EARLY BLAST OFF:
Bringing Bioinformatics to Secondary Schools

By Esther Landhuis

Two decades ago at a genomics workshop for educators, a high school biology teacher isolated DNA from a snippet of his hair and got it sequenced. He then used a computer algorithm to compare his DNA sequence to that of Neanderthals, ancient primates that roamed Earth some 200,000 years ago.

It was not only an auspicious journey into human history but also "my introduction to bioinformatics," says **David Form, PhD**, who teaches at Nashoba Regional High School in Bolton, Massachusetts. His next thought: "This would be exciting for students."

When Form started teaching, genome sequencing and bioinformatics were still new-fangled. But biomedical data has since exploded in volume and complexity, and that program Form fiddled with 20 years ago to explore the Neanderthal genome is now a researcher's mainstay. Called Basic Local Alignment Search Tool (BLAST), the algorithm scans multiple DNA or protein sequences for similar regions. It is used to determine evolutionary relationships and gain insight into genetic diseases.

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Building BLAST and other computational resources requires programming skills and advanced mathematics, mostly taught at the undergraduate and graduate levels. So why is it important to introduce bioinformatics in secondary schools?

Facilitating Biological Discovery

For middle and high school students, it's not about learning the technical know-how. "It's about using bioinformatics tools to make biological discoveries," says **Fran Lewitter, PhD**, founding director of the bioinformatics and research computing department at the Whitehead Institute in Cambridge, Massachusetts.

In the classroom, Form shows his biology students how to use BLAST and other computational tools so they can explore human diseases. "They learn which genes and proteins are involved, find a suitable lab model to study the condition, and go from there," Form says. "It's an active way for students to learn some very sophisticated things."

Though Form was self-motivated to develop his bioinformatics curriculum—buying books to bone up on bioinformatics after that first workshop 20 years ago—biology teachers today have a greater imperative to train their students to use computational tools. In 2013, the Advanced Placement (AP) biology exam was revised to include bioinformatics. Test takers are given BLAST data to interpret evolutionary relationships depicted in phylogenetic trees.

Training Workshops

Various institutions—including Cold Spring Harbor Laboratory, Whitehead Institute, Harvard University, University of Utah and Marine Biological Laboratory at Woods Hole Oceanographic Insti-

David Form speaks on how to teach high school students bioinformatics at an educator's workshop at the Whitehead Institute. Photo credit: Ceal Capistrano/Whitehead Institute.

tute—now offer crash courses in modern genetics and bioinformatics to equip teachers to introduce these concepts in their secondary school classrooms. The International Society for Computational Biology, a professional society headquartered at the University of California, San Diego, and the European Molecular Biology Laboratory in Heidelberg, Germany, also offer teacher training in bioinformatics.

Joanne Fox (center) works with high school students in the teaching laboratory/educational facilities at the Michael Smith Laboratories. Courtesy of Joanne Fox.

High school teachers who attended week-long summer bioinformatics workshops in 2008 to 2012 at Franklin & Marshall College in Lancaster, Pennsylvania, not only left with valuable wet lab and computer skills. They also earned professional development credit, made $25 per hour and received an additional $250 toward classroom supplies. "We value teachers' time and wanted to make the experience economically attractive for them," says **Ellie Rice, PhD**, senior adjunct professor of biology, who directed the teacher outreach program. During the week, attendees created bioinformatics-based classroom activities and put their lesson plans on the publicly available Bioinformatics Activity Bank.

Though training workshops give a good introduction to the nuts and bolts of cutting-edge biology, some teachers still come away feeling a bit daunted teaching the material to their students, Form notes. Going into a lab and doing an activity once isn't enough, he says. "You need at least three days to explore the data with someone who knows what they're doing." Many workshops compress the bioinformatics portion into a single day or afternoon. Still, many high school biology teachers, especially those teaching AP or other advanced classes, do incorporate some bioinformatics into their lessons after attending even a brief workshop.

Field Trips

Other educational outreach efforts take a different approach. Rather than trying to equip teachers to bring new concepts into the classroom, some programs invite teachers to bring their classes to a research facility on campus. There, graduate students and scientists teach the visiting students to perform lab experiments and use bioinformatics tools. "Field trips give students the view that science is accessible—something they can see themselves doing," says **Joanne Fox, PhD**, senior instructor in the Michael Smith Laboratories at the University of British Columbia in Vancouver, Canada. "There's power in being in an actual research space and talking with scientists as you do the activity."

Fox helped develop a genomics outreach program that launched in 2009, bringing 1,500 to 2,000 students each year to the Michael Smith Laboratories. When her team first piloted the program, they wanted to get students onto computers browsing genome data right from the get-go. "But the students found [the computational tools] very abstract," notes Fox. "They didn't see the connection to their own lives."

Now, rather than going straight to the computers, students begin by isolating their own DNA from a cheek swab. "It's very impactful for them to see the gooey DNA," Fox says. It also helps equip students to engage in discussions related to personal genomics—such as prenatal screening to test for genetic diseases in unborn babies. The students also get acquainted with bioinformatics as they learn how to transcribe, translate and align DNA sequences.

Bringing the Lab into Classrooms

Instead of bringing classes into research labs to learn lab techniques and bioinformatics, other programs do the reverse—they bring the lab into the classroom. Every year since 2006, bioinformatics@school has deployed its DNAlab to some 60 high schools in the Netherlands, reaching a total of 17,000 students. "We go into classrooms and run a two-hour lesson," says education coordinator **Judith Rotink, MS**. "We bring our own computers, even our own networks." Funded by Radboud University Medical Center and a government grant, the program is free of charge to schools and taught by science students at Radboud University in Nijmegen.

Teachers can also download guides and lessons to lead the course themselves. In one project entitled "Murder at the Airport," students learn that a man lies dead on the floor next to a bottle containing a liquid. The students use online databases to figure out which of four suspicious proteins in the liquid was responsible for the man's death.

"Bioinformatics tools can make abstract concepts more understandable," Rotink says. □

RESOURCES:

DNA Learning Center (Cold Spring Harbor):
https://www.dnalc.org/programs/teacher_training.html

Bioinformatics workshops, courses and course materials (Whitehead Institute): http://jura.wi.mit.edu/bio/education/

Harvard Life Sciences Outreach programs:
http://outreach.mcb.harvard.edu/index.htm

Genetic Science Learning Center (University of Utah):
http://learn.genetics.utah.edu/

Professional development workshops (Marine Biological Laboratory at Woods Hole Oceanographic Institute):
http://discover.mbl.edu/workshop.htm

Howard Hughes Medical Institute (HHMI):
http://www.hhmi.org/
A philanthropic organization that supports US biomedical research, produces online multimedia resources for educators, including a series of virtual labs that let students practice wet lab techniques such as DNA sequencing and polymerase chain reaction (PCR), as well as learn to analyze DNA sequences, in an interactive setting on their own computers.