ARTICLE
Professor Eric Can't See: A Project-Based Learning Case for Neurobiology Students

Judith Mosinger Ogilvie[1] **& Eric Ribbens**[2]
[1]*Department of Biology, Saint Louis University, St. Louis, MO 63103;* [2]*Department of Biological Sciences, Western Illinois University, Macomb, IL 61455.*

"Professor Eric Can't See" is a semi-biographical case study written for an upper level undergraduate Neurobiology of Disease course. The case is integrated into a unit using a project-based learning approach to investigate the retinal degenerative disorder Retinitis pigmentosa and the visual system. Some case study scenes provide specific questions for student discussion and problem-based learning, while others provide background for student inquiry and related active learning exercises. The case was adapted from "'Chemical Eric' Can't See," and could be adapted for courses in general neuroscience or sensory neuroscience.

Key words: case study; drawing-to-learn; primary literature; project-based learning; retina; Retinitis pigmentosa; translational medicine; visual system

BACKGROUND AND CONTEXT

"Professor Eric Can't See" is adapted from "'Chemical Eric' Can't See," a case study written by one of us (ER) and available through the National Center for Case Study Teaching In Science (Ribbens, 2014). "'Chemical Eric' Can't See" is targeted at introductory students with objectives focusing on the visual system, genetics and humanizing patients. Students are highly engaged by the autobiographical and factual nature of "'Chemical Eric' Can't See." We have taken advantage of these features to develop a case study more suitable for advanced undergraduates majoring in neuroscience or biology. Specifically, this case was adapted for a Neurobiology of Disease course targeted at juniors and seniors, with a Cell Biology prerequisite. One of us (JMO) has taught it twice. The case could also be used in other upper level general Neuroscience or Sensory Neuroscience courses.

The retinal degenerative disorder, Retinitis pigmentosa (RP), is investigated using a project-based learning approach (University of Delaware, 2016) that incorporates a variety of active learning exercises including problem-based learning (Barrows, 1986), drawing-to-learn (Quillin and Thomas, 2015), and the CREATE method for using primary literature in the classroom (Hoskins et al., 2007).

The case itself begins with a scene from Eric's real life experience in which visual deficits are first identified. Working individually, in small groups, or sometimes with the whole class, if class size is small, students generate questions and research the answers using a problem-based learning approach. A number of excellent resources on this approach are available (Barrows, 1986; Duch et al., 2001; Torp and Sage, 2002; Hmelo-Silver, 2004; Savery, 2006; Walker et al., 2015). The case serves as a launching point for learning about normal visual function at the molecular, cellular, and systems level as well as how visual function is disrupted at these different levels by a retinal degenerative disease. A drawing-to-learn exercise (Quillin and Thomas, 2015) has been developed for this activity. Students are provided descriptive text and are tasked with drawing a visual model of the text. This exercise fosters understanding of the sequence of events in visual transduction and spatial relationships in visual pathways. The middle third of the project uses the CREATE method (consider, read, elucidate hypotheses, analyze and interpret data, think about the next experiment) developed by Hoskins et al. (2007) to foster critical analysis skills with primary literature. The final third of the RP unit focuses on the challenges and potential for therapeutic intervention with emphasis on translational research. The project culminates in student proposals to a hypothetical Foundation Board of Directors requesting funding for research on a therapeutic approach to treating RP.

Student materials and implementation notes are available from the corresponding author or from cases.at.june@gmail.com.

LEARNING OBJECTIVES

At the end of the unit, students will be able to:

- identify key components of phototransduction signaling, explain their function, and graphically represent the visual pathway.
- describe the symptoms and inheritance patterns of RP, interpret diagnostic tests, and explain molecular mechanisms of photoreceptor degeneration.
- give examples of related retinal disorders and compare and contrast them to RP.
- describe how optogenetic techniques can be applied in living organisms.
- critically evaluate the strengths and weaknesses of treatments and potential therapies for RP.
- analyze primary literature, identify and formulate hypotheses, develop and evaluate an experimental design, predict results, and interpret the evidence.
- critically evaluate biomedical information in the popular press and on the internet for reliability and oversimplification.
- demonstrate effective oral communication skills.

CLASSROOM MANAGEMENT OVERVIEW

This case is comprised of five scenes and an in-class worksheet. The unit is taught in six 75-minute class periods. Students should have a good understanding of cell biology as it applies to neurons and very basic knowledge of the visual system. For example, they should be familiar with photoreceptors (rods and cones) and aware of concepts such as visual field and light adaptation that will be explored in more depth in this unit.

1. *The Eye Exam, Part I* introduces the students to RP and some key terms. It is taken directly from Dr. Ribbens' case. Also during the first class period, students work in small groups to draw models based using the *Phototransduction & the Visual System Worksheet.*
2. The second scene, *The Eye Exam, Part II*, is assigned as individual homework. It introduces students to a psychophysical vision test, providing actual data from Dr. Ribbens. The third scene, *The Specialist,* is modified considerably from Dr. Ribbens' case. Together with short videos, these scenes bring the focus of RP to the cellular and molecular level. Students use a problem-based learning format to identify what they don't know and then research the answers.
3. In the third class period, students share their research, facilitated by the instructor, to provide a solid understanding of RP and related disorders. Setting the case study aside, students are next introduced to reading primary literature with the CREATE approach developed by Hoskins and colleagues (2007). An article in which an optogenetic treatment was used to restore visual responses in a mouse model of RP (Busskamp et al., 2010) was selected. The class analyzes the first figure together to become familiar with this approach and then each student is assigned a figure or part of a figure as homework.
4. The fourth class period is devoted to analyzing the Busskamp (2010) journal article in some depth. At the end of the class period, students return to the case study with the fourth scene, *Thinking About Therapies*, which has been written specifically for this adapted case. This scene provides a segue for exploring current and potential therapies for RP. Each student is given a reading assignment related to a specific therapeutic approach.
5. *The Foundation Meeting* is handed out in the fifth class. It describes a scene, also new to this adapted case study, in which each group of students will assume the role of researchers presenting a proposal to the board of a charitable foundation for funds to support further work on their assigned therapeutic approach. Students spend this entire class period working in groups to research their assigned therapy and plan their presentation.
6. Students present their proposals in the final class period. Presentations are followed by Q&A. Then, changing hats from researchers to board members, the students will vote on which proposal should be funded – they can vote for any proposal except their own.

CASE EVALUATION

Several in-class and homework assignments allow for assessment of student performance throughout the unit. In the classroom, prior to the last class period, students were asked to create a list of what they thought the learning objectives were for this unit. Note that students were not provided this information at the beginning of the unit. This exercise provides a useful tool to determine the success of the unit. In most courses, students are told the learning objectives for the course in the syllabus and faculty often provide specific learning objectives at the beginning of each lecture. Students generally use this information when preparing for exams. But when they are asked to identify the learning objectives, they must give more thought to what they have learned and what was important. The students successfully identified and clearly stated all of the learning objectives, suggesting that the objectives had been successfully incorporated into the unit. The students included a level of detail beyond the original learning objectives. This is consistent with several factors, including their lack of experience in writing learning objectives, countered by their experience in using this information as a study guide for exams.

In the two semesters that this unit has been used in the classroom, homework and other in-class assignments were assigned participation points, so a grading rubric has not yet been established, although it would not be hard to do so if desired. For the drawing assignment, consideration should be given to how much background students have had. If this material is new, then allowing students to

Learning Objective	Type of question	Average Grade
Identify key components of phototransduction signaling, graphically represent visual pathways	Short answer/graphic	82.5%
Describe symptoms of RP, and explain molecular mechanisms of photoreceptor degeneration	Multiple choice	94.4%
Describe inheritance patterns of RP, interpret diagnostic tests	Short answer	96.3%
Compare and contrast related retinal disorders to RP	Short answer	81.7%
Critically evaluate strengths and weaknesses of treatments and potential therapies for RP	Short answer	86.9%
Formulate hypothesis, develop an experimental design, and predict results	Essay question	85.2%

Table 1. Examples of learning objectives assessed on the unit exam are shown with types of questions and student performance.

correct their drawings prior to grading would be important to enhance their learning.

A unit exam comprised the primary means of evaluating the unit. The exam included a mix of multiple choice and short answer questions with one in-depth essay question. Short answer questions may ask students to draw a figure, label a drawing, interpret data, etc. The essay question provides an observation and asks students to formulate a hypothesis, design an experiment, and predict the results. The overall class average on the exam was 83.9%. Some specific examples are provided in Table 1.

Students were asked to respond to an assessment survey, however, the response rate was too low to draw any specific conclusions. Students that did respond liked that the case concerned a real person. They identified with Eric as both a college professor and a patient. One student stated that the CREATE approach to primary literature was most helpful for learning the material. Several students were intrigued by the wide range of therapeutic approaches currently under active investigation and clinical trials. In the first year this case study was taught, a Jigsaw strategy was used for exploring therapeutic approaches. Feedback indicated that students felt they became expert in one area, but learned little about the others. The revised approach included in this case study received overall very positive feedback.

SUMMARY AND FUTURE DIRECTIONS

The unit on RP follows a unit on Alzheimer's disease (AD) in this Neurobiology of Disease course. Most students in the class are directly or indirectly familiar with the progressive and degenerative nature of AD, but are unfamiliar with retinal degenerative disorders. RP is similar to AD in being a progressive degenerative disease of the central nervous system, but differs most importantly in that it is not fatal. Patients can continue to live full and productive lives, but must adapt to the progressive changes. This case study engages students by providing a biographical context – Professor Eric could be teaching one of their classes.

This case study could be adapted and/or shortened for other classes in a variety of ways. An Introductory Neuroscience course could use the first scene and drawing-to-learn exercise to introduce the visual system or to reinforce lecture content in a single class period. The primary journal article could be omitted or articles from popular press about therapeutic approaches could be substituted with students doing on-line research to evaluate the accuracy of the popular press. Many such articles can be found, often with "click-bait" headlines. If time is a consideration, the last two scenes and class periods investigating therapeutic approaches could be shortened or omitted.

The original case study, "'Chemical Eric' Can't See," provides a rich resource of alternative scenes that can be added or substituted in order to address alternate learning objectives. Several of these modules focus on the impact of disabilities, pushing students to consider both attitudes towards people with disabilities as well as the perspective of an individual coping with a disability. They include thought-provoking activities and discussion points.

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Address correspondence to: Dr. Judith M. Ogilvie, Department of Biology, Saint Louis University, 3507 Laclede Ave., St. Louis, MO 63103. Email: ogilviej@slu.edu