Context Breaks: A Health-Related Case Study as a Unifying Teaching Tool in General Biology

Sophie K. Hill, Rhesa N. Ledbetter

Abstract
Many biology students eventually pursue careers in the health sciences. To create explicit links between introductory biology content and the health sciences, we implemented Context Breaks—a series of seven mini-lectures linking course content to lactase persistence/nonpersistence. Context Breaks were implemented over the course of a semester in a punctuated case-study format and received positive feedback from students. They most highly associated them with deeper learning of material.

Key Words: lactose intolerance; lactase persistence; introductory biology; pre-health professions.

Introduction
General biology is designed as an introduction to a wide breadth of material and often influences students’ professional pursuits. To facilitate and encourage students in making their own connections with course material—particularly those pursuing health science careers—we developed and implemented “Context Breaks.” Context Breaks were designed as a semester-long, punctuated case study consisting of seven learning modules that connected lactase persistence/nonpersistence to major topics (structure and function, metabolism, genetics, and evolution) covered in a first-year college biology course. We implemented this into a general biology course (BIOL 1101) at Idaho State University, where students were both biology majors and nonmajors, with many pursuing health-related careers.

Most mammals lose the ability to break down lactose (milk sugar) following infancy, due to decreased production of the enzyme lactase (Burger et al., 2007). This is also observed in over 65% of humans. However, in some populations, the production of lactase has evolved to persist through adulthood (Storhaug et al., 2017). Many high-quality materials exist on lactase persistence/nonpersistence in human populations. By drawing on these resources, we were able to create modules that align closely with course learning objectives based on published national standards (American Association for the Advancement of Science, 2011). It is important to note that we prefer using lactase persistence/nonpersistence to encompass the evolutionary adaptation to digest dairy following weaning. However, at times, we also link the familiar terms lactose tolerance/intolerance for clarity in the teaching presentations (see Supplemental Material available with the online version of this article).

Overview of Context Breaks
Context Breaks draw from the literature surrounding case studies in student instruction, and our method implemented a case study in a punctuated format (Herreid, 2005), which we treated as a pause in regular lecture material and generally followed major units/topics. Each Context Break varied from 10–25 minutes (Table 1) and incorporated short lectures and student response elements (see SI for full materials). Context Breaks were also taught by a separate instructor (the first author), a teaching intern in the course.

Individual Context Break Presentations

1. Introduction
Students were introduced to the medical condition of lactose intolerance in the case study of Braeden, a young college student who experienced discomfort after eating a meal rich in dairy products. Students used the scientific method to hypothesize causes for his symptoms. Through discussion, lactose intolerance was identified as the cause and students’ prior knowledge was assessed. Finally, we introduce the evolutionary concept of lactase persistence resulting in lactose tolerance into adulthood.

2. Lactose Versus Lactase
Associated with the general chemistry unit, we discussed the monomers of lactose and how this sugar is broken down and transported in the human body. We emphasized differences between lactose and the enzyme lactase, which is used to break down the sugar lactose.
3. Transport in the Gut

Associated with cell anatomy, structure, and membrane transport, students received an overview of general anatomy and function of the human digestive tract. We highlighted the role of microvilli and enterocyte cells in absorption of molecules that pass through our gut. We also compared transport mechanisms for molecules and concluded that active transport was essential for moving glucose into the bloodstream.

We compared the guts of lactase-persistent and lactase-nonpersistent individuals and reviewed the membrane proteins involved in lactose breakdown and active transport from the gut across the enterocyte. We also discussed glucose transport within the bloodstream and how conditions there differ from those in the gut, thus utilizing different methods for facilitating cross-membrane movement. Finally, we considered how osmotic imbalances lead to osmotic diarrhea, a symptom resulting from the inability to break down lactose.

4. Fermentation & Food

Associated with metabolism, we discussed the use of fermentation in food processing. We reviewed cheesemaking and discussed the role of microbial fermentation in breaking down lactose. We also introduced nondairy fermentations (soy sauce, beer, wine, vinegar). We then discussed how the lactose content of various dairy products may affect reaction severity for lactase-nonpersistent individuals.

5. Lactase & Your DNA

Associated with discussions of DNA and gene expression, we reviewed karyotypes and how they are created. We then discussed genes located within the human genome that impact lactase production. Mutations on the LCT gene, which codes for the enzyme lactase, contributes to congenital lactose intolerance, a rare and severe disorder in infants. The MCM6 gene, immediately ahead of the LCT gene, contains a regulatory element that helps control LCT gene expression. Lactase production decreases in 65% of the global population as individuals age; a mutation on the MCM6 gene allows some individuals to continue producing lactase. We discussed how these types of mutations have allowed at least two (East African and northern European) populations to digest lactose into adulthood.

6. It Evolved More Than Once?

Associated with evolution and population genetics, we reviewed how mutations are passed down within a population. We discussed ecological regions where lactose digestion provides an evolutionary advantage, specifically looking at pastoralist groups across Africa, as well as northern European populations (Storhaug et al., 2017). We then considered populations in East Asia. Finally, we reviewed the lactose, protein, and fat content found in milk across other mammalian species and discussed evolutionary links.

7. Wrap-up & Semester Review

To tie all Context Breaks together, assess learning gains, and garner feedback, we implemented a semester wrap-up, highlighting major themes.

○ Conclusions and Student Feedback

Context Breaks were well received by the students with feedback suggesting that they were most effective in aiding student understanding material at a deeper level (Figure 1). Additional student feedback suggested that “Context Breaks were actually applicable” and “an excellent idea.” Others suggested that they were “interesting and insightful,” and it was “cool to see how lactose intolerance correlates with our subject for the course.”

After the first case study, one student recognized the symptoms in his own life. After consulting with his doctor, he was confirmed lactose intolerant. This student shared his experience with the class as part of a final project. “Overall, I was extremely grateful for the chance to see in real life not only the application of what I was learning in class, but to receive knowledge that helped me curve my diet and understand my body much better than I did before!”

Table 1. An overview of the seven Context Breaks implemented into a general biology course. Included are the topics and core principles they addressed, as well as the average time each took.

| Overview | General Topics | Core Principles | Time |
|----------|----------------|----------------|------|
| 1. Introduction | The process of science | — | 10 |
| 2. Lactose vs. Lactase | Molecular diversity of life | Structure & function | 20 |
| 3. Transport in the Gut | Osmotic diarrhea & other symptoms of lactose intolerance | Cell anatomy & membrane transport | Pathways & transformation of energy, matter & systems | 25 |
| 4. Fermentation & Food | Byproducts, its use in food production & the microbiome | Metabolism & the microbiome | Pathways & transformation of energy & matter | 15 |
| 5. Lactase & Your DNA | Human chromosomes, LCT & MCM6 genes & mutations | Karyotypes & gene expression | Information flow, exchange & storage | 20 |
| 6. It evolved more than once | Advantages of lactose digestion & mutations in different populations | Evolution & population genetics | Evolution | 25 |
| 7. Wrap-up & review | Feedback & learning gains | — | 20 |
Less positive qualitative feedback expressed potential burnout with the single subject, suggesting we “change the topic once in a while.” We also received feedback that Context Breaks were geared “too much toward just medical degrees. But good.” This suggests that our goal of targeting pre-health professions students might come at a potential cost to others. One student suggested that he “only listened to about 50% of them just because I understood the topics being presented.” This suggests that while students may have found the subject interesting, they might not engage if not deemed necessary for their success in the course.

Context Breaks also demonstrated an effective way to provide teaching opportunities for interns in a large college classroom without the strain of preparing full lectures. This technique could be adapted to a variety of courses at many levels to provide interns an opportunity to engage in instruction.

In summary, by utilizing this well-studied topic of lactase persistence/nonpersistence, we drew on a wealth of research, general information, and personal history that made the subject readily applicable to individuals within our general biology course.

References

American Association for the Advancement of Science. (2011). Vision and Change in Undergraduate Biology Education: A Call to Action. AAAS.

Burger, J., Kirchner, M., Bramanti, B., Haak, W. & Thomas, M.G. (2007). Absence of the lactase-persistence-associated allele in early Neolithic Europeans. Proceedings of the National Academy of Sciences, 104, 3736–41.

Herreid, C.F. (2005). The interrupted case method. Journal of College Science Teaching, 35, 2.

Storhaug, C.L., Fosse, S.K. & Fadnes, L.T. 2017. Country, regional, and global estimates for lactose malabsorption in adults: A systematic review and meta-analysis. Lancet Gastroenterology & Hepatology, 2, 738–46.

SOPHIE HILL (sophiehill892@gmail.com) is a postdoctoral researcher in the Department of Plant and Wildlife sciences at Brigham Young University, Provo, UT 84602. RHESA LEDBETTER (rhesa.ledbetter@hastings.edu) is an assistant professor in the Biology Department at Hastings College, Hastings, NE 68901.
Article Categories

A note about article word count: Please recognize that tables, figures, and photographs add to the overall length of the article. One page of text has approximately 1,000 words, therefore a 1/4-page graphic will count for 250 words. More extensive graphics should be budgeted accordingly. References are also included in the final article word count.

**Feature Article** (up to 4,500 words) includes topics of general interest to readers of *ABT*. Consider the following examples of content that would be suitable for the feature article category:

- Research on teaching alternatives, including evaluation of a new method, cooperative learning, concept maps, learning contracts, investigative experiences, educational technology, simulations and games, and biology and life science education standards
- Social and ethical implications of biology and how to teach such issues as genetic modification, energy production, agriculture, climate change, health care, nutrition, and cultural responsiveness
- Reviews and updates of recent advances in the life sciences in the form of an “Instant Update” that brings readers up-to-date in a specific area
- Imaginative views of the future of biology education and suggestions for adjusting to changes in schools, classrooms, and student populations
- Other timely, relevant, and interesting content such as discussions of the role of the Next Generation Science Standards in biology teaching, considerations of the nature of science with implications for the classroom, considerations of the continuum of biology instruction from K–12 to post-secondary teaching environments, or contributions that consider the likely/ideal future of science and biology instruction

**Research on Learning** (up to 4,500 words) includes reports of original research on innovative teaching strategies, learning methods, or curriculum comparisons. Studies should be based on sound research questions, hypotheses, discussion of appropriate design and procedures, data and analysis, discussion on study limitations, and recommendations for improved learning outcomes.

**Inquiry and Investigations** (up to 3,500 words) is the section of *ABT* that features discussion of innovative laboratory and field-based strategies. Strategies in this section should be original, engaging, practical, and related to either a particular program such as AP and/or linked to standards such as NGSS. Submissions should also be focused at a particular grade/age level of student and must include all necessary instructions, materials list, worksheets, and assessment tools. Other appropriate contributions in this category are laboratory experiences that engage students in inquiry.

**Tips, Tricks and Techniques** (up to 1,500 words but may be much shorter) features a range of suggestions useful for teachers including laboratory, field, and classroom activities; motivational strategies to assist students in learning specific concepts; modifications of traditional activities; new ways to prepare some aspect of laboratory instruction; etc.

Writing & Style Guidelines

The *Chicago Manual of Style, 17th Edition* is the guide for questions of punctuation, abbreviation, and style. List all references in alphabetical order on a separate page at the end of the manuscript. Please review a past issue for examples. Use first person and a friendly tone whenever appropriate. Use concise words to emphasize your point rather than capitalization, underlining, italics, or boldface. Use the SI (metric) system for all weights and measures.

While calls for specific themed issues of *ABT* are infrequent, February and April are traditionally themed editions on Evolution and the Environment, respectively.

Preparing Tables, Figures, and Photographs

**General Requirements**

- When your article is accepted, we will require that figures be submitted as individual figure files in higher resolution format. See below for file format and resolution requirements.
- Authors should be aware that color is limited within the journal. All artwork, figures, tables, etc. must be legible in black and white. If color is important to understanding your figures, please consider alternative ways of conveying the information.

**Article Photographs**

Digital files must meet the following guidelines:

- Minimum resolution of 300 DPI, 600 DPI is preferred
- Acceptable file formats are TIFF and JPEG
- Set to one-column (3.5” wide) or two-column size (7” wide)
- If figure originates from a website, please include the URL in the figure caption. Please note that screen captures of figures from a website are normally too low in resolution for use.

**Tables and Figures**

- Minimum resolution of 600 DPI, 1200 DPI is preferred
- Acceptable file formats are TIFF, BMP, and EPS
- Set to one-column (3.5” wide) or two-column size (7” wide)

If you have any questions, contact Valerie Haff at managingeditor@nabt.org.

*continued*
Submission Guidelines

NOTE: All authors must be current members of NABT or a charge of $100 per page is due before publication.

All manuscripts must be submitted online at http://mc.manuscriptcentral.com/ucpress-abt

- Authors will be asked to register the first time they enter the site. Upon receiving a password, authors can proceed to upload their manuscripts through a step-by-step process. Assistance is available in the “Author Help” link found in the menu on the left side of the page. Additional assistance is available from the Managing Editor (managingeditor@nabt.org).
- Manuscripts must be submitted as Word or WordPerfect files.
- Format manuscripts for 8.5 x 11-inch paper, 12-point font, double-spaced throughout, including tables, figure legends, and references.
- Please place figures (including photos) and tables where they are first cited in the text along with appropriate labels. Make sure to include figure and table citations in the text, as it is not always obvious where they should be placed. At the time of initial submission, figures, tables, and images should be low resolution so that the final file size remains manageable.
- If your article is accepted, the editors will require that figures be submitted as figure files in higher resolution form. See section on Preparing Tables, Figures, and Photographs.

Supplemental Materials

In order to maintain the word count for individual articles, we are pleased to facilitate publication of supplemental materials accompanying the online issue. If authors have materials (figures, examples, worksheets, appendices, multimedia files, etc.) that support but are not essential to the printed text of the article, authors can include those as separate files with their article submission.

Editorial Procedures

- Communications will be directed only to the first author of multiple-authored articles.
- Typically, three individuals who have expertise in the respective content area will review each article.
- The editors attempt to make decisions on articles as soon as possible after receipt, but the process can take six to eight months, with the actual date of publication to follow. Authors will be emailed editorial decisions as soon as they are available.
- Accepted manuscripts will be forwarded to the Copy Editor for editing. This process may involve making changes in style and content. However, the author is ultimately responsible for scientific and technical accuracy. Page proofs will be sent to authors for final review before publication at which time only minor changes can be made.

Submitting Images

Cover Images

Submissions of cover photographs from NABT members are strongly encouraged. Covers are selected based on the quality of the image, originality, composition, and overall interest to life science educators. ABT has high standards for cover image requirements and it is important for potential photographers to understand that the required size of the cover image generally precludes images taken with cell phones, point-and-shoot cameras, and even some older model digital SLR cameras.

Please follow the requirements listed below.

- Email possible cover images to Kathleen Westrich at kmwestrich@yahoo.com.
- ABT covers feature an almost-square image with a slight vertical orientation.
- Choose an image with a good story to tell. Do not crop the subject too tightly. It is best to provide an area of background around the subject.
- Include a brief description of the image, details of the shot (i.e., circumstances, time of day, location, type of camera, camera settings, etc.), and your biographical information in an email message.
- Include your name, home and email addresses, and phone numbers.
- Please ensure that the image meets the minimum standards for publication listed below and has not been edited or enhanced in any way. The digital file must meet the minimum resolution of 300 pixels per inch (PPI)—preferred is 400 PPI—and a size of 8.5 x 11.25”. We accept TIFF or JPEG images only.

Thank you for your interest in The American Biology Teacher. We look forward to receiving your manuscripts.

William McComas, Editor-in-Chief
ABTEditor@nabt.org

Valerie Haff, Managing Editor
managingeditor@nabt.org