

## REVIEW

# Open Educational Resources for Neuroscience

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Open educational resources (OERs) promise to play an increasing role in making educational materials such as textbooks available to all and in helping to (slightly) mitigate exorbitant costs often associated with post-secondary education. True OERs provide the ability to use, distribute and even adapt available resources to fit with the needs of the user. Many other free resources often get lumped in with OERs but may have restrictions prohibiting specific forms of use, modification or distribution. In neuroscience, there is a growing collection of OER and open-access materials for

instructors to consider incorporating into their courses, ranging from textbooks and other books to entire courses, a single lecture or videos and animations. This paper briefly reviews two free online textbooks for neuroscience. Further, the available platforms for organizing and distributing OERs are outlined and briefly discussed, with an emphasis on their usefulness at the present time for neuroscience education.

*Key words: open educational resources (OER); textbook; free resources; open access*

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## WHAT IS AN OPEN EDUCATIONAL RESOURCE (OER)?

With the increasing cost of a college education in the United States, faculty and students alike are often searching for opportunities to help defray some expenses. One growing expense is the cost of college textbooks, which has risen in recent years topping out at an average of \$1298 for a year of books at a four-year university in 2019-2020 according to the College Board (2021). Further, a typical college textbook in STEM fields is consistently priced higher than books in the humanities, and while there are some reduced cost options available at times (e.g., used books, textbook rentals), these are not guaranteed, especially with the increasing use of publisher-owned software for additional course materials (with an additional fee). Faculty are increasingly looking for ways to reduce costs for students, thus embracing open educational resources to provide free learning materials and textbooks, and in doing so helping to provide equal access for all students.

Open educational resources (OERs) are defined as materials for teaching and learning, digital or otherwise, that reside in the public domain or have been released under a license allowing them to be accessed, used, modified, and redistributed with no restrictions (Sparks, 2017; UNESCO, 2021). These are often confused with other teaching and learning resources that may be accessed freely, or even shared freely with others, but which may not be adapted or modified in any way. Examples of OERs range from single videos or lesson plans to entire online courses, curriculums, or textbooks.

This paper seeks to highlight OERs and other open access neuroscience-related resources for use in a wide variety of neuroscience courses, with an emphasis on undergraduate neuroscience education. This article will intentionally include both forms of free resources (true OERs and open-access free but non-modifiable resources), as both can be useful to faculty seeking to provide resources to their students, or looking to find readily accessible, no or

low-cost enhancements for their teaching. All attempts will be made to distinguish between these two types of resources as they are discussed in this article. The Faculty for Undergraduate Neuroscience Summer Virtual Meeting in 2020 highlighted many lab-based resources for use, thus this paper will focus predominantly on non-lab resources. The emphasis will focus heavily on available neuroscience textbooks and platforms for obtaining access to other OER materials such as entire courses, lectures, videos, and podcasts.

## OER TEXTBOOKS FOR NEUROSCIENCE

There are two comprehensive basic neuroscience textbooks available in OER or open-access formats. First is *Neuroscience: 2<sup>nd</sup> Canadian Edition*, which uses a traditional textbook format and can be adapted according to the needs of the instructor (Ju, 2020). The second is *Neuroscience Online, an electronic textbook for the neurosciences*, which is a free online neuroscience resource developed and maintained by Department of Neurobiology and Anatomy at The University of Texas Health Science Center Houston, McGovern Medical School (Byrne, 1997). Both of these textbooks will be briefly reviewed here for strengths and weaknesses to help readers who may consider adopting either of these resources as a replacement for standard, frequently expensive, undergraduate neuroscience textbooks.

These two textbooks are best suited for and targeted to introductory level undergraduate neuroscience courses. Both textbooks do a very decent job covering topics related to basic neuroscience form and function. Where they differ is largely in their focus and coverage of other topics within neuroscience, thus faculty are encouraged to look closely at both textbooks and consider which is more suitable for the specific topics they will be covering in their particular neuroscience course. Both textbooks, for example, are somewhat lacking in behavioral neuroscience content, incorporating different aspects to some extent, but with no

focused emphasis on how the brain impacts behavior.

### Neuroscience: 2<sup>nd</sup> Canadian Edition

*Neuroscience, 2<sup>nd</sup> Canadian Edition* (<https://ecampusontario.pressbooks.pub/neurosciencecdn2/>), is a true OER electronic textbook published via the Pressbook Open Library that can be viewed online, adapted in Pressbooks according to the user's need, or printed for use or distributed electronically. Content is divided into four main sections covering (1) Neuroscience – the basics, (2) Neurodegeneration, (3) Fundamental neuroscience techniques (and when to use them), and (4) Emergent topics in neuroscience. Each of these sections is further subdivided into four to ten additional subsections of differing lengths that are easy to navigate using the table of contents. Most of the different units have student checkpoints where students are able to assess their learning by answering questions embedded into the text. Students or instructors who choose to print the book will lose some of the embedded links to videos or images that make the textbook more interesting. At present it has very little behavioral neuroscience but should appeal highly to those with a more clinical approach to neuroscience or those who are looking to emphasize neurodegenerative disorders.

This textbook has the look and feel of a traditional textbook that will likely be familiar to students. One nice benefit to this textbook, similar to most publisher-developed books, is the soon to be available instructor resources developed to complement the book and that are in the process of being released for those who adopt this textbook, according to the book's main author, Dr. William Ju. Further, the book is undergoing regular expansion and updates to cover a wider range of topics, as some common topics such as learning and memory are currently missing from this book. All signs indicate that this textbook will only improve over time, thus if it is not sufficient for your needs at the present time, it may be worth checking in again with the release of a third edition at some point in the near future.

### Neuroscience Online: An Electronic Textbook for the Neurosciences

*Neuroscience Online* (<https://nba.uth.tmc.edu/neuroscience/>) is an easy to navigate web-based electronic textbook. Content is divided into four main sections covering (1) cellular and molecular neurobiology, (2) sensory systems, (3) motor systems, and (4) homeostasis and higher brain functions. These main sections are further divided into an additional 8-15 chapters, each of which is clearly labeled and easy to navigate using the online table of contents. There are relatively few static images, as embedded videos and animations are predominantly used to support the text. This can be an advantage, as students do not need to click to see these enhanced contents, as they might need to in a standard digital textbook. In some cases, entire video lectures are also available on some of the content pages, which might provide additional opportunities for students who benefit from multiple formats or repetition of material. While all the content available in this electronic textbook is open access, and thus entirely free, it is not open for editing or modification to meet an individual's specific

course needs. This textbook takes a very anatomy-based approach to the brain, often introducing the pathways and brain regions relevant to a particular system before considering the functional output of the system.

This electronic textbook looks and feels like the website it is, which may or may not represent a downside to this resource. While some students may be fine with this uncommon textbook format, it bears at least a passing thought for faculty considering adoption of this resource. At the same time, the fact that this textbook exists only in this website format means it is readily updated and maintained, without needing to alter the entire book. This suggests errors can quickly be corrected and new findings or developments in different areas of neuroscience can be added with relative ease, a definite advantage over a standard printed textbook. In fact, all pages in this electronic textbook are marked with the most recent edit date, and at the time of writing of this article, all pages had been reviewed within the past ten months, and several within the past couple of months. This lends supports to the idea that this resource is and will continue to be actively and well-maintained in the foreseeable future, and thus should not become dysfunctional or fade into oblivion any time soon. However, some faculty have reported having issues with images in this resource since flash has been phased out, although the author did not have any problems and so individuals interested in this textbook should look closely before adopting it.

One potential advantage to this resource is the paired *Neuroanatomy Online: An Open-Access Electronic Laboratory for the Neurosciences* (<https://nba.uth.tmc.edu/neuroanatomy/>). I will not review the laboratory resource here but recognize that it could be a determining factor for some faculty looking for "all-in-one" shopping for both lecture and lab content and resources.

A similar free neuroanatomy resource is *Functional Neuroanatomy* (<https://www.neuroanatomy.ca/>), which provides a range of interactive modules, MRI images, 3D rendering, videos, and other resources that can support a more general neuroscience course or may provide substantial content for a neuroanatomy specific course.

While it is certainly possible that neither of the textbooks reviewed above will meet all the neuroscience teaching needs of any individual faculty member, perhaps if they cover 80-90% of the content in a particular course, the instructor will be able to assemble appropriate resources for the remaining content while keeping costs down for students. At a minimum, either of these textbooks may be a great supplemental resource, for example in an upper-level neuroscience elective or lab class where a general textbook will not be assigned, but students may benefit from a reference text for basic neuroscience content. This may be especially true for today's students, as so few students actually purchase and keep their textbooks beyond the semester in which they are required to have them for a class.

### Other textbooks

Other OER or open access textbooks are available in a variety of more specialized areas of neuroscience. These will not be reviewed here individually but can be found on

platforms such as those identified in Table 1. Examples of OER textbooks include, but are not limited to, *Introduction to Cognitive Neuroscience* (Jaaskelainen, 2012), *Computational Cognitive Neuroscience, 4<sup>th</sup> edition* (O'Reilly et al., 2020), and *Psychology as a Biological Science* (Lindberg, 2021), which seems to be targeted as an introductory neuroscience text for non-majors.

## OTHER OERS FOR NEUROSCIENCE

In addition to neuroscience-related textbooks, entire courses, modules or individual lecture content are available. You may also find books, laboratory exercises, tutorials, educational materials for K-12, podcasts, videos, and more. Numerous platforms exist to organize these many resources and make them generally available. Table 1 lists many of the different platforms and the relative amount of neuroscience content available. Some of these platforms have overlapping items, however many of them also have items identified only in their databases. Several of the platforms with greater available neuroscience-related materials will be discussed briefly in the following paragraphs.

The top platform for neuroscience content and resources is undeniably MERLOT (<https://www.merlot.org/merlot/>). This website is well organized, allowing the user to search not just by keyword, but also filtering by material type. The ability to filter by material type is particularly useful in MERLOT as they also have the largest number of options for different material types of all the sites in Table 1. Materials were all dated with both date of creation and most recent update.

Further, MERLOT includes a system for review of

materials, and a user rating system, allowing individuals to make more educated decisions about whether to consider a particular resource for use. This is particularly useful as not all OERs are created equal, and thus quality control can be an issue. The MERLOT website also include links to other libraries, which can further identify other resources (though note these are not necessarily open access or free ). The second and third platform in terms of resource availability for neuroscience are IntechOpen (<https://www.intechopen.com/>) and the Directory of Open Access Books (<https://www.doabooks.org/en>) respectively. Both of these sites have numerous neuroscience-related textbooks, books, or book chapters available. IntechOpen requires a free registration in order to download content.

One specialized neuroscience-related OER worthy of a brief mention pertains to the area of neuroethics. Two different organizations maintain sites that provide OERs relevant to teaching neuroethics. First, the Center for Neuroscience and Society at the University of Pennsylvania maintains OERs related specifically to neuroethics (<https://neuroethics.upenn.edu/portfolio/category/neuroethics-open-educational-resource/>). Their resources include a lot of short video lectures with experts in the field, as well as other teaching resources such as course reading suggestions, syllabi, and more. Second, the Neuroethics Society, formed in 2006, maintains a list of available resources for teaching neuroethics at many levels, and while many of the resources are free or open access, it is important to note that not all are free (<https://www.neuroethicssociety.org/education-resources>).

These resources vary from articles suggestions for current topics in neuroethics to course outlines, reading lists, and

Platform Name	Number of hits for "Neuroscience" in database <sup>1</sup>	Content Type	Website address
Merlot	656	Mixed <sup>2</sup>	<a href="https://www.merlot.org/merlot/">https://www.merlot.org/merlot/</a>
IntechOpen	347	Textbooks, books, book chapters	<a href="https://www.intechopen.com/">https://www.intechopen.com/</a>
Directory of open access books (DOBA)	301	Textbooks, books, book chapters	<a href="https://www.doabooks.org/en">https://www.doabooks.org/en</a>
Libre Texts	151	Textbooks, individual units from textbooks	<a href="https://libretexts.org/index.html">https://libretexts.org/index.html</a>
Oasis	58	Mixed <sup>2</sup>	<a href="https://oasis.geneseo.edu/index.php">https://oasis.geneseo.edu/index.php</a>
OER Commons	54	Mixed <sup>2</sup>	<a href="https://www.oercommons.org/hubs/open-textbooks">https://www.oercommons.org/hubs/open-textbooks</a>
Teaching Commons	36	Mixed <sup>2</sup>	<a href="https://teachingcommons.us/">https://teachingcommons.us/</a>
BC Campus Open Ed	19	Textbooks	<a href="https://open.bccampus.ca/">https://open.bccampus.ca/</a>
Open Textbook Library	6	Textbooks	<a href="https://open.umn.edu/opentextbooks/">https://open.umn.edu/opentextbooks/</a>
Open Stax	0	Textbooks	<a href="https://openstax.org/">https://openstax.org/</a>

*Table 1.* Cross-disciplinary platforms collating true OER and open access resources for educational purposes. <sup>1</sup> A search for "neuroscience" was conducted in each platform, and while every search included at least some materials relevant to neuroscience, each individual hit returned was not individually checked for relevance to neuroscience. <sup>2</sup> Mixed content frequently includes but is not limited to: Textbooks, books, courses, course materials, modules, syllabi, videos, podcasts, etc.

syllabi for those looking to provide much more in-depth coverage. There is some overlap between the two sites, but both offer some independent resources for teaching neuroethics.

## CONCLUSIONS

The push for OERs in recent years seeks to help equalize access to education resources across the globe, making quality education much more available in developing countries that cannot afford to provide even minimal resources. Even here in the USA, where the cost of college continues to rise at unsustainable rates that far outpace inflation, OERs provide at least one small avenue for making access more equitable.

Despite the many benefits of OERs, it is necessary to acknowledge the downsides of OERs as well. Perhaps the largest downfall is the need for content validation. Since anyone can create and distribute an OER, individual faculty typically must decide whether any given OER is high quality and appropriate to a particular subject matter, course level, or group of students. Increasingly this is being addressed by the larger OER platforms by including a review process or rating system. This peer review process will be critical to assuring that all OER content is of high quality. Additionally, because there are many different types of open licenses, OER users must be careful of the fine print about how the material can be reused, adapted, or distributed. This can often lead to confusion initially, since some of the materials billed as OER do not technically fall into that category. For example, a video that has a creative commons license might not necessarily be truly open; the agreement may instead allow it to be freely used but not altered or repurposed. In an effort to limit confusion, many of the platforms distributing OERs clearly indicate the license type to make clear how a particular resource can or cannot be used, modified, or shared.

Neuroscience is a growing field at the undergraduate level and thus it is likely that the use and adoption of OERs in neuroscience will increase. As more neuroscience faculty choose to use, or better yet, contribute to the pool of available OERs in neuroscience, the benefits to the

discipline as a whole will continue to grow.

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