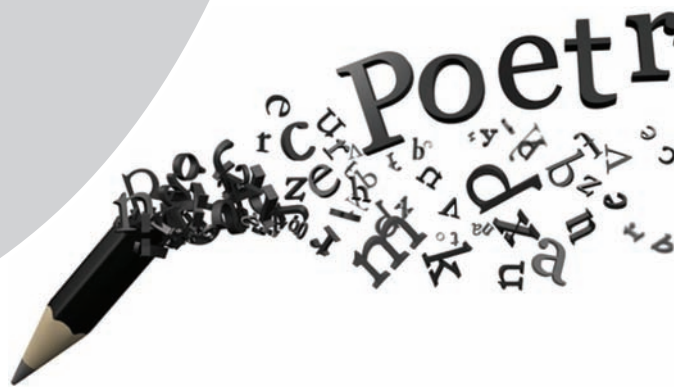


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**ABSTRACT**

Traditional assessments in college biology classrooms, such as exams and lab reports, often have limited utility in promoting long-lasting understanding of course material and do not always engage students from all backgrounds. The inclusion of creative scientific writing assignments, especially those that require application of sophisticated course material, is an underutilized strategy in higher education. Here, we describe our use of student-generated poetry in two midlevel undergraduate biology classes. We have found that by encouraging students to write poems in response to carefully crafted prompts and having them assess the scientific accuracy of the poems, we can encourage them to identify misconceptions prior to exams, potentially resulting in deeper and longer-lasting understanding of course material. Furthermore, the inclusion of poetry empowers students who might not otherwise participate in class to contribute, resulting in a more inclusive classroom climate.

**Key Words:** active learning; nontraditional assessment; poetry; STEAM.

**○ Introduction**

A major goal of college-level biology teaching is to promote deep understanding and the ability to apply learned material to new situations, rather than just memorization. One effective way to accomplish this is to engage students in various forms of scientific writing, with the purpose of having them apply their knowledge and clarify their thinking (Glynn & Muth, 1994; Moore, 1994; Halpern & Hakel, 2003; Quitadamo & Kurtz, 2007). Typically, these writing assignments take the form of lab reports and analyses of scientific papers, which often require students to follow a template. These writing exercises can be powerful, especially when the students use them to reflect on the scientific process. However, their inherent structure may lead students to assume that there is a “right way” to do the assignment in order to get a good grade and tempt them to plagiarize or paraphrase their responses from outside sources. In addition, these types of assignments often do not relate to students’ real-world experiences and are therefore not inherently motivating. To address these issues,

less prescriptive types of writing assignments have been popularized in “Writing Across the Curriculum” efforts. These activities provide students with opportunities to explore scientific concepts in novel contexts and include persuasive essays, letters to parents or siblings, or editorials to local newspapers (Glynn & Muth, 1994; Pelger & Nilsson, 2016).

In the past five years, efforts to incorporate arts into the STEM (science, technology, engineering, and mathematics) disciplines have become popular with the STEAM movement (Bequette & Bequette, 2012; Henriksen, 2014). In particular, STEAM has encouraged instructors in college-level science courses to use a variety of creative writing assignments, such as narrative storytelling in physiology (Bunker & Schnieder, 2015), analysis of science fiction in biology and physics (Copeland et al., 2018), and popular science writing in molecular biology (Pelger & Nilsson, 2016). Creative writing through poetry has also been incorporated into teaching in various scientific disciplines, both in K–12 education (Frazier & Murray, 2009; Forster et al., 2018; Jones, 2018) and in undergraduate chemistry and physics classes (Alber, 2001; Schmidt, 2013; Araujo et al., 2015; Radhakrishnan, 2017). More recently, writing “code poems” has become popular in the computer sciences. However, published examples of poetry being used in the teaching of college-level biology are rare, particularly in courses intended for biology majors.

Here, we present one way in which we have introduced the arts into our upper-division Marine Biology and Molecular Biology classes, which are typically taken by undergraduate biology and biochemistry majors. At least once each semester, we ask the students to write a poem about a scientific concept or process related to a central theme of the course. The goals of these assignments are to (1) promote thoughtful and creative student engagement with class material according to specific prompts; (2) help students analyze the material by distilling it into their own words; (3) allow students and instructors to discover misconceptions and misunderstandings prior to exams; and (4) provide an alternative, nonthreatening mechanism of assessment. Through the combined 40 years that we have been using this assignment in our courses, we have found

that it provides us with information about student understanding that is often difficult to obtain via traditional assessments, and it infuses the curriculum with energy.

## ○ Description & Examples of Poetry Assignment


To encourage students to engage with the class material early in the course, we offer them a poetry-writing assignment approximately two weeks before the material will be assessed on an exam. Students have one week to submit their poems. In their responses,

they must include specific biological details that they have learned in the course and correctly use vocabulary relevant to the topic. Beyond this, there is no requirement for type of poem or formatting. In the past, students have submitted limericks, sonnets, haikus, ballads, epic poems, raps, and various types of visual poetry.

Examples of the assignment prompts and a sample student submission for each are shown in Figures 1 and 2. Both poems demonstrate that the students have a well-developed, but not perfect, understanding of the subject material. For example, the author of the trematode poem (Figure 1) correctly describes the parasite's life cycle, although it isn't clear how deep her understanding is of the relationship between the organism's life stages and its hosts.

**Question of the Week**  
**Bio 164 – Marine Biology**

**Assignment:** Write a poem (limit to one page, please) about the life cycles of trematode flatworms, based on lectures and textbook readings.



The poem can be serious or humorous, and can be rhymed or not. The only requirements are that it be typed, and that it be something that you couldn't have written before you took this course. Try to get some real biological detail in there, but also have a good time writing the poem.

**You must use each of the following words at least once in your poem:**

itch (or some variation, like itchy)	animal
cercaria	miracidium
wine (or beer)	fish (or vertebrate)
spring break	snail (or gastropod)
parasite	flatworm
trematode	awesome

The Curious Case of the Trematode Lifecycle: A Poem

One afternoon during this year's spring break  
I happened upon a strange creature whose life cycle made me quake.  
A trematode flatworm, that's what it's named,  
And for living inside other animals as a parasite it has been blamed.

I found it quite curious, this tiny little thing,  
For it must pass through three hosts in order to finally reign king.  
First, I recall, the adult flatworm expels its fertilized eggs in the current host's waste,  
Allowing the tiny egg capsules to be eaten by the first intermediate host with haste.

Next came said host- a gastropod, no less-  
In which the egg capsules burst, freeing the miracidium to impress.  
This tiny larva replicates asexually, always steady,  
Creating either sporocysts or redia with germ balls at the ready.

The germ balls are released to create the cercaria larva, all genetically the same,  
Whose goal is to lyse from the snail and find a fish to take aim.  
Once inside this second intermediate, the meta-cercaria encysts,  
Remaining dormant and praying a final host exists

That will eat the fish and allow this tiny creature  
To develop into an awesome feature.  
Once the larva reaches its final path,  
The cycle starts again, the flatworm on a warpath.

So there I sat,  
contemplating this platyhelminth and sipping on my beer drawn straight from the keg,  
When I suddenly felt a strange little itch in my left leg.  
What could it be, you may inquire?  
Perhaps a tiny cercaria in my skin coming to retire.

**Figure 1.** Poetry prompt and sample student response for Marine Biology.

**DNA Repair Poem**  
**Bio 105 – Molecular Biology**

Directions: We have discussed many different pathways which are employed by cells to repair their DNA when it is damaged. For this assignment, choose your favorite DNA repair/DNA damage tolerance pathway from the list below.

Mismatch repair  
 Base excision repair  
 Direct reversal of damage (DNA methyltransferase or photolyase)  
 Nucleotide excision repair  
 Transcription-coupled repair  
 Translesion synthesis  
 Non-homologous end joining  
 Homologous recombination

For your chosen pathway, compose a **poem** in which you do the following:

- (1) Explain the basic mechanism of the pathway, including the type(s) of damage that it repairs
- (2) Include some of the key proteins in the pathway, making reference to their roles
- (3) Highlight the importance of the pathway so that your audience has a greater appreciation of its role in protecting and/or repairing DNA.

Your poem will be evaluated based on how accurately and completely you address the three components above. Any type of poem is OK—limerick, sonnet, haiku, rap, or visual poem. Feel free to unleash your wit and creativity in this assignment.

**Translesion Synthesis**

When replicating three billion bases,  
 It's natural to get stuck in places.  
 A large, mutated nucleotide  
 Is far too big, can't fit inside  
 The active sites of pol one or three  
 And so they leave the job to me:  
 Translesion synthesis—I'll get you past  
 And keep replication moving fast.

With several pols for different lesions  
 I'll handle anything—even deletions.  
 With wide active sites, pol five and four  
 Can fit in bases plus a little more,  
 To pair off adducts with a dNTP  
 That happens to be in proximity.  
 And no proofreading safety catch,  
 Means added bases don't have to match.  
 Sure, that means more errors in code—  
 At least replication's not permanently slowed.  
 Because thymine dimers from UV light,  
 Or some other similar DNA blight,  
 Shouldn't be enough to stop cell division  
 When pol eta can add two As with precision.

Not bound and tethered by PCNA  
 I'll fix your hitch and be on my way.  
 I'll dissociate when the fork's progressed  
 So clamped pol III can handle the rest.  
 Success comes quickly cause I delay  
 Fixing the damage that's in the way.  
 Forget removal, or fancy ablation,  
 Just leave it 'til next replication.  
 Synthesis leaves no time to spare,  
 And sometimes you just need band-aid repair.

**Figure 2.** Poetry prompt and sample student response for Molecular Biology.

She incorporates scientific terminology in appropriate ways and correctly uses some words that weren't required, such as metacercaria, platyhelminth, and germ balls, indicating that she is digging deeper into the biology than was required for the assignment. Similarly, the author of the DNA repair poem (Figure 2) accurately states what types of damage are bypassed during translesion synthesis, although it isn't clear at the beginning of stanza 2 if she is referring to missing DNA bases or deletions of nucleotides (which cannot be bypassed). She nicely highlights how the physical structure of the translesion polymerase allows it to copy past the damaged DNA base, the event that happens next, and the underlying reason behind the use of this biological mechanism. Importantly, she addresses fundamental concepts that are the focus of the learning objectives for the instructional unit and does so in a clever but accurate way. In both cases (and in most student poems), the understanding of the biological phenomena is good, and the instructor also gains insight into misconceptions that may need to be addressed.

## ○ Student Participation & Assessment

Typically, we have made these poems optional assignments, so as not to penalize students for whom writing a poem seems too difficult. Students who complete the assignment and demonstrate application of their scientific knowledge are awarded extra credit

toward their final grade. Assessment of the poems is holistic and based on the students' ability to fully address the prompt. The instructors provide written feedback on the poems well in advance of the exam, focusing on the accuracy of the scientific content. We have found that the percentage of students who submit poems varies between 60% and 75% in any given year. Interestingly, we have found that some students will spend an hour or more writing their poem, indicating a high degree of intellectual investment. Because we do not require that the poem be written in a specific format or that it rhyme, we have found that much of the students' focus is on incorporating course material, rather than on the mechanics of the poetry.

Free-response comments on end-of-course evaluations suggest that most students enjoy the poetry assignment. They appreciate how it allows them to make connections between major topics in the class while having fun with the material. In addition, many of the comments suggest that students are reviewing and integrating important concepts while writing their poems. We have noticed that this type of assignment can be difficult for non-native English speakers, and we have occasionally received comments on student evaluations to this effect. However, because the assignment is counted solely as extra credit, its low-stakes nature may encourage students who do not feel comfortable writing poetry to at least make an attempt.

Examples of student comments on a poetry assignment dealing with the functioning of the fish swim bladder can be found in Figure 3.



**Prompt:** If you did the most recent poem-writing assignment about swim bladders, how useful did you find it? What aspects of the assignment helped you engage with the course material?

**Sample Responses:**

I found it be very useful – not only was it fun to write, it made me review the material and now I have a much better grasp on it.

The assignment forced me to go back and really understand the functioning of the swim bladder. Since it was a poem, in order to write it, I really had to conceptualize what was going on.

I thought that it was helpful in getting me to think about swim bladders in a different way, and it challenged me to describe how swim bladders work through more artistic (as opposed to scientific) wording.

I actually found this assignment very useful, because it gave me a chance to apply knowledge from this class in a completely new way. I found myself thinking hard about how the given words were related as I tried to get them to rhyme.

In order to construct this poem we had to have a good understanding of the material. It also pushed me to do outside research about the stuff I didn't understand.

creativity in a science class. Because the process of writing a poem requires the students to synthesize information and make useful connections between different concepts in a novel way, they are more likely to retain the information, not only for subsequent assessments such as exams, but sometimes well beyond the end of the class. For example, one Molecular Biology student, in an email to the professor, wrote: “Amazingly I still remember that poem and it is from almost three years ago.” While we have not conducted a formal analysis comparing the benefits of this type of writing assignment with more traditional writing assignments or other active pedagogical techniques, our anecdotal evidence from student evaluations suggests that it is well-received and engages students from a wide variety of academic backgrounds. Furthermore, while we have utilized it in a course setting designed for biology majors, it could easily be adapted for a nonmajors course.

## ○ Conclusion

While the use of poetry in science has been adopted multiple times in K–12 educational settings, it is rarely used in college biology courses. We argue that its inclusion in the curriculum can be extremely effective, especially when combined with assignments involving other forms of scientific writing. One example of this approach is found at Wellesley College, where a chemistry professor writes and performs her own poems for her students, using personification to teach complex chemistry concepts (Radhakrishnan, 2017). These poems have been subsequently used as a basis for analysis of chemistry concepts at other institutions (Araujo et al., 2015). We have taken this one step further by having the students create their own poems describing complex biological phenomena and then analyze them in a nonthreatening setting in order to help address common misconceptions. Based on our experiences, we propose that crafting poems about biological topics allows students who struggle with traditional scientific writing assignments to become more invested in the learning process, leading to better educational outcomes and more vibrant science classrooms.

## ○ Acknowledgments

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**Figure 3.** Student impressions of a poetry-writing assignment about swim bladders.

## ○ Dealing with Misconceptions

As might be expected, some students include misconceptions or inaccuracies in their poems. In addition to having the instructor identify these in written feedback, we have found it beneficial to have the students actively engage in the review process. This can take several forms. In Marine Biology, the professor chooses a few submissions that are well-detailed and largely correct but that reveal some key (and often common) misunderstandings. These are distributed to the class, and the students engage in peer review in small groups, looking for misconceptions or important omissions. In Molecular Biology, a review panel composed of professors in the biology and English departments chooses some of the best poems in each DNA repair pathway category, and willing students read their poems aloud in a “poetry slam.” During the slam, the students are asked to record important points and any inaccuracies that they hear and submit them to the instructor at the end of class. In all cases, feedback is provided to the participants in written format or in one-on-one meetings with the instructor. Notably, in both classes we have found that the process of reading the poems aloud and engaging in peer review benefits the students in ways that professors’ lectures or explanations do not.

## ○ Effectiveness & Other Considerations

Our multiple years of experience with this assessment technique indicate that it adds instructional value and spontaneity to our courses and is fun for both the students and instructors. The assignment serves as a bridge between the arts and sciences and allows students to exercise

“I really enjoyed that the program was flexible. I was able to complete coursework at my own pace and on my own time.”

—Cayman Adams, Graduate



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