A remote undergraduate biology seminar on SARS-CoV-2 literature

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Abstract
At our small liberal arts college, we require undergraduates majoring in Biology and Biomedical Sciences to take a seminar in the spring of their senior year. Each year, the seminar focuses on a different topic in molecular biology and/or biochemistry. The course operates as a “journal club”—every week, a student presents a peer-reviewed research article, and the instructor moderates a discussion. When the transition to remote learning occurred due to the COVID-19 pandemic in March 2020, the seminar meetings were moved online to a Zoom-based platform, and the course topic was changed to focus on emerging research regarding the novel coronavirus. The continuation of the Biology senior seminar in a remote context was straightforward, and the SARS-CoV-2 virus furnished a rich theme for exploration of diverse topics in molecular biology and genetics.

KEYWORDS
active learning, biology seminar, biotechnology education, COVID-19, curriculum design, distance learning, integration of research into undergraduate teaching, journal club, learning and Web-based learning, remote learning

At the undergraduate level, “journal club”-style seminars provide an optimal venue to introduce students to primary literature, giving them critical experience in reading, analyzing, and explaining peer-reviewed research reports. Journal clubs have a long history in biology education, having originated in medical schools in the early 20th century.1 At the undergraduate level, journal clubs have been implemented as an active learning strategy to enhance students’ skills in scientific communication by training them to read, understand, and present scientific journal articles.2,3

For the last decade, we have required that all senior Biology majors at our small liberal arts college complete a one-credit senior seminar that functions like a journal club. The course familiarizes students with the process of reading and interpreting primary literature from various subfields of biology, including biochemistry, protein/macromolecular structure, cellular and molecular biology, microbiology, and evolutionary biology. Each week, a student delivers an oral presentation on a pre-selected article, after which the instructor moderates a discussion. This student-centered active learning approach enhances undergraduates’ skills in science communication and fosters the use of research strategies to address scientific questions.

Every year, the seminar focuses on a different topic. Past topics have included precision medicine and immunotherapy as cancer treatments. At the beginning of this past semester in January 2020, we began senior seminar with a focus on the role of metals in biological systems. When the COVID-19 pandemic forced the transition to distance learning in mid-March 2020, we implemented two key changes: (1) our weekly 90-min seminar began meeting through Zoom rather than in person, with presentations delivered via screen sharing; and (2) our course theme was changed to focus on the latest scientific research related to the new coronavirus, SARS-CoV-2.
Course materials, readings, and assignments continued to be distributed, submitted, and graded via the Blackboard content management system. The transition proved smooth, as students adapted quickly to virtual presentations via screen-sharing on the Zoom platform.

Because the senior seminar was being taught as the pandemic unfolded, articles were chosen week-to-week as new research was published, resulting in a highly topical and diverse reading list (Table 1). The focus on papers covering different aspects of SARS-CoV-2 allowed us to explore a variety of topics in molecular biology, genetics, and biotechnology. Papers ranged from highly technical genomic analyses to more applied clinical case reports, a broad sampling of topics suitable for a group of senior Biology majors with varied interests and ambitions, many of them aspiring to medicine.

Dialectical tools and assignments have been shown to improve class participation and discussion in journal club courses. To ensure that all students read and understood the journal articles prior to class, the instructor assigned detailed discussion questions focusing on the key points of the paper, including methods, data analysis and interpretation, and big-picture takeaways (discussion questions for each article listed in Table 1 can be found in the Data S1). This led to animated and profound discussions, particularly with regard to the development of COVID-19 therapies and vaccines. Students often commented that they found the discussions “empowering,” a particularly meaningful outcome given the fear and apprehension felt by so many as a result of the pandemic. We opened to the course to the rest of the college community and publicized it using the hashtag "#knowledgeispower" on our Instagram site (@mmcbiology). During the 7 weeks of remote learning, our Zoom sessions hosted a multitude of guest observers, including faculty from other departments, students, family members, and alumni.

The final course grade was calculated from presentations (70%), discussion questions (15%), and attendance/participation (15%). In the instructor's view, this assessment did not give sufficient weight to the time-consuming discussion question homework; future iterations of the course will alter the ratio to 60%, 25%, and 15%, respectively.

In anonymous surveys, students offered positive comments regarding the learning effectiveness of the seminar and its focus on COVID-19 (Table 2). On a 5-point Likert scale, all respondents strongly agreed (75%) or agreed (25%) with the statement, “This course was effective in teaching me how to read scientific journal articles.” All respondents strongly agreed (50%) or agreed (50%) with the statement, “This course worked effectively as a

| Week after transition to remote learning in March 2020 | Peer-reviewed journal article presented (with references) | Foundational topics addressed |
|------------------------------------------------------|----------------------------------------------------------|-------------------------------|
| 1 (3/26)                                             | A new coronavirus associated with human respiratory disease in China | Phylogenetic analysis, RNA sequencing, genetic recombination, protein structure and function, viral infection |
| 2 (4/2)                                             | Characteristics of pediatric SARS-CoV-2 infection and potential evidence for persistent fecal viral shedding | Epidemiology, clinical aspects of COVID-19 infection, human physiology, pediatric medicine, RT-PCR testing |
| 3 (4/16)                                            | The proximal origin of SARS-CoV-2 | Computational biology, bioinformatics, molecular evolution, protein structure and function |
| 4 (4/23)                                            | Microneedle array delivered recombinant coronavirus vaccines: Immunogenicity and rapid translational development | Immunogenicity, vaccine design, antibody response, RNA translation, biotechnology, protein structure and function |
| 5 (4/30)                                            | SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor | Phylogenetic analysis, viral infection, antibody response, protein structure and function |
| 6 (5/7)                                             | Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: A retrospective review of medical records | Epidemiology, clinical aspects of COVID-19 infection, human physiology, reproductive medicine, medical imaging and radiology |
| 7 (5/14)                                            | A human monoclonal antibody blocking SARS-CoV-2 infection | Immunotherapy, viral infection, antibody response, genetic engineering, transgenesis, biotechnology, protein structure and function |
remote, Zoom-based seminar.” All respondents strongly agreed (100%) with the statements, “This course increased my understanding of the novel coronavirus,” and “This course helped me apply the knowledge I have gained while earning my Biology degree.” They unanimously rated the learning effectiveness of the seminar 5 out of 5 points.

The survey results indicate that this remotely taught, COVID-focused senior seminar successfully achieved its learning goals, allowing the students to employ foundational knowledge from their undergraduate biology coursework to read, analyze, and explain peer-reviewed research articles. Overall, the pandemic forced a fruitful test of active learning in a remote context and also provided a highly topical theme that promoted extraordinary student interest and engagement.

ACKNOWLEDGMENTS
The author is grateful to the senior Biology and Biomedical Sciences majors in the Class of 2020 at Marymount Manhattan College for their enthusiasm, resilience, and excellent work in Senior Seminar (BIOL 490).

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SUPPORTING INFORMATION
Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Leri AC. A remote undergraduate biology seminar on SARS-CoV-2 literature. Biochem Mol Biol Educ. 2021;49:313–315. https://doi.org/10.1002/bmb.21503