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Using iBiology as a Tool for Undergraduate Neuroscience Education

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This article presents iBiology, a free website that produces online resources for science education. iBiology develops material that can be used in preparation prior to lecture or as part of the curriculum and includes videos (research talks and technical videos), flipped classroom curriculum, and professional development courses. Neuroscience educators can find videos of leading scientists explaining crucial experiments in their field or demonstrating critical laboratory techniques like fluorescence microscopy. Here we provide examples on how educators integrate iBiology into their curriculum.

Key words: iBiology; Educational Resources; Flipped Classroom Curriculum; Professional Development; Career Exploration

Educators are increasingly using online educational resources to shape and enhance their classroom curriculum. iBiology is a compelling example of such a resource being used in the biological sciences. iBiology (https://www.ibiology.org) is a non-profit organization that aims to make scientific information accessible to anyone by producing free, open-access, online video content (Goodwin, 2014). The organization, founded in 2006 by professor Ron Vale at the University of California, San Francisco, is best known for its professionally produced seminar-style videos starring well-established biology experts. These scientists discuss their field, research stories, techniques, and other topics relevant to the scientific community. iBiology's videos are available over three YouTube channels that cumulatively have over 8 million views and over 79,000 subscribers (Figure 1). iBiology speakers are nominated by collaborators, former speakers, and its audience, among other sources. iBiology aims to expand its pipeline by inviting outstanding scientists who can add novel content not covered in previous videos. iBiology's content is produced with educators in mind, with an entire section on the iBiology website devoted to educators (Appendix, Item #1). This resource is tailored to support educators as they prepare flipped courses, develop their curriculum, and innovate their teaching styles. For example, many teachers find these resources useful for designing a "flipped" course by assigning students to watch iBiology videos to cover major concepts prior to a lecture or classroom activity. In a traditional setting, educators can also integrate the content found on this website as part of their lectures, laboratories, and homework.

BRING NEUROSCIENTISTS FROM THE LAB INTO THE CLASSROOM

iBiology currently supplies hundreds of videos in their database from scientists in all reaches of biology, including a sizeable catalogue of neuroscience-related topics and techniques (Appendix, Item #2). A large proportion of iBiology videos are multipart research seminars, which are valuable tools for educators interested in expanding their curriculum beyond neuroscience textbooks and developing a dynamic learning experience. In these videos, speakers use a mix of data and storytelling to detail the journey behind their scientific papers. Each multipart research talk is split into two or three individual videos each lasting approximately 30 minutes (Figure 2). The first video often introduces the field and basic concepts while the second and third videos delve into the scientist's work. These videos can be watched in series or independently.

In addition to the multipart research talks, the iBiology website hosts "Discovery Talks" (Appendix, Item #3). In these videos, scientists tell the stories behind their historic, and often award-winning, research. There are currently 45 Discovery Talks, 10 of which describe momentous achievements in neuroscience. For instance, Nobel Prize winner Dr. Michael Rosbash describes his collaboration with Dr. Jeff Hall that led them to discover circadian rhythm genes (Appendix, Item #4). And Dr. Karl Deisseroth, a 2015 Breakthrough Prize winner, details the development of optogenetics, which has revolutionized neuroscience by allowing the use of light to modulate neuronal activity (Appendix, Item #5).

Using iBiology to prepare lectures and improve curriculum

Educators use iBiology's growing educational resources in many different ways. A poll conducted in 2016 with iBiology-registered educators showed that, regardless of

YouTube Channel	Views	Subscribers
iBiology (created June 2009)	5,302,037	47,143
iBiology Techniques (created May 2012)	2,376,227	20,955
iBiology Science Stories (created Sept. 2010)	1,141,404	11,132
Total	8,819,668	79,230

Figure 1. iBiology YouTube Views and Subscriptions. YouTube Analytics for iBiology's YouTube Channels representing the lifetime data for each channel (from its inception through July 30, 2018).

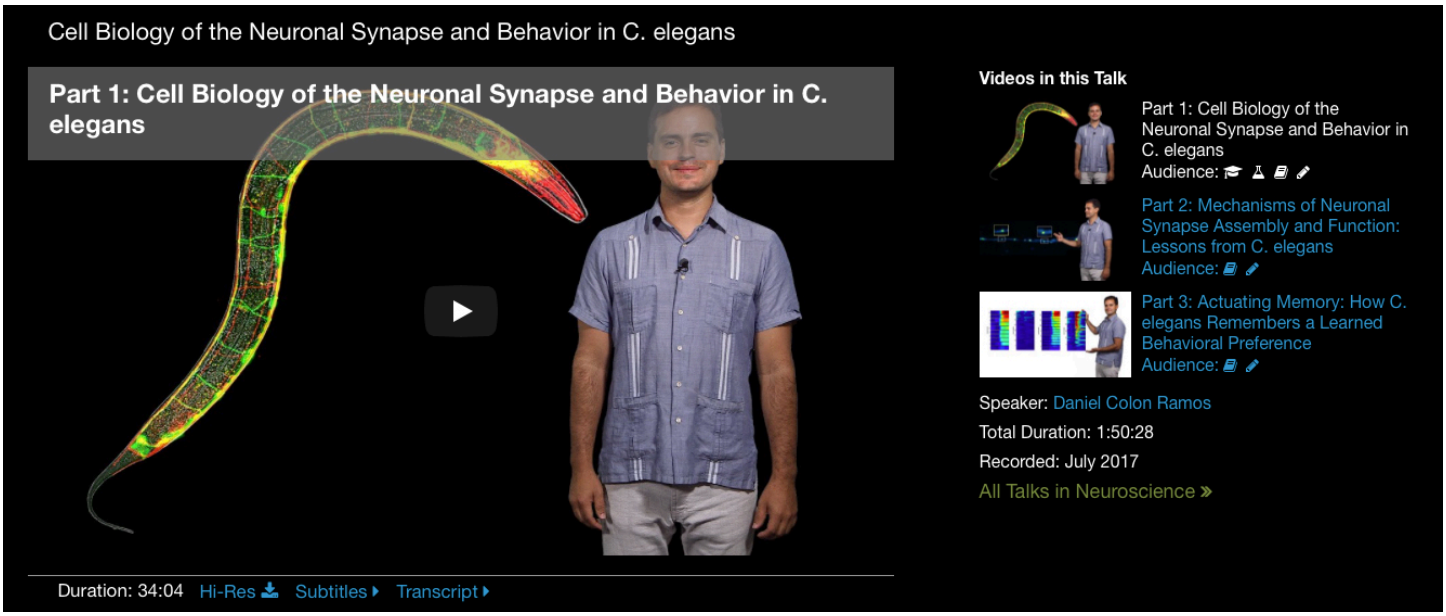


Figure 2. iBiology Multipart Research Talks Structure. The iBiology interface is a user-friendly platform displaying the title, speaker, duration, and audience for each video. This figure contains an example of a three-part research talk. The audience can easily switch between parts, view with subtitles or closed captioning, and explore additional talks.

academic level, iBiology is used by educators from around the world (Figs. 3A and B). Nearly all active users participating in the survey found iBiology useful. Thirty-five percent of all educators use iBiology lectures as preparatory teaching materials and 34% incorporate the content directly into their own curriculum (Figure 3C). Educators employ these tools as discussion prompts and assigned homework and also use the tool to help teach more efficiently (Figs. 3 and 4). For instance, these seminars can be used as out-of-class assignments, freeing up class time for active learning exercises and discussions. iBiology provides a platform that allows educators to expose students to high quality science for free, which is hard to accomplish in rural and/or low-income institutions (Figure 4). One educator from rural Mississippi stated in a survey: "They [iBiology] provide me access to speakers my students would never otherwise hear, talking about discoveries in which they have participated. They also allow me to 'flip' or partially flip some of my courses, reducing my lecturing burden and allowing me to do more problem solving and critical thinking activities in class."

iBiology also develops flipped courses each year. Each course covers one field and is customized around iBiology videos already on the website. Past courses include "Engineering Life" (Appendix, Item #6), "Cell Biology" (Appendix, Item #7) and "Evolution" (Appendix, Item #8). Each course consists of several sessions, which include carefully selected iBiology talks along with discussion questions. All of this content is openly available online but registered educators can access additional questions and answers specific to each video. The flipped courses are an example of the type of curriculum educators can design themselves around iBiology's content. Future planned iBiology Flipped courses include immunology, neuroscience and more, depending on educator feedback.

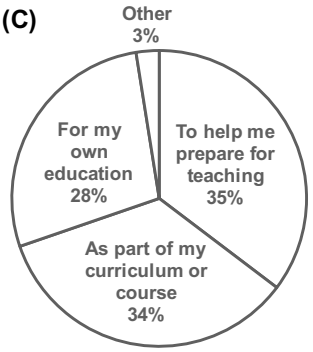
Learning microscopy and other techniques using iBiology

Each year, iBiology produces technique videos covering classic and cutting-edge techniques used by biologists.

(A)

Educator Location	Educators (%)
Africa	1.1
Asia	7.8
Central/South America	6.7
Europe	13.3
North America	6.7
USA	64.4

(C)



(B)

Level of the students	Educators (%)
High School - Advanced Placement (AP)	13.0
4-Year Undergraduate - Advanced Level	70.7
Community College/Technical College	4.3
Health Professions (MD, PharmD, LPN)	2.2
Graduate (PhD)	5.4
Other	4.3

Figure 3. Analysis of the 2016 iBiology-Registered Educators Survey. A questionnaire survey was administered to iBiology-registered educators in June 2016. A total of 92 educators participated in the survey. Here we show the demographic of the educators (A), what level educators are teaching (B), and how educators are using iBiology resources (C).

Examples of how Educators use iBiology Seminars

University	Country	Subjects Taught	Quote
Democritus University of Thrace (International)	Greece	Neurobiology	- I use the clips during the lesson to stress important findings - I use 2-3 lectures as part of the distance learning part of a course - I usually choose one or two lectures by key figures in the field as a starting point of discussions on science progress - I also encourage students to visit the site and follow lectures that they find interesting.
University of Michigan	Michigan, USA	Biophysics	After completion of the assignment, students took a short survey in which most of the students really found the lectures highly useful because they were given the freedom to interact with the lecture however best fit their style. So, this meant students can pause and look up things they didn't understand or freely scroll back and forth through the lecture to grasp key points.
Blue Mountain College	Mississippi, USA	Teaches 12 courses (undergraduate, lab, master's in education)	They provide me access, in rural Mississippi, to speakers my students would never otherwise hear, talking about discoveries in which they have participated. They also allow me to 'flip' or partially flip some of my courses, reducing my lecturing burden and allowing me to do more problem solving and critical thinking activities in class.

Figure 4. iBiology use examples. These quotes from educators represent how iBiology resources are being used by educators.

The most popular example of this is the microscopy series (Appendix, Item #9). From visualizing whole mount slides of brain tissues to detecting fluorescently-labelled neurons and observing live neurons in model organisms, microscopy is an important research technique used in neuroscience. Whether it is in a classroom, laboratory course, or undergraduate research, understanding microscopy is critical for a solid science education.

The iBiology microscopy series contains over 70 videos covering different aspects of microscopy. Each video in the course is a stand-alone module with assessment questions and answers that are not hidden behind educator registration. Since it began, this course has been very popular, gaining over 880,000 views on YouTube. The videos incorporate various video formats, from lectures about microscopy history to demonstrations, laboratory tips, and good practices (Figure 5). With such a variety of content, educators can easily select videos and modify the set course that fits their curriculum.

Approximately 44% of the microscopy course introduces basic principles and fundamentals (Figure 5). These introductory videos span a large range of topics. For example, Dr. Daniel Fletcher explains the important properties of light, lenses and how light-lens dynamics create images (Appendix, Item #10); Dr. Nico Stuurman explains how photosensitive receptors can create digital microscopic images (Appendix, Item #11). These videos are a dynamic take on information presented in textbooks, better preparing students for hands-on microscopy exercises, or, as a supplement to in-class lectures.

As an educator, it is not always possible to show students cutting-edge technology due to time, budget, or location constraints. Therefore, the iBiology catalogue offers video content that brings the student into the lab with instructors who describe state-of-the-art microscope components, use, and analysis. Since the majority of the videos are taught by active researchers, it is also an excellent opportunity for undergraduate educators to demonstrate how neuroscientists are actively using microscopy in their own labs. For instance, Dr. Hari Shroff's video, "Dual-View Inverted Selective Plane Illumination (diSPIM)," can be used to introduce diSPIM and how it is an extension of selective plane illumination microscopy (Appendix, Item #12). However, in the same 20-minute talk, Dr. Shroff also explains how his lab uses diSPIM to understand neural conductivity organization and execution in *C. elegans* (Figure 6). He brings viewers to see the actual instrumental set up and how data is ultimately collected. Educators can use the entire video or make shorter clips to emphasize the basic principles, the technology or its neuroscience applications.

Career Exploration, Advice, and Professional Development

As neuroscience undergraduates advance in their academic career, they often turn to educators for guidance in career development. iBiology provides an array of career resources that can be used when advising students' professional development and career exploration (Figure 7 and Appendix, Item #13). These tools are valuable for students interested in either exploring research-based careers or jobs beyond the bench. iBiology contains an entire section devoted to career development in a variety of fields. There are also resources for educators to use when discussing important issues in the science community, including but not limited to, mentorship, diversity, communication, and advocacy. Continuing to innovate their resources, last year iBiology began building a career development platform on Open edX (Appendix, Item #14) and launched their first course called "Planning your Scientific Journey." Although this course is aimed primarily at life science graduate and undergraduate students, it could also be useful for postdocs, staff scientists, and

Microscopy Series – Course Highlights

Topics	# of Videos	Examples
Microscopy History	3	Historical Contributions from Light Microscopy: What Can You Learn with a Light Microscope?
General Microscopy Principles	29	1) Objectives and Eyepieces 2) Tip: Correcting for Spherical Aberration with a Correction Collar 3) Measuring Dynamics: Photobleaching and Photoactivation
Fundamentals	7	1) Bonus: Photons: What is Light? 2) Polarized Light and its Interaction with Material 3) Cameras and Detectors I: How Do They Work?
Demonstrations	3	1) Lab: Abbe Diffraction Demonstration 2) Bonus: Examples of Using Polarization Microscopy 3) Lab: Phase, Polarization and DIC Microscopy Lab
Intro to Technology	14	1) Measuring Dynamics: Fluorescent Speckle Microscopy 2) Optical Sectioning and Confocal Microscopy 3) Miniature Microscopes for Deep Tissue Imaging
Skills	17	1) Lab: How to Focus: The Focal Plane 2) Tip: How to Clean Objective Lenses and Filters 3) Lab: Using Software to Control Microscopes
Extra	1	Mobile Microscopy

Figure 5. iBiology's Microscopy Course Structure

others who could benefit from learning or reviewing these topics. Educators can also use this course to help students navigate their careers in science, including how to set goals and maintain progress in their research projects.

Resources for educator training

iBiology is committed to supporting educators' needs and help them grow in their profession. As such, iBiology provides videos tailored specifically to meet educators' needs and issues. An example of this is the iBiology Scientific Teaching Series (Appendix, Item #15). In this series, undergraduate biology instructors discuss the methods they designed and use in their own undergraduate courses. These include, but are not limited to, clickers and the think-pair-share methods. In short videos, multiple instructors explain how they implement these active learning tools in their own classrooms and suggest tips for others. In using iBiology's educator resources, undergraduate educators can join a network of educators who continue to grow, learn, and discover innovative ways to improve science education.

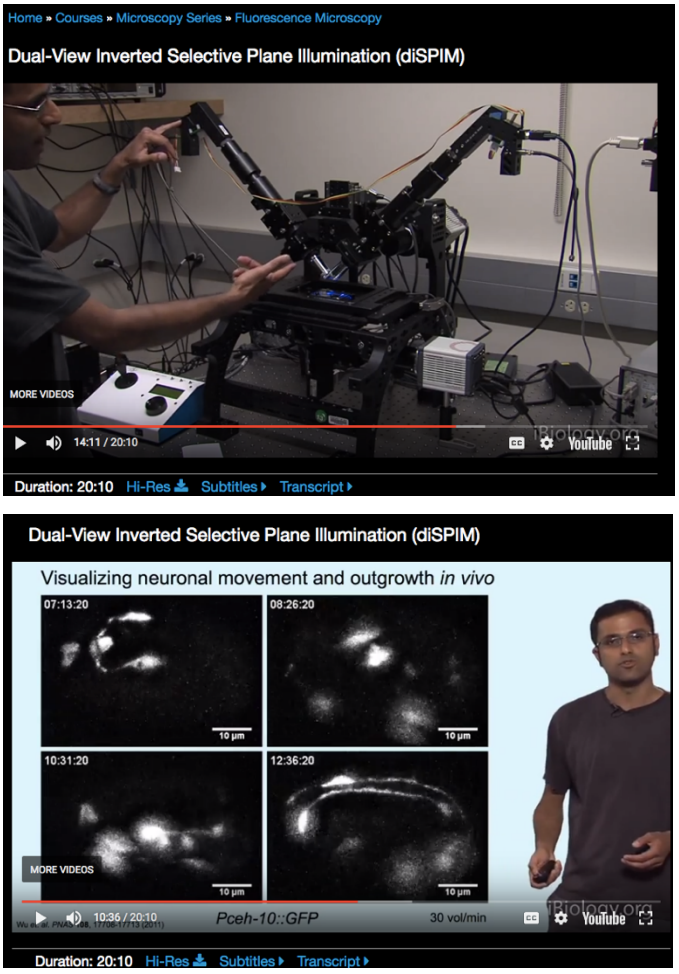


Figure 6. Dual-View Inverted Selective Plane Illumination: An Example of a Microscopy Technique used in Neuroscience Education. This example shows how scientists in the microscopy course teach, in their videos, both the technical side of the instrument, and how the instrument is used in neuroscience research.

Playlist	# of talks
Business Concepts for Scientists Course	13
Ethics, Rigor and Reproducibility	3
Funding in Science	8
How I Became a Scientist	12
Improving Diversity in Science	17
Mentoring Science Trainees	13
Non-Research Careers	8
On Scientific Training	15
Outside the Lab	11
Research Careers	9
Science Communication, Education, & Advocacy	37
Scientific Teaching Series	9
Tips for Science Trainees	26

Figure 7. iBiology develops resources in Career and Professional development to help scientists progress in their careers. From career exploration to videos covering important ethical issues in science, iBiology contains a comprehensive list of materials that can be used by educators to help students.

CONCLUSION

The educational resources and teaching tools found in iBiology's database can help neuroscience educators expand their own course content and aid in their professional development. iBiology continues to grow and expand its content to keep up with current, innovative research. This continued growth is driven by regular introspection and analysis of feedback. As such, iBiology has increased its effort in developing educator-specific content, which includes teaching tools, flipped classroom curriculum, and basic science videos. iBiology provides research talks in neuroscience, and neuroscience-related fields (e.g., microscopy). As such, there are endless possibilities for neuroscience educators to use, adapt, and incorporate educational iBiology tools to enhance their own teaching and to strengthen neuroscience education.

REFERENCES

Goodwin SS (2014) iBiology: communicating the process of science. Mol Biol Cell. 25(15):2217-9.

APPENDIX: LIST OF URLS

(1) Educator Resources
https://www.ibiology.org/educators/
(2) Talks in Neuroscience
https://www.ibiology.org/research-talks/neuroscience/
(3) Famous Discoveries Playlist
https://www.ibiology.org/playlists/famous-discoveries/
(4) Understanding Circadian Rhythms: A Tale of Friendship, Behavior, Genetics, and Luck by Michael Rosbash
https://www.ibiology.org/genetics-and-gene-regulation/circadian-rhythms/
(5) Development of Optogenetics by Karl Deisseroth
https://www.ibiology.org/neuroscience/optogenetics/

(6) Engineering Life Flipped Course
https://www.ibiology.org/online-biology-courses/engineering-life-flipped-course/
(7) Cell Biology Flipped Course
https://www.ibiology.org/online-biology-courses/cell-biology-flipped-course/
(8) Evolution Flipped Course
https://www.ibiology.org/online-biology-courses/evolution-flipped-course/
(9) Microscopy Series
https://www.ibiology.org/online-biology-courses/microscopy-series/
(10) Refractive Lenses and Image Formation by Daniel Fletcher
https://www.ibiology.org/talks/refractive-lenses/
(11) Introduction to Fluorescence Microscopy by Nico Stuurman
https://www.ibiology.org/talks/introduction-fluorescence-microscopy/
(12) Dual-View Inverted Selective Plane Illumination (diSPIM) by Hari Shroff
https://www.ibiology.org/talks/selective-plane-illumination/
(13) Career Exploration
https://www.ibiology.org/career-development/career-exploration/
(14) iBiology Courses
https://courses.ibiology.org/
(15) Scientific Teaching Series
https://www.ibiology.org/playlists/scientific-teaching-series/

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