CCAS
Council of Colleges of Arts & Sciences

REMOTE TEACHING RESOURCES FOR SCIENCE LABS

With thanks to Martin Samuels, PhD, Associate Director for Science, *Derek Bok Center for Teaching and Learning at Harvard University* for the following suggestions:

"Science labs are often either integrated as components of larger lecture courses (lab sections) or comprise the entirety of smaller lab courses. In both scenarios it is worth defining what the labs are meant to achieve before selecting an online alternative. Below are three possible scenarios based on the focus of the labs. Since your labs are likely a combination of these scenarios then you could likewise combine these recommendations keeping in mind the appropriate level of time commitment for the combined activities.

(1) If the focus is on **learning techniques** and their application to specific experimental situations, consider asking your students to engage in online simulations that may cover at least portions of, if not the entirety of a protocol.

- Harvard's LabXchange has just released a suite of lab simulations with assessments that focus on basic molecular biology techniques; MERLOT offers a collection of virtual labs in a variety of science disciplines; PHET offers interactive simulations that allow students to vary parameters; and many textbooks also provide interactive lab-based resources.
- You might consider having your students watch videos of experiments; you can ask your students to first make predictions and then discuss the results. The Journal of Visualized Experiments offers thousands of videos of experiments, including many designed for students.

(2) If the focus is on **interpreting experimental data,** consider extracting datasets from the published literature that are aligned with the experiments students would have encountered in lab and develop problem sets that focus on the interpretation of the data. One could also combine the experimental protocols with interspersed questions that explore the reasons behind specific steps so that students gain deeper intuition into why certain proce-

dures are performed. In place of actually performing the experiment, students can gain a critique-based understanding of the method followed by data interpretation.

- One type of question you may want to ask students involves providing them with a random sequence of steps involved in the experimental methodology, and asking them to put them in the correct logical order. This requires students to critically understand why each step has to come before the next in a protocol. You can also provide students with a blank step, which they would need to fill in for themselves once they identify what step is missing. An example of such a question from LabXchange can be found here (click on "Design" on the right-hand side).

(3) If the focus is on project-based lab research, as is often the case in lab courses, your students have already been working on their projects since the start of the term. Furthermore, there is usually a capstone assignment in the form of a final paper, grant application and/or poster that describes their work, both with context and future directions defined. Consider asking your students to switch to the capstone assignment now with an emphasis on interpreting the data they have already gathered or if they have not generated their own data yet, focus on having them predict their experimental outcomes and design the next experimental steps in detail. Divide up the rest of the semester into draft submissions of sections of the capstone that will allow you to provide formative feedback and enable your students to experience experimental design, further hypothesis building, and predictive data analysis. This approach aligns especially well with a written capstone styled like a grant application.

The above recommendations combine what resources are available to support virtual lab exercises with assignments that combine data interpretation with the experience of experimental design, hypothesis building, and self-reflexive critiques of the methods and outcomes that students develop."