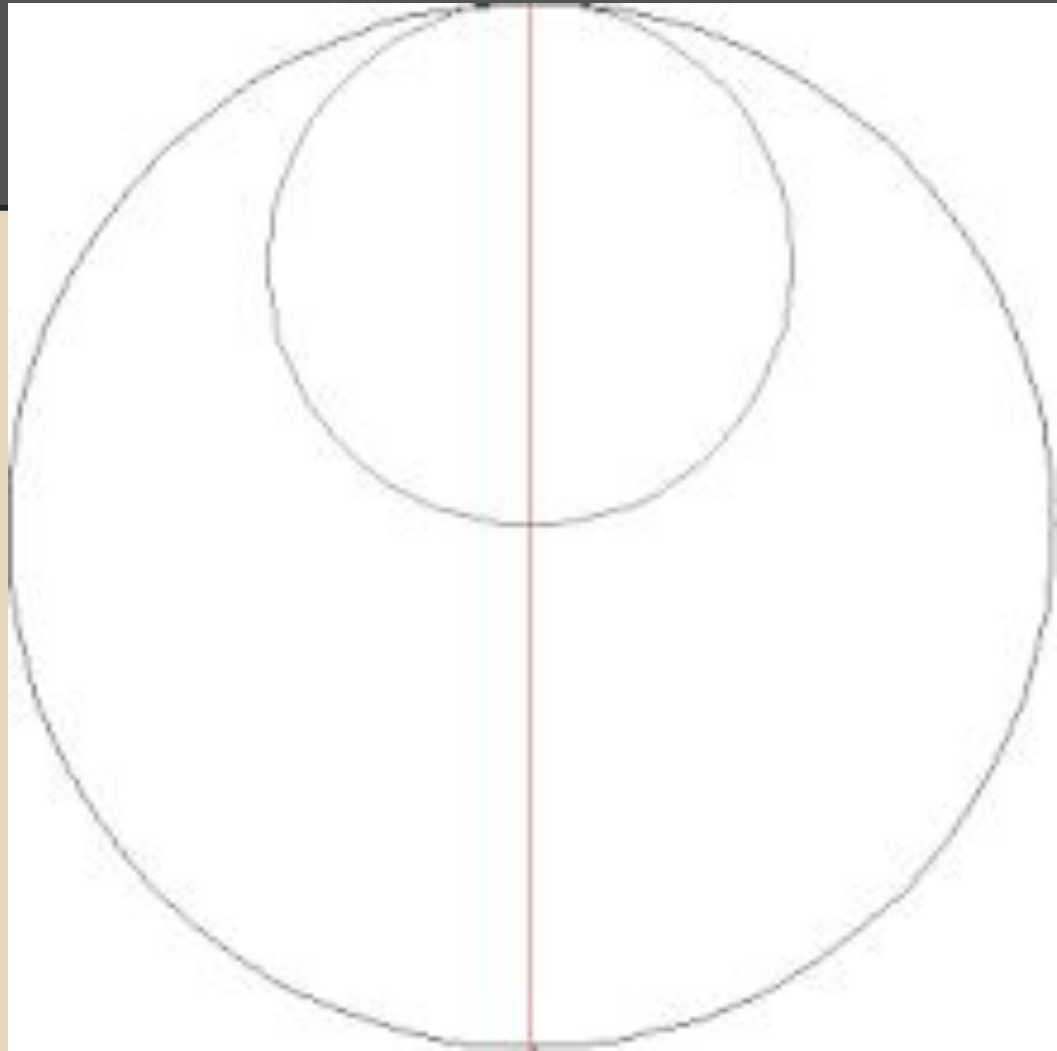


# Science in Dar al-Islam

# 1. Astronomy: Tusi Couple

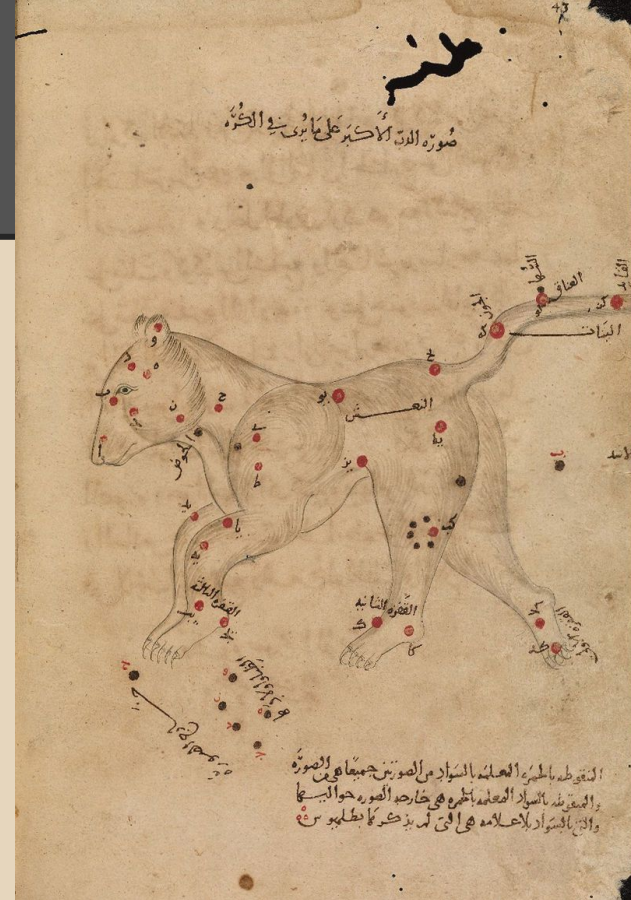
Nasir al-Din al-Tusi invented a geometrical technique called a Tusi-couple, which generates linear motion from the sum of two circular motions (see diagram on next slide). Using this method, al-Tusi showed that “uniform motion in circles can actually appear to make something appear to move in a straight line.”<sup>1</sup> He made the most advanced model of the solar system, showing that planets did not move in perfectly circular orbits, as the Roman astronomer Ptolemy believed. Rather, they moved in elliptical orbits, and he formulated and incredibly accurate tables for calculating the position of the planets. Later astronomers used the Tusi-Couple to further study the motion of celestial/astronomical objects. In the 1500s, Copernicus would use the Tusi-couple to propose his heliocentric theory, arguing that the Sun, not the Earth, was at the center of the solar system.

The Tusi-Couple: The Tusi-Couple was comprised of two circles such that the smaller circle with half of the diameter of the bigger circle would roll tangent (just touching the circle) inside of the larger circle.



# Astronomy

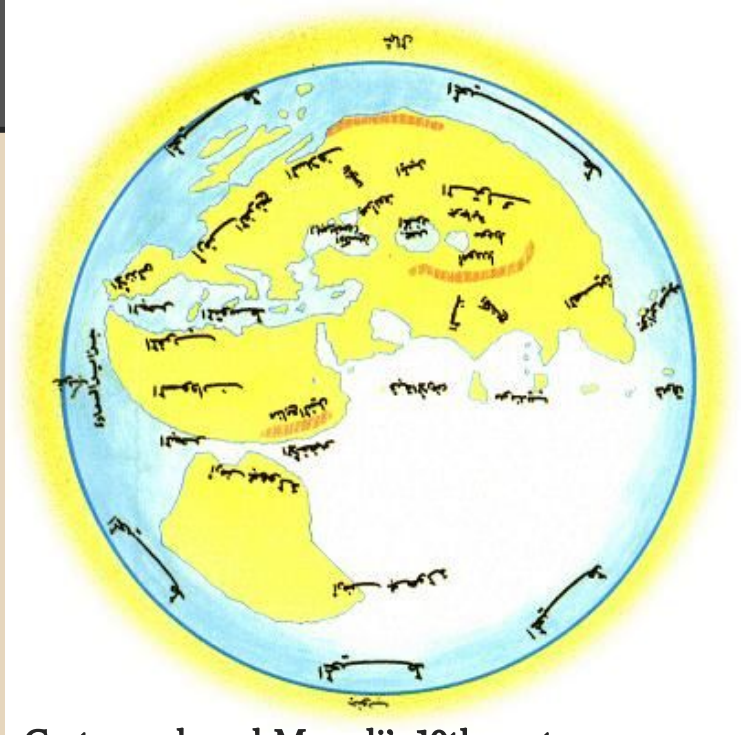
Around 964 CE, Abd al-Rahman al-Sufi produced *The Book of Fixed Stars*, a comprehensive categorization of stars and constellations, greatly expanding on Ptolemy's 48 known constellations. In it, he also wrote the first definitive reference to what we now know is the Andromeda Galaxy, the nearest spiral galaxy to our galaxy.



The Great Bear, which includes the 7 stars of the Big Dipper.

## 2. The Size of the World...and unknown continents??

After determining the size of the Earth in the (see advanced in mathematics), Al-Biruni determined that, according to understandings of the world at the time,  $\frac{3}{4}$  of the world was nothing but water. Using logic and reasoning, he concluded “There is nothing to prohibit [prevent] the existence of other inhabited lands in the Eastern and Western hemispheres. Neither extreme heat nor extreme cold stand in the way . . . it is therefore necessary that some supposed regions do exist beyond the [known] remaining regions of the world surrounded by water on all the sides.” He published these beliefs in his *Codex Masudicus* (1037 CE), and the voyages of the Vikings around 1000 CE and Columbus in 1492 would confirm his suspicions—unknown or unexplored lands existed in uncharted parts of the world. Finally, Biruni used his observations to show that the sun was mobile, not fixed in the sky as Ptolemy postulated.



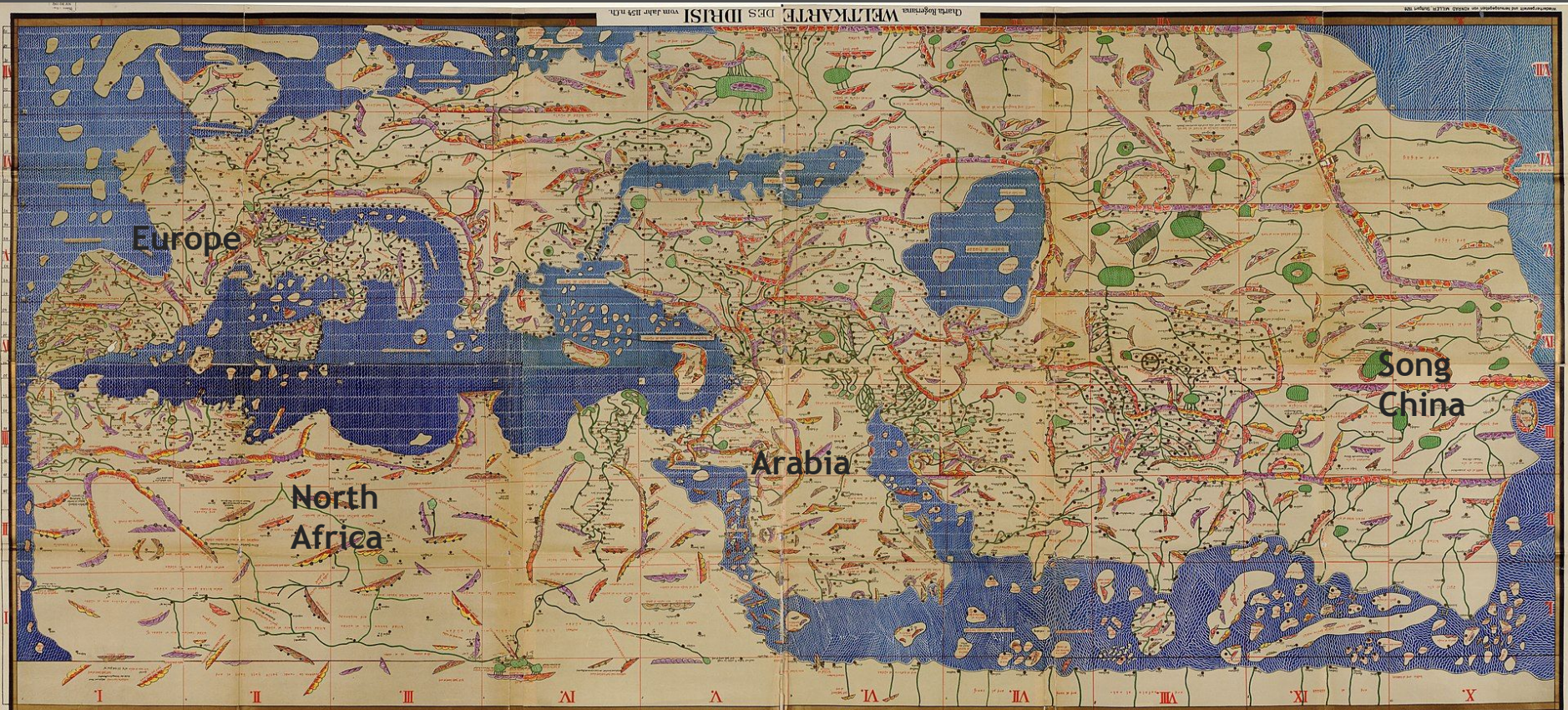
**Cartographer al-Masudi's 10th century map showing a potential continent outside of the Old World. Masudi based his beliefs in another continent on the alleged journey of navigator Ibn Aswad across the Atlantic in 889 CE.**

# 3. Cartography & Geography

The spread of Islam promoted travel and trade, leading to a proliferation of more accurate maps. In 1154, Arab geographer al-Idrisi created one of the most detailed and accurate maps of the medieval world. He also included descriptions of the people, climates, resources and industries of these regions. He incorporated the knowledge of Africa, the Indian Ocean and the Far East gathered by Arab merchants and explorers with the information inherited from the classical geographers like Ptolemy to create the most accurate map of Afro-Eurasia in pre-modern times. See his map on the next page.



# Al-Idrisi's Map in *Tabula Rogeriana*. For reference, I have labeled a few regions.





# 4. Modern Chemistry

Medieval Muslim scientists built off alchemy (the ancient forerunner to chemistry usually focused on turning metals into gold or an elixir), deciding to build off the speculative nature of Greek alchemy and instead apply new methods and experimentation, creating the foundations for a new science: chemistry. They discovered alcohol, nitric and sulphuric acids, silver nitrate and potassium. They also determined the weight of many bodies and mastered the technique of sublimation, crystallization and distillation. Muslim chemistry also took many industrial uses, including tinctures and their applications in tanning and textiles; distillation of plants and of flowers, the making of perfumes and therapeutic pharmacy, glazes for pottery, rosewater (the distilled essence of roses), hard soap, gunpowder, and various types of glass. Distillation was used at Baku in Azerbaijan to produce a light flammable liquid called “white naft,” roughly equivalent to kerosene, from crude oil. The distillation of kerosene would not be “discovered” in the US until 1846.



Arabic manuscript held in the British Library showing the distillation process in a treatise of chemistry.



# Jābir ibn Ḥayyān, Father of Modern Chemistry

Jabir's works contain the oldest known systematic classification of chemical substances, and the oldest known instructions for deriving an inorganic compound (sal ammoniac or ammonium chloride) from organic substances (such as plants, blood, and hair) by chemical means (for example, how ammonium chloride could be derived from Nitrogen, Hydrogen, Chloride) He defined chemical combinations as a union of the elements together, in too small particles for the naked eye to see. In addition, he invented a kind of paper that resisted fire and an ink that could be read at night. Jabir's other achievements, gathered from various sources, led him to perfect chemical processes such as sublimation [direct transition from solid to gas], liquefaction, purification, amalgamation [mixing], oxidation, crystallization, distillation, evaporation, and filtration, which are described in detail. He also identified many new products, including alkalines, acids, salts, paints and greases. Jabir's works with metals and salts subsequently helped develop foundry techniques and glazing processes for tiles and other ceramics.

# Al-Razi & Modern Chemistry

AL-Razi contributed to modern chemistry by setting up the modern laboratory with more than 20 instruments he described in detail. In his work *Secret of Secrets*, he made the very useful classification of natural substances, dividing them into earthly, vegetable and animal substances, to which he also added a number of artificially obtained ones such as lead oxide, caustic soda, and various alloys. He went further in the cataloguing and description of his experiments, describing first the materials he used, then the apparatus, and methods and conditions of his experiments. In the *Secret of Secrets*, he describes in great detail such chemical processes which he performed, and which have their modern equivalent form of distillation, calcination, crystallisation.



European depiction of Al-Razi in the Latin version of one of his treatises

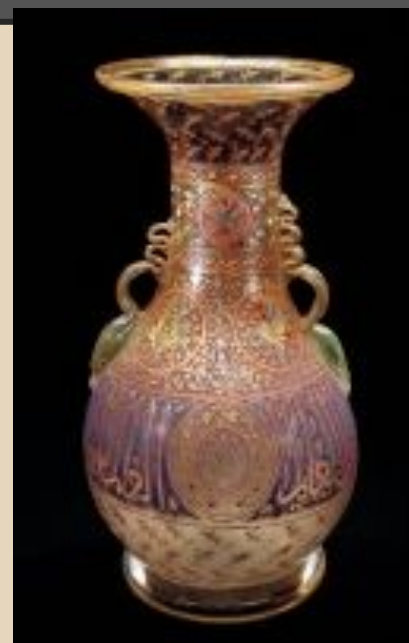
# Using Chemistry to Perfect Glassmaking



9th century Egyptian bowl,  
9th century



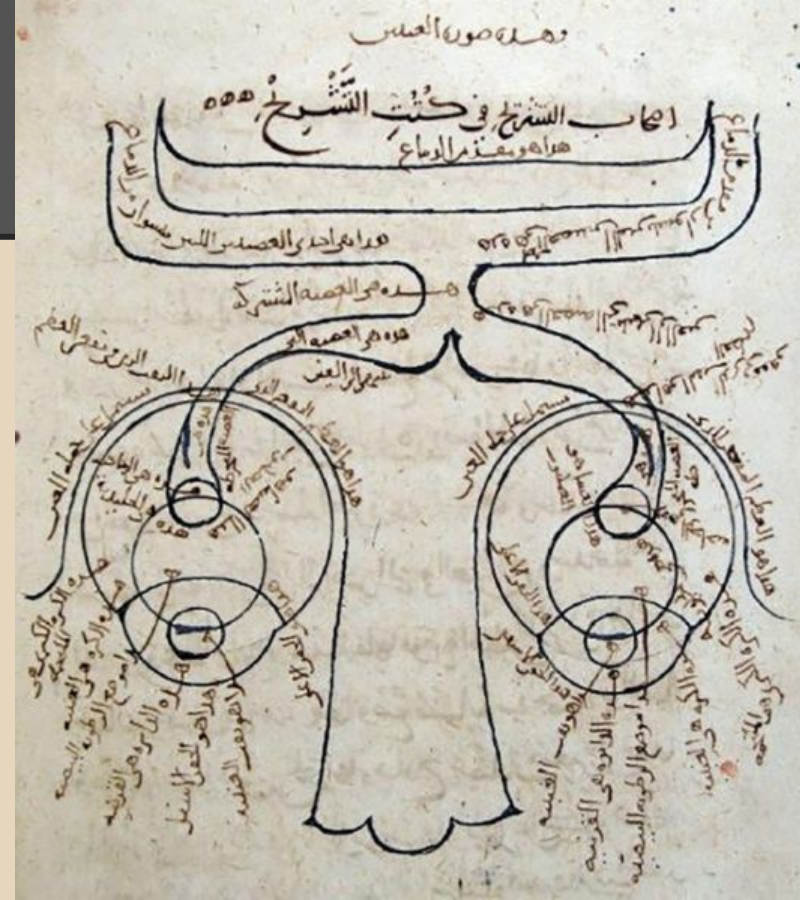
Fatimid Caliphate flask,  
11th or 12th century



Handled Vase from 13th  
century Syria

# 5. Optics

According to Greek philosopher Aristotle, when we look at an object its essence mysteriously flows into our eyes and that is how we see. Another Greek philosopher claimed light rays come out of our eyes. See how Ibn-Haytham (aka Alhazen) sought a mathematical explanation that corrected these ideas about vision and used experimentation to make major developments in optics and physics. Ibn-Haytham's experiments helped him create a detailed anatomy of the human eye. He is often referred to as the "father of modern optics." He is also regarded as world's first true scientist and father of the scientific method for his insistence that everything must be supported not only by logic, but also by math and science and detailed experiments that could be replicated.



al-Haytham's anatomy of the eye