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CourseSource

Lesson

Introducing Immunology Research Literature to Understand B-cell Receptor Gene Expression

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Abstract

Immunology is relevant to our everyday lives, driving a need for more engaging and inclusive undergraduate immunology education. One way to engage a diverse group of learners is by teaching them how to read and interpret the scientific literature. This introduction can be challenging for immunology research, which often includes jargon and significant background information. The lesson described here meets this challenge by first teaching students the basics of reading a journal article. Students then read a seminal research article in the field and discuss the data and conclusions via think-pair-share in the classroom. This lesson teaches students the overall structure of a journal article, how to read a journal article, and the ability to read and interpret a research article's findings. Additionally, students learn specifically about the organization and expression of the genes encoding B-cell receptors.

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Supporting Materials: S1. BCR Research Literature – Example Questions for Summative Assessment; S2. BCR Research Literature – Lecture Presentation Slides

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Learning Goals

◊ Immunology Course:

» Students will understand the organization and expression of B-cell receptor genes.

◊ Science Process Skills:

» Reading research papers

» Interpreting results/data

» Analyzing data

Learning Objectives

Students will be able to:

◊ characterize each section of a journal article, including the purpose of each section.

◊ describe and interpret key aspects of Hozumi & Tonegawa 1976 (1):

» explain the techniques used in this paper.

» summarize and interpret key results that supported the authors' conclusions.

» paraphrase the authors' main conclusions and evaluate how they contribute to our current understanding of B-cell receptor expression.

INTRODUCTION

Engaging and effective immunology education has become increasingly relevant to our everyday lives. The COVID-19 pandemic has meant almost-daily publication of news articles based on immunological research on preprint servers. Some celebrities and other public figures use social media to promote an anti-vaccination movement (2). And recent advancements in immunotherapies to treat cancer suggest that in our lifetime we will need a basic understanding of immunology to understand the benefits and risks of these exciting new treatment options.

Immunologists around the globe have taken note of the increased importance of growing and diversifying the field to meet these challenges and opportunities. In order to meet the demand for immunology education of the general population, there have been calls for more innovative and inclusive teaching of immunology courses, particularly at the undergraduate level (3–5). Many innovative educators have risen to this challenge, and the American Association of Immunologists (AAI) has a variety of pathways for immunology educators to share their educational innovations. The lesson described here continues the trend of sharing educational ideas in the field of immunology and provides a straightforward entry point into active learning and engagement in the research literature for an undergraduate immunology course.

This lesson reinforces the basics of V(D)J recombination – an American Association of Immunologists-recommended subtopic for undergraduate immunology (6). V(D)J recombination is the process through which variable, diversity, and joining gene segments undergo recombination in B cells to produce a unique set of B-cell receptors. The lesson also

incorporates the important science process skills of reading and interpreting research articles, which is often a challenging activity for undergraduate immunology courses. A variety of approaches have been used to introduce research literature into the undergraduate biology classroom (7–18). The current lesson is specific to the field of immunology and provides an easy entry point into the research literature. One major challenge in teaching primary literature in immunology is the jargon and large amount of background knowledge required (19). This lesson is unique, as it identifies a specific seminal research article that instructors can use that is accessible to students, even fairly early in the semester. Additionally, while other lessons or curricular approaches provide a semester-long course or strategy (7-10), this lesson can be completed in one class period for instructors interested in trying out active learning or introducing the research literature for the first time.

Intended Audience

This lesson is intended for upper-level undergraduate biology majors and/or pre-medicine students enrolled in an introductory immunology course. Students should have some knowledge of genetics, gene expression, and molecular biology techniques as a prerequisite for this lesson. The lesson was field-tested at a large research university, but is suitable for any institution.

Required Learning Time

This lesson was taught in one 50-minute class period as part of an undergraduate immunology course. Students watched an instructional video and read the research article prior to class, which took them upwards of an hour.

Prerequisite Student Knowledge

Students completing this lesson should be familiar with the cellular and molecular components of adaptive immunity, basic concepts of genetics and gene expression, and basic molecular biology techniques such as restriction enzyme digestion and gel electrophoresis. They should also have been previously introduced at least briefly to the organization and expression of lymphocyte receptor genes. In our class, students learn these concepts via readings and in-class lecture based upon Chapter 6 of Kuby Immunology 8th edition (20), which corresponds to Chapter 5 of Janeway's Immunobiology 9th Edition (21). Additionally, iBiology has an open access Immunology flipped course with a lecture that could serve as background for this activity.

Prerequisite Teacher Knowledge

Instructors should be familiar with the organization and expression of lymphocyte receptor genes. They can prepare for this activity by reading Chapter 6 of Kuby Immunology (20) or another textbook chapter discussing organization and expression of lymphocyte receptor genes and/or by watching Session 5: B Cells: Development, Selection, and Function of the iBiology Immunology flipped course.

SCIENTIFIC TEACHING THEMES

Active Learning

Students are actively engaged in this lesson. Prior to the class period, they watch an instructional video that includes a worksheet they can fill out while reading the journal article. Next, they read a primary research article (1). During the class period, students are frequently asked to engage in small group and large group discussions. Students partner up for think-pair-share (22–26) periods and the instructor circulates around the room to listen for questions, ideas, and misconceptions.

Assessment

In the author's classroom, this lesson included formative and summative assessments to evaluate student learning. Think-pair-share activities are the primary basis of the formative assessment of student learning for this lesson. During the "pair" portion of the activity, the instructor circulated around the room to listen to student discussions and address questions during the activity, which allowed the instructor to gauge student understanding and identify any misconceptions. During the "share" portion of the activity, the instructor and students had another opportunity to address misconceptions. By utilizing the think-pair-share approach, students were able to self-assess their learning immediately during class during partner and large group discussion times. Additionally, students responded to questions about this lesson on both a unit and final exam as a summative assessment of their learning (S1. BCR Research Literature – Example Questions for Summative Assessment).

Inclusive Teaching

This lesson attempts to include all participants and acknowledges the value of diversity in science in a variety of ways. First, by utilizing active learning techniques, known to narrow achievement gaps for underrepresented students in STEM disciplines (27), this lesson aims to support the success of all students. Second, the lesson was taught in a classroom at a large public Midwestern research university to students who may not have met many people from other countries. By selecting a paper written by Japanese scientists, students can see the contribution that scientists from around the globe make to science. Third, research from Cooper *et al.* revealed that some active learning strategies may increase anxiety to an unproductive level for some students, but that there are ways to mitigate this risk (28). Based on suggestions from Cooper *et al.* (28) and the instructor's conversations with students who have expressed these same concerns, this lesson structure takes measures to alleviate some of this stress. For example, students know ahead of time to expect peer discussion. The instructor also allows students to self-select their partners or groups, and groups volunteer to report out their discussion results rather than utilizing cold or random call. Fourth, the instructor made efforts to ensure that all students wanting to participate were included in a group. During the "pair" portion of think-pair-share, the instructor circulated the room and asked solo students if they would like to join a group. If they said yes, the instructor facilitated introductions to a group nearby. Finally, introducing research literature to an undergraduate course not only improves students' ability to read and interpret research articles, it can change their perceptions of science identity and self-efficacy, and benefits a diverse set of students (8, 29, 30), suggesting that the introduction of research literature will aid in efforts to diversify the field of immunology.

LESSON PLAN

Student Preparation for the Lesson

To prepare for this lesson, students spend the prior class period learning about V(D)J recombination from Chapter 6

of Kuby Immunology: The Organization and Expression of Lymphocyte Receptor Genes (20). From the textbook, students were familiar with the conclusions of the journal article, but not necessarily the methods. They were also assigned to watch an online instructional video from our university's Center for Undergraduate Research explaining how to read a journal article and to read Hozumi & Tonegawa 1976 PNAS (1).

Instructor Preparation for the Lesson

The instructor should also read Hozumi & Tonegawa 1976 PNAS (1) and come to class prepared to lead discussion.

Activity During Class

This lesson is designed to be completed within a 50-minute minute class period after students have been introduced to the molecular details of B-cell receptor expression, including V(D)J recombination (see Table 1 for timeline).

To start the class period, the instructor can ask students as a larger group or in smaller groups for initial reactions to reading this journal article: what did they think about it? Had they read a journal article before? What sections did they find were easier or harder to read? This discussion can get students talking and is also a great time for instructors to normalize the challenge of learning to read research literature.

The instructor can then transition to discussion of the actual article with a brief introduction of the paper's authors, title, and journal. The instructor can explain that this article led to our current understanding of B-cell receptor expression and V(D)J recombination and led to a Nobel Prize for the authors.

The instructor uses the PowerPoint slides (S2. BCR Research Literature – Lecture Presentation Slides) to progress through each section of the paper. For each section of a journal article, the instructor asks the students to first describe what general information is provided in this section of a journal article and then describe what this particular journal article describes in that section. The instructor utilizes a think-pair-share approach (22–26) in asking the students to first consider their answer, talk to a student-selected partner or small group about the possible answer, and then share their collective responses with the larger group. To avoid monotony, and in case time begins to run short, the instructor can either directly pose questions to the larger group or implement a pair-share without extra time for the student to first develop an answer. The instructor should circulate around the room to identify any misconceptions, answer questions, and make sure all students have found a partner or group for discussion. This monitoring of the discussions also provides an opportunity for formative assessment and clarification of any misconceptions either within a small group or to the whole class.

TEACHING DISCUSSION

Based on formative and summative assessments, the instructor found that this lesson is effective in helping students meet lesson learning outcomes. During the class period, the instructor could hear students eventually arriving at correct answers to questions, and these answers were repeated to the entire class during the sharing portion of the class period. The instructor also addressed any misunderstandings or incorrect responses while circulating in the room and during the whole-class discussion time. Students performed well on questions tied to the lesson learning outcomes on a unit exam and a cumulative final exam. In addition to finding this an effective lesson, students also seemed to enjoy the challenge and opportunity to discuss a seminal research article in the field and mentioned the lesson positively in both discussions with the instructor and anonymous student evaluations of teaching.

The aspect of this lesson that students seemed to find most challenging was in understanding the relationship and progression between the research question, the methods, the results, and the conclusions. Many students struggled with at least one of these steps or relationships in the progression of the research. For example, a student may have struggled with understanding why the method selected would help address the question of interest, or the student might have struggled with understanding why a particular conclusion was appropriate given the results of each experiment. Most of the students in the class said they had been asked to read a research article for an earlier class or independent research, but most indicated they had previously read very few articles, around 1-2. Therefore, this struggle to apply their knowledge of the scientific process seems appropriate for their level of experience with the research literature. The instructor can uncover and address these challenges by asking many "why" questions during their circulation of the room. They might ask one group "why do you think the authors chose this method?" or "why is this conclusion appropriate – what data support it?" If instructors are finding that most of the class is struggling with the same challenge, instructors can address these struggles during the "share" portion of the think-pair-share in similar ways.

This lesson is well-suited to modification in a variety of ways, including to the size of the class. For example, while I taught this lesson to a class of about 125 students, a think-pair-share format is easily scalable to a much larger or much smaller class size.

The lesson is also adaptable in format. I taught this lesson in a face-to-face course, but it lends itself well to online or hybrid formats. For instructors teaching fully online, the students could engage in their discussions synchronously via Zoom breakout rooms, Slack, Microsoft Teams, Discord, or any other video conferencing or chat software programs. These discussions could also take place asynchronously via a Learning Management System (LMS) discussion board, Slack, Microsoft Teams, Discord, a Google Document, or any other online chat, discussion board, or text-saving software program. Alternatively, online instructors could edit the discussion questions a bit to instead ask students to answer questions and/or annotate where in the article you would expect to find certain types of information, highlight the data supporting a particular conclusion, etc. Science in the Classroom provides excellent examples of this type of annotation of research articles. Instructors teaching in a hybrid format during the COVID-19 pandemic and beyond could use any of these options. If hybrid instructors choose to use some of their face-to-face class time to implement this lesson, given social distancing and masks, students could use one of the chat

software options mentioned above to discuss the questions and submit answers to the instructor, and the instructor can provide feedback to the entire class verbally.

Instructors may also want to expand upon this lesson to incorporate more structured approaches to regularly teaching primary literature to undergraduates (7). This approach would be an especially good idea if instructors are planning to incorporate primary literature and discussion into multiple class periods of the course. Instructors could also use this lesson as a template to incorporate discussion of any other seminal research articles that are well-suited to undergraduate students due to their shorter length and approachable language, for example: (31–34).

SUPPORTING MATERIALS

- S1. BCR Research Literature – Example Questions for Summative Assessment
- S2. BCR Research Literature – Lecture Presentation Slides

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Table 1. Recommended timeline for this lesson.

Activity	Description	Estimated Time	Notes
Preparation for Class			
Instructor preparation	Read article to prepare for discussion	1 hour	
Student preparation	Students watch the instructional video and read the research article	1-3 hours	
Class Session			
Brief discussion	Gauge how students felt about the assigned reading	5 minutes	Questions could focus on whether students read research articles previously, their understanding of this article, what they found surprising, etc.
Group discussions	Pose questions to small and large groups	45 minutes	Depending on class size and time available, students can respond via large group or think-pair-shares. Each set of questions addresses the general purpose of each section of a research article and then asks about the article they read.