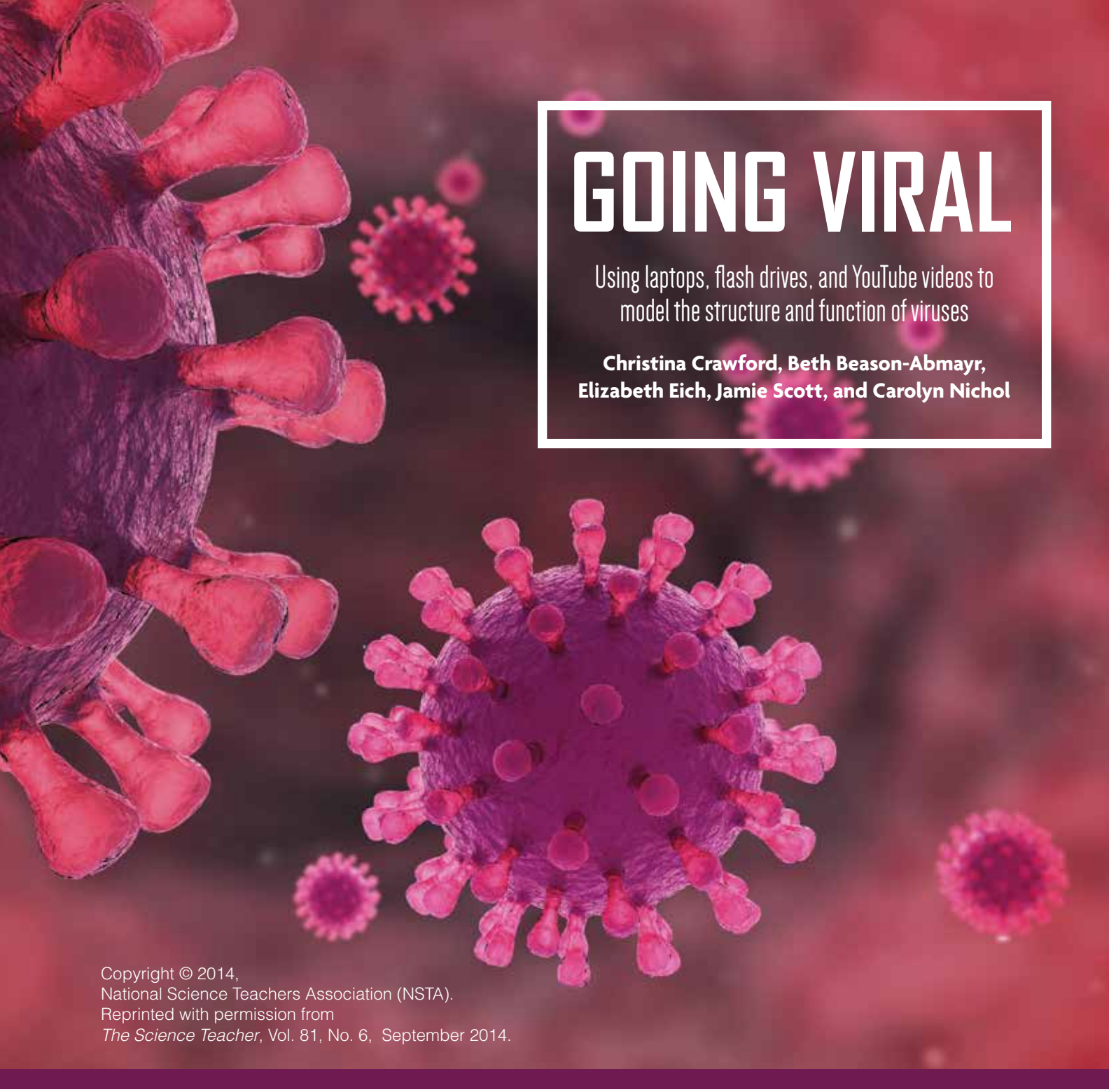

GOING VIRAL

Using laptops, flash drives, and YouTube videos to model the structure and function of viruses

Christina Crawford, Beth Beason-Abmayr, Elizabeth Eich, Jamie Scott, and Carolyn Nichol

Viruses are all around us—and within us. They replicate inside the cells of living organisms. An estimated 1.6 million to 40 million of them occupy each cubic meter of the air we breathe (Whon et al. 2012). The activity described in this article helps students understand how the structure of a virus allows it to infect a specific set of organisms and cell types. Students also explore the relationships between viral components and mechanisms of replication.

This activity uses the techniques of active learning to engage students with a tactile representation of a biological process, making them active participants in the classroom (Aydede and Kesercioglu 2010). A student engaged in active learning discovers, processes, and applies new information to solve problems (McKinney 2004). While the teacher acts as facilitator or coach, students assemble their own understanding of the concepts (Wood 2009). Students actively engaged in the classroom may attain higher levels of achievement within all socioeconomic backgrounds (Rotgans and Schmidt 2011).

The activity

We use a brief YouTube video, "Flu Attack" (Figure 1), to introduce in simple terms how viruses work. The video uses the analogy of a lock and key to explain how a virus binds to its host cell. Our classroom activity, involving students working in groups of three to six students, builds on the same analogy. The activity requires:

- Backpacks (at least two more than the number of groups in the class)
- A unique lock and key for each backpack
- One gigabyte or larger flash drives attached to each key
- Different videos describing a viral replication process (e.g., from the list in Figure 1) accessible from each flash drive. You have two options: (1) Load a text file on the flash drives containing the video link, which students will click on to stream the video (Wi-Fi access required); or (2) Load teacher-created videos or videos with a Creative Commons license directly onto the flash drives.
- Laptops or tablets with an available flash drive port (one per backpack). If using tablets without USB ports, place a teacher-created QR code on a piece of paper that students can scan to link to a steaming video (Wi-Fi access required).
- At least one backpack/laptop combination is needed per group. To reduce costs, the teacher may: Divide the class into fewer (and larger) groups; check out school laptops in advance; use a variety of lockable backpacks, suitcases, and boxes instead of acquiring new ones; and ask a school administrator or a gym coach if school bags may be borrowed for the activity.

Part 1: The hook

Provide each group of students with a key attached to a flash drive (Figure 2) and a worksheet with guiding questions on which students will take notes while watching a video retrieved from the flash drive. Tell students what each component of the activity represents: "You represent an active virus hunting for a host cell to infect." The key represents the viral protein that will let the virus access a host cell (represented by a backpack) through interaction at the cell surface (represented by the lock). The flash drive represents the viral genetic material inserted into the host cell's genome (represented by a laptop inside the backpack).

Designate a home base for students to return to once they have found their host cell. Provide additional motivation by setting a time limit, such as stating, "You must reach a host cell that you can infect within two minutes, or your protein coat will denature." And they are off.

Part 2: The hunt

Before class begins, hide the host cells (locked backpacks or other lockable book bags with laptops or tablets inside) around the classroom or a certain area of the school. If backpacks are hidden outside the classroom, inform assistant principals and administrators so they can help limit the search area and be mindful of the location of school equipment, and be sure to keep the backpacks in secure locations. Students will be eager to find and infect their host cell. **Safety note:** If the classroom is crowded, caution students not to bump into each other. While students search for their host cells, monitor each group's progress. Help students as needed by asking leading questions, such as: "Have you checked in all the cabinets or under all of the desks?"

FIGURE 1

Links to online videos about viruses.

Video titles	Links
Flu Attack! How a Virus Invades the Body (introduction video)	*http://bit.ly/1kKjI9T*
Retrovirus Replication 3-D Animation (HIV)	*http://bit.ly/1naroUq*
HIV Life Cycle: How HIV Infects a Cell and Replicates Itself	*http://bit.ly/1f1VpFv*
Hepatitis C	*http://bit.ly/1lvzITf*
The Life Cycle of the Hepatitis C Virus	*http://bit.ly/UIragQ*
Bacteriophage Lambda	*http://bit.ly/SQw09U*
Influenza Animation—Flu Virus Mechanism	*http://bit.ly/1oAX77L*
Bacteriophage Lytic Cycle	*http://bit.ly/1pcIB28*
Bacteriophage T4 Assembly	*http://bit.ly/1lB9Rb4*

FIGURE 2

Students receive a key attached to a flash drive, then search for the matching lock attached to a backpack holding a computer or tablet.

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Part 3: The infection

For infection to occur, viral proteins (key attached to the flash drive) must be able to bind to the surface proteins of the cell (the lock holding the backpack shut). Students will know that an infection has occurred when their key is able to unlock a backpack. Once students have found a cell (backpack) to infect, they insert the viral genetic material (flash drive) into the host cell's genome (laptop). Students view the video on the flash drive while using the worksheet to note pertinent details about the structure and life cycle of the virus described in the video (Figure 3, p. 54).

Select videos for the flash drives carefully to cover a variety of virus types. In our class, we selected two complementary videos (only one per flash drive) for each virus. Encourage students to watch their videos repeatedly until they are experts on their virus. Then the team should pair with another team whose video described the same virus, consolidating information to prepare for class presentations. We used the videos listed in Figure 1. Your educational objectives may require different videos; for example, in a unit on human health, you might select videos only about viruses that cause human disease. You may also record your own short presentations to customize the examples for your class.

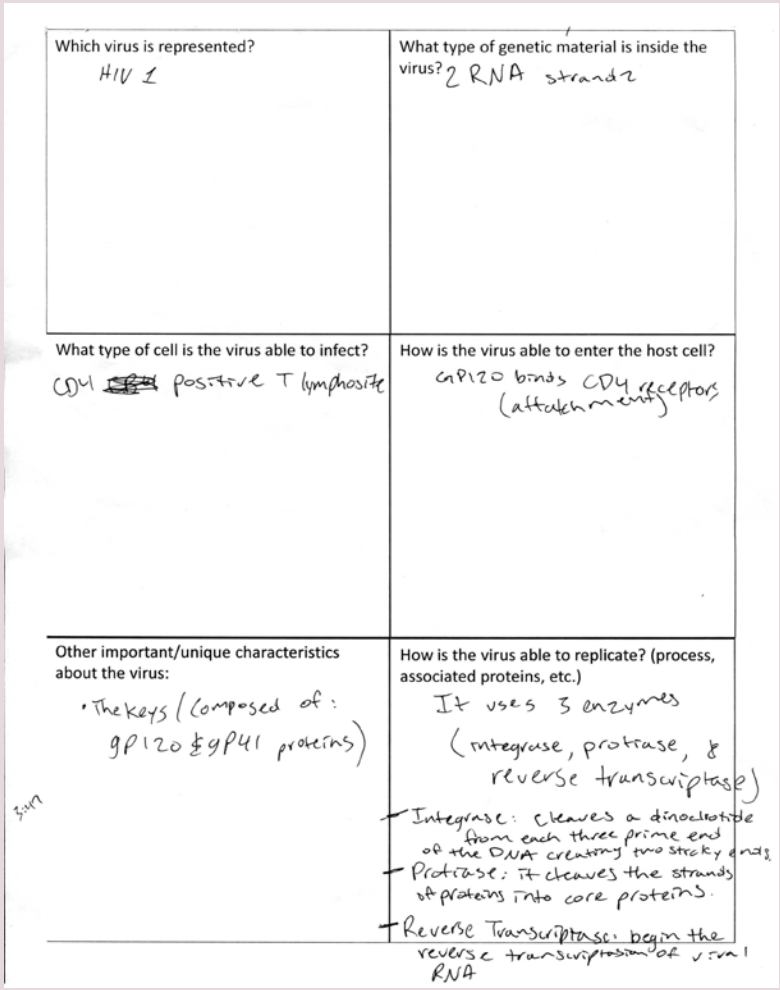
Part 4: The dispersal

To assess students' understanding of viral replication, each group or paired groups share their knowledge through class presentations, limited to five minutes. Provide a rubric (Figure 4, p. 55) to help them prepare.

These presentations inform the class as a whole about the different viruses and allow students to practice communicating scientific information to their peers, an important scientific practice identified in the *Next Generation Science Standards* (NGGS Lead States 2013) (see Figure 5, p. 56, for other connections to education standards). Students can inform classmates about the type of virus they modeled, the type of cell(s) infected, the method of viral replication, and other viral characteristics of their choosing. Once every group has presented, encourage students to compare their virus with others and to ask each other questions that compare and contrast the viral components with methods of infection and replication. For example, "Do both DNA and RNA viruses make RNA?" or "Why does one virus replicate the same way as another but can't infect the same cell?"

FIGURE 3

Example of notes a student made on a virus data worksheet during the activity.



Assessment

By the end of the activity students should be able to:

- Identify an aspect of a virus's structure that makes it infect a specific subset of cells.
- Explain how replication differs for DNA viruses, RNA viruses, and retroviruses.
- Compare viruses based on how the genetic structure influences the mode of replication.
- Explain how this "backpack" model—like all models—has both strengths and weaknesses.

This activity offers two forms of formative assessment. First, student groups comparing their video notes are participating in a self-checking process. The groups should address any conflicts in their notes before they give their presentation. The second form of assessment is the class presentation. The presentation allows the teacher to determine how effectively each group describes the structure and replication of their virus.

A summative assessment was suggested by teachers who tried the activity. Students, after comparing their virus with another based on information from the presentations, would then fill out worksheets with guiding questions, make physical models, or use diagrams to demonstrate the comparison. An optional challenge could be to use their knowledge to design their own "supervirus."

Teacher feedback

This activity was initially demonstrated to 25 teachers serving a large urban Title I district in Houston, Texas, during a professional development program in 2013. This yearlong program provided teachers of students with low socioeconomic backgrounds hands-on training to implement the lesson. Of the 25 teachers, 15 used the activity in their classrooms and provided feedback about how well it worked. Overall, the activity scored highly in effective use of time and increases in student understanding (see "On the web"). All teachers who used the activity agreed or strongly agreed that it improved student understanding of how a virus identifies a target cell.

One teacher noted: "Having the groups collaborating and comparing answers really brought out conversations and higher-level thinking questions without my prodding."

Additional feedback highlighted that the activity was easy to modify for different numbers of students, to work within specific classroom space, and to fit within allotted class time. Participating classrooms ranged from 25 to 32 students. Teachers tested the activity in classrooms, a computer lab, and spread throughout the campus. Their suggestions included using quick response (QR) codes instead of flash drives and assigning roles for team members, such as a timekeeper who makes sure the team returns to home base on time. Another suggestion was to extend the activity over two

class periods, with the activity and preparation for presentations done in the first and the presentations themselves in the second. This approach would allow the teacher to guide and expand discussion when needed. Students would also be encouraged to do additional research on their own to provide more information during class presentations.

Conclusion

To demonstrate the *NGSS* crosscutting concept of structure and function, we used active learning to relate components of viral structure to the functions of invading and replicating within a host cell. Often the relationship between structure and function is only examined through the example of protein-protein interactions. This activity employs not only the

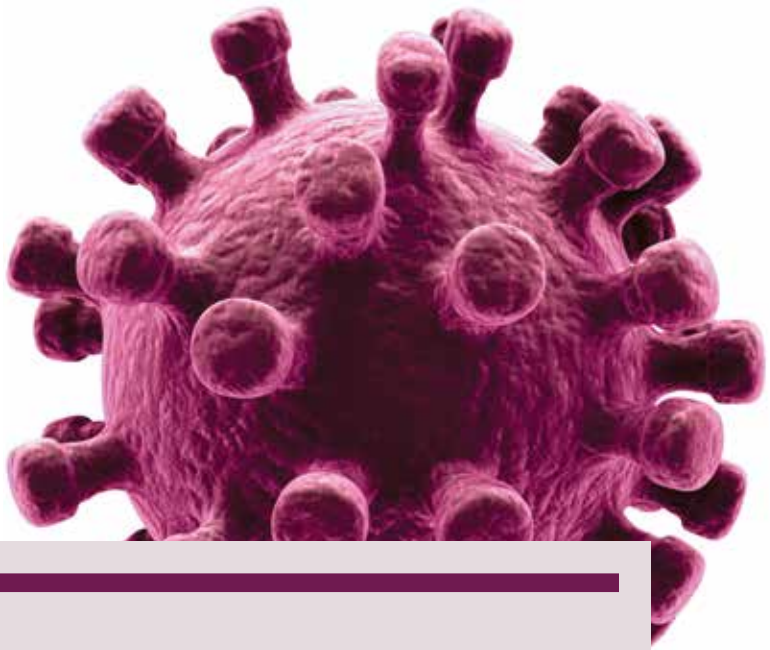
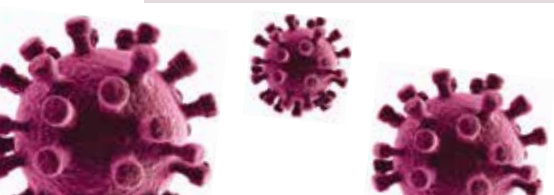


FIGURE 4

Rubric to assess student presentations.

Component	**Exceptional** (5 Points)	**Acceptable** (3 Points)	**Marginal** (1 Point)	**Total points**
Elocution	Students use a clear voice and correct, precise pronunciation of terms so that all audience members can hear presentation.	Students' voices are mostly clear; students pronounce most words correctly; most audience members can hear presentation.	Students mumble, mispronounce terms, and speak too quietly for many students to hear.	
Enthusiasm	Students demonstrate a strong positive feeling about topic during entire presentation.	Students occasionally show positive feelings about topic but mainly appear indifferent.	Students show no interest in the topic presented.	
Subject/content knowledge	Students demonstrate full knowledge of virus by identifying the virus name, type of cell or cells the virus infects, and mode of replications. Students answer all class questions with explanations and elaboration.	Students demonstrate partial knowledge of virus by identifying two or fewer of the following: virus name, type of cell or cells the virus infects, and mode of replications. Students can answer most questions; however, they make incorrect statements and/or teacher intervention is required.	Students do not have grasp of the virus; they only state the name of the virus with extra characteristics; students cannot answer questions about subject.	
Total group effort	All students work as a cohesive unit and equally participate in the presentation.	Most students participate in the presentation, but some members are not engaged.	Few students effectively participate in the presentation.	



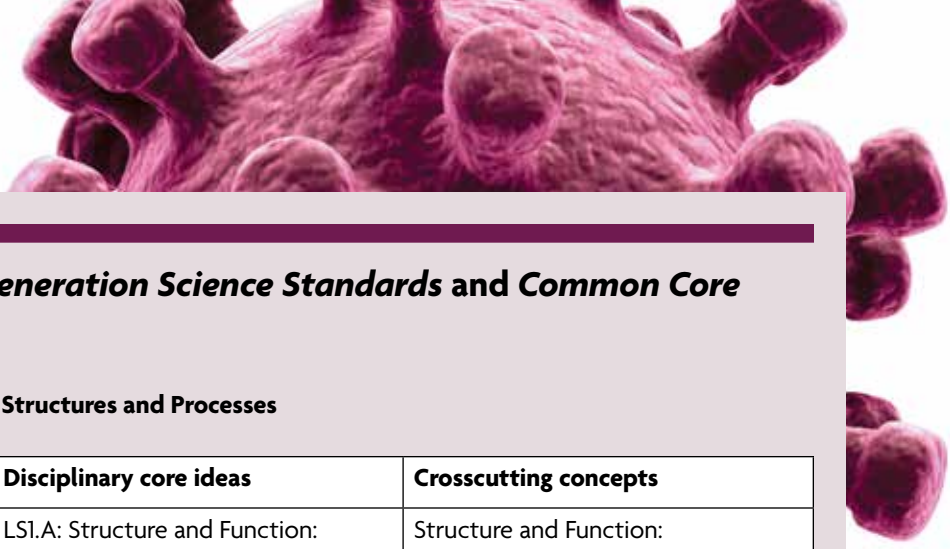


FIGURE 5

Connections to the *Next Generation Science Standards* and *Common Core State Standards*

Next Generation Science Standards
HS-LS1 From Molecules to Organisms: Structures and Processes

Science and engineering practices	Disciplinary core ideas	Crosscutting concepts
Constructing Explanations and Designing Solutions: Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	LS1.A: Structure and Function: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins.	Structure and Function: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Common Core State Standards
ELA/Literacy
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-LS-1-1)

example of protein-protein interaction during viral docking but also highlights that the structure of the genetic material within a virus influences the replication process. Selecting content for presenting to the class also gives students practice communicating relevant content to address a question or problem. This activity addresses the pervasive misconception that biomolecules intentionally seek out interaction partners. Students did not move directly to an assigned backpack but had to find an interaction permitting viral docking.

"The students absolutely embraced their role as a virus trying to find their 'cell,'" one teacher noted, "and it really engaged them in a new way, not just the usual animation or lecture styles." ■

Christina Crawford (cc45@rice.edu) *is an assistant director of biology and life sciences in the Rice Office of STEM Engagement (ROSE); Beth Beason-Abmayr* (bbeason@rice.edu) *is a faculty lecturer and laboratory coordinator in biochemistry and cell biology; Elizabeth Eich* (lizmc@rice.edu) *is a lecturer and laboratory coordinator in biochemistry and cell biology; and Carolyn Nichol* (cnichol@rice.edu) *is the director of ROSE programs, all at Rice University in Houston, Texas; and Jamie Scott* (jamie.scott1976@gmail.com) *is a life science teacher at Carnegie Vanguard High School in the Houston Independent School District.*

On the web

Activity survey results: *www.nsta.org/highschool/connections.aspx*

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