers attempted to improve Ptolemy’s cosmological construction, finding the equant and eccentric points philosophically objectionable—e.g. Ibn Rushd (Averroes).
- Others wanted the planetary circles to be physical and to construct a mechanical model of the system. (Maimonides noted that Ptolemy had the equant point for Saturn falling right on the spheres for Mercury.)
- Al-Tusi eliminated the equant by adding two additional small epicycles.

Ibn Al-Shatir

- Ibn Al-Shatir (in Damascus) developed a scheme for a mechanically satisfactory set of nested spheres.
- He was able to eliminate the equant by using al-Tusi’s idea of two smaller epicycles.
- (This was only discovered in the 1950s by scholars at the American University in Beirut.)
- There is some discussion whether Copernicus could have known about this work since he first used a similar scheme for removing the equant.
- (But unlikely that knowledge of Al-Shatir’s work ever got to Europe.)

Larger cosmological issues

- Aristotle argued (as we have seen) that the Earth (and hence the Universe) are eternal.
- This was difficult to reconcile with the idea of creation in time in the Quran.
- Another point of disagreement with Aristotle was the immortality of the soul.
- There was also a continual tension between the Islamic legal conservatives and Greek philosophy (faith vs. reason).
- In the Islamic West, Ibn Rushd became an outstanding authority and commentator on Aristotle (in later Latin publications of Aristotle his commentaries were often published along with the text.)
Ibn Rushd (Averroes)

- Ibn Rushd had answers for both these issues: continuous creation, moment by moment, and when a person dies his/her soul joins the single, eternal world-intellect.
- His approach to the faith/reason or Quran/Aristotle debate was to argue that both are sources of truth and so they must agree.
- The Quran provides truth that can be understood by everyone, but philosophy requires exceptional intellects to penetrate and follow its rational development.
- We will see this debate again and again.

Decline of Islamic science

- Islamic science under the Abbasids in Baghdad began to decline in the 11th C, but continued to flourish in the Islamic West, especially in Cordoba and Toledo.
- However, from the 12th C onward there was decline everywhere, and little was left by the 15th C.
- Among the causes scholars offer for this:
  - conservative religious forces gained prominence,
  - infighting and warfare both within Islam and from outside (Crusaders took Toledo in 1085, Cordoba in 1236, and Seville in 1248),
  - Baghdad fell to the Mongols in 1258, ending the Abbasid dynasty.

Summary

- The Greek achievements in science were lost to western civilization after the collapse of the Graeco-Roman empire.
- Fortunately, much of Greek culture was maintained in the Greek-speaking Byzantine and Persian empires.
- With the Islamic conquests, the Greek tradition was brought into the Islamic empire, translated into Arabic, and diffused throughout the vast empire, where it was assimilated and developed further.
- It was when these Arabic translations of the Greek texts made their way to Europe, especially from Spain, that the Greek tradition re-appeared in the Europe.