Using a Case Study Article on Earwax to Enhance Understanding and Interest in Genetics

By Doug Van Hoewyk

The next time your students clean their ears, they might be tempted to examine their earwax and have a better appreciation for genetics. For four consecutive semesters, students in an Introductory Biology class at Coastal Carolina University were assigned to read a case study article that explores the link between a single gene and earwax type. The case study article, broadly defined as a story with an education message (Herreid, 2007), was originally published by the *New York Times* (Wade, 2006) and summarizes original research performed by Yoshiura et al. (2006).

Briefly, the case study article explains that humans either have wet or dry earwax and continues by highlighting that Japanese researchers have recently identified the gene that determines the type of earwax an individual is destined to have. The gene, designated *ABCC11*, has two different alleles. A single point mutation in the *ABCC11* gene, in which an "A" for *a*denine substitutes "G" for *g*uanine, will produce the dry earwax phenotype only if the person has two copies of the recessive allele. In contrast, individuals with at least one dominant "G" allele will have wet earwax. Individuals with African and European ancestry are more likely to have wet earwax, while dry earwax is most prevalent among Koreans, Japanese, and Han Chinese in northeastern Asia. The article concludes by noting a difference in opinion as to why the dry earwax allele is still persistent in the human population. The researchers correctly noted that dry earwax is strongly associated with less sweating and decreased body odor, which they opine may be an adaptation to cold winters typically experienced in northeastern Asia. Other scientists have rationalized that genetic drift may simply best explain why the allele for dry earwax is still found in some Asian ethnicities and that this allele was not likely favored by natural selection as postulated by the original researchers.

The case study article is assigned to students after a three-week unit covering Mendelian genetics, transcription, and translation. The article is read just prior to introducing the different types of mutations that can occur in DNA. Students are required to answer questions that pertain to the article prior to the next lecture. The case study article refrains from using common genetic terms that students have learned and previously used to solve genetic problems. Terms that are not included, but can be inferred from the case study article, include: *dominant, recessive, heterozygous, homozygous, genotype, phenotype,* and *alleles*. I take advantage of the omission of these terms and have students apply these definitions as they answer the following questions:

- Are there two types of genes or alleles that determine earwax?
- What phenotypes are associated with each gene variant?
- Which gene variant is recessive and which is dominant?
- What is the chance a child will have wet earwax if one parent has a heterozygous genotype and another parent has dry earwax?
- Speculate if earwax type and body odor are influenced by nurture, nature, or both.
- What's the difference between natural selection and genetic drift? Which do you believe is more responsible for the prevalence of dry earwax among Native Americans?

Reading the case study on the genetics of earwax has several advantages. Case-based learning has gained popularity in the past decade and is perceived by faculty to increase critical thinking (Yadav, Lundeberg, Dirkin, Schiller, & Herreid, 2006); furthermore, it can increase comprehension and retention of learned material, as well as promote the use of higher-order thinking skills (Allen, 1996; Smith & Murphy, 1998; Dori, Tal, & Tsausu, 2003). In one example, students using a case study on aerobic respiration demonstrated critical thinking and increased students' learning gain fourfold after correcting for a pretest, compared with students

who did not use the case study (Rybarczyk, Baines, McVey, Thompson, & Wilkins, 2007). Advantages of the earwax case study and suggestions on how to effectively use the article—including tips to promote an in-class discussion and higher-order thinking skills—are outlined below.

Students who have a sound conceptual framework of genetics will be able to apply their knowledge of genetics and the terms they have learned to the case study article. It is also hoped that comprehension of the earwax article may build student confidence and entice them to read other science articles that appear in the mass media. Another incentive to assign the case study is to allow students to independently learn that mutations can be neutral. The article dispels the popular misconception that genetic mutations are always negative and result in genetic disorders. This fallacy is partially understandable, as textbooks and Punnet-square problems often bias "mutant" alleles that cause disease and syndromes in humans. After reading the case study article, more than 98% of the students responded that the mutation that causes dry earwax is neutral today, as one type of earwax obviously does not confer a reproductive advantage or disadvantage for survival. Additionally, data reveal that students who read the case study were more likely to later recall that mutations can be neutral and result in new traits (e.g., dry earwax) that have no effect on the fitness of a population compared with students who were not assigned the case study article (Table 1); however, a chi-square test indicates difference between the two groups was not significant ($X^2 = 3.72$, $p = .06$). The fact that many mutations are likely to be neutral during the course of human evolution is reinforced during a brief in-class discussion, which leads to the third advantage of the case study.

The case study article can also initiate a very lively discussion in class. After all, compared with the inheritance of alleles causing human genetic disorders, a discussion on the genetics of earwax types and its association with sweating and body odor is fun and frivolous, lending to laughter. In class I mention the correlation between dry earwax and decreased sweating, which may have been an adaptive trait in cold climates (Yoshiura et al., 2006). This allows the instructor to highlight that there has been an ongoing debate among biologists as to whether the prevalence of the dry earwax allele in northeastern Asians was favored by natural selection or random genetic drift. Although recent research has indicated that the dry earwax gene underwent positive selection in northern climates (Ohashi et al., 2010), I emphasize that disputes are not only common in biology but also a healthy and vital part of all sciences. Critically inquiring students have also asked why this research was performed, which is always a welcome and perfectly valid question. I respond by explaining two applications of this research. First, the research can be used to understand previous human migration patterns (Sakai, Imai, Ogawa, & Iwaoka, 2009). The case study mentions that Native Americans have dry earwax, and the future anthropologists in class are quick to explain that Native Americans are descendents of eastern Asians who crossed the Bering Strait roughly 15,000 years ago. Another practical application of this research is revealed when I mention that a simple genetic test of an individual's earwax gene can serve as a diagnostic tool for dermatologists whose patients might seek removal of glands that cause armpit odor (Nakano, Miwa, Hirano, Yoshiura, & Niikawa, 2009; Toyoda et al., 2009). I point out that wet earwax and sweating are strongly correlated and although sweat itself does not smell, skin bacteria can transform sweat into an unpleasant odor. Students learn that wet earwax is rare in Japan and that axillary osmidrosis (body odor) is considered a disease in Japan and covered by Japan's national health care system.

The case study article can also

TABLE 1

Fill-in-the-bank question addressing the misconception that mutations are always harmful.

Question: Mutations _____ and result in new traits that _____ the health of populations.

a) are always harmful, negatively affect
b) can be neutral, negatively affect
→ c) can be neutral, have no effect on
d) are always necessary, improve
e) are always beneficial, might have no effect on

Group	Correct	Incorrect	X^2 value	*p*-value
+ case study (*n* = 34)	65% (22)	35% (12)		
– case study (*n* = 36)	42% (15)	58% (21)	3.72	.06

Note: n = all students in two different sections of an Introductory Biology class completing a postassessment survey two weeks after covering mutations in lecture.

be used as a method of assessment to gauge students' understanding of genetics and higher-order thinking skills (Rybarczyk et al., 2007). In fact, initially I used the case study article with accompanying questions on the final exam of an Introduction Biology class. However, if the case study is used to assess students' understanding of genetics, it is recommended that it be done midsemester so there is an opportunity to guide the class in a spirited discussion that touches on some of the topics.

Last, the article can also serve as a seamless transition to new topics in an Introductory Biology class. This includes material covering population genetics or the difference between how natural selection and genetic drift may guide evolution. If teaching cell biology, the case study can be a stepping stone to protein degradation pathways, now that the molecular and cellular pathway leading to the dry earwax phenotype has been elucidated. (Briefly, Toyoda et al., 2009, demonstrated that the protein encoded by the dry earwax allele is not properly glycosylated, and as a result the misfolded protein is ubiquinated and destroyed by the proteasome.) Alternatively, I spend the rest of lecture covering the different types of mutations that can occur in genes. I conclude class by assigning three additional questions that again relate to the case study article:

- Is the allele conferring dry earwax caused by a point mutation or an insertion/deletion?
- Did the mutation in the dry earwax allele most likely produce a silent, missense, nonsense mutation in the coding protein?
- Suggest how a new allele for damp earwax type be introduced into the human population.

Although the case study article refrains from describing the different types of mutations, students can infer and discover that the dry earwax allele is caused by single point mutation in DNA, which most likely causes a missense or nonsense mutation in the protein. These questions again allow students to relate learned material in lecture to the case study article. Thus, the case study may be ideal for instructors who challenge their students to apply the genetic concepts learned in class. ■

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