Textbook Review: **OpenStax Biology**

Reviewed by Bianca Breland

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**The textbook:**

OpenStax ©1999-2017, Rice University
Main website: [https://openstax.org/](https://openstax.org/)
Direct link to Biology content: [http://cnx.org/contents/185cbf87-c72e-48f5-b51e-f14f21b5eabd@10.99](http://cnx.org/contents/185cbf87-c72e-48f5-b51e-f14f21b5eabd@10.99)
Last revision: 02/07/17

Full citation (Biology):

Summary (copied verbatim from website): “Biology is designed for multi-semester biology courses for science majors. It is grounded on an evolutionary basis and includes exciting features that highlight careers in the biological sciences and everyday applications of the concepts at hand. To meet the needs of today’s instructors and students, some content has been strategically condensed while maintaining the overall scope and coverage of traditional texts for this course. Instructors can customize the book, adapting it to the approach that works best in their classroom. Biology also includes an innovative art program that incorporates critical thinking and clicker questions to help students understand—and apply—key concepts.”

Off-line access:
--can download pdf version for offline reading and/or printing
--offline HTML copy is available (media and support files available when working offline)

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**Using OpenStax Biology text in my BIO 100 (Perspectives in Biology) course:**

In BIO 100 I am charged with teaching students how scientific knowledge is generated; beyond that, the content is largely up to me. My expertise is in evolutionary biology and genetics, so my version of BIO 100 is heavy on these topics and touches only briefly on other avenues of biological science as they are relevant to case studies or extensions on that central focus. I much prefer this approach over a more typical intro-biology curriculum which surveys all avenues of biological science and therefore must sacrifice depth (and nuanced understanding) for breadth.

There is no textbook that I have yet found that does a decent job of putting the method (how science is done) front and center—at best, there may be half a chapter on hypothesis-testing as a mode of inquiry plus occasional “boxes” (read: asides) that highlight application of the method in key historical experiments. Since most or all textbooks focus on breadth of content instead of context, and because my course would make use of just a few chapters of that content, I don’t ask students to purchase a standard textbook at all. Instead, they read two books on evolutionary biology, one by a science journalist and one by a professional scientist writing for the general public. I supplement the case studies, history of discovery, and contextualization provided by these books with articles from the primary literature.
Although the books and articles I employ in class serve my pedagogical aims better than a standard textbook, there are some places in the course where I must introduce new terminology and outline fundamental mechanisms—content for which standard textbooks offer the best reference/review/study material. Any of a handful of widely used (paper) textbooks would suffice, but—again—I would use just a few of the many chapters. Asking students to pay large sums for a textbook they would hardly use seems unjustified. Also, the web offers innumerable resources that explain the fundamentals (Wikipedia, websites published for other college-level courses but made available to a global audience, other sources). Websites, though, vary widely in the depth, complexity, the use of discipline-specific jargon, and accuracy. To help students access the resource material I think they need, I could curate a list of useful websites I find appropriate, or I could offer an on-line textbook. The latter option saves me time, plus should provide a consistent “voice” and a linear, accessible presentation of college-level content. I chose OpenStax (the last time I taught BIO 100, in the Fall of 2015) because at the time it was the only open textbook of which I was aware.

I review the OpenStax textbook with respect to several characteristics. These are named and defined in bold font, and my review follows. The first 10 characteristics, plus their definitions, are taken verbatim from the Open Textbooks Review Criteria developed by BCampus. The last three items are my own additional criteria I hope to apply in choosing a textbook appropriate to the unique format of my own course.

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**OpenStax Textbook Review:**

1. **Comprehensiveness**—The text covers all areas and ideas of the subject appropriately and provides an effective index and/or glossary.

The eight chapters span biological science at all levels, from biological molecules through cell structure and function, genetics, evolution and the diversity of life, plant and animal anatomy and physiology, and ecology. I detect no serious omissions. The Table of Contents, linked in the header, is easy to access from anywhere at any time. Chapter titles in the Contents can be expanded, and this option is useful for finding specific material, presuming the user has a general understanding of biological organization. Each chapter section (i.e., subchapter) has its own glossary, and the terms in the glossary correspond to terms that are highlighted in bold font in the text proper. Unfortunately, the highlighted terms do not link to the glossary, so the user must scroll down to look up a word, then scroll back up to the text to resume reading.

A search field in the header can be used to produce a list of all uses of a word or phrase in the textbook—the search bar functions as an index but is not particularly helpful for quick look-up of a definition. The search bar is perhaps too good at finding a term in the textbook, as it offers so many options (every occurrence of the term rather than only those pages where the term is a key part of the content) that the user will be overwhelmed with options and uncertain where to find the information s/he needs.

2. **Content Accuracy**—Content is accurate, error-free and unbiased.

Flaws exist at a rate considerably higher than standard textbooks. Parts of the text are contradictory. For example, the intro states clearly that proof is rare in biology, and then a summary statement about an experiment says scientists “proved” that DNA was the transforming principle (section 14.1). Precision of
language is often wanting. For example: “viruses, like the flu...” (Section 19.1, Everyday Connection box) should read: viruses, like *Influenza sp.*, which cause the flu.... Or: “Evolution of these viruses means continued adaptions to ensure survival, including adaptations to survive previous vaccines” (Section 19.1, Everyday Connection box), which is entirely wrong in more ways than one. Non-random mating is partly defined correctly and partly conflated with sexual selection (Section 19.2). I find these errors particularly jarring because they are typical of the misunderstanding students bring to class in the first place, the kind of misinterpretation of evolutionary principles I try so hard to undo. Oddly, most of the main text of a chapter can be clear and correct, and then another separate paragraph applying the same principles, a “boxed” example, or a section summary, can err. Section Summaries can so oversimplify a concept as to border on inane. For example: “DNA was first isolated from white blood cells by Friedrich Miescher, who called it nuclein because it was isolated from nuclei” (Section 14.1). My guess is there is a too-many-authors problem, and that some pieces are not written by specialists in the chapter’s topic.

The more I dig deep into this text to accomplish this review, the more errors I uncover. Here’s one that the authors should catch no matter how well they understand the content, from the legend of Figure 3 in section 11.1, a schematic drawing demonstrating the multiple meiotic products possible from independent assortment in a diploid cell with two sets of homologous chromosome (n=2). “The total possible number of different gametes is $2^n$, where $n$ equals the number of chromosomes in a set. In this example, there are four possible genetic combinations for the gametes. With $n = 23$ in human cells, there are over 8 million possible combinations of paternal and maternal chromosomes.”

I am not alone in this complaint: of the 19 reviews of OpenStax Biology provided on the Open Textbook Library (https://open.umn.edu/opentextbooks/BookDetail.aspx?bookId=167), most reviewers find errors, some of them as disconcerting to them as the errors I’ve identified have been to me (likely because they were found in the reviewer’s area of expertise).

If bias exists, it is in favor of the well-worn textbook examples. There are no novel illustrative examples in this text—which, given its brevity and its intended general audience, is to be expected.

3. **Relevance Longevity**--Content is up-to-date, but not in a way that will quickly make the text obsolete within a short period of time. The text is written and/or arranged in such a way that necessary updates will be relatively easy and straightforward to implement.

Barring wholesale upending of biological science, the relevance is fine. The basic content is not dissimilar from any standard textbook I have used since I was an undergraduate myself. Some examples given are fairly contemporary, such as multiple references to our current understanding of HIV. These would warrant updating if some other issue became a more pressing concern and were as widely studied, but although our understanding of biology is likely to progress, very little is likely to be rewritten. The molecular (DNA, etc.) tools of biological science progress so rapidly that these should be updated frequently. The text here explains techniques that have been in wide use for several years, but not major recent breakthroughs like CRISPR technology.

4. **Clarity**--The text is written in lucid, accessible prose, and provides adequate context for any jargon/technical terminology used.

The text is very easy to read, and complex grammatical structures are avoided. New vocabulary are highlighted in bold font in a sentence which defines the term (usually in the first mention or a few lines
down from its first usage in the text), and the definitions are in clear language. Short paragraphs refine the definition of a term and put it into context. Because the text is short compared to standard textbooks, definitions follow one after the other in rapid succession. Mastery of any term would require rereading or (better) additional sources to provide deeper context than this text provides. The order of introduction of new vocabulary is sometimes odd—terms are occasionally used well in advance of when the definition is provided. Careful reading and rereading of the text would be required for full understanding (which is fine: students should be rereading anyway).

The organization of chapters follows the levels of organization of life (molecules, cells, individuals, species, communities), which provides a fairly linear and accessible “enlarging” of perspective from one chapter to the next.

Clarity of writing does not equal precision, however, and some definitions are flawed for lack of nuance. For example, the excerpt below (from the section introducing meiosis) has a number of inaccuracies. Bracketed, italicized text is my own:

Most animals and plants are diploid, containing two sets of chromosomes. In each somatic cell of the organism (all cells of a multicellular organism except the gametes or reproductive cells, the nucleus contains two copies of each chromosome, called homologous chromosomes [not quite: reproductive cells of the germline are also diploid; only after the first meiotic division of these cells occurs are gametocytes haploid]). Somatic cells are sometimes referred to as “body” cells. Homologous chromosomes are matched pairs containing the same genes in identical locations along their length. Diploid organisms inherit one copy of each homologous chromosome from each parent; all together they are considered a full set of chromosomes [“they” refers to what exactly?: the contribution from a single parent, or the combined contributions that make up the genome of the offspring?]. Haploid cells, containing a single copy of each homologous chromosome, are found only within structures that give rise to either gametes or spores [no: some whole organisms are haploid and multicellular]. Spores are haploid cells that can produce a haploid organism or can fuse with another spore to form a diploid cell [no: by definition, spores can divide and grow into multicellular haploid organisms; only gametes can fuse with another gamete to form a diploid cell]. All animals and most plants produce eggs and sperm, or gametes [all plants produce gametes in every other generation, except those that multiply by vegetative growth]. Some plants and all fungi produce spores [all plants produce spores in every other generation, except those that multiply by vegetative growth; fungi at some point in their life cycle do make gametes, although this is not their main form of reproduction].

The same paragraph suffers from a “staccato” tone that detracts from a logical flow. The first mention of and definition of homologous chromosomes is followed by a definition of somatic cells which is then followed by a clarification on the definition of homologous chromosomes. Although grammatical simplicity aids naïve readers (and especially those whose first language is not English), jumping from definition to definition and back again aids no one.

5. Consistency--The text is internally consistent in terms of terminology and framework.

The structure of the chapters is consistent throughout. Introductory sections to each chapter give a brief overview, several subheadings are provided to break the text into clear concepts or steps in a process.
Sections summaries review the main points. All chapters are peppered with clarifying diagrams. Review questions follow each subchapter so students can check their understanding. A glossary is provided for quick study.

Terminology is consistent throughout the text, although (see Content Accuracy and Clarity sections above), the precision of the definition, spelled out or implied, varies among and sometimes within sections.

Supplementary materials (Links to Learning) are provided for some tricky concepts (photosynthesis, meiosis, genetic drift). These might take the reader to an article in a science-news journal, to a more in-depth “textbook” explanation with images or animations, or to an interactive tool. These all vary widely in simplicity of language, quality, and accuracy.

6. **Modularity**--The text is easily and readily divisible into smaller reading sections that can be assigned at different points within the course (i.e., enormous blocks of text without subheadings should be avoided). The text should not be overly self-referential, and should be easily reorganized and realigned with various subunits of a course without presenting much disruption to the reader.

Sections are small and correspond to what I might cover in a single lecture or two lectures, so reading assignments are easy to pair up with topics on a syllabus. Text is somewhat referential, but in ways that building up content/complexity/understanding would require. For example, meiosis references mitosis, which is logical—I’ve never seen a textbook that doesn’t do the same (and I find it hard to imagine how one might treat the division of sex cells without first explaining the division of cells generally).

It would pose little difficulty to assign chapters out of the order they’re presented here.

7. **Organization Structure Flow**--The topics in the text are presented in a logical, clear fashion.

For the most part, the organization is fine. In some places, terms are used before they are defined, but the definition comes soon enough to be useful. Occasional reference to preceding chapters occurs, but I have noticed no reference to succeeding chapters. The order in which vocabulary and concepts are presented follows a logical path students would need to follow to construct their understanding.

8. **Interface**--The text is free of significant interface issues, including navigation problems, distortion of images/charts, and any other display features that may distract or confuse the reader.

Links seem to reliably go where they should.

“Figure” links carry a reader back to an image earlier on the same page. When this happens, it’s hard for the user to go back to where s/he was before clicking the link. Often the link to a figure just says “Figure” rather than “Figure 2.3,” so the reader may be uncertain which figure is being referenced (or, if the Figure link is clicked, where the jump will land).

Some figures contain small details or small font, but the View Image function (accessed with a right-click on a PC) opens the image in a new tab and magnifies the image to fill more of the screen. Some figures are of too low a resolution, though, so zooming produces a blurred image.
Accessory interactive tools (“Links to Learning”) open a new tab, which allows the reader to simultaneously reference the text and practice the lesson.

Moving from section to section requires loading the “next” page, which is no problem unless the internet connection is slow. If pages are slow to load, this makes progress through a complete chapter or searching throughout the text for multiple references to a topic cumbersome (and frustrating).

9. Grammatical Errors--The text contains no grammatical errors.

I have noted few if any grammatical errors. Occasional pronouns are ambiguous about their antecedents.

10. Cultural Relevance--The text is not culturally insensitive or offensive in any way. It should make use of examples that are inclusive of a variety of races, ethnicities, and backgrounds.

I see nothing offensive. Examples of biological phenomena in the text involve various animals, plants, fungi, bacteria, viruses, etc. Human examples are rare but are treated with scientific detachment (as is appropriate). “Career Connections” boxes, where one might most hope to see inclusive imagery, avoid the issue entirely by speaking in generalities about the job instead of introducing the reader to a certain person with that job. For example, the Career Connections box on Immunologists (Section 5.1) describes what immunology is, what types of things immunologists do in their work, and what level of study (PhD or MD) and coursework it takes to become an immunologist.

11. The Scientific Method—The text includes a basic overview of hypothesis derivation, experimental design, statistical analysis, and inference, and then incorporates these elements throughout the text to elucidate example applications of the method and ways in which the method can be modified to fit particular circumstances.

The scientific process is given fairly short shrift in the introduction to the text. Since the writing is terse and condensed as a rule in the whole textbook, this comes as little surprise. The fraction given to the scientific method seems on par with standard (print) textbooks that I have used in the past.

The explanation of science as a branch of inquiry and as a process is circular. The brevity in combination with the circular reasoning is confusing. The difference between inductive reasoning and deductive reasoning is explained well, but the deductive if/then structure of hypothesis/prediction is flawed. Given that students struggle with this construction so much (even first-year majors stumble frequently here), the lack of clarity in the text on this matter is disappointing to say the least.

Later chapters include explanations of some key experiments in the advancement of our understanding of biology (for example, Mendel’s crosses with pea plants, the Hershey and Chase experiment identifying DNA as the genetic material), but these describe the experimental design, the outcome, and the resulting inference without referencing the hypotheses and predictions at all. The authors do not indicate “where” the pieces of an experiment they describe fit in the structure of the scientific method, nor do they reiterate whether they describe an inductive or deductive approach. These issues are sadly typical of many (most?) standard textbooks, so despite this (to me, fatal) flaw, this itself is no cause to abandon the OpenStax text.
12. **Student Self-assessment**—The text offers tools for students to gauge their own understanding of the textbook content. Ideally, these tools are interactive in some way.

Each chapter section ends with a few multiple choice review questions plus a few free-response questions. A “Show Solution” link is provided for each. The answer is provided with no additional information—no explanation for why the correct answer is right nor why the other options are wrong. Most standard textbooks now offer e-supplements with more interactive multiple choice review, and even end-of-chapter review questions with back-of-the-book answers give more explanation.

13. **Other Issues**

Links are often slow to load, including when moving from one subchapter to the next. The delay is very aggravating and likely to deter students from extensive reading or exploration of the material available to them.

Drawings in series or animations that are provided in supplementary Links to Learning are often (but not always) of low quality—too simplistic, often campy, and sometimes imprecise or inaccurate.

The OpenStax website claims to offer “an innovative art program that incorporates critical thinking and clicker questions to help students understand—and apply—key concepts.” I don’t know what they mean by “art program,” but images in the text are nothing special. If by clicker questions they mean the review questions at the end of each section, these could be adapted for use in the classroom but they are not innovative in the least, especially not when compared to the on-line supplements available through the major publishers.

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**Overall Estimation**

In addition to the cost-savings it provides students (as would any open textbook), the strengths of the OpenStax Biology text are its consistent easy-to-read tone and the fact that it offers readers ease of cross-referencing content, exploring supplemental learning aids, and self-assessment.

The problem with OpenStax Biology is the high frequency of substantive error in the text and supplements. Although students generally have a keen sense when to take on-line-only content with a grain of salt, by calling OpenStax Biology a textbook—and (regardless of what you call it), it does very much resemble a standard textbook in layout, language, and breadth—this skepticism is very likely to be put aside. The textbook label will inevitably suggest to students that they take the text as authoritative, the way they’ve always read textbooks. There is real danger here that students will adapt a wrong or imprecise understanding which, once present, becomes very difficult to undo.

I still intend to teach BIO 100 next Spring without a textbook again, and to assign readings from some on-line sources to bolster student understanding of fundamental terminology and biological processes. I would very much prefer to have that on-line reference material be consistent in tone and structure (what a textbook can provide but an assemblage of websites cannot), but I am unlikely to choose OpenStax Biology for that purpose again.