

# The Scientific Process: An Example from Biology

## Problem Solving Series

### *Instructor's Guide*

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DEVELOPED BY THE TEACHING AND LEARNING LABORATORY AT MIT  
FOR THE SINGAPORE UNIVERSITY OF TECHNOLOGY AND DESIGN



# Introduction

## When to Use this Video

- In SOPH 304, at home or in recitation, before or after lectures discussing important historical experiments and discoveries (e.g., Lectures 6 and 7 on Heredity). Also, in any introductory course in which the scientific method is discussed and/or practiced (e.g., CHEM 101).
- Prior knowledge: familiarity with the scientific method and its central role in the investigation of scientific phenomena.

## Key Information

*Duration:* 13:06

*Narrator:* Prof. Adrian Lee

*Materials Needed:*

- paper
- pencil

## Learning Objectives

After watching this video students will be able to:

- Describe the general steps of the scientific method.
- Recognize the complex and multi-faceted nature of the scientific process.
- Explain how the discovery of *Helicobacter pylori* and its connection to peptic ulcer disease exemplifies key aspects of the scientific process.

## Motivation

- The scientific method is frequently introduced to students in the form of a sequential checklist. In reality, scientists do not follow a fixed series of steps, but instead take a highly iterative approach in their own research.
- While the scientific method is at the heart of every major scientific discovery, this example will help students understand that there are several other internal and external factors that also contribute to the overall process of scientific inquiry.

## Student Experience

It is highly recommended that the video is paused when prompted so that students are able to attempt the activities on their own and then check their solutions against the video.

During the video, students will learn about the iterative nature of scientific investigation by “dissecting” an important concrete medical example.

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## Video Highlights

This table outlines a collection of activities and important ideas from the video.

Time	Feature	Comments
01:40	Prerequisite Knowledge and Learning Objectives	
02:11	Chapter 1: The Scientific Method	Brief review of the scientific method.
02:20	Student Activity	Recall specific steps of the scientific method
03:12	Chapter 2: The Helicobacter Story	Adrian Lee introduces Robin Warren and Barry Marshall and the discovery that provides the context for the rest of the video.
07:01	Marshall drinks bacteria!	Marshall uses himself as a test subject.
09:25	Chapter 3: The Scientific Process In Action	This segment identifies various reasons for Warren and Marshall's scientific success.
09:46	Student Activity	Identify the steps of the scientific method used by Warren and Marshall in their process of discovery.
10:37	Student Activity	Identify other factors which contributed to Warren and Marshall's success.
12:25	To Review	
12:44	Inspirational quotes from Barry Marshall and Robin Warren	

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### Video Summary

This video provides a brief, factual account of the groundbreaking work of Robin Warren and Barry Marshall and their discovery of the bacterial cause of peptic ulcer disease. Their story is a concrete example of the “Scientific Process” in practice. It illustrates that although the scientific method is often presented as a didactic list of steps, there is no one fixed sequence of events that occurs in order for important scientific discoveries to be made.

# Soph 304 Materials

## Pre-Video Materials

When appropriate, this guide is accompanied by additional materials to aid in the delivery of some of the following activities and discussions.



1. The scientific method is used all the time to investigate new knowledge and to revise existing knowledge. Students may have applied the scientific method (or parts of the scientific method) to various classroom and laboratory problems, for example, in an engineering design project, or in a chemistry lab module. Ask students to identify the steps involved in the scientific method based on their own experiences. Discuss why the scientific method is so important in scientific discovery and problem-solving.



2. *Childbed Fever: A Medical Mystery* is a short case study with relevant discussion prompts to help students review the important steps of the scientific method using a progressive disclosure method. That is, Part I, II, and III of the case (see reference below) should be given to students piece-wise, with substantial time for discussion in between. Students should work in pairs to answer the discussion questions before reconvening for a whole group discussion. The case will require about 30 to 40 minutes to conduct in small groups.



Case study reference: Colyer, C. *Childbed fever: a nineteenth-century mystery* [PDF document]. Retrieved from: National Center for Case Study Teaching in Science website: [http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case\\_id=429&id=429](http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=429&id=429).

## Post-Video Materials



1. Continue with Part IV of the case study, “Childbed Fever: A Medical Mystery” (see reference above). Students should work in pairs to answer the discussion questions before reconvening for a whole group discussion.



2. After watching the video, introduce the following discussion questions:

- What are some of the ethical concerns about Marshall’s decision to use himself as a test subject and swallow a sample of *Helicobacter pylori*? Would you do it? Why or why not?
- Robert Koch established four criteria, also known as “Koch’s postulates”, which must be fulfilled for a pathogen to be considered the cause of a disease. For each of the four criteria listed below, discuss whether or not Warren and Marshall met them and, if so, how.

- The pathogen must be found in diseased animals but not in healthy ones.
- The pathogen must be isolated from the diseased animal and cultured outside the body.
- The cultured pathogen must produce the disease in an experimental animal.

IV. The same pathogen must be re-isolated from the experimental host and identified as being the same as the original pathogen.

- (c) Why was Warren and Marshall's discovery significant? Do you think it is worthy of a Nobel Prize? What lessons can be learned from their story?
- (d) Describe how the following quote applies to Warren and Marshall's story:  
"Discovery consists of seeing what everybody has seen and thinking what nobody has thought." - Albert Gyorgyi, 1937 Nobel Laureate in Physiology and Medicine

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# Additional Resources

## Going Further

A clear, logical progression of thinking and method of working is crucial to successful experimentation, whether one is a chemist, a doctor, an engineer, or a computer scientist. The Scientific Method provides an objective, standardized approach for investigating phenomena and acquiring new knowledge. Now that students have a good general understanding of the scientific process, they should seek to acquire and practice the skills associated with each individual step (e.g., data analysis, experimental design, data presentation).

## References

The following article motivates the discussion of the Scientific Process and common student difficulties:

- Duncan, D.B., Lubman, A., Hoskins, S.G. (2011). Introductory Biology Textbooks Under-Represent Scientific Process. *Journal of Microbiology & Biology Education*, 12(2), 143 -151.

The following article describes the work of Ignaz Semmelweis on childbed fever:

- Colyer, C. *Childbed fever: a nineteenth-century mystery* [PDF document]. Retrieved from: National Center for Case Study Teaching in Science website:  
[http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case\\_id=429&id=429](http://sciencecases.lib.buffalo.edu/cs/collection/detail.asp?case_id=429&id=429).

The following resources provide details on the discovery of *Helicobacter pylori*:

- Blaser, M.J. (1996), The bacteria behind ulcers. *Scientific American*. 104-107.
- Lynch, N. (2005), *Helicobacter pylori and ulcers: A paradigm revised* [PDF document]. Retrieved from: Federation of American Societies for Experimental Biology website:  
<http://www.faseb.org/portals/0/pdfs/opa/pylori.pdf>.
- Meuler, D.A. (2011), *Helicobacter pylori and the bacterial theory of ulcers*. *National Center for Case Study Teaching in Science*.

For a well-written and interesting personal account of the discovery of *Helicobacter pylori*:

- Marshall, B.J. *Barry J. Marshall - Biographical*. Retrieved from: Nobelprize.org website:  
[http://www.nobelprize.org/nobel\\_prizes/medicine/laureates/2005/marshall-bio.html](http://www.nobelprize.org/nobel_prizes/medicine/laureates/2005/marshall-bio.html).

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