ASP2024: Astronomy Across the Spectrum
ASP Conference Series, Vol. 539
Greg Schultz, Sanlyn Buxner, Joseph Jensen, and Jonathan Barnes, eds.

Science in Literature: Teaching Astrobiology Using Octavia Butler's *Dawn*

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3D-1: 10-minute Oral Presentation
Thursday, August 22, 2024

Conference Strand: *Teaching Astronomy – New Opportunities, Challenges, Tools, and Innovations*

Abstract. This paper describes methods for teaching students about fundamental concepts in search for extraterrestrial intelligence (SETI) and origins-of-life in the context of an interdisciplinary science and literature course. Students read, among other novels, Octavia Butler's *Dawn* (1993) and discussed its literary themes in parallel to its speculative science. After almost a full semester of discussing various ideas in evolution in discussion of various other texts, *Dawn* provided an effective framing for discussing fundamental questions in origins-of-life research. The pedagogical results and affective student response were much stronger than in a comparable lecture-based evolution general-education course.

1. Introduction

The methods and results described below took place in a general-education course offered jointly in the College of Liberal Arts and the College of Science at the Pennsylvania State University.

2. The Course: ENGL 142N Science in Literature

The context for these activities is the course ENGL 142N (cross-listed in the College of Science as SC 142N) "Science in Literature." This course fulfills a Penn State graduation requirement for all bachelors degrees. All students must take 9.0 credits of courses designated as "general education" courses in the Natural Sciences category, and 6.0 credits from each of the categories of Social Sciences, Arts, and Humanities. Additionally, students must include an Integrative Studies overlay, which can be fulfilled by choosing 6.0 credits from "inter-domain" courses designated to fulfill standards for two of those categories. The goal is to circumscribe particular learning outcomes (Pennsylvania State University Office for General Education):

> Integrative Studies courses have a distinctive intellectual dimension. Because these courses ask the student to consider a topic from the perspective of two different General Education Knowledge Domains, they aim to advance the student's ability to comprehend things from multiple perspectives, to see connections, and to grasp the concept that one must employ different modes of thinking, different epistemologies to understand more adequately the nature of things; one domain is not fully equal to the task of understanding the world around us.
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> Inter-Domain courses provide the immediacy of incorporating the intellectual frameworks and methodologies of two Knowledge Domains in equal proportion in the same course. Additionally, students will synthesize perspectives from both domains in assignments or other course assessments to practice integrative thinking.

ENGL/SC 142N is an inter-domain course with designations in both Natural Sciences and Humanities.

Dr. Scott Smith and I developed this course in 2016, and we taught it together in 2017, 2018, 2019, 2021, and 2022. (Subsequently in 2023 and 2025, I taught the course by myself.) Dr. Smith has appointments in both the English and Comparative Literature departments. I am in the Department of Biochemistry and Molecular Biology. Both of us teach a wide range of courses (majors, service, and general education courses; lower- and upper-class undergraduate and graduate courses). In particular, I also teach BISC 2 Genetics, Ecology and Evolution, a fairly large (100–200 students) conventional lecture course focused on many of the same evolution topics as ENGL 142N.

2.1. Course Topics: Evolution

During the first two times we taught Science in Literature, we explored a range of texts and science topics: "the atom," nuclear weapons and energy in twentieth-century culture; biotechnology; neuroscience and neuroactive drugs; environmental crises, especially climate change; and evolution.

Starting with the third run, however, we decided to focus solely on evolution, in order to deepen the experience with an entire semester of depth on a single topic.

2.2. Course Mechanics: Discussion

Enrollment is capped at thirty students, a compromise to balance very heavy student demand with a seminar atmosphere. Course assignments reflect a dynamic interplay between writing and discussion. (Yaqelski 1995, Mason 2001)

The course meets for 75 minutes twice a week, a structure which we exploit as follows. After the first introductory week, during which we lead discussion together, each week has a familiar rhythm:

An important aspect of the course when we teach it together is that both instructors participate conspicuously in all the meetings. The instructor leading the discussion stands in front of the group, using the blackboard and projector, while the other instructor sits among the students and raises his hand in order to be recognized. When the assigned classroom permits, we arrange the seats into a circle at the start of each meeting. All of these practices aim successfully at fostering and improving rapport among students and between students and us. Our participating "as students" in each others' discussions models high standards and clearly stimulates the students. Often students

Table 1. Some of the texts used over the years in ENGL 142N Science in Literature.

Text	Author	Year
Arcadia (play)	Tom Stoppard	1993
Mendel's Dwarf	Simon Mawer	1997
Galápagos	Kurt Vonnegut	1985
Dawn	Octavia Butler	1987
The Time Machine	H.G. Wells	1895
Noor	Nnedi Okorafor	2021
The Book of Phoenix	Nnedi Okorafor	2016
Oryx and Crake	Margaret Atwood	2003
Borne	Jeff Vandermeer	2017
At the Mountains of Madness	H.P. Lovecraft	1931
Cat's Cradle	Kurt Vonnegut	1963
Parable of the Sower	Octavia Butler	1993
Jurassic Park (film)	Steven Spielberg	1993
28 Days Later (film)	Danny Boyle	2002

Table 2. Assignment categories in ENGL 142N Science in Literature.

Category	Frequency	Description	Proportion
Class participation	all 30 meetings	asking and answering questions in discussion	25%
Incidental writings	10 per term	jottings from class	25%
Short responses	5 per term	300-word compositions	25%
Papers	1 or 2 per term	1,000-word compositions	25%

Table 3. Weekly rhythmic discussion structure in ENGL 142N Science in Literature.

	Tuesday	Thursday
led by	Howell	Smith
discussing	science topics	literary analysis

work in small groups. In particular, the metronomic alteration between Tuesdays and Thursdays imposes a structure to the schedule that students refer to positively course evaluations. (When I have taught the course myself, I strictly adhere to this pattern of alternating Tuesday and Thursday discussion schedule.)

A personal note: I had been teaching large (200–400 students) lectures in cavernous auditoria for years when Dr. Smith and I began teaching this seminar course together. Watching him lead discussions, trained and experienced as he is in teaching humanities courses, immediately changed the way I teach. Almost ten years later, my still-quite-conventional lecture courses have been much improved by the addition of discussion activities—admittedly constrained by classroom architecture and other

factors. Still, I owe Dr. Smith a debt of professional gratitude that I am happy to acknowledge here.

There seems to be a perception that discussion-style activities require more upfront preparation (Goldstein 2006) than conventional, linear lectures. But there can be little doubt about the return on investment: discussion produces much more rich experiences for students—and instructors.

Another advantage of twice-weekly meetings is that each meeting is 75 minutes (thrice-weekly meetings are 50 minutes), which allows for more time to prepare for and thoroughly pursue discussions. A very effective method for supporting discussion is short informal writing prompts at the beginning of a meeting. We provide these prompts on US letter/A4 sized paper with plenty of room for handwriting, so I call them "worksheets." Depending on the particular role we plan for a prompt, we might allow 5, 10, or even 15 minutes of reflection and writing. Sometimes these are individual efforts, and sometimes they are group work. These worksheets may or may not be turned in at the end of the meeting as assignments in the "Incidental Writing" category. Sometimes the worksheet will serve as a draft that students use as a starting point for more deliberate (and polished) submissions in the "Short Responses" category.

The central idea, though, is that all efforts in the classroom aim to enrich and facilitate discussion. Simultaneously, discussion is the engine that drives learning generally and writing in particular.

Here are some typical discussion prompt that might appear on a worksheet.

> (Literary.) Consider the range of human characters' different responses to their predicament. Describe a character (other than Lilith) whose responses resonate with you—whose responses match how you might react to their situation. Highlight both positive and negative behaviors and attitudes. How are those responses different from Lilith's? Why would you respond that way?
>
> (Science.) Consider the possibility of our species and aliens from another biosphere breeding to produce fertile offspring. Does this idea seem plausible to you? Why or why not?

2.3. Course Concepts: Peripatetic Pleonasms

Focusing on a single science topic—evolution—obviously allows for more depth. Using the extra time gained by eliminating other popular topics (climate change, nuclear energy/weapons) also and more importantly allows discussions to alight upon certain concepts repeatedly. In conventional lecture courses, there is a notion—a misconception, in my view—that redundancy (in a particular course, or even in a degree curriculum) represents a wasted opportunity to "cover" more material. My experience in this course in particular has convinced me that "redundancy," particularly when topics are revisited organically in discussions, means depth and connections rather than inefficiency.

Topics throughout the course that I strategically repeated, re-introduced, and pounced upon student recollection during discussion included

- Deep Time (the 4.5 billion-year natural history of the Earth)
- convergent vs. divergent evolution

- evolution vs. natural selection (which is much more nuanced than competitive "survival of the fittest!")
- phylogeny: relatedness and descent
- contrasting the *simple–complex* axis vs. *primitive–derived* axis
- molecular genetics: replication, transcription, translation, mutation, genetic drift, etc.

3. *Dawn* (1987)

Octavia Butler (1947–2006) was a multi-award-winning author of hard science fiction who died before her time. She won the top awards in science fiction, the Hugo (twice) and Nebula awards, and was awarded a MacArthur ("genius") fellowship, among many posthumous honors. Her works tend to deal, deftly, with themes of power (see below). Recognition for her and her oeuvre have been more significant since her death, prompted in part by the uncanny precience of her *Parable of the Sower* (1993) in anticipating the rightward populist turn in U.S. politics.

Dawn (1987) is the first in a trilogy (followed by *Adulthood Rites* (1988) and *Imago* (1989).

3.1. Summary of the Plot

Lilith Iyapo, an African-American woman, wakes up in captivity on a giant ship in orbit, held by aliens called Oankali. In her last memories, Earth's biosphere was destroyed by a global nuclear war. As it turns out the Oankali have rescued and put into suspending animation all the humans that survived the apocalyptic war, a population of only a few thousand.

Oankali technology is unimaginably advanced, all organic. They have three sexes, all required to interact intimately in order to carry out successful reproduction. They can communicate telepathically via touch, and they can modify their own genetics and physiology (and those of humans) at will. Over eons, this species has merged and hybridized with countless other species. *These mergers are their highest innate drive.*

The Oankali intend to merge with humans, making a new hybrid species, with the plan of terraforming and resettling the still-ruined Earth. These motives and planned outcomes are held by the Oankali to be the very zenith of altruism, despite the biological necessity for them to do so and despite the strong opposition of the vast majority of the humans including Lilith.

Lilith has a very special role in these plans: she is among the first humans awakened. She is informed that she will be one of the first human females to breed with Oankali and give birth to hybrid offspring. Moreover, it is her task to awaken a group of other humans, convince them from within captivity that the Oankali (who choose not to reveal themselves initially) exists, and persuade her human companions to accept the fate of humanity.

Needless to say, these challenges are daunting. But the device of putting a group of a couple dozen captive humans from all walks of life in America under the leadership of a modified-to-be-superhuman African-American female allows Butler an anthropological laboratory to explore all of the best and worst of people under extreme stress and duress. This she does with great skill, often with nothing more than terse dialogue.

Stepping back, when the humans eventually interact directly with the Oankali—like in all good science fiction—both action and dialogue provide a dialectical stage upon which fundamental questions of human nature can be drawn out with exquisite imagination and evocation. *What makes us human?*

3.2. Summary of Themes

Characteristically, Butler explores themes of power and its disparities (reviewed by Nanda 2013, among many others in a rich literature). When interviewers referred to *Dawn* as her "slavery novel," Butler bristled and denied a connection (e.g. Sanders 2004). Personally I prefer to read this denial as "unconscious" rather than "disingenuous." In any case, students have no qualms discursively putting their fingers right on the nose of slavery in their discussions and writings. They correctly identify themes such as

- captivity, deception, coercion, manipulation, even torture
- forced breeding, forced surgeries, forced sterilization; non-consensual sex, imposed addiction
- ethical behavior in an ethically compromised system
- ends vs. means: intentions vs outcomes
- power vs. responsibility; power vs. consequences

One final observation about Butler's rhetorical tactics: the science in Dawn is, in Clarke's classic formulation (1962), "indistinguishable from magic." It simply is the case that Oankali have "technology," in this case built into the symbiotic physiology they share with their living ships, that allows them to travel between stars and manipulate genetics of any species without apparent limit. Narratively, this vagueness is an asset allowing suspension of disbelief, but analytically it erodes our ability to interrogate mechanistic details in any biotechnology-oriented context.

4. The Fateful Discussion

After the class had spent about three-quarters of the semester discussion evolution (in the context of other novels and plays), and we had read about two-thirds of *Dawn*, we were ready to frame the discussion of SETI and origin-of-life topics.

4.1. The Prompts

We began a science-discussion meeting with the following prompts.

> Consider the possibility of our species breeding with aliens originating from another biosphere in such a way that the mating produces fertile offspring. Does this idea seem plausible to you? Why or why not?
>
> Forget aliens for a moment. Imagine an advanced *human* technology, possibly in the near future, that would permit a human to produce fertile offspring with another species on Earth. Imagine children that are human-turtle hybrids, or human-beetle hybrids, or human-fungus hybrids. What would it even mean? And how, in principle, could it be accomplished?

My not-so-hidden aim with these prompts was to steer students into exploring the concept of a "common ancestor," and to consider phylogenetic distances, the mechanism of storing and propagating heritable information, and the like. From there we could and did proceed to broader questions.

4.2. The Results

In a flippant moment, I considered subtitling this paper "Or, How to Get Non-Science Majors to Think in Just 12 Weeks." The punchline is that this activity only worked in the context of all the course activities that preceded it since the beginning of the term.

In short, the simple questions quoted above organically led students to the much broader, central questions in the field:

- are conditions on Earth rare or common?
- what conditions *were* required to form life here?
- what conditions *could* form *other* life elsewhere?
- generalizing: defining life and its components
- generalizing: groping for landmarks in complexity (multicellularity, aerobic respiration, etc)

In particular, I was able to steer the discussion (via probing/leading oral questions) to the conclusion that *this* biosphere is *one endpoint* of a four-billion-plus-year random walk through a very sparse, very high-dimensional search space (of possible Earths).

Again, this built on previous activities in the course that scaffolded towards this end. By the last few weeks of the semester, the group had a solid vocabulary with which to grapple with fundamental questions of molecular genetics and evolution. In contrast, as mostly non-science majors, the students lacked rigorous backgrounds in physics, chemistry (no mental picture of the periodic table), thermodynamics and metabolism, neuroscience (in order to frame any mechanistic model starting with molecules, moving to living neurons, moving to living brains, and addressing subjective experience).

At this point in the term, however, they were already familiar with ideas like:

- a very very long, highly contingent natural history
- that *this* biosphere has changed radically on cosmic time scales
- that overall organismic complexity increases over natural history monotonically

Students also had read (depending on the year) (1) a published debate (Sagan and Mayr 1996) between Carl Sagan (who argued that life and intelligence are commonly distributed in the galaxy and Ernst Mayr (who argued that intelligence is almost certainly very rare); and/or (2) Noam Chomsky's commentary (2010) on Mayr's work, concluding that intelligence may be maladaptive, likely leading quickly to extinction.

5. Conclusion

Here I offer one example of an organic pedagogy for general education, namely exploiting the key ingredients of

- small seminar focused on refining discussion skills
- framing discussion with provocative, imaginative fiction
- motivating thinking about hard problems (SETI) with evocative relevance (SETI)

I conclude that interdisciplinary teaching, itself rewarding and stimulating on its own terms, *also is very effective for student learning and engagement*. Student feedback is unanimous on this count. Motivating and empowering students to think requires effort, infrastructure, and scaffolding; this scaffolding cannot be linear: it must be repetitive (*not to say redundant*), it must be practiced, and it must be applied.

I further conclude that astrobiology is a compelling topic for integrating and synthesizing science learning. Carl Sagan was a recurring guest on Johnny Carson! This stuff is compelling for everyone.

This approach—using fiction to frame fundamental questions of our place in the cosmos—will in my view be effective not just for evolution course, but also for chemistry, genetics, etc.

In short, what makes *research* in SETI frustrating is what makes *teaching* in SETI rewarding: addressing fundamental, but unanswered, questions.

Finally, it is interesting to compare this approach to another course I teach, BISC 2 Genetics, Ecology, and Evolution. This course is much larger (100–200 enrollment), taught in a typical auditorium, and does not include reading fiction. Although I have integrated small-group activities to facilitate discussion, this course is mechanically much more like a typical "lecture" course. Live discussion in this course has never been as successful as in the more intimate seminar atmosphere of Science in Literature.

In both courses we discuss a very similar list of topics; the lecture course has time to go into even more detail because there is no literary-analysis component. Students in both courses clearly find questions of origins-of-life compelling. But the discussion of the topic is never as rich in the lecture course as it is in Science in Literature.

Acknowledgments. Special thanks to Dr. Scott Smith (English, Penn State) for developing and teaching this rewarding course with me. Thanks also to Dr. Jason Wright (Astronomy and Astrophysics, Penn State) for a series of stimulating discussions that dramatically improved my SETI and origin-of-life teaching materials.

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