The Scientific Revolution of the 17th Century

and

The Political Revolutions of the 18th Century

At first glance, there may not seem to be much of a connection between the "Scientific Revolution" that took place in Western Europe starting in the 17th century CE, and the political revolutions that took place in Western Europe and its colonies beginning in the late 18th century. What could the development of calculus and the discovery of laws of physics (such as gravitation) possibly have to do with the overthrow of monarchical and colonial governments and the establishment of new democracies?

In fact, they have a lot to do with one another. In order to understand the connection, and also to understand both the scientific and the political developments better, we must look to the **philosophical ideas they share**.

There are **2 ideas that are fundamental to both the "Scientific Revolution" and the political revolutions**. These 2 ideas appear in one form or another in the basic documents of both. They are:

- **the idea that the universe and everything in it work according to "laws of nature."** These laws are established by the Divine Being (generally the God of Judaism, Christianity, and Islam).(1) Thus the universe is ultimately run by a divine being, but this divine being does not do things at random or capriciously; rather, the divine being makes things work in an orderly and regular fashion. This idea is accompanied by

- **the idea that the laws of nature are discoverable by means of reason.** Reason of course needs observation (we need something to reason about, some data to work with). But the point is that **if we want to understand the way the universe works, we can do so by means of observation and reasoning**. All human beings are supposed to have the ability to reason, although many do not use or cultivate this ability much.

Now, the idea that **we can learn true things about the universe by means of observation and reasoning** has important implications for politics, thought, and life in general. First, everyone is capable of observing things, and everyone is capable of reasoning. If we were not able to observe and reason, we could not be expected to make choices, obey laws and religious rules and moral standards, etc. Of course, some people lack the ability to observe certain things (blind people cannot observe colors, for example), but everyone can observe something.

If we all have the ability to observe and reason, then in principle we all have the ability to learn true things about the universe, according to the writers of the Scientific Revolution and the European "Enlightenment." In other words, if we want to learn about how the universe works - from how volcanoes form to how diseases occur to how stars develop to what kinds of laws are fair to humans - we can do it by training our powers of observation and reasoning. **We can train our powers of observation and reasoning by learning mathematics (arithmetic, algebra, geometry) and logic, by carefully recording and checking our observations, and by doing experiments. All humans are capable of doing these things.** And, if we write down our findings and show our reasoning carefully, others can check our results.

Galileo (1564-1642; Italian) is an example of a writer who put forth these ideas.

In his book *The Assayer*, written in 1623, Galileo said, "Philosophy is written in this grand book of the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and to read the alphabet in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles and other geometric figures, without which it is humanly impossible to understand a single word of it; without these, one wanders in a dark labyrinth."

(By 'philosophy' Galileo means both what we would call philosophy and also natural sciences, which were in his time studied as part of philosophy. For more on the great astronomer, physicist, and mathematician Galileo, see the excellent web site of Prof. Fowler at the University of Virginia.)

What Galileo is saying is that the workings of the universe are understandable, and that we need mathematics in order to understand them. This may seem to many people today to be a very obvious point: of course we need to learn mathematics in order to understand things; so many fields rely on measurements, statistics, "facts and figures." But it was not so obvious in Galileo's time, and he was tried and imprisoned for his theories that were based on this idea.

Why would anyone want to punish Galileo for this?

Galileo was punished by certain important members of the Catholic Church. Remember that in Europe in Galileo's time, there was no separation of church and state; the religious authorities ran the universities and could censor publications, and worked hand-in-hand with the governments of the various countries. Galileo lived in Italy, which was Catholic, and got into trouble with some people close to the Pope.

The basic problem that these religious authorities found was that some of Galileo's scientific discoveries appeared

to contradict the official Catholic interpretation of Christian scripture, or to contradict the official Catholic interpretation of Aristotle. (Why the Catholic Church accepted the works of Aristotle is a long story; here I will say only that the 17th-century Church interpretation of Aristotle's scientific work is not necessarily what Aristotle intended.) For example, Galileo discovered more stars in the sky than are mentioned in the Bible or Aristotle, because he had a telescope and Aristotle and the ancient Hebrews did not. Galileo discovered that a heavier object falls no faster than a lighter one (the Church interpreted Aristotle as saying that heavy objects fall faster than light ones; a close examination of Aristotle's texts suggests that this is a misunderstanding or a mistranslation of Aristotle's words). Therefore the Church authorities claimed that Galileo had contradicted sacred truths. **They believed that if human observation and reasoning seemed to say something different from holy scripture (or from their interpretation of holy scripture), then the human observation and reasoning must be wrong.** [(2)]

Galileo pointed out that he was not denying God's perfection or role as a creator; that the Bible did not specify exactly how many stars there were; that some statements in the Bible are not understood literally (for example, even the Church agreed that the sun does not literally "rise").

But Galileo was unable to convince the Church authorities of this, even though Aristotle himself would have agreed with Galileo about the need for independent investigation, reasoning, and proof. What was really at stake here was **what counts as knowledge, and why; who can get new knowledge, and how.** The Church held that knowledge was revealed in Scripture that a person with a religious calling and lots of training in accepted interpretations could learn. Other people should be content to hear these trained religious people explain things. The Church was more interested in the ultimate nature of things (as revealed by God) and in how to achieve salvation than in the everyday workings of things, so a lot of areas were just not covered by Church teachings. Galileo and the Scientific Revolution argued that perhaps religious revelation was needed in order to learn the ultimate meaning of things and the way to salvation, but that observation and reasoning would tell us about *how* things work on an everyday basis; and that any human could learn these things if he or she worked hard enough.

This sets the stage for Rene Descartes (1596-1650; French).

Descartes set himself a dual task: (1) Show that Galileo was right about how to seek knowledge; and (2) Avoid getting imprisoned or executed for this.

This meant that Descartes had to show (1') that true things can be discovered by means of observation and reasoning; and (2') that this independent inquiry does not violate any religious or moral rules.

Descartes was uniquely equipped for this project in that he was a mathematical genius (he invented analytic geometry, or what became analytic geometry; the Cartesian coordinate system is named after him), a scientist (he did work in optics and physics), and a philosopher. He was educated in Catholic schools and knew their teachings well.

Descartes argued that the very essence of being human was the ability to think or reason (see for example *Discourse* Part Four; *Meditation* Two). The Catholic Church could not deny that this ability had been given to us by God, since only by means of this ability can we have an idea of God, understand scripture, worship, etc. Descartes continued by saying that "we should never allow ourselves to be persuaded except by the evidence of our reason" [(3)] (22). The senses and imagination, Descartes felt, could be important sources of raw information, but they might give us erroneous information, so we must be careful always to examine our sensory impressions and ideas by using reason. Some of our ideas may turn out not to be true, Descartes says, but "all our ideas or notions ought to have some foundation of truth, for it would not be possible that God, who is all-perfect and all-truthful, would have put them in us without that."[(4)] Note that Descartes does not claim that all of our ideas are true, but rather that even the false ones have some basis in truth. Our false ideas come from our reactions to real things or to our impressions of real things, and our reactions and impressions may be confused, or we may have insufficient information to make a true judgment, etc. Through reason, he says, we can find out the truth.

How are we to find out the truth? Descartes provides a method of reasoning that is very much like today's mathematical and scientific methods (see *Discourse* Part Two).

What truths will we find out? Descartes says in Part Five of the *Discourse* that he has "showed what the laws of nature were": There are, he says, "certain laws that God has so established in nature and of which he has impressed in our souls such notions, that, after having reflected sufficiently on these matters, we cannot deny that they are strictly adhered to in everything that exists or occurs in the world."[5] God has made the universe work according to laws, Descartes holds; and God has given us impressions of these laws. By reflection and reasoning, we can gain clear knowledge of these laws. The laws Descartes is talking about are such things as the laws of physics, the principles of respiration and circulation, and so on.

Descartes was very careful in his publishing, and got into only minimal trouble with religious authorities. Times were beginning to change politically. But Descartes had to stay out of certain countries for his own safety. He found safe havens in places with more tolerant regimes, and even served as a sort of professor to the Queen of Sweden, who was a very able philosopher and scientist in her own right. Descartes also sent his work informally to philosophers and scientists who he thought would be sympathetic to his projects, and this got the word out. In addition, he did something new and clever: he put his work out in French as well as in Latin. Latin was the language of the Catholic Church and the universities, so it was important for Descartes to use it. But many people in Europe knew only minimal Latin, and some of these people were able to be very helpful. The people who knew

Latin well were Catholic (and some Protestant) clergy, and those who could study at universities. But most of the people at universities were nobility, and all were men. There was a growing number of noblewomen, and members of the merchant and artisan classes of both sexes, who had the resources and the interest to study philosophy and science. They had not had much of a chance so far. French was a language that many people knew; it was used often outside of France. So these people read Descartes with great interest, and provided him with scholarly discussion as well as in some cases political and financial support.

But what does that have to do with political revolutions?

One immediate connection can be seen in the fact that Descartes was arguing that reasoning was an ability all people have, and that this ability we all have is exactly what we need in order to learn about the world. We don't need a special upbringing or education or religion (Descartes reached out to people of all religions that he knew). And Descartes made sure that every human who could read French would have a chance to try. In this way, he was very egalitarian. This was very much different from the way most institutions worked in his time, where only a small number of people had any political power or religious authority, and others did not have a chance to try for it.

The idea of natural equality and rule by reason was also getting an explicitly political interpretation at this time. **Thomas Hobbes (1588-1679; English)** wrote in *Leviathan* (1651), "Nature hath made men so equal, in the faculties of body and mind; as that, though there be found one man sometimes manifestly stronger in body or of quicker mind than another, yet when all is reckoned together, the difference between man and man is not so considerable, as that one man can thereupon claim to himself any benefit, to which another may not pretend as well as he....From this equality of ability, ariseth equality of hope in the attaining of our ends"[(6)] (Chapter XIII). Given scarcity of resources, people tend to fight for survival, power, and protection; and the result, according to Hobbes, is that the "state of nature" is a state of war. But we don't have to remain always at war, because **nature itself gives us a way out, and that way out is discoverable by reason:** "The passions that incline men to peace are fear of death, desire of such things as are necessary to commodious living, and a hope by their industry to attain them. And reason suggesteth convenient articles of peace....These articles are they wich otherwise are called the Laws of Nature..." (also Chapter XIII).

According to Hobbes (Ch. XIV), a law of nature is "a precept or general rule, found out by reason, by which a man is forbidden to do what is destructive of life, or taketh away the means of preserving the same; and to omit that by which he thinketh it may be best preserved."

The first two laws of nature, according to Hobbes, are (1) "that every man ought to endeavor peace, as far as he has hope of attaining it; and when he cannot obtain it, that he may see and use all the helps and advantages of war"; and (2) "that a man be willing, when others are so too, as far forth as for peace and defense of himself he shall think it necessary, to lay down this right to all things; and be contented with so much liberty against other men, as he would allow other men against himself" (Ch. XIV). Hobbes explicitly connects the second law with Chritian scripture.

Now, it is true that Christian writers in Europe had been saying for over a millennium that all people were equal in the sight of God. What was so different here?

-- First, some Christian writers had allowed for the "divine right of kings" and secondarily for the special rights of aristocrats: the kings, assisted by the aristocrats, were supposed to be those who ruled the earth according to God's will. Kings and aristocrats had special responsibilities (which some took seriously and some did not), but also special rights and privileges. *Hobbes is saying that no one can rightly claim special status by birth; one can only be a leader by the agreement of those who are to be led. No one is to violate certain natural rights; no king is to take land from a person just because the king wants to, for example. As Hobbes says in Ch. XV, it is a law of nature that everyone must acknowledge the others as one's equals by nature*.

-- Second, Hobbes is claiming that the laws of nature are discoverable by reason. You don't need special instruction in interpreting scripture in order to discover these laws; and they apply to everyone no matter what their religion. Hobbes thinks his laws are in keeping with Christian religious law, or with its true spirit. But he thinks that this is because Christian teachings follow the laws of nature, not the other way around.

John Locke (1632-1704; English) took these ideas even further.

John Locke was familiar with the work of Descartes and Hobbes, and was himself a source of many ideas of the French Enlightenment, the American Revolution, and the French Revolution. Here are some passages from his *Second Treatise of Government* (1690), illustrating once again the idea of laws of nature discoverable by reason.

Like Hobbes, Locke begins from a picture of the "state of nature" or "natural state" of humans; but Locke's picture of it is less harsh than Hobbes' picture: The state of nature for all men, he says, "is a state of perfect freedom to order their actions and dispose of their possessions as they think fit, within the bounds of the law of nature, without asking leave, or depending on the will of any other man....A state also of equality, wherein all power and jurisdiction is reciprocal, no one having more than another..."(Chapter II). This is not necessarily a state of war, Locke thinks.

According to Locke, "The state of nature has a law of nature to govern it, which obliges everyone; and reason, which is that law, teaches all mankind who will but consult it, that, being all equal and independent, no one ought to harm another in his life, health, liberty, or possessions" (Chapter II). Locke is explicit that slavery is against the law of nature and argues that it should therefore be against civil laws

too (Chapter IV).

Compare these passages from Locke and Hobbes with some articles of the Declaration of the Rights of Man and Citizen (French Revolution):

Article 1: Men are born and remain free and equal in rights....

Article 2: The purpose of all political association is the preservation of the natural and imprescriptible rights of man. These rights are liberty, property, security, and resistance to oppression.

Article 4: Liberty consists in the ability to do whatever does not harm another....

Article 12: The safeguard of the rights of man and the citizen requires public powers. These powers are therefore instituted for the advantage of all, not for the private benefit of those to whom they are entrusted.

NOTES

1. Most of the scientists, philosophers, and political activists in Western Europe and its colonies at this time were Christians of some sort (various kinds of Protestants, as well as Catholics). Some were Jewish. (Remember that there were very few Muslims left in Western Europe at this time.) However, the descriptions of the divine being that these scientists, philosophers, and political activists used would fit the beliefs of Judaism, Christianity, AND Islam. That is, the revolutionary writings describe a divine being who is all-powerful, all-knowing, all-good, and the creator of the universe. Most do not say anything that is specific to any one monotheistic religion. An excellent example of this is found in Descartes' *Discourse on the Method for Rightly Conducting One's Reason and Seeking Truth in the Sciences*, Part Four.

2. It is important to note that some Catholic theologians saw nothing wrong with what Galileo was doing, and even supported it. However, the ones who supported Galileo were not the most powerful politically.

3. All quotations from Descartes are from *Discourse on the Method for Rightly Conducting One's Reason and Seeking Truth in the Sciences*, translated by Donald Cress. The edition used here is *Discourse on Method and Meditations on First Philosophy*, fourth edition (Hackett Publishing Co., 1998). The quotation is from Part Four of the *Discourse*. The page in that edition is 22; if you are using another edition of the same translation your page numbers may be different.

4. Also from Part Four; page 22 in the edition noted above.

5. Quotations are from pages 24 and 23, respectively, in the edition noted above.

6. Hobbes generally uses the word 'man' in a way that suggests that he refers to all humans. Great debate ensued as to whether the notion that all "men" were equal should entail that women should have the same political, social, and economic rights as men. Similarly, over the next couple of centuries, debates arose as to whether all peoples of the world should have the same rights.
Quotations from Hobbes come from the version of the text used in this class:
http://ebooks.adelaide.edu.au/h/hobbes/thomas/h68l/

7. All quotations from Locke on this page come from the version of the text used in this class:
http://ebooks.adelaide.edu.au/l/locke/john/l81s/