EUREKA!

50 SCIENTISTS WHO SHAPED HUMAN HISTORY

BY JOHN GRANT

STUDY GUIDE

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ABOUT THE BOOK:

Albert Einstein explained how the universe works. William Harvey discovered the circulation of the blood. Ada Lovelace invented computer programming. Galileo Galilei fought with the Vatican to spread the word that the earth and the other planets went around the sun. Marie Curie opened up the world of radioactivity to our understanding. Isaac Newton derived the laws of gravitation, co-invented the calculus, and "unwove the rainbow." Charles Darwin discovered the principle that molds new species. Rachel Carson forced us to face up to the damage we do to our surroundings, and the consequences to our survival if we fail to change our ways. Louis Pasteur unmasked the root cause of infectious diseases, so that we could start learning to tame them.

These are only a few of the scientists, from Pythagoras to Stephen Hawking, whose insatiable curiosity and zeal for discovery have shaped the world we live in and our comprehension of the universe around us.

ABOUT THE AUTHOR:

John Grant is the author of some seventy books, both fiction and nonfiction. His nonfiction has included *The Encyclopedia of Walt Disney's Animated Characters*, *The Encyclopedia of Fantasy* (with John Clute), and an informal series of books on the misuse and misunderstanding of science, begun with *Discarded Science* and continued most recently with Denying Science. For his nonfiction he has received the Hugo (twice), the World Fantasy Award, and a number of other awards and nominations.

His *A Comprehensive Encyclopedia of Film Noir*, the largest film noir encyclopedia in the English language, was published in October 2013. *Debunk It!*, designed for young adult readers, came out in 2015.

ABOUT THE GUIDE AND COMMON CORE STANDARDS:

This study guide is designed to help teachers, educators, and parents further explore the book's topics with students in grades 5 to 10, though the material can be adapted to any context. The "Keywords & Concepts" section provides a text cross-reference where central terms and ideas are explained. The "Reading Response" section offers questions that check for comprehension. And the "Group Discussion" section provides prompts for small-group or class discussions that personalize the issues and encourage self-reflection.

Each section in the study guide is aligned with the following science-related Common Core standards (CSS.ELA-Literacy):

Common Core Standard Grade 6-8: RST 6-8.1, RST 6-8.2, RST 6-8.4, RST 6-8.5, RST 6-8.6, RST 6-8.8
Common Core Standard Grade 9-10: RST 9-10.2, RST 9-10.5, RST 9-10.6, RST 9-10.8

BIOGRAPHICAL ESSAYS

(In chronological order)

Pythagoras (ca. 570-ca. 495 BCE?)
Hippocrates (ca. 460-ca. 370 BCE)
Euclid of Alexandria (ca. 325-ca. 270 BCE)
Archimedes of Syracuse (ca. 287-212 BCE)
Ptolemy (ca. 90-ca. 168)
Hypatia of Alexandria (ca. 355-415)
Alhazen (ca. 965-ca. 1040)
Nicolaus Copernicus (1473-1543)
Tycho Brahe (1546-1601)
Francis Bacon (1561-1626)
Galileo Galilei (1564-1642)
Johannes Kepler (1571-1630)
William Harvey (1578-1657)
Isaac Newton (1642-1727)
Gottfried Leibniz (1646-1716)
Émilie du Châtelet (1706-1749)
Carolus Linnaeus (1707-1778)
Mikhail Lomonosov (1711-1765)
James Hutton (1726-1797)
James Watt (1736-1819)
Antoine Lavoisier (1743-1794)
Edward Jenner (1749-1823)
John Dalton (1766-1844)
William Smith (1769-1839)
Michael Faraday (1791-1867)
Charles Darwin (1809-1882)
Ada Lovelace (1815-1852)
Ignaz Semmelweis (1818-1865)
Gregor Mendel (1822-1884)
Louis Pasteur (1822-1895)
Bernhard Riemann (1826-1866)
James Clerk Maxwell (1831-1879)
Marie Curie (1867-1934)
Lise Meitner (1878-1968)
Albert Einstein (1879-1955)
Alfred Wegener (1880-1930)
Erwin Schrödinger (1887-1961)
Edwin Hubble (1889-1953)
Howard Florey (1898-1968)
Cecilia Payne-Gaposchkin (1900-1979)
Werner Heisenberg (1901-1976)
Rachel Carson (1907-1964)
Subrahmanyan Chandrasekhar (1910-1995)
Alan Turing (1912-1954)
Jonas Salk (1914-1995)
James Lovelock (b. 1919)
Rosalind Franklin (1920-1958)
Stephen Hawking (b. 1942)
Jocelyn Bell Burnell (b. 1943)
James Hansen (b. 1941)

KEYWORDS & CONCEPTS

Pythagorean theorem (10), Music of the Spheres (11), Hippocratic oath (15), *Elements* (Euclid) (18), Archimedean principle (20), *Almagest* (Ptolemy) (26), heliocentric cosmology (36), supernova (39), Scientific Method (43–4), inclined plane (48), phases of Venus (49), Jupiter's moons (49), regular convex polyhedra (55), Kepler's laws (56–7), circulation of the blood (61), Newton's laws of motion (65), reflecting telescope (68), wave and corpuscular theories of light (68), calculus (74), taxonomy (81), catastrophism (86), neptunism (86), uniformitarianism (87), phlogiston (92), conservation of mass (93), vaccination (98), atomic theory (101), Periodic Table (101), stratigraphic column (104), electromagnetic induction (107), evolution by natural selection (114–15), computer programming (121), hospital hygiene (123), laws of heredity (126), genetics (128), stereochemistry (130), pasteurization (130), spontaneous generation (131), germ theory of disease (132), non-Euclidean geometries (136), electromagnetic field (139), radioactivity (144), nuclear fission (150), photoelectric effect (154), Brownian motion (155), special relativity (156), luminiferous aether (156), spacetime (157), $E = mc^2$ (157), general relativity (157), gravitational waves (160), unified field theory (161), continental drift (163), plate tectonics (164), quantum mechanics (167), Schrödinger's Cat (168), Big Bang theory (172), penicillin (173), chemical composition of the universe (177–8), Heisenberg's uncertainty principle (180), *Silent Spring* (185), Chandrasekhar limit (188), Turing machines (191), Turing test (192), polio vaccination (194), Gaia hypothesis (198), DNA (201), black holes (206), time travel (208), Many Worlds hypothesis (209), pulsars (212), climate change (214), runaway greenhouse effect (215).

READING RESPONSES

- Who discovered that Jupiter has moons? (page 49)
- Which famous astronomer had to defend his mother on charges of witchcraft? (page 58)
- Charles Darwin spent nearly eight years studying and classifying a single type of creature. What type? Clue: not finches. (page 114)
- Who first pointed out that the overuse of pesticides was destroying the environment? (page 185)
- Alexander Fleming discovered penicillin, but who realized its medical potential and brought antibiotics to the world? (page 173)
- What event in a star's evolution does the Chandrasekhar limit define? (page 188)
- For what achievement was Albert Einstein awarded the Nobel Physics Prize? (page 154)
- What was Pangaea? (page 164)

SUGGESTED DISCUSSION TOPICS

1. Quite a few movies based on the lives of scientists are mentioned in the book; examples are *Agora* (about Hypatia of Alexandria), *Creation* (Charles Darwin), *The Theory of Everything* (Stephen Hawking) and *The Imitation Game* (Alan Turing). In all instances the accounts are largely fictionalized. Do they nevertheless help us understand the scientists concerned—what drove them, the context in which they lived, the breakthroughs they made? What other benefits might a fictional treatment offer?

2. The Scientific Method (page 44), formulated over the centuries by people like Francis Bacon, is an invaluable tool in finding out the truth about ourselves and the universe in which we live. Famously, though, it's less useful when it comes to analyzing things like human relationships. Try to imagine what it would be like if we applied the Scientific Method to something like choosing our next boyfriend or girlfriend, or deciding what to eat for dinner tonight.

3. In 1820 the poet John Keats published a narrative poem called *Lamia*, in which he criticized the then-new idea that reason (i.e., science) could be used to unravel the mysteries of the universe:

Philosophy will clip an Angel's wings,
Conquer all mysteries by rule and line,
Empty the haunted air, and gnomèd mine—
Unweave a rainbow . . .

Keats's point was that the rainbow is more beautiful if we don't understand it—if we accept it as a miracle. In 1998 the biologist Richard Dawkins countered this in the title of one of his books, *Unweaving the Rainbow*: he argued that the phenomena of the universe, from distant galaxies to living cells, become *more* beautiful once we understand them. Which of the two arguments do you think is the correct one? Or does the truth lie somewhere in between?

SUGGESTED DISCUSSION TOPICS

(Continued . . .)

4. Most of the scientists discussed in this book were/are men. This is because, until really about the middle of the last century, science was regarded as being almost exclusively a male preserve—female scientists were few and far between, and the obstacles placed in their way were often literally insurmountable. There were a few exceptions, like Marie Curie (page 143) and Cecilia Payne-Gaposchkin (page 176), but, even in the latter part of the last century, science was overwhelmingly male-dominated. Things are at last changing for the better, but the rate of improvement is still slow. Can you think of ways to accelerate it? Is it a matter of changing the attitudes of male scientists, or finding ways to make science careers more appealing to female students, or funding organizations to promote women in the sciences? Do you think any or all of these tactics—or others—could be effective?

5. The idea of the Turing test (page 192) is that, if you're having a conversation (written or otherwise) and you can't tell if you're speaking to a machine or a human being, then, if it's in fact a machine, to all intents and purposes that machine is intelligent. Of course, there are lots of computer algorithms that can fool us in the short term, but sooner or later we cotton on. In the future, however, there are likely to be machines that pass the Turing test with flying colors. Do you think they'll *really* be intelligent? Or do you think they'll just be producing better and better *imitations* of intelligence?

6. Quite a number of the great scientists discussed in the book were difficult to get along with. Albert Einstein, for example, annoyed his professors so much (page 153) that he had difficulty getting good job references out of them—it's one of the reasons he ended up at the Bern patent office—while throughout his life Isaac Newton engaged in bitter and often completely pointless feuds with his fellow scientists (page 67). Even though plenty of other scientists were, like Charles Darwin or Edmond Halley, renowned for their affability, is there some connection between scientific genius and personal abrasiveness?