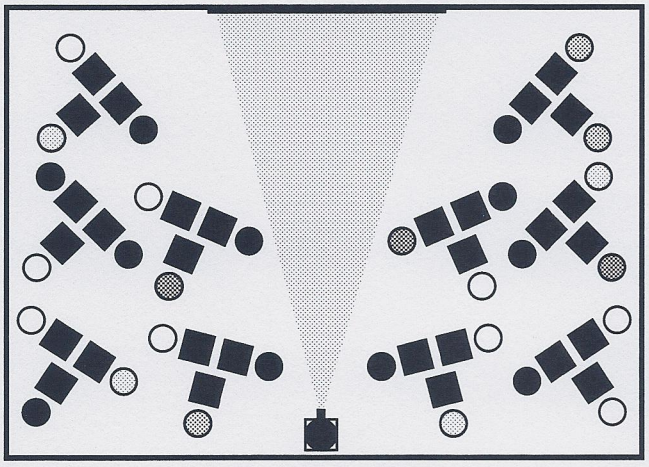
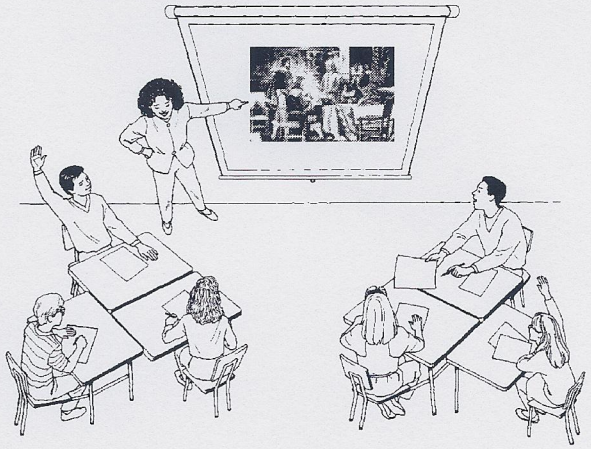
Charting Scientific Breakthroughs

Response Groups

Overview

This **Response Group** activity allows students to create flow charts chronicling five scientific breakthroughs of the Scientific Revolution. Groups receive partially complete flow charts that trace the scientific breakthroughs of William Harvey, Galileo Galilei, Nicolaus Copernicus, Issac Newton, and Andreas Vesalius from their origins to the lasting impact of their discoveries. Groups then attempt to place pieces of information relating to one of the five scientists into appropriate categories of the flow chart. Presenters from each group present to the class their findings about each scientist. Afterward, the teacher reveals the correct answers.





Procedures at a Glance

Divide students into heterogeneous groups of three. Project Slides 4.1A through 4.1E, and introduce students to the Scientific Revolution. Pass out **Student Handouts 4.1A** and **4.1B** to each group. Tell students they will learn about the discoveries of five scientists by completing flow charts chronicling their breakthroughs. Demonstrate how to complete a flow chart by completing the flow chart for William Harvey with the class. Allow groups to complete the remaining four flow charts on their own. Once all groups have finished, project **Overhead Transparency 4.1C**. Assign the role of Presenter to one student in each group, and have Presenters record their group's answers for Copernicus on the transparency. Have Presenters explain and justify their group's answers. Then reveal the correct answer, and provide students with additional information about Copernicus. Repeat this process for each of the remaining scientists. Rotate the role of Presenter for each scientist.

Procedures in Detail

1. Before class, divide students into heterogeneous groups of three. Make one copy of **Student Handout 4.1B:** Information Cards for each group, and cut the information cards along the dotted lines.

2. Tell students this activity will allow them to learn about five scientific breakthroughs that occurred during the Scientific Revolution. Project Slides 4.1A, 4.1B, 4.1C, 4.1D, and 4.1E, which show William Harvey, Nicolaus Copernicus, Andreas Vesalius, Galileo Galilei, and Issac Newton respectively. Explain that these five men challenged traditional beliefs about science and helped usher in the period known as the Scientific Revolution, which emphasized careful observation of the natural world. Tell students this activity will enable them to learn about the contributions of each of these scientists and how they helped pioneer the Scientific Revolution.

3. Give each group a copy of **Student Handout 4.1A:** Flow Chart on Scientific Breakthroughs (a two-page handout) and one set of information cards from **Student Handout 4.1B**. Have groups tape the pages of **Student Handout 4.1A** together. Explain to students what a flow chart is and how it is organized. (**Note:** You may want to provide students with an example of information organized in a flow chart.) Tell groups they must use the clues from **Student Handout 4.1A** to attempt to place the information cards in the appropriate place to complete the flow chart.

4. Before groups begin working on their own, demonstrate how to complete the flow chart for William Harvey with the entire class. Point out that the two pieces of information provided on their handout—(1) the traditional belief was that food is turned into blood in the heart and that arteries and veins are empty and serve as air tubes and (2) Harvey observed that a bound artery would fill with blood in the section nearer the heart, while the portion away from the heart would empty—give clues about what Harvey's daring idea might have been. Have groups look through their cards to see if they can find the appropriate card for the "Scientist's Daring Idea" box. Students should look for information related to the functions of the heart, arteries, and veins. Card F is the correct answer because the information clearly challenges the traditional belief and can be observed in the way described on the flow chart. Have groups repeat this process for the headings "Reaction from Community" and "Lasting Impact." Students should cite Cards N and B, respectively, as the correct answers.

5. Once students have a clear understanding of how to complete a flow chart, allow groups to complete the four remaining flow charts on their own. If groups struggle with the placement of some of the information cards, don't reveal the answers. Instead, encourage them to make their best guess based on the clues and by process of elimination.

6. After all groups have finished filling in the flow charts, give each group a number. Assign the role of Presenter to one student in each group. Project **Overhead Transparency 4.1C:** Flow Chart Answers. Tell groups they will now discuss their findings on Copernicus with the rest of the class. Circle "Copernicus" at the top of the transparency. Place an "X" through the boxes under the heading "Scientist's Daring Idea," since the information was already provided to groups as a clue. Turn the overhead projector off, and have Presenters write their group's answers for Copernicus in the appropriate row on the transparency. Once all Presenters have recorded their group's answers—by simply writing the information card letter in each of the blank boxes—turn on the projector to reveal the answers. In most cases, there will be some discrepancies. Have Presenters explain and justify their answers. After all arguments have been heard, use **Teacher's Guide 4.1A** to reveal the correct answers. In addition, you may want to use the information provided in the **Teacher's Guide to Scientists** to give students more detailed information about Copernicus. As you do so, you may want to project Slide 4.1B again, which shows Copernicus.

7. Continue this process for Vesalius, Galileo, and Newton. Rotate the role of Presenter within each group for each scientist. Encourage Presenters to clearly explain their choice of information card for each category.

8. Finally, ask students: **Given these scientific breakthroughs, why do you think the period in which these scientific breakthroughs took place is called the Scientific Revolution?**

Idea for Student Response: After students have completed this activity, have them draw a line on the left side of their notebooks to create a spectrum that ranges from "Most Influential" to "Least Influential." You may want to physically create this spectrum at the front of your classroom using a 10- to 15-foot piece of masking tape. Have students representing Harvey, Copernicus, Vesalius, Galileo, and Newton stand on the spectrum where they think the influence of each scientist is accurately represented. Once all five scientists are represented on the spectrum, hold a discussion in which students justify the ranking of each scientist's influence on the modern world. Afterward, have students record their responses—which may differ from those generated during the class discussion—on the spectrum in their notebooks, with a one-sentence justification for the placement of each scientist. Expect student responses to vary, but emphasize the need for students to explain their placements clearly and succinctly.

Idea for Class Notes: Have students summarize the key details from **Student Handout 4.1A** by creating, on the right side of their notebooks, a matrix entitled "Leaders of the Scientific Revolution" with these headings:

Scientist	Traditional Belief Before Scientific Revolution	Daring Idea	Lasting Impact of Idea

Teacher's Guide to Scientists

- **Slide 4.1A: William Harvey** William Harvey was an English doctor and teacher. He was the first to correctly describe and prove that blood circulates through the body and that the heart is responsible for pumping blood. Harvey's renowned book *An Anatomical Treatise on the Movement of the Heart and Blood in Animals,* published in 1628, has been called the most important book in the history of physiology. Its primary importance lies not in its direct applications, but in the basic understanding it provides of how the human body works.

- **Slide 4.1B: Nicolaus Copernicus** Nicolaus Copernicus, a Polish canon, is consideved the founder of modern astronomy. In his most famous work, *De revolutionibus orbium coelestium (On the Revolution of the Celestial Spheres),* he introduced his heliocentric hypothesis: that the earth was one of several heavenly bodies that, turning on their axes, all revolve around the sun. Although challenged by many other scholars at first, his ideas eventually revolutionized Europe's conception of the universe. Copernicus' book was also an indispensable prologue to the scientific discoveries of Galileo Galilei, Johannes Kepler, and Issac Newton.

- **Slide 4.1C: Andreas Vesalius** With his monumental work, *De humani corporis fabrica (On the Structure of the Human Body)*, the Flemish physician and anatomist Andreas Vesalius brought innovation to the study of human anatomy that had been dormant for more than 1,500 years. His observations challenged the works of Galen, a second-century physician whose theories, based on the dissection of animals, were widely believed. Vesalius's work also established the principle that scientific knowledge is found by observing nature, not by reading and thinking about ancient books. His *Fabrica* recorded the first sizable body of scientific observation since ancient times, and its publication marked the dawn of modern science.

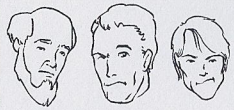
- **Slide 4.1D: Galileo Galilei** Galileo Galilei of Italy is considered one of the most influential scientists in European history. He is renowned for scientific discoveries such as the law of inertia, his invention of the telescope, his astronomical observations, and for his genius in proving the Copernican hypothesis. Perhaps his greatest legacy, however, is his perfection of the scientific method. Galileo's emphasis on careful, quantitative measurements continues to be a basic feature of scientific research.

- **Slide 4.1E: Isaac Newton** Isaac Newton of England is considered the greatest and most influential scientist in history. Newton made major contributions to the understanding of motion, gravity, heat, and light. He is said to have discovered the principle of gravity when he saw an apple fall to the ground at the same time that the moon was visible in the sky. He described this theory and many others in his *Mathematical Principles of Natural Philosophy*. Newton also created a system of advanced mathematics called calculus.

Flow Chart on Scientific Breakthroughs

Directions: Cut along the dashed line, and tape these two pages together. Read the clues provided on each of the flow charts below. Then review your information cards, and place them on the flow chart where you think they belong.

	Traditional Belief Before Scientific Revolution	Scientist's Daring Idea	Scientist's Observations	Reaction from Community	Lasting Impact
William Harvey (1578–1657)	Food is turned into blood in the heart. Arteries and veins are empty and serve as air tubes.		Observed that a bound artery would fill with blood in the section nearer the heart, while the portion away from the heart would empty. 		
Nicolaus Copernicus (1473–1543)		 The earth and other planets revolve around the sun.			

Andreas Vesalius (1514–1564)			Dissected large numbers of human bodies and made precise sketches of what he saw. 	 His ideas were accepted by many, but he wrote a book to defend his ideas against a few powerful critics.		
Galileo Galilei (1564–1652)	Celestial bodies (the moon, planets, and stars) are perfect spheres made of ether (a type of gas).			Church officials refused to accept his claims. Some claimed that what appeared in the lens of the telescope were optical illusions. 		
Isaac Newton (1642–1727)	Spirits and divinities control the movement of the planets.				His theories (ideas) created the foundation for many scientific fields, including astronomy, engineering, and physics.	

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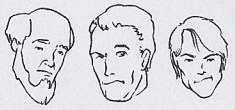
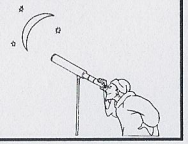
	Traditional Belief Before Scientific Revolution	Scientist's Daring Idea	Scientist's Observations	Reaction from Community	Lasting Impact
William Harvey (1578–1657)	Food is turned into blood in the heart. Arteries and veins are empty and serve as air tubes.	**Card F** The same blood is constantly recycled through the heart. Arteries and veins carry the blood to and from the heart, which acts like a pump.	Observed that a bound artery would fill with blood in the section nearer the heart, while the portion away from the heart would empty. 	**Card N**  Many physicians were unwilling to accept the idea that human blood is constantly being recirculated through a closed system of arteries and veins.	**Card B** His research is considered the origin (starting point) of the modern science of physiology (the study of how the body functions).
Nicolaus Copernicus (1473–1543)	**Card M** The earth is at the center of the universe. It stays fixed in a permanent place, with the sun and the planets revolving around it. 	 The earth and other planets revolve around the sun.	**Card G** Spent years mapping the locations of the planets, using complex mathematical calculations.	**Card A** His ideas were rejected by most people, many of whom claimed that it would take more than mathematics to explain how the planets moved. 	**Card L** His theory (idea) provided the foundation for the modern science of astronomy (the study of planets).

Andreas Vesalius (1514–1564)	**Card H** It is a sin to dissect dead human bodies.	**Card O** To completely understand human anatomy, it is necessary to dissect the dead bodies of humans, not those of animals.	Dissected large numbers of human bodies and made precise sketches of what he saw. 	 His ideas were accepted by many, but he wrote a book to defend his ideas against a few powerful critics.	**Card I** His work proved wrong many ancient ideas about human anatomy and helped begin the modern sciences of anatomy and physiology.
Galileo Galilei (1564–1652)	Celestial bodies (the moon, planets, and stars) are perfect spheres made of ether (a type of gas).	**Card E** Only through precise observation can one determine what celestial bodies are made of. 	**Card K** Used personally built telescope and observed that the moon was not smooth, but had numerous craters and high mountains.	Church officials refused to accept his claims. Some claimed that what appeared in the lens of the telescope were optical illusions. 	**Card D** Invention of the telescope led to a series of important astronomical discoveries: Jupiter had moons, the sun had large spots, visual proof that the earth revolved around the sun.
Isaac Newton (1642–1727)	Spirits and divinities control the movement of the planets.	**Card C** The same force that pulls an object to earth—like an apple falling to the ground—keeps the moon and planets in orbit around the sun.	**Card P** Used complex mathematics to demonstrate that any two objects in the universe pull toward each other.	**Card J** His ideas were accepted by most scientists, and he was praised by England's queen. 	His theories (ideas) created the foundation for many scientific fields, including astronomy, engineering, and physics.

Information Cards

Card A

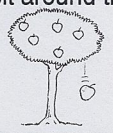
His ideas were rejected by most people, many of whom claimed that it would take more than mathematics to explain how the planets moved.

Card B

His research is considered the origin (starting point) of the modern science of physiology (the study of how the body functions).

Card C

The same force that pulls an object to earth—like an apple falling to the ground—keeps the moon and planets in orbit around the sun.

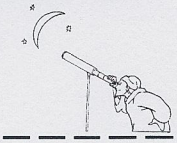


Card D

Invention of the telescope led to a series of important astronomical discoveries: Jupiter had moons, the sun had large spots, visual proof that the earth revolved around the sun.

Card E

Only through precise observation can one determine what celestial bodies are made of.



Card F

The same blood is constantly recycled through the heart. Arteries and veins carry the blood to and from the heart, which acts like a pump.

Card G

Spent years mapping the locations of the planets, using complex mathematical calculations.

Card H

It is a sin to dissect dead human bodies.

Card I

His work proved wrong many ancient ideas about human anatomy and helped begin the modern sciences of anatomy and physiology.

Card J

His ideas were accepted by most scientists, and he was praised by England's queen.

Card K

Used personally built telescope and observed that the moon was not smooth, but had numerous craters and high mountains.

Card L

His theory (idea) provided the foundation for the modern science of astronomy (the study of planets).

Card M

The earth is at the center of the universe. It stays fixed in a permanent place, with the sun and the planets revolving around it.

Card N

Many physicians were unwilling to accept the idea that human blood is constantly being recirculated through a closed system of arteries and veins.

Card O

To completely understand human anatomy, it is necessary to dissect the dead bodies of humans, not those of animals.

Card P

Used complex mathematics to demonstrate that any two objects in the universe pull toward each other.

Flow Chart Answers

William Harvey | Nicolaus Copernicus | Andreas Vesalius | Galileo Galilei | Isaac Newton