Creating Stop-Motion Animations to Learn Molecular Biology Dynamics†

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INTRODUCTION

Molecular processes are dynamic and involve objects too small for the naked eye. Students typically depict them with cartoons, where arrows represent change. However, this does not adequately capture molecular mechanisms in 3D space over time, and the large number of arrows and steps is often confusing (5). Here we describe stop-motion animation: students pick a molecular mechanism, plan how best to represent it to peers, produce a movie of it, and post it on the internet. Stop-motion animation involves taking a photo of a scene, slightly moving the objects and taking another photo, and then playing the sequence rapidly to make the objects appear to move. Such digital filmmaking is associated with higher levels of learning in Bloom’s taxonomy (9). Most stop-motion animation literature focuses on cellular-scale processes, such as mitosis, in 2D and for K-12 students and undergraduate freshmen (1, 2, 6). Here we found animations helpful for learning complex molecular processes in 3D. In this case study, upper level undergraduate students examine figures from textbooks and primary literature and create clay models of the molecular factors (Appendix 1).

Students learn and recall information more effectively when they engage different senses (4). Stop-motion animation allows for multisensory learning: physical materials offer tactile learning, while narration and visual aspects provide different learning experiences. For example, when making a movie about transcription, students physically assemble RNA polymerase subunits, narrate its processive movement along the DNA, and visually animate it, creating new mRNA (Fig. 1). Furthermore, the 3D aspect helps students learn how the process really works; even watching animations in 3D increases students’ retention of molecular biology information (7). Although powerful 3D animation software programs are available, they often have a steep learning curve and do not offer tactile learning (5).

This assignment is an appropriate activity for all undergraduate levels. It could be started in a lecture and finished for homework or carried out in a lab session.

PROCEDURE

Choosing a process

In groups of two, students choose a process to animate. Molecular biology is replete with important principles waiting to be illustrated. Upperclassmen might choose a pathway or technique from the primary literature. For lowerclassmen, the project can be a fresh approach to learning basic processes like transcription or translation.

Materials

The materials are simple: a smart phone, an app, and some type of 3D models. Many apps are free such as Stop Motion Studio (https://itunes.apple.com/en/app/stop-motion-studio/id441651297?mt=8). In general, 3D models can be made from a variety of materials such as pipe cleaners or Styrofoam. We have found plasticine a useful material. Colored clay can also be used, with water to keep it fresh.

Planning and rehearsals

Consulting textbooks and other literature, students make a storyboard and narrative with several scenes to determine how their process can best be represented to their audience. They devise a scheme for how each factor will move and then get feedback on their work.

Full rehearsals are critical since it is not easy to revise just one section of the animation. One solution is to perform a trial run (~1–2 minutes) for the instructor without filming it, with feedback incorporated into the subsequent film.

Filmmaking

The students assemble their clay molecules, take a picture, slightly move the objects and take another picture. They repeat this for the whole process. We initially tried three- to five-minute movies but realized that one- to two-minutes is more appropriate. Several hundred shots are feasible and provide a much smoother sequence than tens of shots. A voice-over narrative is helpful and can be added with the app. Finally, to keep the objects and labels in focus, we found that a makeshift camera stand is useful.
Students often make multiple versions of their movie; this iterative process also solidifies their learning (8).

Distribution

The highlight for the students is showing their videos to their peers. We did this in around 20 minutes for 15 students. Furthermore, videos can be uploaded to YouTube (https://www.youtube.com/) or Vimeo (https://vimeo.com/) to reach a broader audience. We encouraged students to respond to comments and questions posted on their movies.

Safety issues

There are no safety issues since neither hazardous materials nor live organisms are used.

CONCLUSION

We found the process—from text figures to video—straightforward. Even on the first try, the assignment enabled students to interact with biological processes in a tangible way. We discovered that a rehearsal was helpful and that one- to two-minute movies were the appropriate duration. Students enjoyed the assignment, particularly watching each other’s videos. Their comments reflected their learning, such as “I know this process really well.”

Showing their animations to an audience made students feel their work was valued (3). Many students had turned to YouTube themselves to study for a biology exam and felt accountable for the content in their movie, knowing that other students would comment publicly on the clarity and accuracy of their video. They consulted their team and decided on a level of abstraction to create a relevant open-education resource.

SUPPLEMENTAL MATERIALS

Appendix 1: A case-study assignment using claymation
Appendix 2: Suggested grading rubric emphasizes clarity, accuracy of content, and the planning process over artistic abilities

ACKNOWLEDGMENTS

Thanks to Katie Linder and Johan Paulsson for helpful comments. We thank Melanie Berkmen and Tamara Brenner for advice and Amanda Arcand and Andy Arcand for initial conversations and assessment discussions. This work was supported by Suffolk University and the Research Corporation for Science Advancement Cottrell College Science Award. The authors declare that there are no conflicts of interest.

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