iBiology: communicating the process of science

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ABSTRACT **The Internet hosts an abundance of science video resources aimed at communicating scientific knowledge, including webinars, massive open online courses, and TED talks. Although these videos are efficient at disseminating information for diverse types of users, they often do not demonstrate the process of doing science, the excitement of scientific discovery, or how new scientific knowledge is developed. iBiology (www.ibiology.org), a project that creates open-access science videos about biology research and science-related topics, seeks to fill this need by producing videos by science leaders that make their ideas, stories, and experiences available to anyone with an Internet connection.**

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INTRODUCTION

The ability to communicate effectively is one of the most essential skills to have as a scientist. Not only is the exchange of ideas critical for the advancement of research and human health, but also communicating major discoveries to the public is essential to the future of biomedical research funding. Although the Internet has opened the door to new ways of communicating scientific ideas and results, cutting-edge research is still mostly presented in the form of scientific articles published in journals with a pay-per-view or subscription service. iBiology (www.ibiology.org) provides a free and open online platform for communicating the practice of science. The site, which is split into iBioSeminars, iBioMagazine, and iBioEducation sections, holds a growing collection of more than 275 videos by scientists about research and topics related to science. These videos have been viewed more than 3 million times in 170 countries. The project is funded by the National Science Foundation, the National Institute of General Medical Sciences, and the Howard Hughes Medical Institute and is supported by the American Society for Cell Biology and the University of California at San Francisco.

THE IMPORTANCE OF SEMINARS

Seminars are one of the most important forms of communication within the scientific community. In addition to allowing scientists to convey their findings to one another, seminars usually lay out the thought process behind a series of experiments, set them in the context of the field, and describe the steps taken to reach the conclusions presented. Often seminars present years of experiments and results, making them an effective way to learn about an area of science. As new technologies are rapidly being developed and applied in novel ways, seminars are useful for keeping up with the latest cutting-edge techniques. Scientists also develop fresh ideas after attending seminars, resulting in new experimental directions or interest in a new area of research. Despite their importance, accessibility to seminars by scientists who are leaders in their field is limited, as speakers can travel to only a small number of institutions or conferences each year.

In 2006, Ron Vale, of the University of California at San Francisco, realized that the Internet could be used to make cutting-edge research seminars accessible to anyone with an Internet connection. To give a face and personality to the scientist, he used green-screen technology to allow viewers to see both the slides and the speaker simultaneously. With some seed money from the Carnegie Foundation and the Howard Hughes Medical Institute, the first videos, called iBioSeminars, were created with seminars by Joseph DeRisi (University of California at San Francisco), Julie Theriot (Stanford University), Baldomero Olivera (University of Utah), and Martin Raff (Medical Research Council). Since then, iBioSeminars has produced more than 80 seminars covering topics ranging from ecology to chemical biology, allowing a worldwide audience to hear talks from leading researchers.

LESSONS LEARNED FROM SCIENTISTS

Two years after launching iBioSeminars, Ron Vale developed another series of videos, called iBioMagazine, aimed at offering more insight into what it really means to be a scientist, with videos about famous discoveries, professional development, education, outreach, and scientific careers.

These short videos provide interesting insights into the scientific profession. Nobel Laureate Tom Cech quietly did an early experiment to show that RNA can catalyze splicing because he thought that the experiment might not work and did not want it to fail in

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front of his lab (Cech, 2010). Ron Vale discovered kinesin after a slam-dunk control experiment did not work (Vale, 2010). Cynthia Kenyon could not convince a graduate student to work on aging, so she published her first paper on the subject with several rotation students (Kenyon, 2010). For Nobel Laureate Martin Chalfie, a decision to only clone the coding sequence of green fluorescent protein instead of using an existing plasmid with an extra gene sequence was instrumental in seeing green fluorescence in *Escherichia coli* (Chalfie, 2011). These are a few of the many behind-the-scenes iBioMagazine stories about major discoveries that demonstrate that trusting one's intuition, overcoming significant roadblocks, and allowing for uncertainty and guesswork are key aspects of major scientific discoveries. Research articles typically present the end result and the culmination of years worth of work, leaving out some of the realities of the scientific process. The iBioMagazine videos allow aspiring scientists to learn these important lessons directly from the authors of these studies.

iBioMagazine videos include other types of advice for young scientists. In his talk, Bruce Alberts describes the lessons he learned from his failures and advises aspiring scientists to study their failures carefully and learn from them, pointing out that successful people never make the same type of mistake twice (Alberts, 2010). Lydia Villa-Komaroff talks about how persistence through tough or discouraging times is one of the most important attributes for a scientist (Villa-Komaroff, 2011). Enrique De La Cruz emphasizes the need to use time wisely and have a weekly plan that is constantly being revised and evaluated to make sure one is spending time as productively as possible (De La Cruz, 2014).

iBioMagazine talks also provide a window into the unexpected career paths of successful scientists. Alfredo Quiñones-Hinojosa, a neurosurgeon at Johns Hopkins University, came to the United States from Mexico as an undocumented immigrant when he was a teenager and worked on a farm before going to college (Quiñones-Hinojosa, 2011). Erich Jarvis, a neuroscientist at Duke University, chose science over a career as a professional dancer (Jarvis, 2012). Yixian Zheng, a cell biologist at the Carnegie Institution for Science, grew up during the cultural revolution in China and was an aspiring novelist before realizing that she enjoyed biology (Zheng, 2011). These life stories demonstrate that scientists came from a variety of backgrounds and took a wide range of paths before they became the successful scientists they are today.

Each of these videos offers unique insights into the experiences of scientists and provides important lessons for young scientists or students thinking about a career in science. By identifying common themes—the importance of persistence, trusting one's instinct, learning from failure—we can also start to identify characteristics that successful scientists share and that aspiring scientists can learn from.

RESOURCES FOR EDUCATION

In 2013, iBioEducation was added to the iBioSeminars and iBioMagazine series, and all were merged into one site named iBiology. iBioEducation is a place for educators to find video resources and accompanying assessments related to biology education.

Over the past several decades, there has been an intense push in biology education to shift away from teaching through lecture and toward helping students develop critical thinking and analytical skills through active learning (American Association for the Advancement of Science, 2011). Study after study has shown that incorporating active learning activities into a classroom increases student learning gains and results in higher grades and lower dropout rates than lecture-based classes (Hake, 1998; Handelsman *et al.*, 2004; Minner *et al.*, 2010; Freeman *et al.*, 2014).

Although iBiology videos are online lectures, can they be used in active learning approaches to promote skill development and facilitate student learning about the process of science? At the University of California at Los Angeles, Utpal Banerjee and Ira Clark have used an iBioSeminar video in their "research deconstruction" model, in which students learn to analyze data and think critically about experiments presented in a scientific seminar. In this model, instructors and students spend each class session analyzing one segment of a seminar, and students learn about the fundamental concepts underlying the experimental approaches, analyze data, and think critically about the research. At the end of this course, students are able to discuss the experiments critically and apply what they learned to other seminars, as well as to hypothetical research scenarios (Clark *et al.*, 2009). iBioSeminar videos have also been used in flipped classroom models, including one developed in a collaboration between iBiology and Jon Scholey at the University of California at Davis. In this model, students watch the iBioSeminars for homework, which gives them the content needed for the next class period. Class time can then be spent discussing a scientific question related to the seminar, analyzing data from the experiments presented in the video, and critically examining conclusions made from the research. Other instructors have also used this flipped classroom approach to increase problem-based learning and small-group work during class time, activities that have been demonstrated to improve student learning (Springer *et al.*, 1999; Allen and Tanner, 2003).

Humanizing the scientific process or providing historical relevance can help provide context when students are learning about topics or concepts (Chamany *et al.*, 2008). iBiology talks about science discoveries, as mentioned in the preceding section, often give insights into the failures, roadblocks, and serendipitous paths that are encountered in the quest for new knowledge. Other talks give historical insights into issues surrounding research on recombinant DNA, stem cells, and the teaching of evolution, giving a societal context to these concepts. iBiology talks can also be combined with corresponding primary literature, giving a face and personality to the scientist behind the research.

iBiology has also developed a collection of videos to promote active learning. The Scientific Teaching Series features videos addressing problems in how biology has been taught traditionally and providing tools for educators to introduce active learning into their classroom. This series incorporates perspectives and experiences from multiple instructors, has classroom footage of active learning in action, and highlights evidence from the literature that supports active learning approaches.

THE FUTURE OF SCIENCE COMMUNICATION

How can resources such as iBiology harness the power of the Web in other ways to increase exposure to scientific ideas and thinking? Recently, iBiology has been using a tool called Google Hangouts on Air to visually connect people from around the world with thought leaders in the scientific community. Google Hangouts on Air provides the ability to host a live question and answer session (Q&A) by creating a video broadcast in which viewers can submit questions and vote on questions submitted by other viewers. To date, seven Google Hangouts on Air have been hosted by iBiology about research, academia, industry, education, and policy, featuring leaders in the scientific community such as Bruce Alberts, Bonnie Bassler, and Lydia Villa-Komaroff.

Prominent speakers such as Gregory Petsko, Keith Yamamoto, and Jon Lorsch had Q&As focused on current biomedical workforce issues. The typical model for these Q&As involved recording an iBioMagazine video before the Q&A, freeing time during the Google

Hangouts on Air broadcast to field questions from the audience. Soon, iBiology plans to build a forum on which scientists can share their expertise and experiences and connect with one another.

With the Web, conversations about science need not be limited to institutions or conferences and can include those outside of the usual scientific circles. Now we can create a global conversation with a worldwide network of people about research, education, and issues in the scientific community, helping to make sure science flourishes well into the future.

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