

*History*  
UNFOLDING

# SCIENCE, TECHNOLOGY, AND THE ENLIGHTENMENT



**MindSparks**  
CHALLENGING STUDENTS TO THINK HISTORICALLY

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# Introduction

## An Age of Reason

By the mid-1600s, Europe had just about exhausted itself after more than a century of bitter religious warfare arising out of the Reformation and Counter-Reformation.

It was as if a kind of spiritual dead-end had been reached.

Yet the times were not quite as bleak as this. Dynamic forces were at work pushing Europe outward in a great age of exploration and discovery. And one of the forces contributing to this process and feeding off of it was a whole new way of looking at the world—a new way of deciding what was true and of understanding nature and human nature. For this was the time when a great scientific revolution began, upsetting notions about everything. This revolution transformed our understanding and unleashed social, political, technical, and economic forces that would change the world. The age of Enlightenment set the stage for the revolutionary era to come. It gave birth to the modern age.

This set uses 12 visual displays to focus on several key themes in this story of the emergence of science, the age of Enlightenment, and the earliest phases of the industrial transformation of economic life in the 1700s and early 1800s. Each lesson uses three visual displays to explore one broad topic. Briefly, the four lessons are as follows:

### **Science and the Universe**

At the heart of the Scientific Revolution of the 1500s and 1600s were new ideas about the universe and the motions of the planets. The illustrations here focus on that key aspect of the emergence of a scientific approach to nature.

### **Science, Man, and Society**

Given a scientific view of the world, how was human nature itself to be understood? The illustrations here focus primarily on that issue.

### **Philosophers and Kings**

Enlightenment ideas had their greatest impact on the educated and wealthy classes of Europe. This is somewhat ironic, given the way the Enlightenment undermined respect for the old order and the aristocratic class that benefitted from it.

### **Reason, Technology, and the Industrial Revolution**

The Enlightenment and the Scientific Revolution together helped trigger a cumulative and accelerating process of technical and economic change. The illustrations here focus on some key themes at the heart of this early phase of the Industrial Revolution.

## Using Photos, Cartoons, and Other Visuals to Teach History

Many textbooks are full of colorful visuals. However, all too often these visuals function primarily as window dressing. They make the text more entertaining, or at least more palatable. Only occasionally do the visuals in textbooks do more than offer simple pictorial reinforcement of ideas already presented in the text. In many cases, they pander to the visual orientation of the young while doing little to help young people master the challenges of the visual media that dominate their lives.

By way of contrast, our approach to using visual materials emphasizes their unique strengths as historical documents. The lessons in this booklet focus students on the visual symbols and metaphors in editorial cartoons, the dramatic qualities of certain photographs, the potential of many images to make abstract ideas more specific and concrete, the implicit biases and stereotypes in certain images, their emotional power, and their ability to invoke the spirit of a time and place. In the process, we make every effort to strengthen students' visual literacy skills in general, as well as their ability to think critically and engage in spirited but disciplined discussions.

## How to Use This Booklet

The booklet is divided into four lessons, with three illustrations per lesson. Each lesson consists of the following:

**A BACKGROUND INFORMATION SHEET** This page provides brief summaries explaining the three illustrations on which the lesson is based and their relevance to the lesson's objectives.

**DIGITAL IMAGES** The booklet's PDF allows you to project the images for use in your class discussions.

### **DISCUSSION-ACTIVITY SHEETS**

Each sheet displays one illustration. It includes a sequence of questions to help you plan an all-class discussion while using the projected images. The questions take students step by step through an analysis of the illustration. If you wish, you may reproduce these pages and hand them out. In addition to the discussion questions on the illustration itself, one or two follow-up activities are suggested. Some of these can be made into individual assignments. Others will work best as small-group or all-class activities.



**OBJECTIVES**

1. Students will better understand why astronomical discoveries of the 1500s and 1600s helped launch the Scientific Revolution.
2. Students will better appreciate the enormous social and cultural impact of these discoveries.

# Science and the Universe

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*Use the background information on this page to help your students better understand the three illustrations making up this lesson. The questions and activities presented in the rest of the lesson can be used to help students clarify meanings and debate important issues.*

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**BACKGROUND INFORMATION****Illustrations 1A & 1B**

In the 1600s, a new way of looking at the world took hold—a new way of deciding what was true and of understanding nature and human nature. It was the beginning of a scientific revolution that would upset notions about everything from matter and motion, to man's place in the universe, to the nature of the mind and the soul. But it began with ideas about the planets, the stars, and Earth's place in the heavens. In Europe's Middle Ages, it was believed that God created the universe as a home for man, and therefore that Earth must naturally be at its center. Greek Egyptian scientist Ptolemy's Earth-centered universe (Illustration 1A) was accepted by nearly all. In the early 1500s, Polish astronomer Nicolaus Copernicus upset this comforting view by proposing that Earth, like the other planets, revolves around the sun. His notion launched an intellectual revolution.

**Illustration 2**

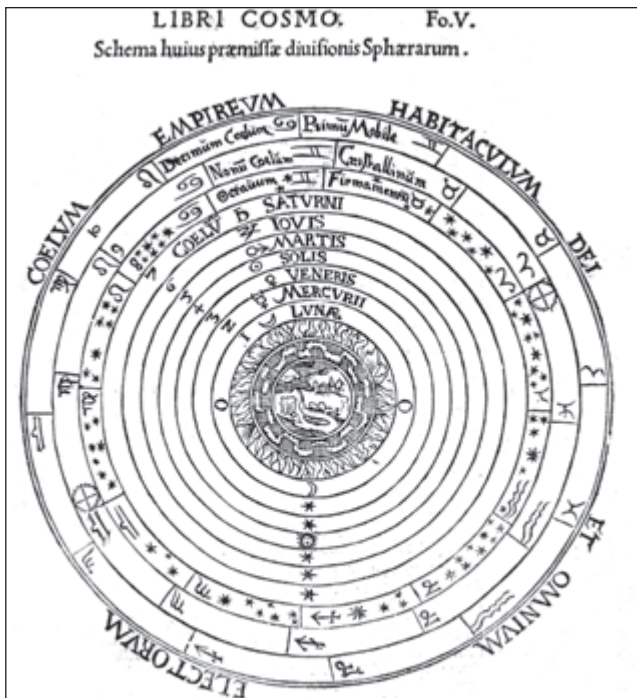
In the late 1500s, Tycho Brahe and Johannes Kepler furthered the work of Copernicus. But it was Italian mathematician Galileo Galilei who, in the 1600s, convinced many that Copernicus was right. With his telescope, Galileo reported seeing mountains on the moon and other moons around Jupiter. In other words, the planets were ordinary matter like the Earth, not the perfect spheres of light previously imagined. The Catholic Church was not happy with Galileo. But this new way of making sense of the world was already attracting wider interest and acceptance.

**Illustration 3**

Copernicus and Galileo set the stage for the Scientific Revolution, which reached its high point with English physicist Isaac Newton. In 1687, Newton published his *Mathematical Principles of Natural Philosophy*, or the *Principia*. In it, Newton worked out fully the problems posed by Copernicus, Galileo, and many others. He did this by describing the basic laws of all matter and motion, both on Earth as well as in outer space. His three laws of motion are shown here. Newton pictured the universe as a giant machine, ruled by simple and sweeping general laws. Moreover, he inspired others to see that these laws could be discovered by human reason and experimentation. Out of Newton's work came a view of the natural world as more impersonal and mechanistic, but also as more knowable and controllable.

# Illustrations 1A & 1B

1A



Courtesy of the Lilly Library, Indiana University–Bloomington

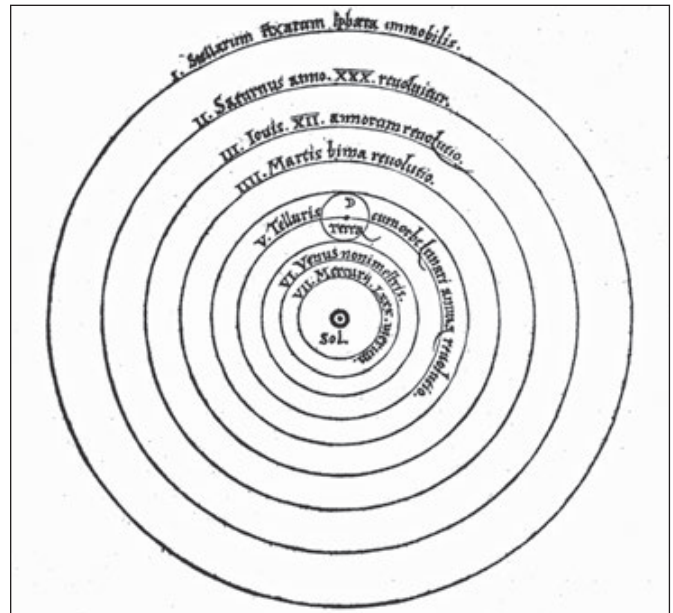
## *Ptolemy's Earth-centered universe*

### **Discussing the Illustrations**

1. In the 1500s and 1600s, a new way of looking at the world began to take hold—a way we would now call scientific. In time, it affected the way people looked at just about every aspect of life. But it began basically with new ways of thinking about the universe. These two diagrams help make the point. Illustration 1A is Ptolemy's version of the universe. Who was Ptolemy?
2. Ptolemy's "geocentric" view of the universe had been accepted for centuries. From the diagram and your knowledge of history, can you explain what this geocentric view of the universe was?
3. In the mid-1500s, a Polish thinker named Nicolaus Copernicus disputed Ptolemy's geocentric view of the universe with his revolutionary new theory of a "heliocentric" universe. Using Illustration 1B, explain what his "heliocentric" theory of the universe was?
4. This heliocentric theory was deeply disturbing and revolutionary in Europe in the 1500s. Why do you think it was so disturbing and revolutionary?

## *Copernicus's sun-centered universe*

1B



Courtesy of the Lilly Library, Indiana University–Bloomington

### **Follow-up Activities**

1. In the second century CE, the Greek Egyptian astronomer and mathematician Ptolemy offered a "geocentric" view of the universe—a universe with Earth at the center. Up to the 16th century, Christians found this geocentric view highly reassuring from a religious point of view. Write an essay explaining why Ptolemy's geocentric view of the universe was so reassuring to them.
2. The ideas and theories of Copernicus were not that believable even to many well-educated people at the time. Pretend you are a well-educated European in the 1400s, before Copernicus was born. A friend in another city has written to tell you about some other ancient Greeks (not Ptolemy) who suggested that the earth revolves around the sun. Write a letter back describing your observations of the heavens the previous day and night, and why you find his theory absurd. Do some reading on this subject in order to make your letter as historically believable as possible.



## Illustration 2



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### Discussing the Illustration

1. Copernicus's theory was actually based mainly on mathematical calculations, not on anything he observed. Why might it have been hard for him to base a theory of the universe on direct observations?
2. Other scientists refined Copernicus's mathematical calculations. Then in the early 1600s, one scientist made direct observations backing up some of Copernicus's ideas. The painting shows that scientist at work. Can you name him and explain how he was able to make better direct observations of the solar system? How does the painting convey the meaning and excitement of what he did?
3. At the time, Church teachings insisted the heavens were unlike Earth. Earth was a realm of imperfect matter. The heavens were a realm of perfection, with the stars and planets supposedly being perfect spheres of light. Galileo's observations of the moon, the sun, Venus, and Jupiter raised big doubts about this. Can you explain why? What else do you know about Galileo's accomplishments?

### Follow-up Activities

1. **Small-group activity:** In 1633, Galileo was put on trial by the Catholic Church. Learn more about the trial. Prepare a one-act play about it and present it to the class. But in writing the play, try hard to look at the issue as someone in the 1600s might have. One historian says: "There are a lot of 'non-scientific' reasons why the Catholic Church decided to 'condemn' Galileo, and neither side in the dispute is above reproach." You don't have to agree with this view. But keep it in mind as you create your play.
2. Galileo's astronomical discoveries won him great fame. But his contributions to the branch of physics called "mechanics" were just as important. Some examples include his descriptions of the movement of bodies along planes, the distance traveled per unit of time in freefall, oscillations of pendulums, and the motions of projectiles. Learn more about these. You may want to ask your physics teacher for help. Prepare a brief report to the class. If possible, demonstrate some of Galileo's ideas for the class.



## Illustration 3



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### Isaac Newton

#### *Laws of Motion*

##### **Law 1**

*Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it.*

##### **Law 2**

*The change of motion is proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.*

##### **Law 3**

*To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.*

#### **Discussing the Illustrations**

1. Isaac Newton was the greatest figure in this age of the Scientific Revolution. His theories tied together the ideas of Copernicus and Galileo's studies of astronomy and mechanics. What is meant here by the word "mechanics"?
2. Galileo described certain aspects of the motion of physical objects. Newton's three laws of motion, along with his theory of universal gravitation, explain not only what Galileo observed but also the motions of the planets. In other words, Newton showed that all natural objects, on Earth and in space, behave alike. From what you know of Newton's theory of universal gravitation, how does it help to show that objects on Earth and in space are alike in their behavior?
3. Newton has been called "the father of the clockwork universe." Can you explain why? What view of Newton does this painting express? Many were upset by Newton's "mechanistic" view of universe. But others found Newton's discoveries reassuring. Why might people differ in their reactions in this way?

#### **Follow-up Activities**

1. Isaac Newton is most famous for his laws of motion and gravity. But he was also deeply religious and had a strong interest in alchemy. Learn more about these other sides to Isaac Newton. Write a brief essay. In your essay, try to relate Newton's interest in spiritual and mystical matters to his mechanistic view of the universe and his belief that precise mathematical formulas describe an orderly universe.
2. Newton's law of universal gravitation relates the motions of the planets to the motions of ordinary objects on earth. Find out more about the law of universal gravitation. Ask your physics teacher to help you create a diagram showing how it explains the motions of objects on earth and the planets in the heavens. Use your diagram as the centerpiece of a brief presentation to class. Talk about why the law of universal gravitation led people to see the entire universe as a mechanism or machine.

**OBJECTIVE**

1. Students will better understand how the Scientific Revolution began to alter the way people thought about human beings and their societies.

# Science, Man, and Society

*Use the background information on this page to help your students better understand the three illustrations making up this lesson. The questions and activities presented in the rest of the lesson can be used to help students clarify meanings and debate important issues.*

**BACKGROUND INFORMATION****Illustrations 1A & 1B**

Newton showed how well reason could explain the natural world. But what about human beings? Were they also ruled by precise laws that reason could discover? A long tradition of medical research already existed. But in the 1500s and 1600s it got a big boost, especially from English scientist William Harvey. Illustration 1A is a diagram of one aspect of Harvey's discoveries about the circulation of blood. As a more scientific view of the human body developed, some wondered: Are we just machines? What makes us human? What about the soul? French thinker Rene Descartes actually believed the soul was located in a small gland in the brain, labeled "H" in his diagram in Illustration 1B. The idea of man as a machine was at odds with the idea of man as a being with a soul. Descartes never really resolved this conflict. But clearly, he and many others felt a strong need to do so.

**Illustration 2**

Influenced by a new faith in reason, some thinkers such as Voltaire began to find fault with much of the human past. "Voltaire" was the assumed name of François-Marie Arouet. He was a key French writer in what has come to be called the "Age of Enlightenment." The 1500s and 1600s had seen a horrifying upsurge in religious violence, including the burning of accused witches. Voltaire called for religious toleration and a sense of shame about the bigotry of the past. "Crush the infamous thing," he often said—by which he meant religious fanaticism and intolerance.

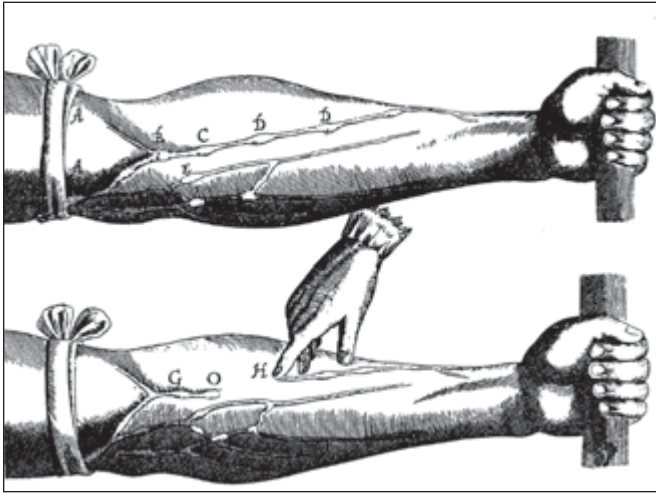
**Illustration 3**

Questioning and doubt were key to the spirit of the Enlightenment. Here, Descartes makes doubt central to his search for truth. The readiness to doubt everything led many to a deep mistrust of traditional ideas and values, especially those of organized religion. But not everyone was sure this was wise. Blaise Pascal, for example, felt a loss of meaning and a sense of emptiness when thinking of the universe as nothing but a vast, impersonal machine. The "infinite spaces," as he calls them here, terrified him. He hoped reason would not undermine the Christian faith. By itself, he said, reason could not reveal God or explain the spiritual reality within a universe of matter and motion. That reality, Pascal believed, could only be found by the heart—that is, by strong faith alone.



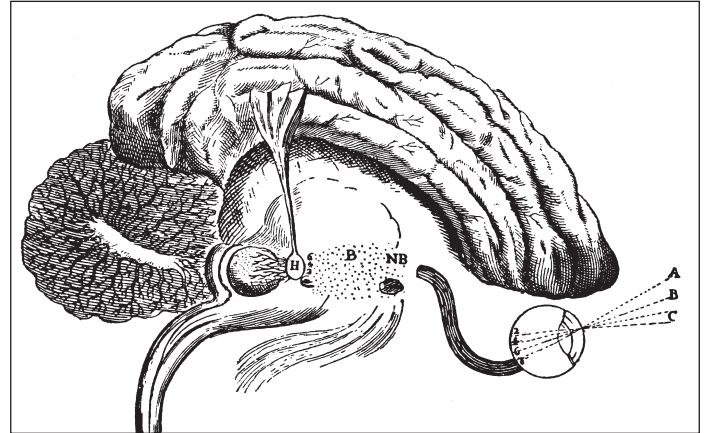
## Illustrations 1A & 1B

1A



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1B



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### Discussing the Illustrations

1. Copernicus, Galileo, and Newton all used careful observation and measurement to discover the truth about material objects. Meanwhile, William Harvey was using a similar approach to study one particular part of nature. Who was William Harvey, and what part of nature did he study?
2. Illustration 1A shows results of Harvey's experiments to learn more about one aspect of how the body works. Using this diagram, can you explain what aspect this was?
3. Given Newton's mechanical universe, some people said humans were also like machines. But this idea raised a key question: If we are just machines, what about the soul? The diagram in Illustration 1B, by French thinker Rene Descartes, shows the soul in a small gland in the brain labeled "H." How scientific do you think this diagram actually is? Why do you think Descartes hoped to find the soul in a specific part of the body? Do you think Christians in earlier ages would have felt a need to do this? Why or why not?

### Follow-up Activities

1. Until the 1600s, most knowledge of anatomy had come from the writings of Galen, an ancient Greek scientist. In the 1600s, English physician William Harvey made a discovery about the circulation of blood through the human body that disproved Galen's ideas. Use Illustration 1A and others you find in the library or online in a brief talk on Harvey's main ideas. Also learn about Galen and include in your presentation a discussion of exactly how Harvey's ideas differed from those of Galen.
2. French philosopher Rene Descartes is famous for the notion of "mind/body dualism." Read more about Descartes's views of the brain, body, mind, and soul. Use the diagram in Illustration 1B and any other visuals you can find on Descartes in a brief talk for the class about Descartes. In your talk, try to explain why this problem of mind and body (or soul and body) concerned him so much.

## Illustration 2



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### Voltaire On Religion, Fanaticism, and Doubt

*I say, that far from forgetting those abominable times, we should frequently take a view of them, to inspire an internal horror for them; and that it is for our age to make reparation by toleration, for this long collection of crimes, which has take place through the want of toleration, during sixteen barbarous centuries.*

*Doubt is not a pleasant condition, but certainty is absurd.*

#### Discussing the Illustrations

1. Religious conflict had been common in Europe throughout the Middle Ages. But it became especially intense in the 1500s and 1600s. What big religious conflict divided Europe in those centuries?
2. This illustration shows one especially frightening form of this violence. Can you guess what it is? What view of this violence does this drawing seem to express?
3. Witches had long been feared and punished. But these fears reached a high point in the 1500s and early 1600s. Why do you think that was so?
4. In the 1700s, a growing faith in science and reason led many thinkers to criticize Europe's religious past harshly. One of the strongest critics was Voltaire. What do you think about the views Voltaire expresses here? How does the illustration help back up the points Voltaire makes in these passages of his?
5. Do you think what Voltaire says here about doubt and certainty is still important in our world today? Why or why not? If so, in what way?

#### Follow-up Activities

1. Voltaire is known for many of his brief aphorisms, or sayings. One of the most famous was: "I disapprove of what you say, but I will defend to the death your right to say it." Find other famous sayings of Voltaire. Share these with the class. In doing so, also include at least one modern-day example of what Voltaire means by each aphorism.
2. **Small-group activity:** Voltaire was one of several thinkers known as *philosophes*. Some others were Charles de Montesquieu, Denis Diderot, Jean Jacques Rousseau, and Jean le Rond d'Alembert. Learn more about these philosophes or any others you come across in your research. What specific traits made them *philosophes*? Are there any *philosophes* today? As a group, choose three or four well-known people alive today who you think could be called *philosophes*. In what ways are your "modern-day" *philosophes* like the Enlightenment *philosophes* you studied? In what ways are they different? Discuss your choices in a presentation to the class.

## Illustrations 3A & 3B

3A



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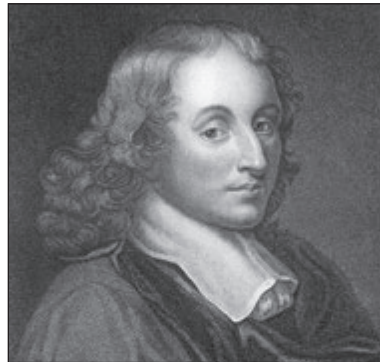
### Descartes

*I shall proceed by setting aside all that in which the least doubt could be supposed to exist. I suppose, then, that all the things that I see are false; I persuade myself that nothing has ever existed of all that my fallacious memory represents to me. . . . What then can be esteemed as true?*

#### Discussing the Illustrations

1. The Scientific Revolution of the 1600s helped launch a broader movement known as the “Enlightenment,” of which Voltaire was one key figure. Enlightenment thinkers questioned many traditional beliefs, saying that only those supported by reason should be accepted. How do Descartes’s views here help to clarify what this trust in reason involved?
2. Enlightenment thinkers said that skepticism about truth, especially religious truth, would lead to greater tolerance. Do you think they were correct? Why or why not?
3. The Enlightenment was an exciting time. But its doubting, questioning spirit also frightened many, including some Enlightenment figures themselves. Blaise Pascal was one such thinker. How can you tell from his words here that he was both excited by the power of reason but also deeply troubled by it? Was he right to be troubled? Why or why not? In what ways, if any, do the two illustrations here reveal the different personalities and attitudes of these men?

3B



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### Pascal

*Man is equally incapable of seeing the nothingness from which he emerges and the infinity in which he is engulfed.*

*The eternal silence of those infinite spaces strikes me with terror.*

*It is the heart which perceives God and not the reason.*

#### Follow-up Activities

1. Descartes and Pascal lived at roughly the same time. Learn more about both of them. Based on what you learn, make up a conversation between them as you imagine it might have taken place. You may use actual quotes from the two men (including the above quotes) or make up your own words for them. Try to be true to their views and to the way you think each would have responded to the other.
2. Descartes believed he could use his own reason to arrive at the truth, but only after doubting everything first. Descartes and others who believed this are often referred to as “rationalists.” Other Enlightenment figures—called “empiricists”—stressed observation and experience as the best way to find the truth. Francis Bacon was a key empiricist, as was John Locke. Learn more about them. Then write an essay answering the following question: “What would Bacon or Locke say to Descartes about his method of doubt as presented above?”

**OBJECTIVE**

1. Students will better understand how the Enlightenment affected views about how society should be organized and what form of government is best.

# Philosophers and Kings

*Use the background information on this page to help your students better understand the three illustrations making up this lesson. The questions and activities presented in the rest of the lesson can be used to help students clarify meanings and debate important issues.*

**BACKGROUND INFORMATION****Illustration 1**

The Enlightenment also affected thinking about society and how it should be governed. The goal was to use reason, not tradition, to decide which form of government was best. Religious notions such as the “divine right of kings” were being used to justify the powerful monarchies rising in Europe in the 1600s. But in *Leviathan*, English philosopher Thomas Hobbes supported “absolute monarchy” as a logical conclusion based on a purely rational understanding of human nature and natural rights. For Hobbes, violence and disorder were humanity’s natural state; thus an all-powerful state was needed to protect individual rights and property.

**Illustrations 2A & 2B**

A key group of Enlightenment thinkers were the *philosophes*, a French word for philosopher. Actually, they were not so much philosophers as writers, journalists, and social reformers commenting on ideas and social conditions. The *philosophes* were sought out by certain monarchs, such as Frederick II of Prussia, seen in his palace library in Illustration 2A. Frederick and other so-called “enlightened despots” believed the new ideas could strengthen their rule and make their nations more modern. Some *philosophes* became celebrities among aristocrats who gathered to discuss ideas in salons such as the one in Illustration 2B. Ironically, these wealthy aristocrats were fascinated by ideas that would soon be used to challenge and undermine their own privileged lives.

**Illustrations 3A & 3B**

John Locke and Jean Jacques Rousseau were two Enlightenment thinkers who still matter today. Both agreed that the only reason for government was to protect the individual’s natural rights. However, they disagreed about many things, as they do here about “representative government.” Locke believed liberty required a government of a few elected officials representing the people. Rousseau favored a “direct democracy” in which the people make key decisions together. He opposed giving such power to any small group, elected or not. Some see Rousseau as the more democratic of the two. Others say his ideas in practice would only give power to those able to sway the mob and force their will on others. As this dispute suggests, the Enlightenment raised many questions about society, but it settled very few of them.



## Lesson 3—Philosophers and Kings

# Illustration 1



Rare Books Division, The New York Public Library, Astor, Lenox and Tilden Foundation

### Discussing the Illustration

1. The Enlightenment also produced new ideas about society and government. One example of this is *Leviathan*, a book by Englishman Thomas Hobbes published in the 1600s. What do you know about it and its importance?
2. *Leviathan* backs the idea generally of an all-powerful ruler as the head of any government. How do the details of this book's cover reveal this point of view?
3. In the 1600s, many European monarchs were increasing their power. They often claimed a right to rule by "divine right." What did this term mean?
4. But Hobbes did not base his views on religious ideas such as the "divine right of kings." He based them, he believed, on reason alone. That is, his reason told him human nature is basically selfish and aggressive. Therefore, only an all-powerful ruler can protect men's rights and security. Do you think this view is logical based solely on "reason"? Why or why not?

### Follow-up Activities

1. Learn more about Thomas Hobbes. Then, study the book cover of *Leviathan* shown here. Pay close attention to each aspect of the book cover and learn more about it. Then plan a brief talk about the book and the cover. Use this image as part of your presentation. Be sure to explain how the book cover illustrates Hobbes's key ideas.
2. Thomas Hobbes's *Leviathan* was published in 1651 during the English Civil War. Find out more about Hobbes, the book, and his attitudes about the English Civil War. Also be sure to learn more about the Civil War itself. Is Hobbes's experience reflected in any way in the views he presents in *Leviathan*? Give short talk to the class about Thomas Hobbes, the English Civil War, and *Leviathan*. Use this overhead as the centerpiece of your presentation. Try to find other visuals as well, if you can, to back up the points you make.



## Lesson 3—Philosophers and Kings

# Illustrations 2A & 2B

2A



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2B



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### Discussing the Illustrations

1. Enlightenment ideas soon became popular with many aristocrats and other wealthy people, as well as several kings and queens. Illustration 2A shows one such king, Frederick II (or Frederick the Great), in his library with a friend. What nation did Frederick lead?
2. Monarchs such as Frederick came to be called “enlightened despots.” Can you name others who were given this title? Why do you think Enlightenment ideas appealed to such monarchs?
3. In Illustration 2B, what appears to be happening? Several aristocrats have gathered specifically to discuss Enlightenment ideas. What were these gatherings called? Sometimes key thinkers like Voltaire, called *philosophes*, would be invited to such gatherings. Who were some other *philosophes*? How do both illustrations make clear who Enlightenment ideas appealed to? Some find this surprising—why? Why do you think so many wealthy, powerful people were attracted to Enlightenment ideals?

### Follow-up Activities

1. **Small-group activity:** As a group, come up with a list of those monarchs known as “enlightened despots.” Then have each member learn about one of these monarchs and about the nature of his or her interest in Enlightenment thinking. In what way, if any, did the Enlightenment affect the way this monarch ruled? As a group, give a class presentation on these “enlightened despots.” Include portraits of them, quotes, maps, or any other visuals you find in the course of your research to help make the talk as interesting as possible.
2. The Enlightenment claimed to be replacing religious myth and fanaticism with reason and a new spirit of tolerance. But was the Enlightenment all that “enlightened” with respect to religion itself and to religious groups? To find out, read more about the views of Diderot and Voltaire toward Christians and Jews. Based on what you learn, write a brief essay answering the following question: “How enlightened was the Enlightenment about Christians and Jews?”

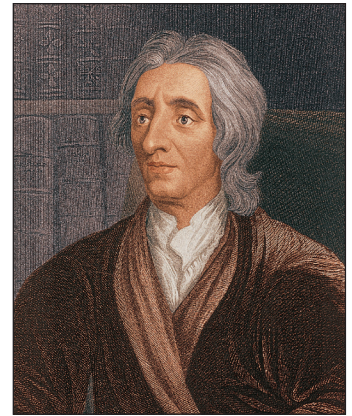
## Illustrations 3A & 3B

3A

### Locke

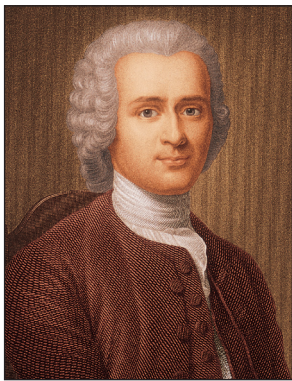
*[The legislature's power] is limited to the public good of the society. It is a power that hath no other end but preservation, and therefore can never have a right to destroy, enslave, or designedly to impoverish the subjects. . . . To this end it is that men give up all their natural power . . . and the community put the legislative power into such hands as they think fit, with this trust, that they shall be governed by declared laws, or else their peace, quiet, and property will still be at the same uncertainty as it was in the state of Nature.*

Second Treatise on Government



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3B



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### Rousseau

*Thus the people's deputies are not and could not be its representatives; they are merely its agents and they cannot decide anything finally. Any law which the people has not ratified in person is void; it is not law at all. The English people believes itself to be free; it is gravely mistaken; it is free only during the election of Members of Parliament; as soon as the members are elected, the people is enslaved.*

The Social Contract

#### Discussing the Illustrations

1. Enlightenment thinkers asked many questions about society. But they rarely agreed on the answers. John Locke and Jean Jacques Rousseau did agree that government exists to protect individual rights. But they differed in many ways—as they do here on the value of representative government. Explain what “representative government” is and how the two men differed over it.
2. One of these two men had a huge influence on the founders of the U.S. government. Which one? Why do you think America's founders were influenced more by him than by the other?
3. Some say Rousseau's ideas are more democratic than Locke's. Others say Rousseau is unrealistic and his ideas would lead either to anarchy or to a “tyranny of the majority.” What do you think these critics mean? With which view do you agree more? Why?
4. What, if anything, do the two illustrations here reveal about these two individuals?

#### Follow-up Activities

1. Many people say Rousseau's book *Emile* was the start of a new, more romantic view of the child as fundamentally good until corrupted by society. Read more about this book. Also, read about Rousseau's own experience as a father. Write an essay about *Emile* in which you summarize the book's views and explain why you think Rousseau's own dealings with his children differed so much from what he recommends in his book. Also, explain whether, in your opinion, this matters when evaluating his views.
2. Mary Wollstonecraft's *Vindication of the Rights of Woman* is considered a major contribution by a woman to the Enlightenment. Read and choose some key passages from this work. You should be able to find it in the library or on the Internet. Choose some passages you think most people today would agree with and some you think they would not agree with. Share these passages with the class and why you chose the selections you did.



**OBJECTIVE**

1. Students will better understand how the Enlightenment and the Scientific Revolution together helped make the Industrial Revolution possible.

# Reason, Technology, and the Industrial Revolution

*Use the background information on this page to help your students better understand the three illustrations making up this lesson. The questions and activities presented in the rest of the lesson can be used to help students clarify meanings and debate important issues.*

**BACKGROUND INFORMATION****Illustration 1**

Adam Smith was an Enlightenment thinker who tried to explain the economy somewhat as Newton had explained the universe. Like gravity in Newton's system, "self-interest" was for Smith the force driving the entire economy. Moreover, natural laws of supply and demand made this "force" work for all of society. That is, Smith thought everyone benefited when each worker or business owner acted in his or her own self-interest. To Smith this meant government should strictly limit its interference in the economy and allow individuals to work and produce as freely as possible. In the 1700s, the "free market" Smith favored was in fact coming into being in England—and it was helping to launch an "industrial revolution" that would change the world.

**Illustrations 2A & 2B**

In the 1700s, science and the Enlightenment spirit rapidly stepped up the pace of technological change in commerce and industry. Thomas Newcomen, for example, developed the first practical steam engine in 1712. Illustration 2A is a diagram of it. Useful in pumping water from coal mines, Newcomen's engine was still quite inefficient. It was Scottish inventor James Watt who in 1769 built the first steam engine suitable for widespread industrial use. Watt's machine, shown in Illustration 2B, was a major breakthrough. But what was more important was the way such breakthroughs now began to follow one another in a systematic way.

**Illustrations 3A & 3B**

The rate of technical innovation in the mid-1700s was perhaps most rapid in the textile industry. Innovations in the spinning of cotton yarn would be followed by new machinery to speed up weaving, which would then lead to new methods of spinning, and so on. One step in this process was the spinning jenny (Illustration 3A) invented in 1764 by James Hargreaves. The jenny could spin a number of cotton threads at once. It was invented in part as a response to the flying shuttle, which had so sped up the weaving process that a shortage of yarn had developed. In time, new machines powered by water or coal-driven steam were too big for the small-scale production of home or shop. Large factories like the one in Illustration 3B began to appear. Science, technology, and the Enlightenment had helped launch a new industrial age.

## Illustration 1



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### Adam Smith

*It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity but to their self-love, and never talk to them of our necessities but of their advantages.*

#### Discussing the Illustrations

1. Newton's laws of motion and his law of gravitation explained how objects move on earth and in space. Enlightenment thinkers admired Newton's method so much that they tried to apply it to other aspects of the world—and of human society. That was true of Adam Smith, shown here with a famous passage he wrote. What aspect of society did he write about? What idea of Smith's character do you get from this illustration?
2. With Newton, the force moving physical objects was gravity. With Adam Smith, a different kind of "force" moved people to play their parts in the economy. From Smith's words here, what "force" moves people to act as they do in an economy?
3. Smith's view is that self-interest is the guiding force in the economy. Some say this removes any moral principle from economic life. But others say it is moral to let the economy be guided by human nature and individual decisions freely made. With which view do you agree more? Why?

#### Follow-up Activity

1. Read more about the life and thought of Adam Smith. Some say his view of the economy is heartless in that he puts all his faith in the concept of self-interest. But Smith also wrote a book called *The Theory of Moral Sentiments* in which he argued that justice and other moral sentiments limit self-interest. Among other points, he said this:

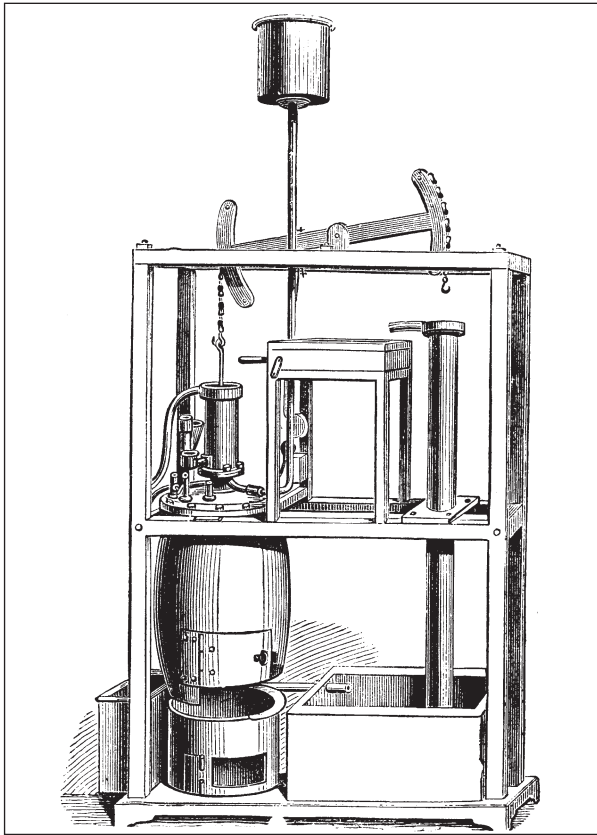
*How selfish so ever man may be supposed, there are evidently some principles in his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it, except the pleasure of seeing it.*

With this quote in mind, as well as the other one presented above, learn more about Adam Smith. Write an essay on Smith and his notions about morality and the economy. You may use the two quotes presented here as the focus of your essay.

## Lesson 4—Reason, Technology, and the Industrial Revolution

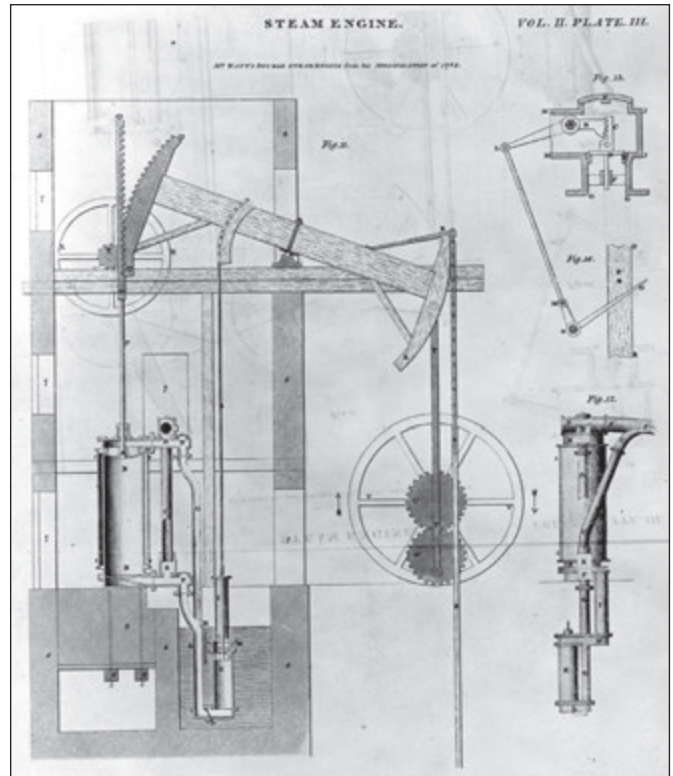
# Illustrations 2A & 2B

2A



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2B



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### Discussing the Illustrations

1. Smith's "free market" was already strong in the 1700s in a nation that soon also launched the Industrial Revolution. What was the Industrial Revolution, and in which nation did it begin? How might a "free market" economy have helped make the Industrial Revolution possible?
2. A main cause of the Industrial Revolution was the use of a powerful form of energy to run machines. Thomas Newcomen invented the machine in Illustration 2A. What is it? What powerful form of energy does it harness?
3. Newcomen's was the first steam engine. But a much better one was developed in the 1760s. Illustration 2B is a diagram of it. Can you name its inventor? What do you know about his improved steam engine?
4. In the Industrial Revolution, technological change became rapid and cumulative. What does this mean? Why might the improvement of diagrams like these two have itself helped make this change possible?

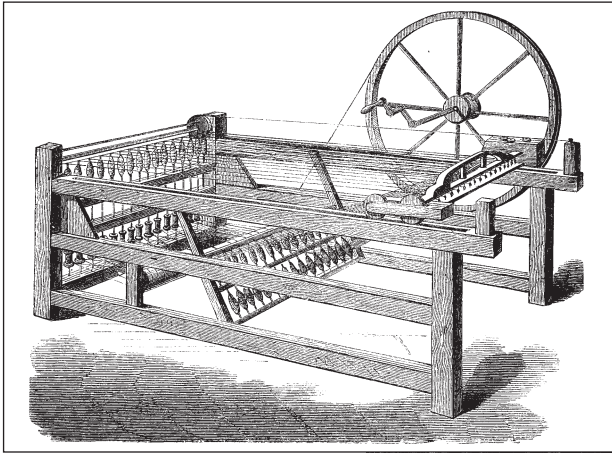
### Follow-up Activities

1. **Small-group activity:** As a group, learn more about the development of the steam engine. Find out more about Thomas Newcomen and the technical changes made between the time of his engine and those in use by the early 1800s. Create a bulletin-board display. As part of your display, create a timeline showing the important stages in the development of the steam engine. You may wish to include other important events going on in the world at the time. Finally, be sure to include as many useful visuals as you can find to illustrate your timeline.
2. Why did the Industrial Revolution begin in England? Find out what your textbook says. Use other sources, including the Internet, to get ideas. Make a list of all the reasons why the Industrial Revolution started in England. Create a chart, listing these reasons under the following four headings: technical, geographical, social, and political. Explain your chart to the class in a short presentation.



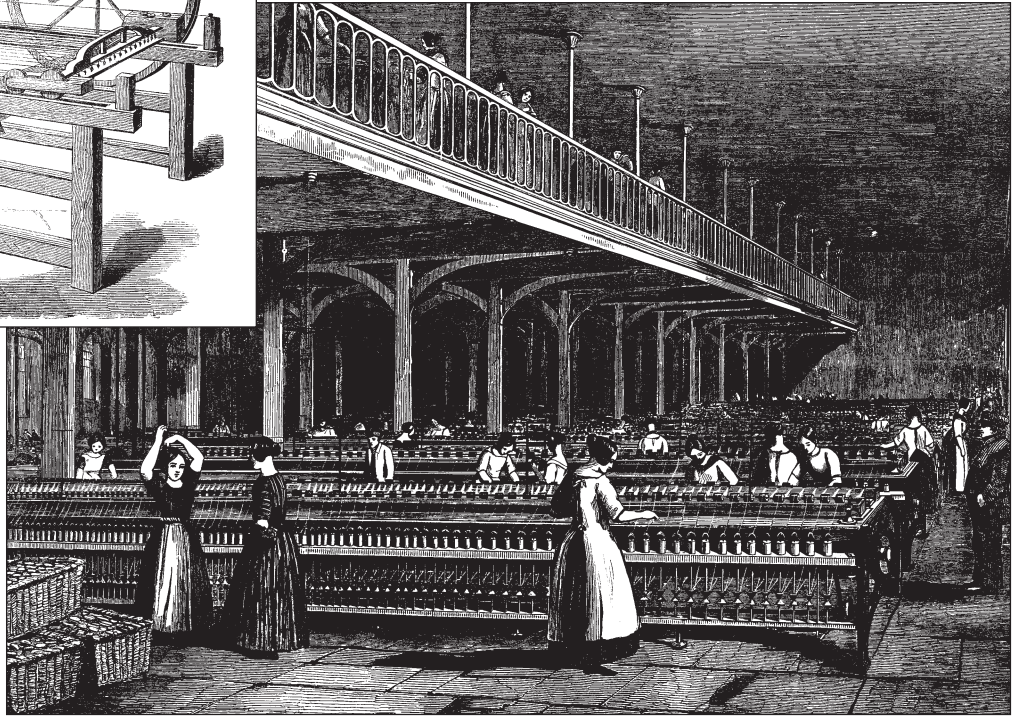
## Illustrations 3A & 3B

3A



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3B



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### Discussing the Illustrations

1. Along with steam power, changes in the textile industry were at the heart of the Industrial Revolution. Why do you think textiles in the 1700s and 1800s were so central to the economies of many nations?
2. Technical change in Great Britain's textile industry definitely sped up in the 1700s. A key change was the invention of the flying shuttle. What was the flying shuttle, and why did it soon lead to a need for faster spinning devices?
3. Illustration 3A is a device that greatly accelerated the spinning of yarn. James Hargreaves invented it. Can you name it? Using this illustration, explain what devices like this suggest or imply about the nature of invention and inventors in the 1700s.
4. In time, these technical changes also changed the way work in general was organized. From Illustration 3B, can you explain what that change was and how it affected life in general in Great Britain and in other industrializing nations?

### Follow-up Activities

1. **Small-group activity:** As a group, learn more about the key developments in the production of cloth in the 1700s. Find out more about James Hargreaves and any others who made important innovations in the spinning and weaving of cloth. Create a bulletin-board display. As part of the display, create a timeline showing the important stages in the development of spinning machines. You may wish to include other important events going on in the world at the time. Include as many useful visuals as you can find to illustrate your timeline.
2. Find images of weavers and spinners working in the home or in small shops in the 1700s. Find other images of textile factories like the one above. Use these images as illustrative evidence for a brief talk to the class on the way work changed as the Industrial Revolution developed. Explain the nature of the changes, their effect on workers and their families, and the problems and opportunities these changes generated.



# **Image Close-ups**



## Science and the Universe

## Illustrations 1A &amp; 1B

*Ptolemy's  
Earth-centered universe*

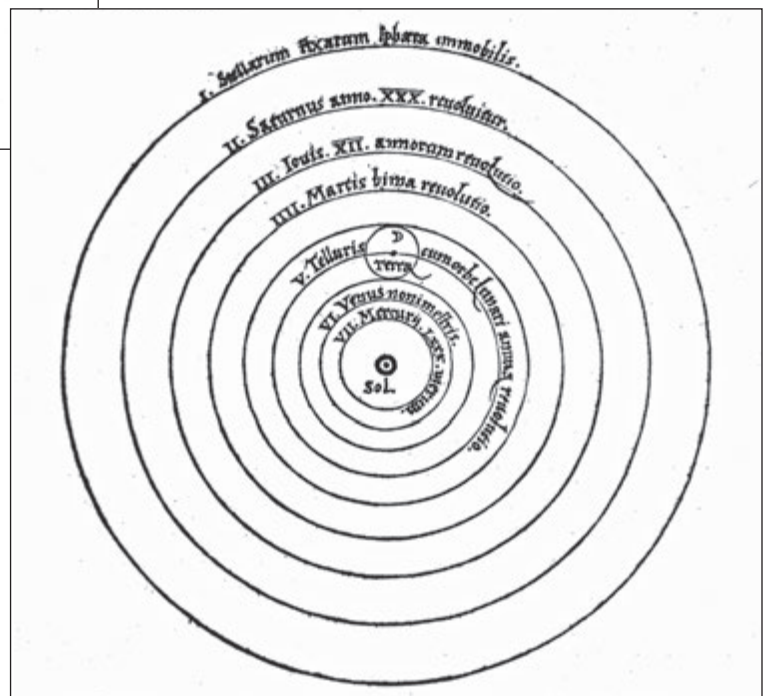
1A



Courtesy of the Lilly Library,  
Indiana University–Bloomington

*Copernicus's  
sun-centered universe*

1B



Courtesy of the Lilly Library,  
Indiana University–Bloomington



Science and the Universe

# Illustration 2

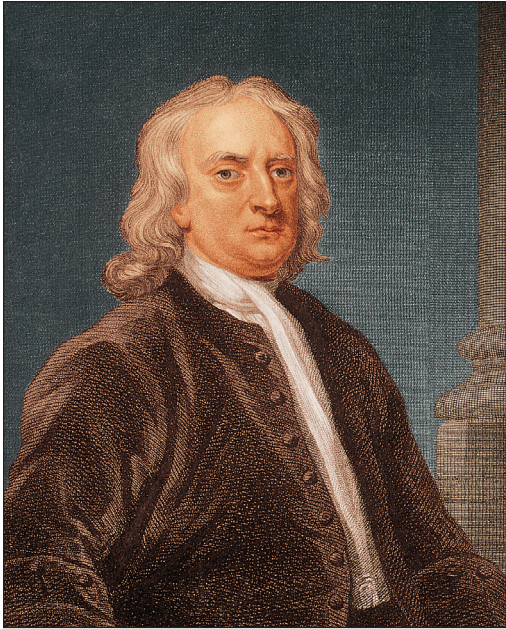


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Science and the Universe

# Illustration 3



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## Isaac Newton

### *Laws of Motion*

#### ***Law 1***

*Every body continues in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it.*

#### ***Law 2***

*The change of motion is proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.*

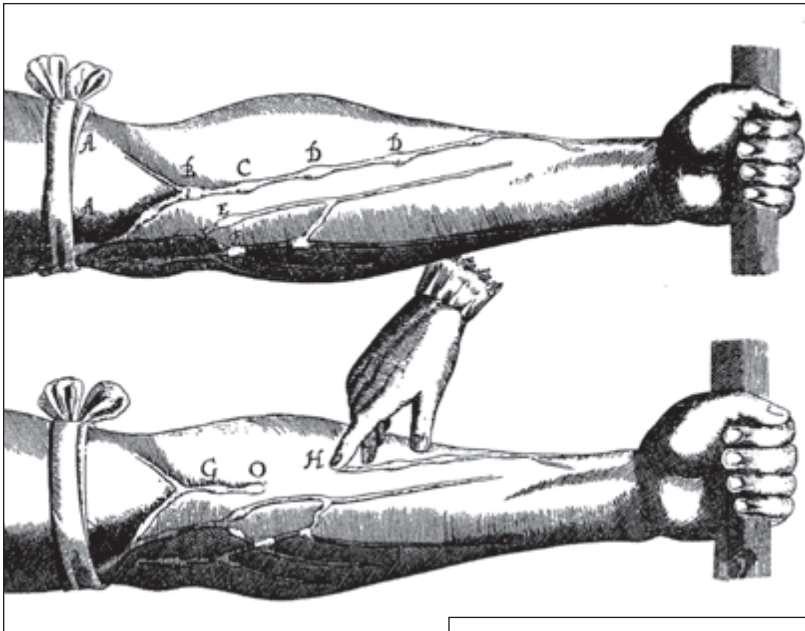
#### ***Law 3***

*To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.*

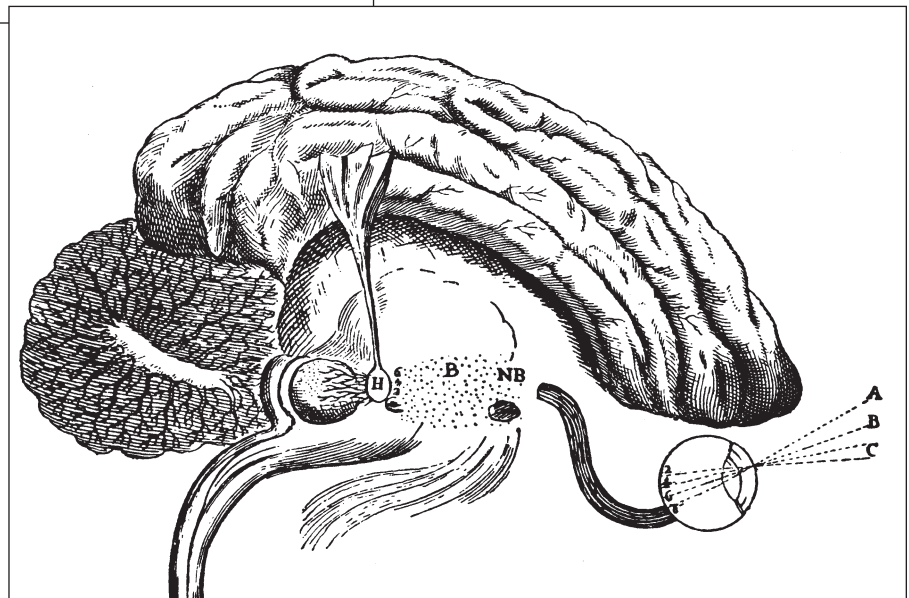
Science, Man, and Society

# Illustrations 1A & 1B

1A



1B



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Science, Man, and Society

## Illustration 2



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### Voltaire

#### On Religion, Fanaticism and Doubt

*I say, that far from forgetting those abominable times, we should frequently take a view of them, to inspire an internal horror for them; and that it is for our age to make reparation by toleration, for this long collection of crimes, which has take place through the want of toleration, during sixteen barbarous centuries.*

*Doubt is not a pleasant condition, but certainty is absurd.*



Science, Man, and Society

# Illustrations 3A & 3B

## Descartes

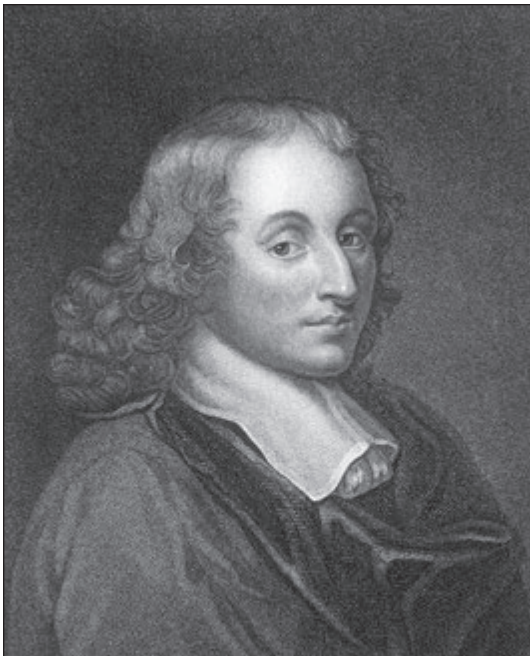
*I shall proceed by setting aside all that in which the least doubt could be supposed to exist. I suppose, then, that all the things that I see are false; I persuade myself that nothing has ever existed of all that my fallacious memory represents to me. . . . What then can be esteemed as true?*

3A



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3B



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## Pascal

*Man is equally incapable of seeing the nothingness from which he emerges and the infinity in which he is engulfed.*

*The eternal silence of those infinite spaces strikes me with terror.*

*It is the heart which perceives God and not the reason.*

## Philosophers and Kings

# Illustration 1



Rare Books Division, The New York Public Library, Astor, Lenox and Tilden Foundation



## Philosophers and Kings Illustrations 2A & 2B

2A



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2B



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## Philosophers and Kings

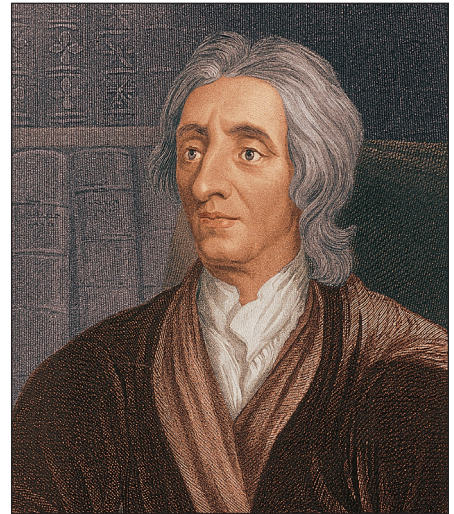
## Illustrations 3A &amp; 3B

## Locke

*[The legislature's power] is limited to the public good of the society. It is a power that hath no other end but preservation, and therefore can never have a right to destroy, enslave, or designedly to impoverish the subjects. . . . To this end it is that men give up all their natural power . . . and the community put the legislative power into such hands as they think fit, with this trust, that they shall be governed by declared laws, or else their peace, quiet, and property will still be at the same uncertainty as it was in the state of Nature.*

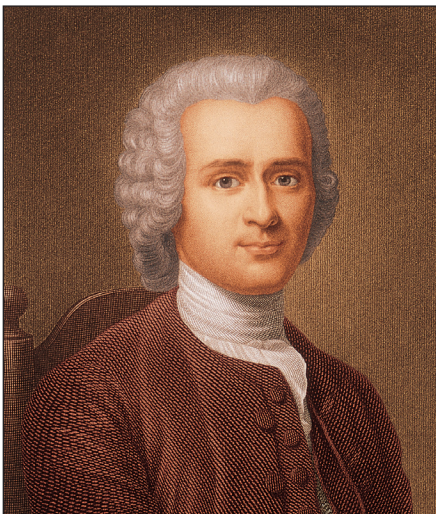
Second Treatise on Government

3A



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3B



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## Rousseau

*Thus the people's deputies are not and could not be its representatives; they are merely its agents and they cannot decide anything finally. Any law which the people has not ratified in person is void; it is not law at all. The English people believes itself to be free; it is gravely mistaken; it is free only during the election of Members of Parliament; as soon as the members are elected, the people is enslaved.*

The Social Contract

## Reason, Technology, and the Industrial Revolution

# Illustration 1



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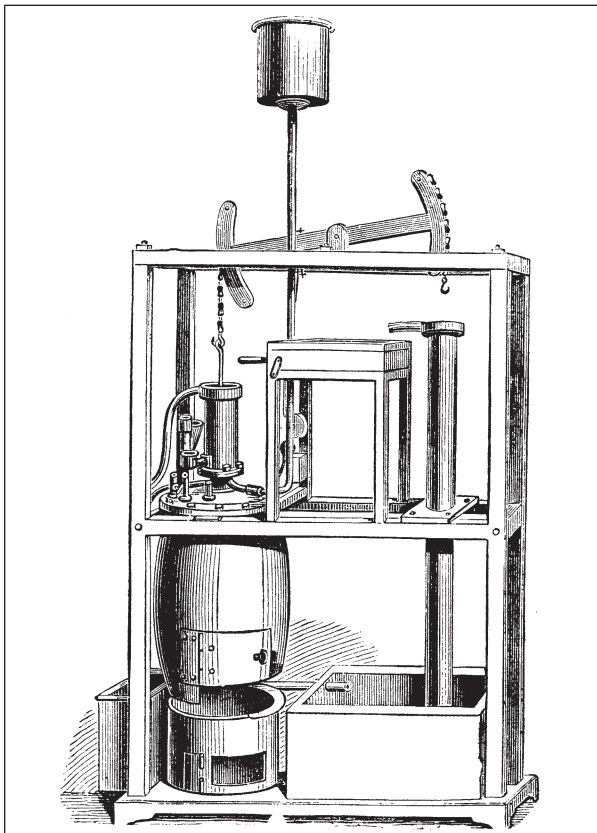
### Adam Smith

*It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity but to their self-love, and never talk to them of our necessities but of their advantages.*

## Reason, Technology, and the Industrial Revolution

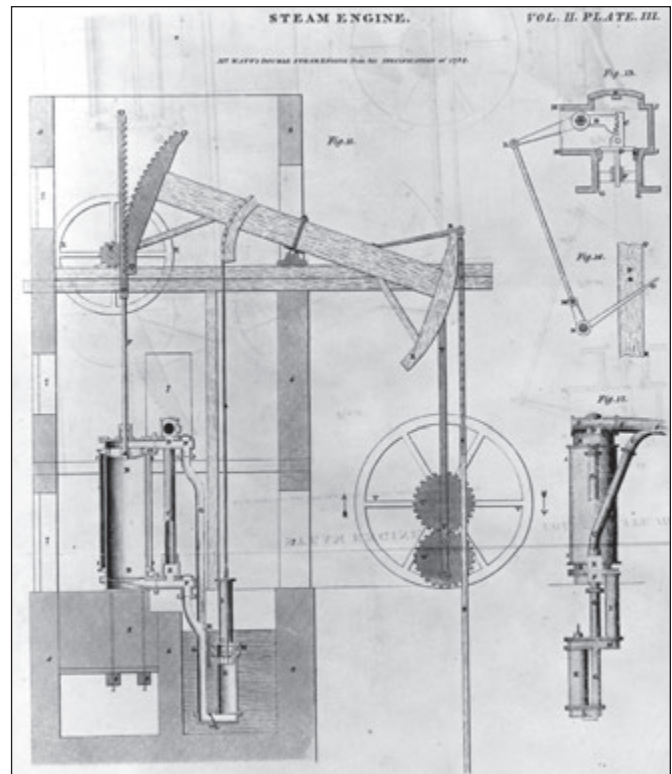
# Illustrations 2A & 2B

2A



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2B



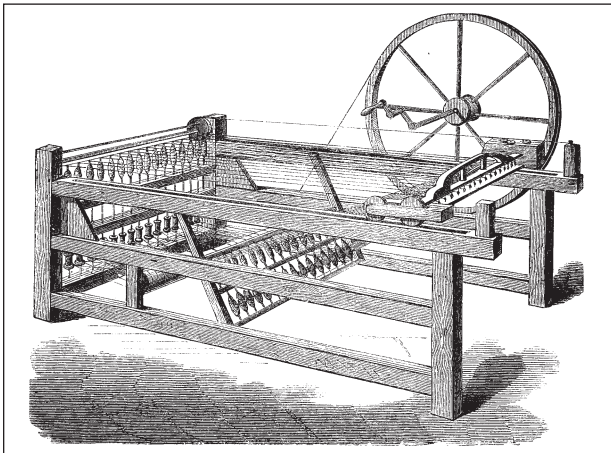
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## Reason, Technology, and the Industrial Revolution

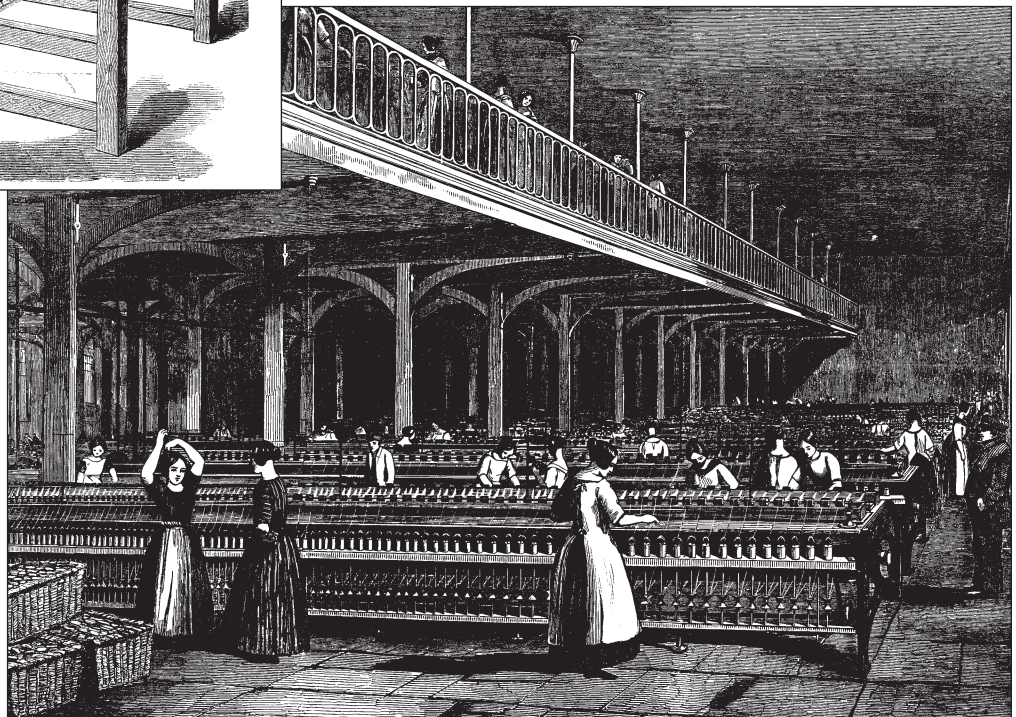
# Illustrations 3A & 3B

3A



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3B



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