Teaching Molecular Biology with the Historical Accounts in *The Eighth Day of Creation*

Elizabeth A. Morton, M. Bryce Taylor

**Abstract**

The Eighth Day of Creation is a narrative history of molecular biology by science journalist Horace Freeland Judson. It uses first-person interviews to tell the story of how scientists in the mid-20th century discovered the basic rules of life that we now call the Central Dogma. The book presents both an in-depth analysis of the foundational research and a look into the lives of the scientists involved. We used this book as the primary text for an advanced undergraduate seminar course at the University of Washington in winter 2020, a class designed to help students critically think about approaches to science, the role of social factors in scientific progress, and the conceptual development of paradigm shifts. In this piece we reflect on our approach designing the course and our experience teaching it and share our syllabus (annotated with some reflections on the course) as inspiration for others.

**Key Words:** molecular biology; nature of science; philosophy of biology; history of science; history of biology; genetics; heredity; molecular genetics.

**Introduction & Motivation for the Course**

Molecular biology was presented in our science courses as a set of conclusions (e.g., the Central Dogma is ...), without deep exploration of the experiments that allowed scientists, over the course of decades, to come to these conclusions. In our experience, this historical format can lead to the misrepresentation of science as a linear progression of discovery. It omits the technical and conceptual challenges faced by scientists, the misdirection of intellectually attractive but unsupported hypotheses, and the role of social forces and institutions in shaping our views. It also leaves out the human element of being a scientist—the self-doubt and uncertainty that accompany scientific investigation, the excitement of a new discovery, and the many different personal approaches to exploring the mystery of life that suggest there is no single “right” way to do science.

The Eighth Day of Creation is a narrative history of molecular biology chronicled by science journalist Horace Freeland Judson in the sixties and seventies (H. F. Judson, 1979). The book details the molecular revolution—the short period during the mid-20th century in which scientists began explaining life in mechanistic terms, what we now call the central dogma. Over the course of a decade (O. Judson, 2013), Judson conducted lengthy interviews with over a hundred scientists (H. F. Judson, 1979), including Francis Crick, Linus Pauling, James Watson, Jacques Monod, Matthew Meselson, and Sydney Brenner. Much of the text is direct quotes, presenting insight into the personalities behind textbook names and allowing these scientists to explain their discoveries and their thought processes at the time (Peifer, 2020). This work has been lauded as one of the first to approach science history from a journalistic perspective (Marchant, 2018; O. Judson, 2013; Pontin, 2011).

After reading the book as postdocs, we both came away wishing we had done so earlier in life. We wondered how it would have impacted our early-life navigation in science. While not universally true, our personal educational experience included only rare instances of historical or personal context for biological discoveries. How did early scientists conceptualize the gene and its function before molecular biology was formalized? How were early results misinterpreted due to preconceptions of the time? How did the personal experiences of scientists contribute to their great discoveries? How did political and social events influence the course of science? These were the details provided in *The Eighth Day of Creation* that captured our attention.

We set out to develop the course we would have liked to take. The experience was gratifying, and we felt like it had a positive impact on our students. To our knowledge this book is rarely if ever used as a course text in modern classes. In conversation with colleagues we (anecdotally) have found that while senior faculty frequently recognized the title immediately, most in our peer group and younger did not. For these reasons we wanted to share our experience with others and promote the book as a useful resource in biology education.

*The American Biology Teacher,* Vol. 84, No. 1, pp. 45–49, ISSN 0002-7685, electronic ISSN 1938-4211. © 2021 by The Regents of the University of California. All rights reserved. Please direct all requests for permission to photocopy or reproduce article content through the University of California Press’s Reprints and Permissions web page, https://www.ucpress.edu/journals/reprints-permissions. DOI: https://doi.org/10.1525/abt.2022.84.1.45.

Central Dogma of Molecular Biology, Francis Crick, copyright 1970. Reprinted by permission from Springer Nature Customer Service Centre GmbH: Springer Nature, Nature.
Course Structure & Reflection

We structured the course around group discussion. Each week students were assigned 30- to 50-page reading excerpts from the text and a choice of prompting questions to which they had to write a short response (Table 1).

We tried to make these questions open-ended and thought-provoking (with mixed success!). Each week during class, we opened with a paired effort then group effort to generate a timeline of the events covered in the week’s reading (Figure 1).

These were frequently followed by diagramming of the more technical aspects of any benchmark experiments up for discussion that week (Figure 2).

Table 1. Course schedule and The Eighth Day of Creation reading list.a

|   | Topic | Assigned pages | Writing prompt                                                                 |
|---|-------|----------------|--------------------------------------------------------------------------------|
| 1 | What is molecular biology? | NA | NA                             |
| 2 | Biology before it went molecular | 27–41, 50–61 | Crick talks about boldness versus caution in terms of scientific approach. What are the benefits of each? Are there types of research or stages in the development of an idea that benefit most from one or the other? |
| 3 | Pursuing the molecular basis of the gene | 94–104, 108–14, 118–29, 133–38, 141–44 | On page 94 Chargaff offers the comment "To the scientist nature is as a mirror that breaks every thirty years." What did he mean by that? Would you agree? If so, would you consider that a feature or a bug of the scientific process? |
| 4 | The structure of DNA | 147–86, 196–98 | There were a number of wrong turns and incorrect models put forward before Watson and Crick proposed the double helix structure. What do you think the multiple incorrect models proposed reflect? • The hurried nature of the research (the perception of a competition) • The difficulty of the problem • The nature of all science (faulty models don’t get as much press) • Other aspects of the story |
| 5 | Difficulties posed by RNA | 186–95, 225–28, 233–34, 248–82 | Pages 193–194 includes discussion about competition: whom Watson saw himself as competing with, opinions on whom he was really competing with, and Watson’s assertion that competition is “the dominant motive” in science. Do you agree with Watson’s statement? What role do you think competition plays in the advancement of science, and is this to science’s benefit or detriment? |
| 6 | The Central Dogma | 333–38, 344, 346–47, 348–84 | Had you heard of Lysenko and the movement of Soviet Science during this time period? What surprised you in the segments that covered his work and influence? |
| 7 | Gene regulation and the lac operon | 384–424 | One of the prevailing ideas at the time was that rRNA was the messenger and ribosomes (as made of protein + rRNA) were specific for specific gene products. Does the eventual overturning of this idea with the discovery of mRNA count as a revolution? Do any of the revelations in this section (the idea of regulation of expression, the PaJaMo experiment, etc.) count as revolutions in biology? What makes a discovery revolutionary? |
The bulk of class time was then devoted to open-ended discussion, paired or whole-group, of more personal reactions to aspects of the text. The majority of a student’s grade was determined by discussion participation. Each class ended with a brief, informal student presentation reviewing a biological concept that might help them better understand the next week’s reading (e.g., “what is lysogeny?” before we dove into Lwoff and Jacob).

Our course was scheduled to meet 2 hours per week for 10 weeks. To fit this limited timeframe and credit load, we cut the 618-page book approximately in half, assigning excerpts instead of full chapters (Table 1). We worried about this abridgement but feel we were able to hit the highlights and give students a condensed but useful experience. Each week we provided feedback on writing assignments in the form of our responses both to the students’ thoughts as well as their writing styles, in the hope of helping them strengthen their writing skills. Students were then encouraged to reuse segments from their (revised) weekly writing assignments in their final essay.

Over the course of the quarter, we shifted much of the explanatory load onto the students. For example, in later class periods we had the students diagram important experiments on a whiteboard.
Mutations are spontaneous. DNA is the heritable material. Alfred Hershey & Martha Chase further Salvador Luria & Max Delbrück
The central dogma describes DNA replication follows a Event Francis Crick, Rosalind Franklin, James Francisco
Matt Meselson & Franklin Stahl reveal Marshall Nirenberg & Johann Matthaei Conclusion or Relevance

Table 2. List of select landmark discoveries and personal reflections described in The Eighth Day of Creation.

| Category             | Event                                                                 | Pagesa          | Conclusion or Relevance                      |
|----------------------|-----------------------------------------------------------------------|-----------------|---------------------------------------------|
| Key experiment       | Salvador Luria & Max Delbrück perform the fluctuation test (1943).  | 50–53, 55–57    | Mutations are spontaneous.                  |
| Key experiment       | Alfred Hershey & Martha Chase further demonstrate DNA is the heritable material (1952). | 130–31          | DNA is the heritable material.              |
| Key experiment       | Francis Crick, Rosalind Franklin, James Watson, & Maurice Wilkins show the structure of DNA (1953). | 102–4, 108–14, 135–36, 153–54, 156–61, 164–66, 171–75a | DNA is a double helix.                     |
| Key experiment       | Matt Meselson & Franklin Stahl reveal semiconservative DNA replication (1957). | 187–92          | DNA replication follows a semiconservative model. |
| Key experiment       | Marshall Nirenberg & Johann Matthaei demonstrate a solution to the coding problem (1961). | 470–72, 476–78, 480–82 | The first specific mRNA codon was identified for an amino acid. |
| Key theoretical advance | Francis Crick proposes the Central Dogma (1957). | 333–38          | The central dogma describes the flow of information in a cell. |
Acknowledgements

We thank Katherine Xue for introducing us to the text and Charles Laird for encouraging us to design a course around it. We thank Clara Amorosi, Abigail Keller, and Chris Large for comments on our selected reading list. We thank Katherine Xue for helpful comments on an early draft of this piece. Lastly, we would like to thank the students of our winter 2020 class, both for taking a chance on a brand new course and for their engagement and enthusiasm that made teaching it so enjoyable.

References

Crick, F. (1970). Central dogma of molecular biology. Nature, 227, 561–63. https://doi.org/10.1038/227561a0.
Judson, H. F. (1979). The Eighth Day of Creation, 1st ed. New York, NY: Simon and Schuster.

Judson, O. (2013). Growing up with The Eighth Day: a reminiscence. In H. F. Judson, The Eighth Day of Creation, commemorative ed. (pp. xv–xvii), Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
Marchant, J. (2018). The best biology books recommended by Sean B Carroll. Five Books. https://fivebooks.com/best-books/biology-sean-carroll.
Peifer, M. (2020). The Eighth Day of Creation: looking back across 40 years to the birth of molecular biology and the roots of modern cell biology. Molecular Biology of the Cell, 31(2), 81–86. https://doi.org/10.1091/mbc.E19-11-0619.
Pontin, J. (2011). Horace Freeland Judson Obituary. In H. F. Judson, The Eighth Day of Creation, commemorative ed. (pp. xiii-xiv), Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

ELIZABETH MORTON is a research scientist in the Department of Genome Sciences at the University of Washington, Seattle; e-mail: emorton@uwashington.edu. BRYCE TAYLOR is an assistant professor in the Department of Biology at Loras College, Dubuque, IA. He was formerly an acting instructor in the Department of Genome Sciences at the University of Washington, Seattle; e-mail: bryce.taylor@loras.edu.
SESSION PROPOSAL DEADLINE:
MARCH 15, 2022

LEARN MORE
nabtconference.com

NABT
INDY
November 10-13, 2022
JW Marriott Indianapolis