Carolina Case Study

BioBuilder Synthetic Biology Kits: Collaboration Brings Advanced STEM Labs to High Schoolers

Have you ever imagined how great it would be for all your students to be able to perform advanced experiments on progressive STEM topics using biology laboratory kits? Or perhaps you are with a company that would like to help local schools enrich their STEM programs with cutting-edge resources.

Sound too good to be true? Well, here’s a surprise—these initiatives can and are being done.

This is the amazing story of how one Tennessee high school is bursting with excited young scientists—thanks to an innovative collaboration of educators, a corporate foundation, scientists based at the Massachusetts Institute of Technology (MIT), and Carolina Biological Supply Company—and can illustrate how to bring advanced STEM opportunities to other schools.

Synthetic Biology Comes to Kingsport

The science department at Kingsport City Schools in northeast Tennessee experienced significant changes last year. It implemented new Tennessee science academic standards, moved into a new STEM center at Dobyns-Bennett High School, and integrated synthetic biology labs into its science curricula. These changes came together at a time when Kingsport educators were looking for ways to elevate their science classes with advanced, college-level topics; real-world investigations; and project-based learning.

What Is Synthetic Biology?

Synthetic biology involves redesigning organisms for specific purposes. These organisms are genetically engineered to have new capabilities, such as producing a particular substance, being able to detect a substance, and having the ability to sequester or degrade a substance. Synthetic biology is being used today in many innovative ways. Examples are to clean up environmental contamination, increase the nutritional value of food, and produce commercial product ingredients (including new plant-based meat substitutes). 1

1. www.carolina.com/education/syntheticbiology
The Eastman Foundation, the corporate responsibility arm of the Eastman Chemical Company, played a major role in bringing synthetic biology to the Kingsport schools. With its global headquarters in Kingsport, Tennessee, one of the Foundation’s priorities is to partner with local schools to help build strong STEM programs for students, who, perhaps, may become future Eastman scientists.

The Foundation’s leaders recognized the power of synthetic biology to drive future innovation in industry and medicine, so they began searching for a world leader in synthetic biology education. Their search led them to BioBuilder Educational Foundation.

BioBuilder is a nonprofit organization created in 2011 by an award-winning team at MIT focused on synthetic biology. Its project-focused curriculum teaches students to integrate biology and engineering by conducting practical, hands-on labs and related activities. The BioBuilder team also provides teachers with professional development that fosters new methods of teaching designed to engage and inspire the young scientists in their classrooms.

BioBuilder selected Carolina Biological Supply Company as a partner because of Carolina’s commitment to quality, support of professional development teacher workshops, technical expertise, and extensive life science product offerings. Carolina is the exclusive supplier of BioBuilder lab kits. The professional supplies, equipment, and instruction in each kit are invaluable as students conduct the advanced, hands-on investigations of synthetic biology.

Dr. Mark Meszaros, a Carolina vice president, states, “We are proud to take part in this impactful program as both a supplier and instruction materials provider. We are grateful to partner with BioBuilder as we mutually pursue student achievement with these cutting-edge labs.”

As the Eastman Foundation’s Maranda Demuth explains, “What we love about programs like BioBuilder is it teaches students how to solve real-world problems through advanced sciences that they may never experience otherwise. We find a world leader like BioBuilder that combines all of the advanced sciences and a strong reinforcement in writing and research to address real-world issues. BioBuilder was a logical good fit for us.”

The Foundation approached the Kingsport schools about integrating BioBuilder synthetic biology content into their high school STEM curriculum. Dr. Brian Cinnamon, chief academic officer for Kingsport schools, explains, “We were changing our philosophy in how we approach teaching and learning, shifting to more of a project-based approach. So the opportunity to include BioBuilder content was a perfect way to do that.”

Teacher Training and Lab Prep
The first step to the successful integration of BioBuilder is for the teachers to learn the curriculum and labs. In January 2019, all of Dobyns-Bennett’s biology teachers, including Kingsport teachers Amanda Blackburn and Evie LaFollette and science specialist Wendy Courtney, traveled to Boston and spent a week at MIT learning BioBuilder. The Eastman Foundation also sent two STEM faculty from East Tennessee State University (ETSU) to the training. ETSU is also located in the northeast Tennessee region, not far from Kingsport. The Kingsport high school and ETSU faculty learned the BioBuilder content together, forging a relationship of mutual support as they both adopt BioBuilder in their classes.

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Dr. Natalie Kuldell, BioBuilder's executive director, and veteran BioBuilder teacher Jo-Anne Purdy, from Westborough High School in Massachusetts, worked with the educators in the MIT lab. They first had the teachers conduct some of the BioBuilder labs from a student's perspective—without any prior knowledge of the procedure.

“At first, we were confused because we didn’t understand all the bits and pieces,” Blackburn says. “It made us realize ‘I know what my kids are going to do. I just have to figure out what I’m going to do.' Then the second time we ran it, it was a walk in the park. It was much more user-friendly than we were letting it be the first time.”

When the week of training was complete, the Kingsport educators returned to Tennessee, where they continued to study the BioBuilder content and share it with their colleagues. In July 2019, as the time for implementation approached, Kuldell and Purdy traveled to Kingsport to again work with the Dobyns-Bennett teachers. They answered the teachers’ questions and watched them conduct the labs again using the BioBuilder curriculum and Carolina kits, this time with some experience under their belts. LaFollette says, “We did it again from the teacher perspective, and we were like wait a second—it’s this easy."

Before learning about BioBuilder, Blackburn and LaFollette agree that if someone had told them they need to teach their students synthetic biology, they would have laughed. But BioBuilder staff’s knowledge and guidance made it simple.

While BioBuilder training was going on, the Kingsport teachers and administration were also working to outfit their new STEM center lab. Some of the advanced techniques used in the BioBuilder experiments require college-level equipment. Cinnamon explains: “We planned for what we call 21st century labs as part of our new STEM center, but even in that planning, we did not have some of this equipment on our radar.” Kuldell and Carolina staff assisted the school in identifying the equipment needed for the new lab, which is now outfitted with Carolina’s state-of-the-art equipment.

The collaboration among diverse organizations provides teachers with a strong support system as they implement BioBuilder in their classrooms and labs.

“It’s a game changer for some of the students to be doing what scientists do. . . . It elevates their knowledge of what scientists do and the possibilities for themselves.”

—Wendy Courtney, Secondary STEM Specialist, Kingsport City Schools

Students explore opportunities that exist in biology and engineering through synthetic biology, elevating their knowledge of what scientists do and possibilities for themselves.
• Kuldell and her team are always available to answer questions and provide assistance.

• Carolina provides kits that make it easy for teachers to teach the labs and excellent technical support when teachers need additional assistance.

• Scientists and engineers at Eastman Chemical and faculty at ETSU act as mentors for the high school teachers and the students.

As Kuldell says, “It is a partnership all around in support of the Dobyns-Bennett teachers and students.”

**Student Impact**

The Dobyns-Bennett High School science educators have watched their students respond to the BioBuilder labs in amazing ways. In the first lab, the BioBuilder® Eau That Smell Kit, students change stinky bacteria into bacteria that smells sweet, like a banana. They learn to grow microbial cells, measure the cells’ growth, analyze the genes on a molecular level, and learn basic synthetic biology concepts related to system design and logic gates.³

“It’s a game changer for some of the students to be doing what scientists do,” Courtney explains. “When I’ve been in the classroom with them, the kids have their lab coats and safety goggles on, and they’re . . . saying, ‘This is what scientists really do. I could do this. This would be a great profession to do or something like this [job].’ It elevates their knowledge of what scientists do and the possibilities for themselves.”

In addition to getting students excited about science, BioBuilder also challenges them to a higher level of learning and thinking. Blackburn describes it well: “When we do the lab, we ask the kids, ‘If you were creating, what would you do? What problem would you solve? Where would you want to go with it?’ The student becomes the scientist in that role. They are the problem solvers. It gets them to start thinking in scientific and engineering ways, and it has been really exciting to see. I think their whole approach and understanding are stronger because they have this experience that ties things together.”

But it is also easy to implement. Carolina and BioBuilder have worked together to ensure that the lab kits contain all the supplies needed for the labs and the instructions are easy to follow. The kits are designed to save teachers time, so they can spend more time with their students.

The Kingsport administrators and teachers are committed to making BioBuilder available to students of all levels of abilities. “We teach a lower level of biology with students that often have Individualized Education Programs,” LaFollette explains. “And then we have a general biology class and continued >>
an honors biology class. So we’ve seen the full spectrum of students doing the BioBuilder labs, and they all enjoy it. They’re asking, “When do we get to do the next one?”

Over the next four years, all 2,500 students at Dobyns-Bennett High School will have hands-on training in synthetic biology. The hope is that some of the students will use their BioBuilder experience to further their education and career goals, perhaps at ETSU or Eastman Chemical Company.

**Replication Encouraged**

As news of this innovative collaboration is relayed throughout the education community, the hope is that it encourages other schools and organizations to explore their own possibilities. Kristina Krautkremer, an advanced placement biology teacher at Dobyns-Bennett High School and a 2019 Presidential Awards for Excellence in Mathematics and Science Teaching (PAEMST) recipient, recently helped to spread the word while at the White House Federal STEM Education Summit. She sent this message to Kuldell:

“We were discussing how our local communities are implementing the STEM Education Strategic Plan. My table was overwhelmed when I spoke of how our new STEM building with all of its resources facilitated learning for all students in STEM. I shared about our partnership with Eastman, in particular BioBuilder, and how our students bioengineered microbes by adding genes to express compounds smelling like bananas, and the extensive professional learning Eastman provided for all biology teachers with Natalie at MIT. No other PAEMST Awardee from any other state had anything similar to share. I’ve always, always appreciated how our local partnerships empower what I do, but their faces spoke volumes. Every one of them would have loved to have the support we have in Kingsport. Thank you for all you do to support what I do.”

Remember, a journey always begins with that first step. Visit Carolina or BioBuilder for more information.

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**What Does a BioBuilder Kit Look Like?**

Teach DNA expression, inheritance, and sterile technique with the “What a Colorful World” lab that extends beyond classic transformation technique through the engineering concept of “chassis selection” when choosing the best host cell. It includes teacher and student manuals in full color and black and white as well as overview slides.

The “Golden Bread PCR” lab explores the science, engineering, and bioethics of a yeast that’s genetically modified to make a vitamin-enriched food. Lab activities include PCR, yeast transformation, codon shuffling, and quantitative analysis of data.

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**References:**

