

# Discussion Guide

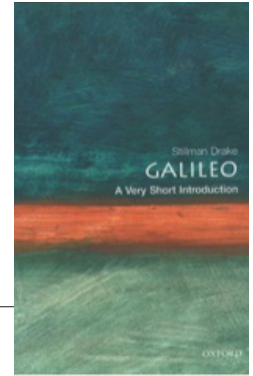
## Stillman Drake, Galileo: A Very Short Introduction

by Kerry Magruder

Overview: p. 1

Discussion guides: pp. 2-9

Dive Deeper (with flowchart): pp. 10-12



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### Overview

Eight 50-minute sessions, discussing 1 chapter at a time, or about 15-20 pages per session.

Supplement the discussion questions with information in the online **Timeline** (not necessarily covered in Drake) and **Dive Deeper** handout.

A few simple guidelines for leading a discussion:

1. Encourage open discussion.
2. Listen attentively.
3. Minimize didactic teaching; emphasize discovery and exploration. Discussion questions are not T/F statements. Complex historical questions require careful interpretation. Encourage interpretation based on information and evidence. Seek to elucidate rationales underlying different perspectives.
4. Encourage everyone to participate.
5. Let pauses happen without rushing in. Or summarize and paraphrase what has been said. This helps everyone collect their thoughts and extend points just made.
6. Gently but firmly remind a “talking head” that the group’s purpose is to listen attentively to everyone in turn, to encourage everyone to participate and to give everyone equal time. Recognize that “talking heads” may not perceive when they are talking too much, so they need gentle reminders. Be direct and diplomatic: “Thank you for sharing your point of view, now let’s hear someone else’s thoughts.”

“Philosophy [i.e., physics] is written in this grand book—I mean the universe—which stands continually open to our gaze, but it cannot be understood unless one first learns to comprehend the language and interpret the characters in which it is written. It is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures, without which it is humanly impossible to understand a single word of it; without these, one is wandering around in a dark labyrinth.”

Galileo Galilei, *Il Saggiatore* (*The Assayer*, 1616)



# Discussion Guide

## Stillman Drake, Galileo: A Very Short Introduction

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### Discussion 1: Preface, Introduction

1. What do you most want to find out about Galileo? What most interests you about Galileo?

Optional video: Janux, “13.1 - Galileo, Starting Assumptions”:

[http://youtu.be/O7fZa0VeM54?list=PLTve54sz-eh\\_P29Sbbv\\_j3bC97OFaArOd](http://youtu.be/O7fZa0VeM54?list=PLTve54sz-eh_P29Sbbv_j3bC97OFaArOd)

Which questions raised in this video most interests you?

3. In the first paragraph of the Preface, Drake cautions against “an assumption of inevitable conflict between science and religion.” Instead of a “conflict thesis,” he urges what we might call a “complexity thesis” for interpreting the story of Galileo. How does Drake argue for this complexity thesis throughout the Preface and Introduction? How does a “complexity thesis” differ from widespread popular impressions of Galileo?

Optional video excerpt: Complexity, <https://vimeo.com/59950001> (3 mins)

4. In an aside remark, Drake suggests that “There is little hope that any new document concerning this matter will be discovered; in a way, the difficulty has long been to reconcile all the documents we have.” To some, history may seem like the patient accumulation of facts in a chronological order. In contrast, how does the last phrase of Drake’s statement (“the difficulty has long been to reconcile all the documents we have”) reflect a view of historical inquiry rather as a form of complex, careful and provisional interpretation? How do historians and investigators in other fields of knowledge gather and interpret their sources or data?

Incidentally, enough new documents have been discovered since 1983, when Drake originally wrote this book, to warrant publication of four thick new volumes in the the National Edition of Galileo-related sources. Drake’s “very short introduction” is a great “first word” on Galileo, but hardly the “last word.” We will return at the end of this study to consider recommended sources to help you dive deeper into Galileo’s world.



# Discussion Guide

## Stillman Drake, *Galileo: A Very Short Introduction*

### Discussion 2: Ch. 1, Background

1. Aristotle is sometimes called “the philosopher of common sense” because of the way he organized ordinary sensory experience in a comprehensive framework that integrated logical reasoning and causal explanation. According to Drake, what were the key features of Aristotle’s theories of natural motion, gravity, and the physical universe?

*Optional video:*

The Renaissance cosmos: <https://vimeo.com/83324155>

2. How does Drake contrast Galileo’s scientific approach to Aristotle’s?

3. Drake indicates that many of Galileo’s most formidable opponents were powerful Aristotelian physicists (or “natural philosophers”) in the universities. How does Drake’s concern to establish this background provide context for understanding his negative description of the universities as lacking in innovative research? Yet to what degree are textbooks, even now, an accurate index of innovative research? How would you respond to a historian of the future who might make a similar generalization about today’s research universities based only upon a survey of surviving undergraduate textbooks? What do you think: How do universities, past and present, foster communities of learning, preserve knowledge, and fuel innovation?

4. What connections do you want to discover between Galileo’s world and your own? The story of Galileo reveals the creativity and interconnectedness of human achievement. Galileo’s works illustrate a lifetime of engagement in science, art, literature, music, religion, philosophy, politics and culture. Galileo’s creative achievements live on today and shape our world in significant ways. The interconnectedness of science and culture which characterized Galileo’s world, and which connect Galileo’s world to our own day, remain the common heritage of humanity which we explore in the history of science, in the library, and in the University of Oklahoma during our 125th anniversary.



# Discussion Guide

## Stillman Drake, *Galileo: A Very Short Introduction*

### Discussion 3: Ch. 2, Galileo's Early Years

1. Drake outlines some of Galileo's early experiences, including life at home, in a monastery, at a Renaissance court, at the universities of Pisa and Padua, and in the cities of Florence, Padua and Venice. What features of Galileo's family, upbringing, education, and early writings seem to you to throw interesting light on his later life? Were you surprised to see his connections to such diverse fields such as medicine, music, art and literature?

2. What was it like to be an engineer in an era of mathematical discovery? How do Drake's brief comments about Galileo and military engineering help explain Galileo's creation of a geometrical compass which he manufactured for sale along with a printed manual? Only 60 copies were printed of this manual, the *Compasso* (1606), the first and rarest of Galileo's printed books. The OU copy is the original proof copy, with Galileo's handwritten corrections.



3. Drake mentions Marina Gamba, Galileo's mistress in Venice. Without a doubt, the most popular book about Galileo is Dava Sobel, *Galileo's Daughter* (Walker, 1999). Have you read it? NOVA aired a 2-hour episode based upon it entitled "Galileo's Battle for the Heavens," which you can watch online. Have you seen it? At the end of the episode, the first credits to appear both for institutions and for consultants are to the OU History of Science Collections. For an overview of the OU Galileo collection, watch the Janux video, 13.2 Galileo's Works (9:06 mins): [http://youtu.be/KnUQ0nnvdfg?list=PLTve54sz-eh\\_P29Sbbv\\_j3bC97OFaArOd](http://youtu.be/KnUQ0nnvdfg?list=PLTve54sz-eh_P29Sbbv_j3bC97OFaArOd)



4. Drake mentions a number of new instruments, including the compass, thermoscope, pulsilogium, pendulum, and inclined plane. How did new instruments extend sensory perception, facilitate new experiments, and promote quantitative methods?

Note: For an account of mathematical analyses of motion that differs from Drake's interpretation for developments prior to Galileo, see Edward Grant, *The Foundations of Modern Science in the Middle Ages: Their Religious, Institutional and Intellectual Contexts* (Cambridge, 1996); and Marshall Claggett, *The Science of Mechanics in the Middle Ages* (Wisconsin, 1959).

# Discussion Guide

## Stillman Drake, *Galileo: A Very Short Introduction*

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### Discussion 4: Ch. 3, Conflicts With Philosophers

1. What does it mean to say mathematics is the language of nature? Drake describes Galileo's conflicts with philosophers as a contest of mathematicians against the physicists. "Natural philosophy" was roughly equivalent to "physics," except that the physics involved was Aristotelian rather than mathematical. The physicists of the day knew nothing of Archimedes, for example. So mathematicians of Galileo's generation believed they could do physics better than the physicists. How does this conflict provide context for Galileo's later famous manifesto (quoted on p. 1 of this guide) that "Philosophy [i.e., physics] is written in this grand book... is written in the language of mathematics, and its characters are triangles, circles, and other geometrical figures...?"
2. What circumstances prompted Galileo's *Difesa*, his second printed book, and do they bear any resemblances to priority disputes, copyright questions, or patent litigation today? The OU copy of the *Difesa* is inscribed by Galileo to a Venetian physician.
3. The OU copy of Galileo's *Sidereus nuncius* (Venice, 1610), the first publication of observations made with a telescope, is inscribed by Galileo to a poet in Florence. What did Galileo discover through the telescope? How did each of his various discoveries undermine traditional Aristotelian conceptions of the universe?
4. Discuss the Janux video: 9.3 Science and Art from Leonardo to Galileo (4:05 mins). What was it like to be an astronomer in an era when art and mathematics were intertwined? [http://youtu.be/xtPtSQQ9mTg?list=PLTve54sz-eh\\_P29Sbbv\\_j3bC97OFaArOd](http://youtu.be/xtPtSQQ9mTg?list=PLTve54sz-eh_P29Sbbv_j3bC97OFaArOd)



5. What was the importance of the *Accademia dei Lincei* for Galileo and his world? Prince Federico Cesi founded the Academy of the Lynx, so named because of the lynx's reputed ability to see clearly through the darkness of night. After Galileo joined the Lincei, it became one of the most notable early scientific societies. In recognition of OU's Galileo collection, the *Accademia dei Lincei* has given OU permission to use the phrase "OU Academy of the Lynx" for our collaborating partners in educational outreach.

# Discussion Guide

## Stillman Drake, Galileo: A Very Short Introduction

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### Discussion 5: Ch. 4, Conflicts With Astronomers and Theologians

1. Was the Sun-centered system of Copernicus accepted because of simple observational proof? Why or why not? If not, how did it come to be accepted?

2. Scripture and Copernicanism: What did Galileo argue in his *Letter to the Grand Duchess Christina* about the Bible and science? What went wrong with theologians and the Church? Does the Galileo affair represent an inevitable conflict between science and religion? Or how might it have been avoided?

•*Optional:* The Biblical Interpretation Exercise (<http://kvmagruder.net/Galileo-hermeneutics/Galileo-Hermeneutics-Exercise.pdf>) shows how both Catholics and Protestants of the time, including those involved in the Galileo affair, had all the intellectual resources they needed for interpreting Scripture as allowing the Earth to be in motion, but they tragically erred because of the weight of long theological tradition, and because of their confidence in their synthesis of common sense science and the Bible.

3. Two key documents from 1616 would later play a critical role in Galileo's trial: an unsigned notary document, and an affidavit given to Galileo from Cardinal Bellarmine. How does Drake reconstruct the events of 1616, based upon inquisition minutes and the assumption of the authenticity of these two documents?

4. Galileo and the Jesuits:

•What went wrong with Galileo's relationship with Christoph Scheiner, a Jesuit mathematician and astronomer? Generally speaking, the Jesuits were highly trained in mathematics and astronomy. Were Galileo's relations with other Jesuits always similarly strained?

•In what sense was the controversy over the comets of 1618 related to the power of new mathematical methodologies?

•*Optional:* Discuss the Janux video: 13.3 The Galileo Affair (9:30 mins). [http://youtu.be/IBvZfkvjbo?list=PLTve54sz-eh\\_P29Sbbv\\_j3bC97OFaArOd](http://youtu.be/IBvZfkvjbo?list=PLTve54sz-eh_P29Sbbv_j3bC97OFaArOd) Compare Magruder's and Drake's interpretations.

7. Discuss the following paragraph:

"One of the most pressing questions for science today is how to facilitate interdisciplinary collaboration. The history of science offers a continuous account of case studies, pro and con, for how disciplines emerge, collaborate, compete, and adapt to new problem sets and methodologies. A perennial challenge for multidisciplinary problems at emerging research fronts is the underestimation by traditional practitioners of new methodologies and approaches. The greatest resistance to Copernicus and Galileo came from physicists and others who underestimated the power of new mathematical methodologies. Physicists and theologians alike were unprepared to recognize the potential of mathematical arguments for the motion of the Earth. From Copernicus to Galileo, mathematicians were challenging the established and reputable domains of physics and theology, both of which had to learn to adapt to the knowledge claims of the new mathematical science. More than a simple battle of science versus religion, mathematicians like Copernicus and Galileo were battling for the unexpected reach of mathematics compared with traditional methodologies."

# Discussion Guide

## Stillman Drake, Galileo: A Very Short Introduction

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### Discussion 6: Ch. 5, The Dialogue and the Inquisition

1. Galileo wrote the *Dialogo* (1632, *Dialogue on the Two Chief Systems of the World*) in a literary form. Would you describe it as a textbook for the new science? Why or why not? The OU copy of the *Dialogo* contains marginal corrections and annotations handwritten by Galileo.



2. In the *Dialogo*, how did Galileo attempt to prove Copernicanism based upon the tides? Did his argument work? (Does Drake seem overly sensitive to defend Galileo's reputation on this point? Cf. pp. 91-93.)

3. How does Drake reconstruct the circumstances of Galileo's trial? How did the two key documents examined in the previous chapter (an unsigned notary document, and an affidavit given to Galileo from Cardinal Bellarmine) pertain to the *Dialogo*?

4. One often hears that Galileo was a heretic. According to Drake, was this an accurate characterization, or is it a common misconception? Was Galileo charged with heresy? If not, what was the official charge, and how did it differ from heresy? If not heresy, then to what charge did Galileo plead guilty?

5. What went wrong with theologians and the Church? Does the Galileo affair represent an inevitable conflict between science and religion? How might it have been avoided?

6. Discuss the Janux video: 13.4 Galileo, Interpretation (5:08 mins).

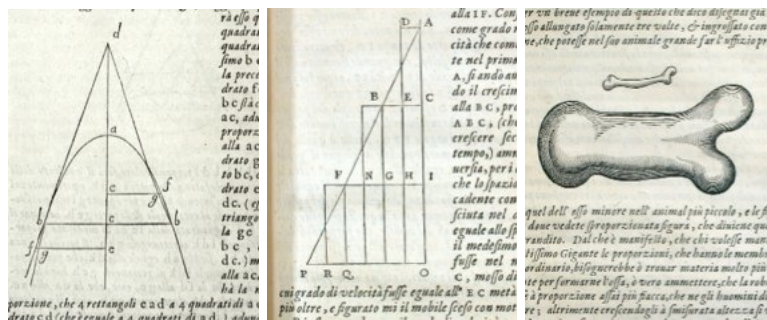
[http://youtu.be/Os8Tujj2358?list=PLTve54sz-eh\\_P29Sbbv\\_j3bC97OFaArOd](http://youtu.be/Os8Tujj2358?list=PLTve54sz-eh_P29Sbbv_j3bC97OFaArOd)

# Discussion Guide

## Stillman Drake, Galileo: A Very Short Introduction

### Discussion 7: Ch. 6, The Final Years

1. How are Galileo’s “two new sciences” connected with other disciplines? What was the significance of Galileo’s masterwork in physics, the *Discorsi* (1636; *Discourse on Two New Sciences*), which developed the sciences of tensile strength and motion? How does this work represent a culmination of Galileo’s work over many decades? How did it lay a foundation for later advances in mathematical physics? Tensile strength encompassed questions about the structure and cohesion of matter, the breaking limits of engineered structures, and even the proportions of the bones of giants compared with those of a human of ordinary size! The new science of motion, or *kinematics*, presented the law of free fall, the parabolic motion of projectiles, and an analytical principle of the independent composition of motion.



2. Many of Galileo’s contemporaries assumed that various disciplines are linked organically, or at least should be coordinated, in a broad enterprise of natural philosophy. On p. 113, Drake writes that until Galileo’s time, “science had been the handmaiden of philosophy, which in turn was the handmaiden of theology. He wished to free science from subservience to philosophy....” What do you make of this statement? Given the prevalent conflicts between the mathematicians and natural philosophers, might we also regard “science” as too broad, and note that mathematics (including astronomy) was the handmaiden of natural philosophy (or physics), just as physics was the handmaiden of philosophy and in turn philosophy of theology? Is it possible to understand the story of Galileo, or of 17th-century science in general, without grasping something of the integrated nature of an encompassing “natural philosophy”? Did much of the controversy underlying the Galileo affair reflect Galileo's attempt to break the mathematical disciplines free of the need to be coordinated with the methods of other sciences, particularly physics and theology? Does the Galileo affair then raise the question: How can different disciplines interact without inappropriately influencing one another? Might historical study of episodes like this help us gain insight for facilitating the interdisciplinary collaboration that is often needed today?



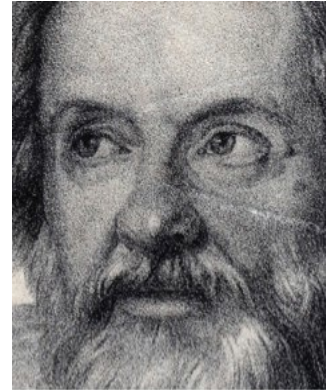
## Discussion Guide

### Stillman Drake, Galileo: A Very Short Introduction

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Discussion 8: Dive Deeper... Where do we go from here?

Stillman Drake was a prominent Galileo scholar. His “Very Short Introduction” remains an accessible introduction to Galileo. Yet although this little book is an effective “first word” about Galileo, it is hardly the “last word,” since the scholarly literature about Galileo has grown considerably since the first edition of Drake’s little book was published in 1983. Incidentally, Drake has a connection to the OU Galileo collection. Five of the Galileo first edition copies at OU were touched by Galileo’s hands, and also by Drake’s. We know this because four of them display handwriting authenticated as Galileo’s by none other than Drake. The fifth is a proof copy of *Il Saggiatore* (1623), which does not contain any annotations, but was owned by Drake himself before being acquired by OU.



1. Survey the gallery titles for Galileo’s World and note the “Big Ideas” associated with each gallery ([oulynx.org](http://oulynx.org), search for “Galleries”). Has reading Drake’s “Very Short Introduction” to Galileo given you some idea of what to expect in these galleries? Which galleries have been touched upon by Drake, and which galleries seem to promise something new and unexpected, largely omitted in Drake’s brief account?
2. What does Galileo mean today? How does the story of Galileo shape popular culture?
2. Read the online **Timeline**. How does it differ from or complement Drake’s account?
3. Look at the flowchart in the **Dive Deeper** handout. Which book would you most like to read next?
4. Explore some of the online resources and watch some of the videos listed in the appendix. See the Janux videos listed on the last page, or the “Works of Galileo: A Guided Tour,” a 1-hr tour of the OU Galileo collection, as if you were to go behind the scenes and see the books in the History of Science Collections vault. The video is also broken down into multiple shorter excerpts which may be watched one at a time.

Coming soon: Galileo’s works will be available in the OU Libraries repository, and in the *Galileotheka* project of the Museo Galileo.

## Read Galileo in English

- Maurice Finocchiaro, The Essential Galileo (Hackett, 2008)
- Galileo, Operations of the Geometrical and Military Compass, trans. Stillman Drake (Dibner Library Publication, Smithsonian Institution, 1978)
- Galileo, Sidereus Nuncius, trans. Albert Van Helden (University of Chicago, 1989)
- Galileo, Discourse on Bodies in Water, trans. Stillman Drake (Urbana, 1960)
- Galileo, On Sunspots, trans. Eileen Reeves and Albert Van Helden (University of Chicago Press, 2010)
- English translations of Galileo's "Letter to Castelli" and "Letter to the Grand Duchess Christina," are in Maurice Finocchiaro, ed., The Galileo Affair (Berkeley: University of California Press, 1989).
- Galileo, *Il Saggiatore*, in The Controversy on the Comets of 1618, trans. Stillman Drake and C. D. O'Malley (University of Pennsylvania Press, 1960)
- Galileo, Dialogue on the Two Chief World Systems, trans. Stillman Drake (Modern Library, 2001).
- Galileo, Discourse on Two New Sciences, trans. Stillman Drake (Wall & Thompson, 1989)
- Galileo, Discoveries and Opinions of Galileo, ed. Stillman Drake (Anchor, 1957)