Lesson 1

Student Handout 1—What is Gunpowder?

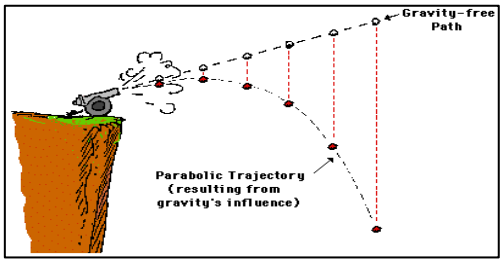
Gunpowder is made of a few simple substances. It works on the idea of rapid oxidation, that is, combustion of carbon to create an explosion that can take place in a closed chamber. The ingredients of gunpowder are ground charcoal, sulphur, and saltpeter. Saltpeter, or potassium nitrate, is the oxidizer. It is a white, crystalline, organic chemical—a byproduct of animal dung. It can be mined in ancient bat caves or bird dung piles as the substance called *guano*. Or it can be produced by subjecting dung to a special process, similar to composting, for about a year.




Saltpeter + Carbon + Sulphur = gunpowder

Gunpowder explodes because the nitrates in saltpeter release oxygen when they are heated, even by a small flame like a match or by a spark made when metal strikes flint (a stone used to make fire). The released oxygen from potassium nitrate acts as a catalyst. It causes the carbon and sulfur to burn (oxidize) rapidly in a quick chemical reaction, that is, an explosion. Normally, combustion occurs in the open air, but the action of saltpeter with heat makes gunpowder burn in a closed place like a rocket tube or the barrel of a cannon.

The proportions of the three ingredients of gunpowder can be varied to produce different explosive force, depending on the desired use—fireworks, mining, handguns, or cannons. The force must be enough to create the desired explosion but not so much as to destroy the barrel of the weapon. On the creative side, a paper or bamboo tube used for fireworks is disposable. The explosion in the tube produces a show by shooting out chemicals that produce colors when burned. On the destructive side, an artillery shell that is shot from a gun and that itself contains gunpowder will explode on impact, scattering dangerous shrapnel and setting things on fire.



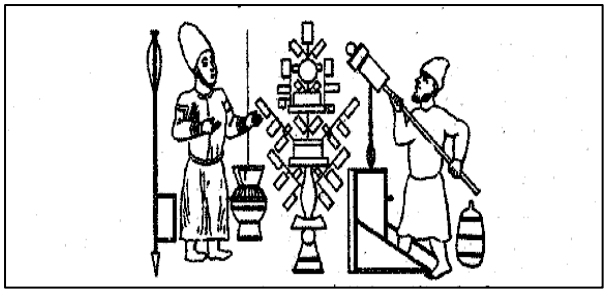
An explosion in a tube that is closed on one end will make an object (projectile) placed between the gunpowder and the open end shoot. This happens because the explosion causes gas to expand. In the case of a rocket, the tube itself is set into motion by the explosion. Laws of physics (force, motion, and gravity) determine the path, or trajectory, of the projectile such as a bullet, cannonball, or rocket. Knowledge of how to predict the trajectory of a flying object allows the user to aim the weapon at a person, mounted soldier,

fortress wall, or ship. The trajectory will vary depending on the weight of the projectile, the angle of the barrel, and the force of the explosion.[1]

Who invented gunpowder and its use in warfare?

The origins of gunpowder are easier to trace than its spread. It is possible that there were several different centers for parts of the invention. Both Buddhist and Muslim alchemists tried to make potions that would give a person immortality or create substances that would change base metals into gold. Both efforts led to experiments with various substances. Although alchemy is considered a pseudoscience (a theory or practice that is not well grounded in scientific evidence), these experiments led to the real science of chemistry, that is, understanding the properties of matter and producing chemical substances with many uses.

Gunpowder is a byproduct of alchemy experiments. Alchemists knew about organic compounds in urine and dung as powerful substances. They experimented with acidic and alkaline substances. They learned in the case of saltpeter that some substances can "transform" others in chemical reactions. Alchemists happened upon knowledge of gunpowder and shared this knowledge widely. A Chinese Buddhist alchemist wrote, "Some have heated together the saltpeter, sulfur, and carbon of charcoal with honey; smoke and flames result, so that their hands and faces have been burnt, and even the whole house burnt down."[2] Honey contains sugar molecules made of carbon, hydrogen, and oxygen, so it would have accelerated the reaction by providing extra fuel. In the Muslim tradition of alchemy, scholars recorded discovery of new substances and processes, as well as equipment such as furnaces and glass vessels, in detailed books on alchemy. Manuscripts that became known in the Latin West included works by Jabir ibn Hayan (d. *ca.* 815) and al-Razi (d. 925). These books recorded recipes for nitric and other acids, called "sharp waters" or *aqua regia* in Latin translations. The knowledge of how to reproduce and purify substances accurately was as important as the knowledge of compounds and their uses.[3]



Two illustrations from the Petersburg manuscript showing the first use of explosive gunpowder and cannon.

Source: History of Science and Technology in Islam, http://www.history-science-technology.com/Articles/articles%2072.htm

[1] "Gunpowder," *New World Encyclopedia*, http://www.newworldencyclopedia.org/entry/Gunpowder
[2] "Gun and Gunpowder," Silk Road Foundation, http://www.silk-road.com/artl/gun.shtml
[3] "Transfer of Islamic Technology to the West," History of Science and Technology in Islam, http://www.history-science-technology.com/Articles/articles%2072.htm

Military uses of incendiary and explosive materials in western Asia date to the mid-first millennium CE. Natural seepage of petroleum, called *naft*, occurs in **Southwest Asia.** People also know that pitch (tar) and resins are very flammable. In the seventh century, the Byzantines used naphtha, or "Greek fire," in warfare. This may have been one source of the knowledge that European Crusaders gained in the eleventh century and later. Knowledge of how to distil substances led to use of compounds in fire-throwing devices. Knowledge of these tools was later applied to gunpowder technologies to make more refined weapons. By the time of the Crusades, grenades and rockets that contained explosives were in use. Examples exist in museums today. Arabic books of that era refer to saltpeter by different names, including "Chinese snow" or "Chinese salt," which points to the spread of knowledge of this substance westward across **Inner Eurasia**.

The first recorded use of gunpowder in warfare in China dates to 919 CE, as shown in this tenth-century fire lance image from the Dunhuang caves in western China.[4] Song historical documents indicate the use of explosive gunpowder in projectiles thrown from catapults. These documents contain terms that refer to cannons, rockets, and firebombs. A Chinese battle that took place against an invading army in 1126 featured bamboo tubes that shot flaming missiles. Bamboo cannons as offensive weapons featured in 1132, when they were mounted on a wheeled platform to attack a city's walls. Catapults evolved from bamboo tubes to a device with a metal, bottle-shaped barrel that would shoot arrows. Archaeologists have discovered a very early gun at a site in Manchuria dated to about 1290.

By the time of the Mongol invasions, both the technology for making gunpowder and its use in weaponry had reached Muslim lands. There is evidence that Mongol forces used Chinese engineers with gunpowder weapons to attack Iran and Iraq. Iranian engineers, using an Arab-designed trebuchet (a machine for throwing projectiles against or over defensive walls), served with Mongols who attacked northern China. European Crusader armies were exposed to gunpowder weapons in the eastern Mediterranean, and forces of the Egyptian Mamluk state used them against the Mongols in Syria.

One of the best sources on gunpowder weapons is *The Book of Military Horsemanship and Ingenious War Devices*, by Najm al-Din Hasan al-Rammah (d. 1295). Written in about 1270, it details "inherited knowledge of the forefathers," including 107 gunpowder recipes, 22 kinds of rockets, and other kinds of gunpowder weapons. Al-Rammah reported modern proportions of ingredients for explosive gunpowder: 75 percent potassium nitrate (saltpeter), 10 percent sulfur, and 15 percent carbon.

[4] Wikipedia, http://en.wikipedia.org/wiki/File:FireLanceAndGrenade10thCenturyDunhuang.jpg

Muslim soldiers in Spain used gunpowder weapons against Spanish Christian forces. Muslim armies possibly served as the path of gunpowder knowledge to Europeans. Contacts between European powers and the Mongols may have been another pathway. The two ideas that were coming together at this time, both in China and in Muslim regions, were the use of high-nitrate gunpowder, and the use of wooden or metal tubes for shooting projectiles.[5]

Chinese gun barrels from 1288 and 1332 date earlier than anything similar found in Europe. The technology may have come to Europe through Russia during Mongol rule. In Spain, both cannon and guns were in use by 1330, and the illustration from an Arabic military treatise (known as the Petersburg manuscript) shows the use of explosive gunpowder and cannon. Illustrations in books show bottle-shaped guns developed in China and Europe, even as far north as Sweden. Although the Mongols were aware of incendiary weapons, they did not develop guns, since these devices did not fit with the culture of warrior horsemen. At most, guns played a part in sieges but not yet with the devastating force of the weapons developed in later centuries.[6]

English scientist Roger Bacon referred to gunpowder recipes in the thirteenth century, probably taken from translated Arabic texts on alchemy. Practical knowledge may have come to England from noblemen fighting in Spain in the fourteenth century. The ability to make gunpowder and use it in battle spread into numerous European countries, where devastating weapons were developed over the course of the fourteenth and fifteenth centuries.[7]

Questions for discussion

- Why is it difficult to determine the time and place of the invention of gunpowder weapons?
- Why do you think the discovery of gunpowder did not occur earlier in history?
- What steps took place in the development of gunpowder weapons?
- What factors contributed to the spread of this technology?

[5] Arnold Pacey, *Technology in World Civilization: A Thousand-Year History* (Cambridge, MA: MIT Press, 1990), 45-9.
[6] Ibid., 48-9; Yaacov Lev, *War and Society in the Eastern Mediterranean, 7th-15thCcenturies* (Leiden: Brill, 1997), 352.
[7] Pacey, *Technology*, 50-2.