EVOLUTION OF THE TEXTBOOK

Publishers are beginning to go digital with textbooks, pushing boundaries to give students a personalized, interactive experience.
on the first edition of Molecular Biology: Principles and Practice when its scientist authors began dreaming up ideas for the second. They would go way beyond words on the page to give students a front row seat to science in action.

It was the summer of 2010, and the collaborators had just met with Adam Steinberg, the book’s artist. On his newly minted iPad, Steinberg showed them a splashy periodic table application called The Elements: A Visual Exploration that rocked their world.

The app included cleverly worded facts and scintillating periodic table trivia. But its real impact was visual. Its creator, scientist Theodore Gray, had gathered a mini-museum’s worth of fascinating objects to represent each element—from an iridescent hunk of bismuth to a dime-store dragon figurine made of copper. App users could see the objects in 3-D and rotate them, front to back and front again, with the swipe of a finger.

It wasn’t quite holding an object and turning it over in your hand, but it was pretty close.

Jennifer Doudna, an HHMI investigator at University of California, Berkeley, and coauthor of the textbook, marveled at how the app transcended the traditional boundaries of a textbook. “When I was in college and learning [molecular biology] for the first time myself, I found the textbook approach very dry,” she says. “It really did not give a sense at all of science being a living, breathing, growing, changing kind of field.”

In the first edition of Molecular Biology, Doudna and her coauthors Michael M. Cox and Michael O’Donnell had set out to humanize their subject matter almost entirely within the confines of the printed page. For instance, they opened each chapter with a first-person vignette from a scientist talking about a moment of discovery.

But Steinberg’s tablet computer demonstration got them dreaming about adding video versions of the vignettes that students could tap into as they read. They imagined 3-D animations and virtual experiments where students could choose their data sets and follow them through to the outcome.

“We have ideas and the ground is definitely shifting quickly,” says O’Donnell, an HHMI investigator at Rockefeller University. “We’re all thinking about it and we’re all very excited.”

So what will college science textbooks look like in five years? A decade? The boundaries have already stretched beyond the physical page to incorporate animations of molecular processes, videos of scientists talking about discoveries, and social networking between researchers and students around the world. Publishers are offering content that teachers can customize as they see fit. However, a flock of unknowns is circling—Will the iPad prevail? Will the cost for developing spectacular apps be more than students are willing to pay?

Jonathan Crowe, an editor in chief at Oxford University Press who works with science authors, predicts the textbook industry will change more in the next few years than it has in the past 50 or 100. And plenty of new and traditional publishers are moving fast to stake a claim to that future.

STILL A SMALL MARKET
College textbooks are big business. Higher education textbooks sales were $4.58 billion for 2010, an increase of 7.8 percent since 2009, according to U.S. publishers’ net sales revenue released by the Association of American Publishers in February.
“WHEN I WAS IN COLLEGE AND LEARNING [MOLECULAR BIOLOGY] FOR THE FIRST TIME MYSELF, I FOUND THE TEXTBOOK APPROACH VERY DRY. IT REALLY DID NOT GIVE A SENSE AT ALL OF SCIENCE BEING A LIVING, BREATHING, GROWING, CHANGING KIND OF FIELD.” —JENNIFER DOUDNA

Digital textbooks, however, make up roughly 5 percent of the textbook market, says Vikram Savkar, publishing director at Nature Publishing Group (NPG), which will soon launch its second college-level digital initiative. Other numbers bear this out: for John Wiley and Sons, a major publisher of science textbooks for the higher education market, $10 million of its $290 million in higher-education revenue last year came from digital-only sales (titles not packaged with a print textbook)—that’s 3.5 percent of the company’s higher-education revenue.

“Everybody in the market says it’s time to go digital, yet year after year people still spend most of their money on print textbooks,” says Savkar. “I personally believe that’s because there haven’t been digital projects that have come out yet that are really exciting to the market and that are designed to be effective replacements for textbooks.”

A NEW ENTITY
Matt MacInnis, CEO of an interactive publishing company called Inkling, says “textbook” is too narrow a term for the new kind of learning content his company is developing. An alumnus of Apple’s international education division, MacInnis envisions traditional print textbooks being replaced by a new generation of media-rich learning platforms.

Inkling, which was born in 2009, takes existing textbooks (and their supplemental online content like animations and self-assessment quizzes), “gently disassembles” them, and then reassembles them for multitouch tablet devices like the iPad. For example, Inkling’s version of Hole’s Human Anatomy and Physiology features 400 interactive “exhibits” embedded in the text, including 3-D animations, anatomical diagrams where students can make the labels disappear and test themselves, and interactive quizzes that give instant feedback. Students can highlight passages with a finger swipe, swap ideas onscreen with friends on blue “sticky notes,” and read handy annotations, in purple, from their teachers.

Brown University School of Medicine recently bought into the Inkling concept. Its incoming first-year students, 108 of them, will be required to purchase an iPad and will use six Inkling titles as their textbooks for core preclinical classes.

NPG, publisher of the journal Nature, is finding ways to make scientific instructional content more accessible to students. In January 2009, NPG unveiled a free collaborative learning site called Scitable, “as a personal research space for undergrads and high school students with a deep love of science,” Savkar says. Users can access a growing library of original content as well as previously published material from Nature, mostly in genetics, cell biology, and ecology.

“Eventually it will have coverage across all of biology,” he adds. Instructors can assign readings, asking students to explore them at their leisure, plus students can log on and ask questions of scientists, communicate with students in other parts of the world, and read student-written blogs on topics like global warming and neuroscience.

The second NPG project is a $49 interactive digital Principles of Biology textbook that will debut in September 2011 at three California state university campuses. Principles of Biology sets out to combine the scientist-produced content and high-quality illustrations of a print textbook with primary literature from Nature, as well as animations, assessment tests integrated into the lessons, and interactive simulations of concepts that students can manipulate.

“Wherever possible, we try to get the student actively engaged,” Savkar says. A “Build a Fly” module, for example, allows students to choose different types of genetic material for a fly and then see how the phenotype changes with their choices.

Students can access the material on a desktop, laptop, smartphone, or tablet. They can also print one color copy of the textbook for free. If teachers want to customize the content—as 25 to 35 percent of instructors have indicated to NPG—the digital textbook will automatically rearrange itself as requested.

Free updates will come continually, after review by an editorial board. “We’re looking at this as a living edition,” says Savkar.

AN INVESTMENT
Issues of price, always a hot topic among cash-strapped college students, are complicated. E-textbooks cost about half the price of print. Inkling’s titles generally cost 15 percent more than e-books, but students can pay as they go for the content at $2.99 per chapter. Teachers can pick and choose chapters for a course, so if they need only 15 chapters, students pay $45 instead of $180 for the full 60-chapter book.

Still, students will need to shell out the $500 or more for the tablet device. And interactive publishers who develop iPad content may save on printing and paper, but they will have higher development costs for the multimedia features, says Alison Pendergast, senior vice president and chief marketing officer at Jones and Bartlett Learning, a large U.S. college textbook publisher.

“I don’t necessarily think technology is going to drive down the cost of textbooks,” says Pendergast. “If anything, it’s going to
keep them priced where they are. All of those additional components—animations, simulations, and interactivity—are expensive to develop.

“We’re continuing to try to find business models that keep the resources affordable for students but at the same time are cutting edge. It’s hard to do this stuff cheaply—and in order to do it well, there has to be investment.”

The nonprofit E.O. Wilson Biodiversity Foundation estimates it will need $10 million to develop a 59-chapter digital biology textbook called *Life on Earth*. But the foundation plans on paying for it with money from private and public donors and making the textbook available to the public for free.

HHMI investigator Matthew Scott, a professor at Stanford University and coauthor of *Molecular Cell Biology*, is a fan of another nonprofit site with free content, Khan Academy. Developed by an MIT graduate named Salman Khan, the site offers upward of 2,000 video tutorials that consist of scrawled notes and colored doodles on an electronic blackboard, with Khan’s voice explaining it all. The content leans heavily toward precollege math and physics but also includes dozens of higher-level biology and organic chemistry videos. Teachers can have their students log on as a class, then direct them to particular videos and assessment exercises and track their process.

“It’s enormously well done,” says Scott. “I use it, my kids use it, and friends who are Stanford faculty use it.”

**EFFECTIVE TEACHING**

At Harvard University, students may be fused to their iPads in their off hours, but they’re not using them in their undergraduate biology classes yet. Instead, teachers rely on the latest in interactive technology such as animated movies that illustrate cellular processes and handheld clickers to gauge the class’s understanding of a particular concept and drive discussion.

“After watching an animation of, say, the transport of proteins across a nuclear envelope, we’ll have a discussion of the core process that’s being shown,” says Robert Lue, a professor of molecular and cellular biology and director of Life Sciences Education at Harvard University as well as an HHMI undergraduate program director. “But then we’ll have a discussion in the context of a living cell—what are some of the things we didn’t show and how are they going to affect the process we’re talking about?

“It becomes a real teaching tool, not like a passive look at something,” says Lue, who runs Harvard’s Biovisions program for digital animations.

The landscape of textbooks is changing rapidly, says Lue, but he’s less interested in whether it brings the latest whizbang interactive features to a nearby screen than in how it’s changing to meet teachers’ increasingly well-defined and precisely planned pedagogical goals. Textbook authors used to focus just on clearly explaining concepts, but “authors now have to spend a lot of time thinking not just about how to present something but about how to teach it,” says Lue.

“In the past, textbooks were simply laying out the information in the written word with still diagrams that were clear. But there is so much we have learned about how best to teach material, how best to use interactivity and activity-based learning methods,” he says. For example, students in biology, computer science, and visual art courses can work together to develop their own scientific animation.

“It’s not just the material between two covers,” Lue says. “It’s also a whole program in terms of how to teach more effectively.”

“The textbook is always there as a framework,” says Dennis Liu, who heads HHMI’s education resources group, which produces materials to supplement textbook content for HHMI’s BioInteractive website (www.hhmi.org/biointeractive). “We have to be mindful of what teachers are teaching now while also exposing them to new content and ideas and helping them to inject cutting edge research into their curricula.” Liu hopes to see BioInteractive animations, some of which are being adapted for smart phones and the iPad, become incorporated as digital assets in new textbook-like products. “I can imagine future partnerships with authors and publishers to custom design some of our media to match new digital textbook content,” says Liu.

**NONSTOP UPDATES**

One dilemma in the life sciences is how to distill into a single course the “enormous explosion” of information that has come with breakthrough discoveries in the past 20 to 30 years. “It’s both a very rapidly expanding area and one where there are still a lot of things that haven’t been settled yet,” says Lue. “That means the life sciences courses and textbooks are constantly responding to revisions of fundamental paradigms.”

With two or three competing models for a particular idea, Lue says the current challenge for textbook authors is to assess the entire spectrum of materials and choose which examples best illustrate fundamental principles. “We have to help instructors use the material most effectively, rather than just handing it over,” says Lue.

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For HHMI investigator Matthew Scott, a particularly compelling part of textbook authorship is distinguishing discoveries that are of enduring value from those that are merely in vogue.

“You don’t want to put in too many of the latest hot things that are perhaps wrong or less important than they may seem at the moment,” he says. “Yet you want the book to seem up to date, so you’re doing a balancing act.”

Oxford University Press’s Jonathan Crowe says with the ability to change digital content at will, it will be “fascinating” to see whether authors will be constantly updating things to keep pace with the latest discoveries, or stick to the old way of curating.

“In theory, their task could never end,” he says. “The molecular biology team I work with, at least they’ve got a couple of years without me breathing down their necks. I could be on them every month, and it could never stop.”

He suspects there will be incremental updates rather than constant ones, and then new editions every three years. For more topical matters, “that’s where things like social networking could come in,” says Crowe. “You could have a Twitter feed associated with the book if a discovery comes in. Anybody who’s following that feed will see it has happened and then go have a look at this journal for this particular advance.” And then when the new version of the textbook comes along, “the authors can build it into the narrative.”

THE BEST OF BOTH

So while authors and educators wend their way through the digital morass, will the paper textbook soon go the way of cave drawings and illuminated manuscripts? Or will students cling to the textbook because sitting in the grass and highlighting a page with a yellow marker is just simpler than highlighting electronically?

The best print textbooks, especially for upper-level courses, will probably not go away as fast as people anticipate, says Pendergast. “It’s still a pretty functional tool.”

“When you’re trying to learn math or chemistry or physics, and this stuff is really hard, I think people use the textbook as a life vest. It’s insurance—you grab onto it and hope that it’s going to provide the explanation you need to understand the concepts you’re trying to learn.”

The advantage of digital content, she says, is that it personalizes the learning experience, so students can process information at their own pace and use visuals to enhance their understanding of the material.

“Instead of reading 20 pages on the Civil War or Civil Rights Movement, they could go on a website and see a video of Martin Luther King,” she says. “They could see and read original text from MLK and JFK and get a much more visual experience over time.”

The iPad is a physical object, too—and one that weighs a mere 1.35 pounds, making the textbook seem more like a millstone than a life vest. In the second edition of Molecular Biology: Principles and Practice, Doudna hopes to fuse the best of print and digital. “I doubt there will be less text, frankly, because we’ve found that faculty want quite a high level of discussion about experimental findings.

“But expanding into other kinds of media like the iPad will allow us to give people more options. We could pick any sort of topic in molecular biology and have an application that would allow students to get real-time information about that concept. We could have discussions with practicing scientists kept very up to date with interviews as new discoveries are made.

“Or it could be a hands-on demonstration of the discovery, showing them data and walking them through how one does the experiment.”

Doudna hopes to have all that out in three years. “We just had our book signing party [for the first edition], and our publisher said, ‘Don’t relax. In a few months I’m going to be calling you.’”

WEB EXTRA: To learn more about digital supplements to textbooks, visit www.hhmi.org/bulletin/aug2011.