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Engaging Students in Molecular Biology via Case-Based Learning

Case It!, an IBI prize–winning module, provides computer simulations that enable student analysis of biological materials not usually available in laboratories.

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Case It! (www.caseitproject.org) originated at the 1995 BioQUEST Summer Workshop (*1*) and has developed over the years into an effective system for case-based learning useful for both high school and university educators (*2*, *3*). National Science Foundation support has enabled us to distribute all project materials at no cost.

Case It v6.06 is a computer simulation that enables students to input DNA or protein sequences and to generate realistic results for procedures including Southern, Western, and dot blotting; simple and multiplex polymerase chain reaction (PCR); single-nucleotide polymorphism (SNP) and expression microarrays; and enzyme-linked immunosorbent assay (ELISA). The free download includes Case It v6.06 and folders containing sequences for case scenarios based primarily on genetic and infectious diseases.

Students first read case descriptions from the Case It! Web site, then use Case It v6.06 to open sequence files associated with particular case scenarios. They select and run the appropriate procedure to analyze the sequences, generating results in the form of images that can then be incorporated into presentations or reports.

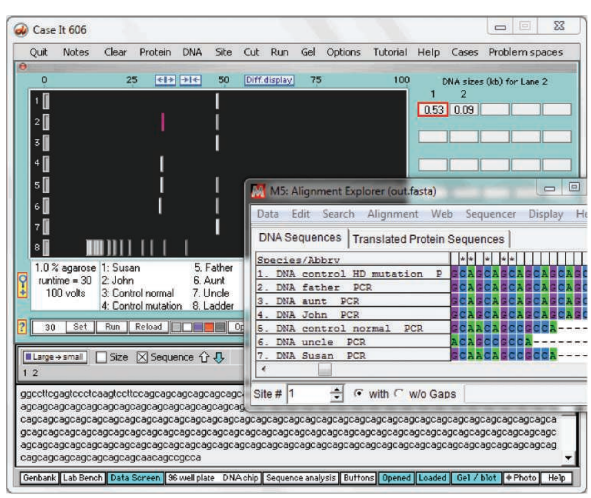
The simulation can be used in a variety of ways for inquiry-based instruction at different learning levels. At the introductory-biology level, students can assume roles of persons in the cases, such as health-care professionals, lab technicians, researchers, or hypothetical family members. They then discuss results either in person or online. Substantial inquiry occurs when students have to answer questions in the role of a physician or counselor and discuss ethical and social ramifications of the results (e.g., genetic testing). Playing the role of a person in the case requires them to develop pertinent questions leading to rich interactions with their peers (*4*).

Undergraduate research assistants developing new cases on honeybee biology. (Left to right) Samual Master, Kathryn Hoffman, Ryan Debner, Brianna Jacques, Jennifer Brooks, Jamie Bolwerk.

For example, in the Huntington's disease case, students enter sequences representing patient samples, perform PCR on these samples, and then analyze the gel results to determine who has inherited the mutation associated with this disease. The sequence of each PCR product can be viewed in Case It v6.06 or aligned using MEGA software (*5*) to illustrate the variable nature of the triplet repeat mutation. Because this is a dominant mutation, anyone with one mutated allele will likely progress to the disease, for which there currently is no cure or treatment. In one scenario of this case, Susan talks her brother John into being tested for the disease, but he is the one who tests positive for the mutation, and her results are normal (see the screen shot at right). Students playing the roles of Susan or John must then imagine what it is like to be in this situation and respond accordingly. In our experience, this kind of interaction enhances learning by making molecular biology more interesting and relevant (*6*).

We have found that role-playing works best when students post case results and communicate with their peers online, switching roles as family members and health counselors. They preferred online discussions to other types of interactions (*4*) and became so engaged in asking questions and responding that they frequently forgot that the class period was about to end. Students felt that they could give more thoughtful and accurate answers online, because more time was available to reflect and consult sources before responding.

Another case example involves Anna, a woman diagnosed with HIV during the second trimester of her pregnancy. Students use Case It v6.06 to test for the presence of HIV-specific antibodies in samples from Anna, her baby, and her boyfriend and then use a bioinformatics extension of the case to examine



PCR results from Case It v6.06, and alignment results from MEGA 5, for a Huntington's case scenario. The sequence for the selected (pink) band is shown.

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relations among the virus sequences of these individuals. They discuss how Anna may have become infected with HIV and provide suggestions for how she can care for herself and her infant.

This example and other Case It! scenarios from the United States and Africa help in understanding how culture, geography, and other social issues affect people infected with HIV. The following quote from a student at the University of Zimbabwe illustrates how the Case It! project is helping students worldwide to better understand principles of molecular biology and their relevance to everyday life: "Case It! is a very useful project for all schools if adopted in Zimbabwe. It will help many in understanding HIV and AIDS in general…. Since Zimbabwe is hard hit by HIV it is important to have this project." Online communication allows collaborations among students at different institutions, so that they experience other perspectives on the issues. After interacting with peers at the University of Wisconsin–River Falls (UWRF), a Zimbabwean student said: "[Case It!] gave me an opportunity to simulate HIV tests and play the role of a medical practitioner and counselor by giving advice to people affected by HIV. It was also interesting to network with international students via conferencing. Indeed, the world is a global village."

Case It v6.06 can also be used as an introduction to quantitative techniques, such as the calculations used in SNP microarrays, as illustrated with a prostate cancer case. In one scenario, Greg, who has just turned 50, is told that his blood level of prostate-specific antigen (PSA) is higher than the normal range. Greg's physician recommends SNP testing to see if his PSA levels may naturally be higher than average and not necessarily linked to prostate disease. Greg's results can be compared with outcomes of DNA testing from individuals determined to have high and low blood PSA levels, and users can search using BLAST probe sequences or gather information from the NCBI SNP database (*7*). Students can determine whether Greg should get further testing, such as a needle biopsy, even though he has no symptoms.

The open-ended nature of the simulation encourages inquiry by enabling users to analyze any DNA sequence, including entire viral or bacterial genomes, with any probe, primer, or restriction enzyme. For example, freshmen at UWRF participating in the Howard Hughes Medical Institute (HHMI) SEA-PHAGES project (*8*, *9*) use Case It v6.06 to generate virtual digests of known phage genomes for comparison with actual gels of their newly discovered phages. They can then use the simulation to search the sequence of any band on the gel via a BLAST search and conduct additional bioinformatics analyses. Another strategy is to engage students in developing new cases, using information from research articles and online databases. They create a case scenario; determine techniques; and obtain sequences and tools, such as PCR primers. Creating new cases can be challenging even for advanced undergraduates, but it helps them to analyze original research and to apply results in a novel context. Undergraduates at UWRF (see the first photo) have found this experience to be valuable and engaging.

Case It! pedagogy has been extensively assessed by means of focus group interviews, analysis of posters and conferencing logs, and pre- and posttests (*4*, *6*). We videotaped groups working through Case It! and found them engaged in interpretation and verification of results and procedures. Creating a Web poster for discussion with peers challenged students to integrate knowledge and to articulate their ideas (*3*). Case It! made them aware of the social contexts involved in global issues, promoted scientific competence, and positively influenced performance (*4*, *6*, *10*).

A final point relates to how simulations can help educators enhance laboratory experiences and undergraduate research in an era of tight budgets. Simulations such as Case It v6.06 can extend wet labs by enabling students to analyze sequences that they could not otherwise access, such as sequences from HIV patient blood samples, and also allows them to conduct research in a cost-effective manner using sequences from online databases.

Our goal is to foster a community of users willing to share their ideas for Case It! via meetings, workshops, and discussion forums at www.caseitproject.org. We welcome your participation in this effort.

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PHOTO CREDIT: ANTONIO BAINES

References and Notes

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