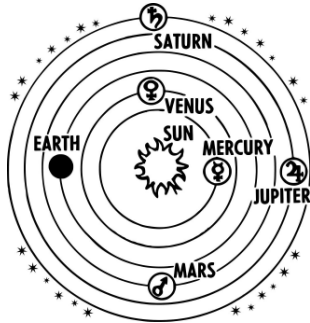




## Copernican Revolution - Teacher's Notes

### Post Renaissance Science - The Age of reason



Although most astronomers still believed the heavens rotated round the Earth until late Renaissance times, the idea that all planets might revolve around the Sun was first raised by the mathematician and astronomer Aristarchus of Samos (310-230BC). He correctly identified the Sun as the "central fire" and correctly placed the planets round

it. He also wrote that stars are probably other suns. This heliocentric idea (Helios = Sun, centric = centered) came in and out of favour with astronomers but not with the general public or with major religions who continued to purport that the Universe revolved around Man and the Earth. When mathematicians and astronomers carefully measured the movements of the planets, they discovered that it was impossible to predict to where they might move to if they used the Earth as the centre of their orbits. Their progressive movements could only be explained if they moved round the Sun and we moved with them.

Nicolaus Copernicus (1473-1543) was a priest who used mathematical



measurements and models to assert that the Sun was at the center of the solar system. He wrote his famous paper "On the revolutions of the Heavenly Spheres" but it was only published towards the end of his life. Do you think you could be as brave as Copernicus? [Any personal opinion.](#)

When he died he was buried in an unmarked grave under the floor of Fromberk cathedral. His ideas weren't commonly accepted for another two hundred years.



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### Using STEM to Find the Body of Nicholas Copernicus

What do the letters in STEM stand for? **Science, Technology Engineering and Mathematics.**

For some classes, teachers may need to make a word wall of unfamiliar names and spelling, for example.

Archaeologists study evidence of the history of Man.

Astronomers study evidence of the history of the Universe.

DNA experts compare and contrast DNA evidence from different sources.

Forensic scientists provide evidence for use in courts.

Geophysicists use evidence from the physical properties of materials to sense what they cannot see.

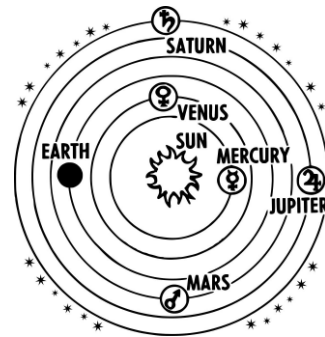
Mathematicians use numbers, data, and space to study change and make models.

Heretics are people who hold opinions at odds with general beliefs.

Read the following true story and answer the questions.

Note: If you recant you publicly state you have changed your mind back to conventional belief.

Copernicus was a brave man to counter conventional wisdom that the Earth was the centre of the Universe. People had been burned at the stake and tortured for saying just that. Copernicus had "done his math's" and had observations which supported his idea. Even so his findings were declared heretical, by the church, he was counseled to recant. His papers did not get published until the year of his death. He was buried in an unknown unmarked grave along with



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fourteen other bodies under the floor of Fromberk Cathedral. He was only a priest and his death wasn't noted in the cathedral's records, only that a replacement for him had been found.

Why do you think that the planets Uranus and Neptune along with the dwarf planet Pluto are not present on the Copernican diagram on the previous page? *All the planets on this diagram can be seen by the naked eye. You need a telescope to see the others. (Uranus 1781, Neptune 1846 and Pluto 1930). Copernicus had to rely on naked eye observations.*

His ideas were generally unacceptable for many years. Galileo Galilei (1564-1642), the famous Italian astronomer, was later threatened with torture for supporting and spreading them. He also was declared a heretic. To escape torture by the Inquisition he had to publicly recant and change the direction of his own research. He spent the rest of his life under house arrest. He was eventually pardoned of heresy in 1992.

Four hundred and seventy three years after Copernicus' death, some scientists, clerics and politicians wanted to erect a special granite memorial dedicated to "the man who turned the Universe inside out". They thought that a solitary tomb would be more acceptable for the great Polish national hero. But how could they find one grave amongst many under the floor of the Cathedral? They used a STEM approach.

Geophysicists used ground-penetrating radar to outline areas of disturbed soil lying under the tiles on the cathedral floor. This work was difficult because they had to pause for religious services, as this was still a working cathedral. Why did they use geophysics radar first and not just start digging?

*This might narrow down possible gravesites without lifting the tiles.*

Archaeologists and priests excavated under the floor of the cathedral to





## Copernican Revolution - Teacher's Notes

check the possible sites. Digging in sandy areas was difficult. When the organ played, its vibrations would shake loose sand, which would fall back collapsing excavation holes. They eventually found over 100 possible gravesites. Many had multiple bodies. Why do you think so many people were buried under the floor inside the church? **People used to believe that the closer to the altar you were buried, the faster you got into heaven.** Only the very rich or religious were buried there. How did Copernicus get to be buried there? **He was a priest.**

They soon found the skull and parts of the skeleton of a seventy-year-old man. Copernicus had died at seventy years. Is this sufficient evidence to say these were the remains of Copernicus? **No. It could be from another man about the same age. It could be used to support other evidence however.**

Police forensic pathologists examined the skull and used computer programs to make measurements of it. These were used by experts in forensic facial reconstruction to create a model of what the head and face of the person with this skull would have looked like. Their model displayed a broken nose, a scar into the bone above its left eye and the same facial features that could be seen in a portrait that Copernicus had drawn of himself. Is this sufficient evidence to say the body belonged to Copernicus? **It certainly supports the data from the archaeologists.**

DNA experts wanted to find descendants of Copernicus to match their DNA with his to be completely sure. Unfortunately Copernicus had no children. Priests and forensic pathologists then examined some of Copernicus own mathematical books, which were still held in a library. They found his hairs trapped between the pages. The DNA scientists compared the DNA from a tooth and a bone to find a perfect match with DNA from the hair. Is this sufficient evidence to say the body was Copernicus? **Yes.**







## Copernican Revolution - Teacher's Notes

The case is complete.

List the pieces of evidence, which put together, convincingly proved the skeleton and skull to be Copernicus?

1. The skeleton was of a 70 year old man. Copernicus died at 70. This alone was not convincing It could have been from another 70 year old man.
2. The skull had a scar, broken nose and facial features which were similar to those of Copernicus. This alone would not prove they belonged to Copernicus.
3. The DNA of Copernicus' hair matched DNA from the skull and skeleton. This is convincing evidence, which is well supported by the two above.

Which STEM trained scientists were involved with solving the case? Place an X in the appropriate box

Geophysicists, archaeologists, forensic pathologists and forensic reconstruction experts, DNA experts. I can't comment on the priests, as I have no data on whether they had expertise in this area or not. In good Science, if you don't know you have to say so rather than give out misinformation.

Expert's area	Science	Technology	Engineering	Mathematics
Geophysics	X	X	X	X
Archaeology	X	X	X	X
Forensic pathology	X	X	X	X
DNA experts	X	X	X	X

**Geophysics.** Remote sensing using physical behavior of the ground to



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## Copernican Revolution - Teacher's Notes

RADAR, gravity and electric currents

Science Good technique for data collection (Observable Measurable Repeatable & Reportable).

Technology Effectively using ground penetrating radar.

Engineering Using equipment suitable for the physical characteristics of the area

Mathematics Mapping and interpreting the numerical data.

**Archaeology** The study of the history of mankind

Science Good technique for data collection (Observable Measurable Repeatable & Reportable).

Technology Use of trowels, brushes, sieves, photography, labeling, measurement and preservation of finds.

Engineering Excavating tools, support of established structures, correct replacement of excavated materials.

Mathematics Mapping and interpreting the numerical data.

**Forensic pathology** Collecting evidence from dead bodies

Science Good technique for data collection (Observable Measurable Repeatable & Reportable).

Knowledge of muscle and skeletal tissues

Technology Effective use of computer programs for facial recognition and reconstruction

Engineering Choice of materials for skull and face reconstruction.

Mathematics Assessment and choice of probable features of skull

**DNA analysis** Using fragments of cell nuclei to determine similarities

Science Good technique for data collection (Observable Measurable Repeatable & Reportable). Selection of material.

Technology Use of computers and appropriate programs. Obtaining good untainted samples



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Engineering As above

Mathematics Understanding of probability of good match.



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