Making Genetics Easy to Understand

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The Human Genome Project and the subsequent explosion of genomic information are transforming our knowledge of how organisms function and how genes and the environment interact. These insights have led to advances in personalized medicine, stem cell treatments, and genetic testing. Students, teachers, and the public must be prepared to make informed decisions about participation in genomics research, genome-related health care, use of genetically modified agricultural products, and public funding for stem cell research. Education has been identified as a crosscutting element that is critical to achieving the potential of genomics research (1).

To address this need for genomic literacy, we have developed two related Web sites, Learn.Genetics (see figure, right, from http://learn.genetics.utah.edu/) and Learn.Genetics.ics (http://teach.genetics.utah.edu/).

Our goal in developing these Web sites has been to make genetics and genomics easy for everyone to understand. The grants and contracts funding the sites have supported development of curriculum-supplement materials for grades 5 through 12 that address the National Science Education Standards (2) and gaps in standards-related, free, online, multimedia educational materials.

Web-site and in-person feedback indicate that the materials are used by a much broader audience. Students from middle school through graduate school use the site to better understand content their instructors present, to assist in completing assignments, and to explore science independently. Higher-education faculty use the materials for courses ranging from introductory biology to professional preparation in education and nursing.

An integrated pair of Web sites for students and teachers supports genetics and genomics education worldwide.

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teaching experience, student populations, and locales; about 5 to 10% of applicants are accepted. Participants receive travel expenses and a stipend.

A typical 4½-day summer workshop begins with talks by scientists and discussions of scientific articles, from which participants distill important concepts for their students. The teachers and our staff work together to define the “big ideas” that emerge from these concepts, around which the module will be organized. Small groups of teachers then develop each big idea, drafting online and classroom learning experiences designed to assist students in learning. The workshops offer a rare opportunity for teachers to develop creative ideas for curriculum materials that will be used worldwide, to interact with scientists, to update their content knowledge, and to work with other teachers from across the country. A glimpse into one summer workshop can be seen at http://learn.genetics.utah.edu/content/epigenetics/credits/. In it, teachers describe ideas that became the Insights From Identical Twins movie and “Gene control” interactive animation on Learn.Genetics and the “DNA and histone model” activity on Teach.Genetics.

After the summer workshop, our team works with the materials the teachers drafted. Ideas may be combined, modified, expanded or contracted, as we plan a module that addresses the big ideas while fitting the anticipated cost within the available budget.

Our materials evolve each year as we learn from past modules and feedback obtained via classroom testing, teacher workshops, and Web-site feedback. At present, key module concepts are addressed in animated and interactive activities, because these appeal to the broadest range of learners. Narration allows users to concentrate on the animation and leads to deeper learning (3); text is available for those who are hearing-impaired or in computer labs lacking headphones. “Learn More” pages provide additional information for those interested in exploring beyond the basics. All pages are designed following standard Web usability guidelines (4), including meaningful visuals and text that is clear, concise, and easily scanned.

Good instruction addresses multiple learning styles, such as visual, auditory, and kinesthetic (5, 6). Therefore, our modules include non–computer-based classroom materials designed to support, extend, and assess online learning. For example, the somatic cell nuclear transfer (SCNT) technique utilized in the “Click and clone” interactive animation is mirrored in the paper-based “Let’s clone a mouse, mouse, mouse” activity. We suggest using the latter as an assessment for the online activity, asking students to use the mouse and petri dish paper cut-outs to create a poster describing the SCNT technique, without giving them the instructions. Additionally, worksheets are provided for many other animations to guide students’ learning.

An entire module comprises 2 to 10 hours of instruction. However, in designing our materials, we recognize that many teachers do not use a curriculum supplement module in its entirety (7). They select materials that address the science standards they are required to teach, are appropriate for their students’ level, and fit their instructional designs (7). For example, in the “Amazing cells” module, a seventh-grade teacher might only use “Inside a cell” and “Cell size and scale.” A high-school biology teacher might use these activities plus “Build-a-membrane,” “Coffee to carbon,” and “The fight-or-flight response.” To address multiple grade levels and teachers’ differing use of the curricula, each animation and classroom activity focuses on a single main learning objective, making it easier for teachers to incorporate the materials into their lessons.

As our team produces a module, they consult the scientists who participated in the summer workshop and others for additional information and to verify scientific accuracy. Currently, module production also includes development of valid and reliable field tests and later added to the resource materials on Teach.Genetics. A medium-sized module, such as “Epigenetics,” takes 3 to 4 months to produce.

Once a module is produced, it is tested in the classroom with students and teachers who were not involved in the development process. Students complete knowledge assessments before, after, and 2 weeks after studying a module. Teachers receive a stipend for their participation and feedback.

We have begun expanding beyond genetics with our “Amazing cells” and “Great Salt Lake ecology” modules. We hope to develop additional materials in the areas of life science and health and other scientific fields. The Web has become the primary information source for individuals with access to the Internet. Online educational materials thus have the ability to affect science literacy, preparing individuals to participate in the workforce, as well as to become informed health-care consumers and citizens of the 21st century.

References and Notes
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