Case It! - a collaborative BioQUEST project to enhance case-based learning in university and high school biology education worldwide via molecular biology computer simulations and Internet conferencing

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Overview of the Case It! project

Case It! is a National Science Foundation-sponsored project initiated by participants in the BioQUEST Curriculum Consortium. The goal of this project is to enhance case-based learning in high school and university biology courses worldwide via molecular biology computer simulations and Internet "poster sessions". Students first play the roles of laboratory technicians as they analyze DNA sequences associated with particular cases and construct web page posters giving results of genetic testing. They then play the roles of genetics counsellors and family members as they ask and answer questions concerning these tests. To accomplish this, students use three software tools: *Case It! Investigator*[1] to gather background information, the *Case It! simulation*[2] to analyze DNA, and the *Case It! Launch Pad*[3] to access a web page editor and Internet conferencing system. (Note: The latest versions of both the Macintosh and PC versions of *Case It! Investigator* and the *Case It! simulation* are currently available for downloading[4], free of charge for educational use. These two applications are also part of the BioQUEST Library of inquiry-based software.)

Although the *Case It! simulation* works with any DNA sequence, we have concentrated on human genetic disease cases because of the high degree of student interest in these cases and ethical ramifications which make them particularly well suited for spirited discussion and debate. Cases developed and class-tested to date include Alzheimer's disease, breast cancer, sickle-cell disease, muscular dystrophy, cystic fibrosis, phenylketonuria, Huntington's disease, and fragile-X syndrome.

Case creation

We originally downloaded the appropriate DNA sequences for the various disease conditions from Genbank, a government repository of genetic information, then modified the sequences to create multiple scenarios involving hypothetical "family members" being tested for the presence

or absence of disease mutations. Thus, cases included with the simulation are reasonably realistic and give results similar to what would be obtained analyzing actual DNA samples.

Students also have the option of creating their own cases because of the open-ended[5] nature of the Case It! software. For example, a freshman non-science major at University of Wisconsin-River Falls successfully created a case involving a rare genetic condition found in the student's own family, one that the student was at risk of contracting. Another student attempted to develop a new breast cancer case using a recently-discovered mutation for this condition. Logistically, however, it is difficult for our target audience (high school students and university undergraduates) to create realistic cases on their own because they must have detailed knowledge of the types of mutations involved, the procedures used to analyze the mutations, and the location of appropriate sequences in the Genbank database. Thus, we generally have students work with prepackaged DNA sequences, arranged so that there are multiple scenarios for each case to provide variability in results and generate interesting discussions, particularly of ethical issues. Three years class-testing have verified the effectiveness of this approach[6].

Case It! Investigator and the *Case It! simulation*

Students use *Case It! Investigator*[1] to provide background information on cases and to assist in the search for additional information from relevant web sites. Students begin by reading the case of choice and a synopsis of the disease which is stored in *Investigator* as an internal HTML file (Figure 1). When students click links or use the button bar to access pull-down menus of links, *Investigator* will automatically open their web browser to those Internet sites, and keep track of them for future reference (upper right corner of Figure 1).

Investigator will open any application on the user's hard drive, including other BioQUEST modules useful for case analysis, via the "tools for case analysis" pull-down menu. Instructors can easily change links, menu items, button names and textual content by changing the content of simple text and HTML files that are automatically read each time *Investigator* starts.

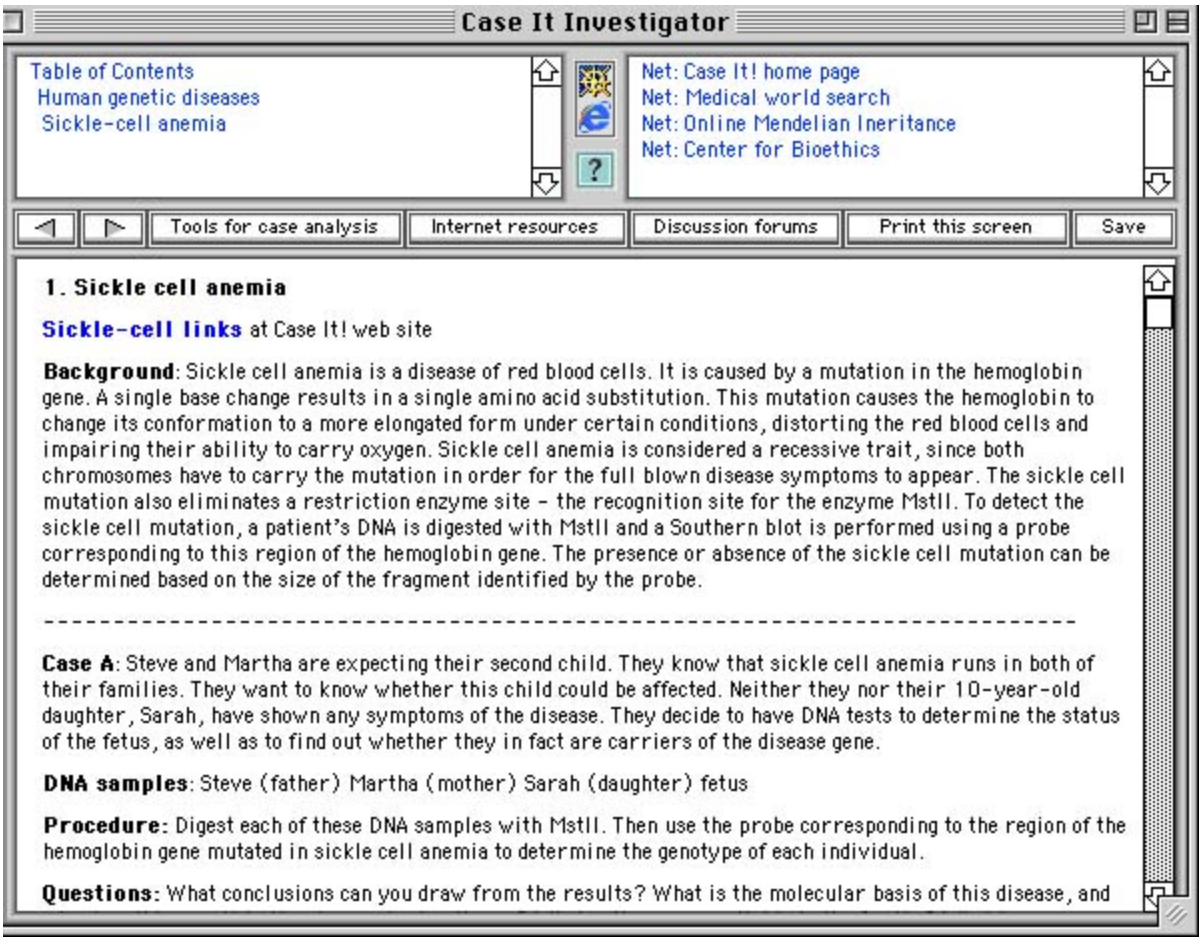

Figure 1. Sample screen from *Case It! Investigator*

After gathering background information, students use the *Case It! simulation*[2] to run analyses for DNA sequences associated with their particular case. Current capabilities of the simulation include restriction enzyme digestion, DNA gel eletrophoresis, Southern blotting, dot blotting, and PCR. The simulation reads data as text files representing DNA sequences, restriction enzyme recognition sites, probes, and primers.

After running analyses, students use the simulation to take "photographs" of the resulting gels and blots and save them as JPG or GIF files for later incorporation into web pages via the web page editor. Figure 2 shows an example scenario from the sickle-cell disease case, run from the "Lab Bench" screen of the simulation. Abnormally large fragments (the ones to the left) move more slowly than normal fragments (the ones to the right), and a "radioactive probe" is bound to the fragments of interest to make them visible on the Southern blot. In this example, the father and mother are both heterozygous for the sickle-cell mutation, since they carry both an abnormal and a normal gene. The daughter carries only the normal gene, but the unborn foetus carries only the sickle-cell gene.

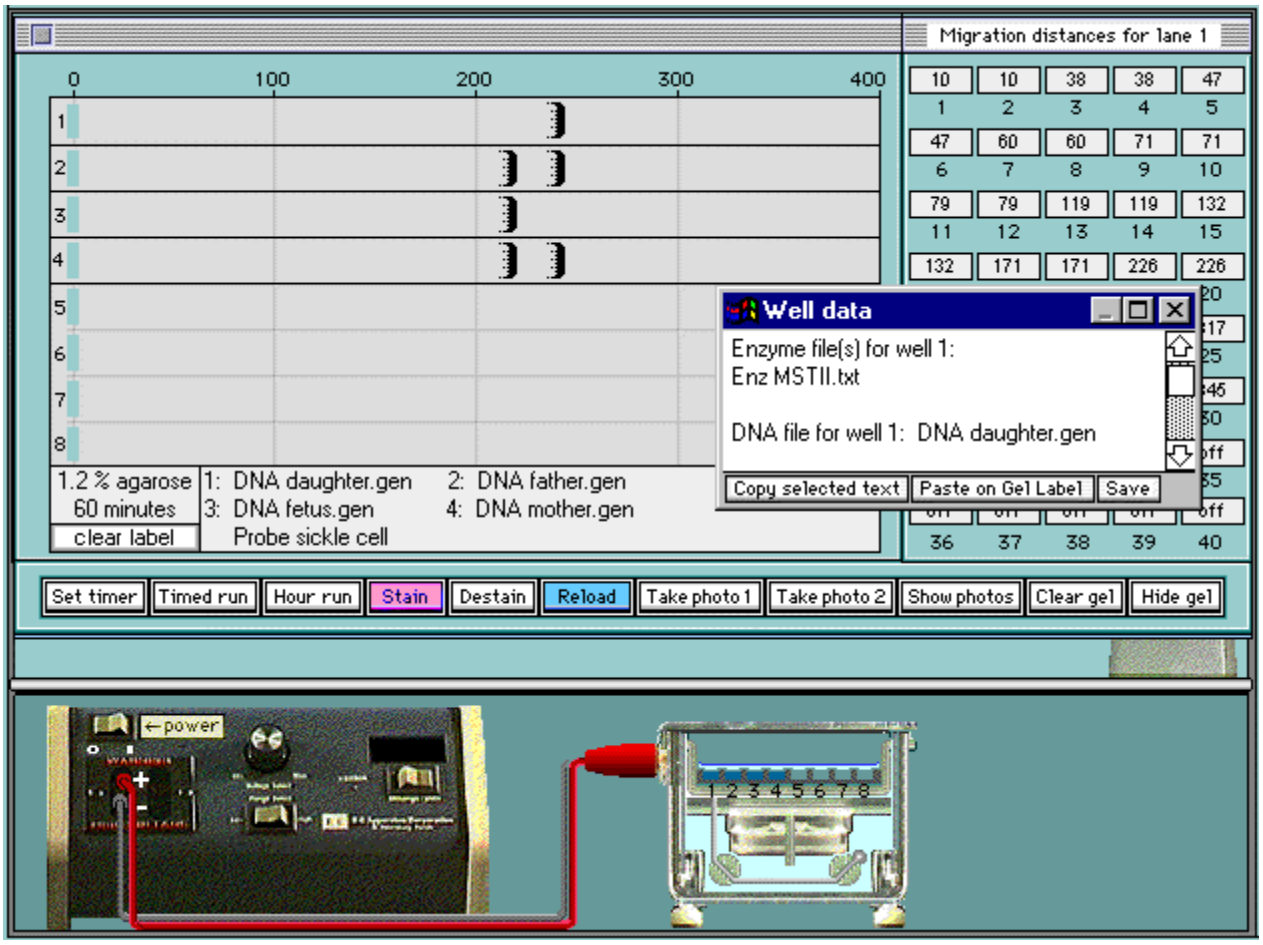

Figure 2. Sample screen from the *Case It! simulation* showing results of one scenario of the sickle-cell case

A second example (Figure 3) illustrates the dot blot capability of *Case It!* Version 4.0. In this example, Elizabeth, her mother, and an unrelated woman have been tested for the presence or absence of three genetic mutations associated with a greater probability of contracting breast cancer. Results indicate that Elizabeth's mother and the unrelated woman test positive for the 185 and 4184 mutations, respectively, but that Elizabeth does not test positive for any of the three mutations. The other positive results on this image are controls for the three mutations.

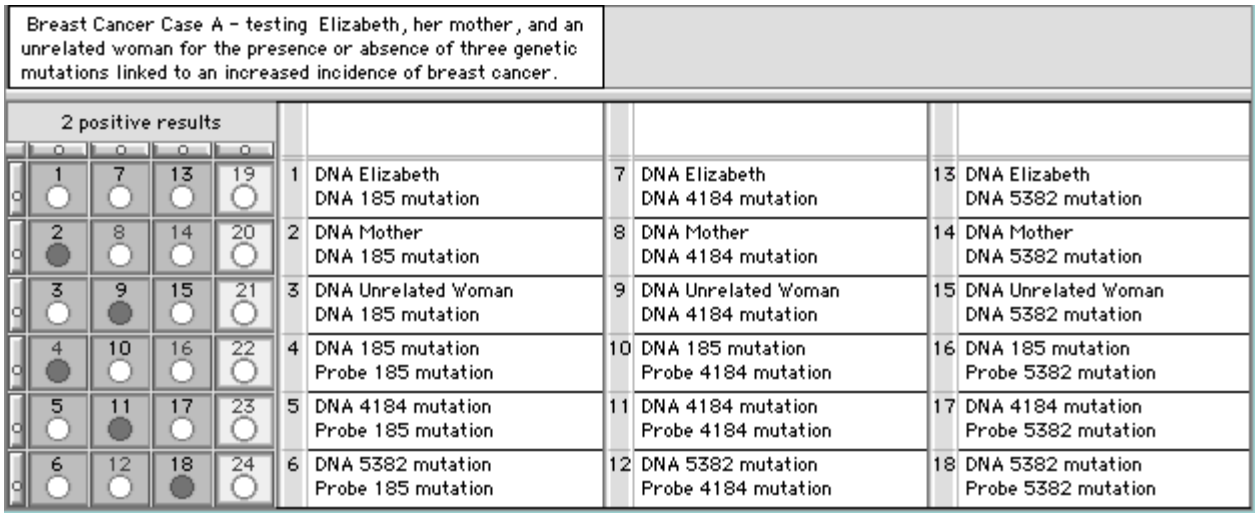

Figure 3. Results of one scenario of the breast cancer case, using the dot blot feature of *Case It!* Version 4.0

Case It! Launch Pad

After using the Case It! computer simulation to analyze DNA, students create "posters" for counselling via a custom web page editor accessible from the *Case It! Launch Pad*[3]. This editor enables students to easily add and edit the various sections of their web pages and to incorporate gel/blot photographs and other images. Text and graphics are automatically uploaded to a central server located at the University of Wisconsin-River Falls when students use the system. The *Launch Pad* also organizes links to each group's discussion forum and published web page, and provides a feature for compiling messages sent by individual students. The integrated web page editor/conferencing system is designed for ease of use, even if students have had no prior experience building web pages or conferencing. A tutorial for using the web page editor is available on-line[3].

Students play the role of genetics counsellors when responding to questions sent to their own group's forum; they play the role of family members when sending messages to other groups' forums. A host of issues can be discussed at these "counselling sessions", including questions regarding the molecular biology of the disease, symptoms, treatment, and ethical issues that might arise. For example, if Susan talks her brother John into being tested for Huntington's disease, and if Susan tests negative but John tests positive, how would the genetics counsellors deal with the hard feelings that might result? If a foetus tests positive for sickle-cell disease and the family member asks about the possibility of an abortion, how should the genetics counsellor respond? How would Elizabeth feel about her mother testing positive for a breast cancer mutation, whereas she herself does not? Should the counsellor recommend a prophylactic double mastectomy when there is a chance that the mother will not come down with breast cancer?

Class-testing and call for participation

Student response to this project has been overwhelmingly positive during the past three years of class-testing[6], and our goal is to expand it to include high schools and universities worldwide. This year class-testing has involved students from three high schools (River Falls High School and Southwest High School in Wisconsin, and Forbes High School in Australia) and three universities (Campbell University in North Carolina, the University of Wisconsin-River Falls, and the University of London).

We cordially invite interested educators to participate in the Case It! project. To download the latest versions of *Case It! Investigator* and the *Case It! simulation*, at no cost, contact the first author at mark.s.bergland@uwrf.edu. This summer the *Case It! Launch Pad* will be fully automated so that instructors can easily add student groups, giving them access to the on-line web page editor and conferencing system. The *Launch Pad* is also available free of charge to institutions willing to participate in the Case It! project; all that is needed is an Internet connection.

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