Case Teaching Notes

for

"A Friend in Need Is a Friend Indeed: A Case Study on Human Respiratory Physiology"

by

William H. Cliff, Department of Biology, Niagara University, Lewiston, NY
Ann W. Wright, Department of Biology, Canisius College, Buffalo, NY

Introduction / Background

One of the greatest challenges students face in learning about the physiology of oxygen handling by the human body is developing a coherent mental model of how oxygen enters and leaves the blood and how it is transported from the lungs to the tissues. To do this successfully, students must combine their notions of how oxygen behaves (1) free in the alveolar air, (2) dissolved in the plasma, and (3) in reaction with hemoglobin. This requires a facility with solution chemistry (including the concepts of partial pressure, solubility, and concentration) as well as an understanding of chemical equilibrium (including the concepts of mass action, reversible binding, affinity, and saturation). Integrating all of these chemical concepts into an understanding of human respiratory physiology can be a daunting task.

This case study was designed to help students strengthen their understanding of the transport of O_2 in the blood through an analysis of the pathophysiology of a common, real-world problem—CO poisoning. The case promotes learning about the chemistry of the oxygen-hemoglobin reaction by asking students to determine the extent that CO poisoning reduces the amount of oxygen delivered to the body tissues. It also helps students solidify their understanding of the role that hemoglobin plays in external respiration by prompting them to localize where CO poisoning disrupts this process.

The case was developed for use by undergraduates majoring in biology, nursing, and education who have had instruction in first-year, college-level sciences and who are enrolled in a two-semester course in human anatomy and physiology. These students are typically sophomores who have successfully passed a year of general chemistry or a one-semester survey of chemistry for non-science majors. The case is a directed case study. To read more about this type of case and how it can be incorporated into this type of course, see Cliff & Wright (1996) and Cliff & Nesbitt-Curtin (2000).

Objectives

The following learning objectives guided the design of the case and its use in class:

- Properly distinguish partial pressure of O_2 (as a measure of the concentration of free oxygen in the plasma) from % O_2 saturation (as a measure of the binding of oxygen to hemoglobin); be able to predict how changes in the function of hemoglobin might alter these measures in light of the mass action of the oxygen-hemoglobin reaction and the exchange of oxygen between the blood, alveolar air, and body tissues.
- Use the oxygen-hemoglobin dissociation curve to determine the amount of oxygen that is transported in the blood and delivered to the tissues; be able to predict how changes in the shape of the curve influence O_2 uptake into the blood and delivery to the body tissues.
- Explain the role played by hemoglobin in external respiration by determining how and where its dysfunction disrupts respiratory gas transfer in the body.

Although these objectives represent significant elements in the understanding of respiratory physiology, they by no means exhaust the instructional purposes that this case can be put to by instructors.

Format

The design of this case study is highly directive. The questions that accompany the case are written in a multiple choice format in order to impose specific constraints on the pathway of student learning. This format also makes it easier to grade—a particularly useful feature in large enrollment courses. The case could easily be rewritten so that one or more of the questions require free responses. It could also be expanded to address a greater range of cognitive and psychomotor learning objectives or designed to call for greater effort in clinical decision making and encompass further aspects of diagnosis, prognosis, and treatment prescription.

Classroom Management

We teach this case using an approach that we had found to be effective in content-rich, coverage-driven courses where available class time is limited (see Cliff & Wright 1996; Cliff & Nesbitt-Curtin 2000). Students receive the entire case study at the beginning of a three-lecture series on the respiratory system. This occurs in the second semester of the course after students have gained experience solving other directed cases designed to help them understand different body systems. Students perform the analysis of the case entirely outside of class, and are free to work individually or in groups. Students submit their answers to the instructor at the end of the final lecture on the respiratory system. An in-class review of the case is then held during the following class period.

The entire case study is provided to the students at the beginning of the first lecture on the respiratory system. We have found that there is pedagogical value to providing students with the complete case study, including all questions, at the beginning of formal instruction in a unit. The case sparks student curiosity and prompts student inquiry, both during in-class instruction and out-of-class study. Furthermore, the case provides a useful means for the students to organize, arrange, and inter-relate different concepts as they progressively assemble an understanding of the underlying physiology of the physiological unit being covered.

Our experiences using this "front-ended" approach to case presentation is consistent with findings about the factors that contribute to the effectiveness of problem-solving as a means for promoting student-centered learning. More meaningful understanding occurs when students are initially presented with a problem that drives their learning (Norman & Schmidt 1992). However, it is likely that the case could also be used effectively if the questions were divided into smaller clusters and disclosed progressively over the period of instruction in the manner of an interrupted case (Herreid 2004).

In-class review of the case is also an important part of the learning process since it provides a summative opportunity for students to receive corrective feedback (Norman & Schmidt 1992). During the review, the instructor facilitates a discussion about each question by prompting individual students to explain their answers to their classmates. This format encourages students to focus their thinking on the learning issues raised by the case, to overcome misconceptions, and to solidify their understanding of the requisite physiology. The instructor also has the opportunity to bring up important, additional implications of the case.

In the discussion, more time and effort are typically needed to review those questions that require more extensive analysis or intellectual effort (specifically, questions 5, 7, 8, and 9) than to review those questions involving simpler reasoning or explanation (questions 1, 2, 3, 4, and 6).

Blocks of Analysis

Detailed case analysis is provided in a separate file that is password-protected. To access this information, go to the **detailed case analysis**. You will be prompted for a username and password. If you have not yet registered with us, you can see whether you are eligible for an account by reviewing our **password policy and then apply online** or write to **answerkey@sciencecases.org**.

The case analysis includes a detailed summary and analysis of student responses. Our analysis of the students' answers to the case questions indicates that most students are capable of using the oxygen-hemoglobin saturation curve to make the necessary quantitative determinations of oxygen delivery to tissues. However, many students still have difficulties creating a realistic mental model of the dynamics of oxygen transfer from alveoli to plasma to red blood cell in light of the solution chemistry of blood oxygen and the equilibrium chemistry of oxygen-hemoglobin reaction. This evidence suggests that use of this case study could be profitably coupled to learning activities that strengthen the comprehension of these underlying chemical concepts. These additional instructional activities should also assist a greater number of students to correct the common misconceptions that they hold about respiratory physiology (Michael et al. 1999) and to develop more accurate and complex understandings of the process of blood oxygen transport.

References

Cliff, W.H., and A.W. Wright. 1996. Directed case study method for teaching human anatomy and physiology. *American Journal of Physiology* 270 (*Advances in Physiology Education* 15): S19–S28.

Cliff, W.H., and L. Nesbitt-Curtin. 2000. The directed case method: teaching concept and process in a content-rich course. *Journal of College Science Teaching* 30:64–66.

Herreid, C.F. 2004. Can case studies be used to teach critical thinking? *Journal of College Science Teaching* 33(6), 12–14.

Michael, J.A., D. Richardson, A. Rovick, H. Modell, D. Bruce, B. Horowitz, M. Hudson, D. Silverthorn, S. Whitescarver, and S. Williams S. 1999. Undergraduate students' misconceptions about respiratory physiology. *American Journal of Physiology* 277 (*Advances in Physiology Education* 22): S127–S135.

Norman, G.A., and H.G. Schmidt. 1992. The psychological basis of problem-based learning: A review of the evidence. *Academic Medicine*. 67:557–565.

Acknowledgements: This case was developed with support from the National Science Foundation under CCLI Award #0341279. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.