BROADER IMPACTS

Communicating accurate scientific concepts to a broad audience is always a good idea. But communicating accurate immunological and epidemiological concepts to a broad audience is an especially good idea during a pandemic. The desperate need for better scientific training of the US populace has been exacerbated by misinformation and disinformation about everything from the virulence of COVID-19 to the safety and efficacy of public health measures.

With this project, we will undertake communication of immunology via the dramatic arts, in a series of plays about *The Drama Within*. We will engage undergraduates and high school teachers to write short plays about immunology and infectious diseases, and we will then select a subset of those plays to be performed for public audiences in 3 capital cities: Lincoln, NE, Denver, CO, and Trenton, NJ. The performances will be orchestrated by theatre departments at each collaborating university (Lewis Center for the Arts at Princeton; XYZ at UN-Lincoln) as well as a sci-fi theatre in Denver, CO (?). Each public performance will be accompanied by Q&A with the audience about the underlying science.

*The Drama Within* will therefore deepen engagement with STEM fields by undergraduates and secondary school teachers, while providing an entertaining forum for science education of secondary school students (if plays are performed at high schools) and the general public (if plays are performed at libraries or museums).

PI Graham, together with Ellen K. Graham, a playwright from Denver, CO, has laid the groundwork for this ambitious broader impact scheme by developing and co-teaching *The Drama Within: Embodying the Immune System on Stage and Screen* as a freshman seminar at Princeton. After over a year of course development including a workshop with Princeton and Rutgers students in spring 2019 (i.e., entirely pre-pandemic), the course was first formally offered in spring 2021.

Within the first six weeks of the semester, eleven novice playwrights (all freshmen, with 9 intending to major in the humanities, 1 in social sciences and 1 in natural sciences) each created a strong and entertaining one-act play that conveys understanding of scientific topics such as immune recognition, immune subversion, and causes of chronicity and virulence of infection. They are presently working on their final projects. In all, the students will produce 22 one-act plays about host-parasite interactions. Going forward, the course will be offered each spring.

To scale up, we will draw upon this foundation, offering annual writing workshops at both collaborating universities in the summers, to be followed by autumn performances for the wider public in Colorado, Nebraska and New Jersey.

*Why communicate host-parasite biology via theatre?*

Host-parasite interactions are especially amenable to theatrical communication. To make this case, we consider 3 themes that transcend scales of biology: from individual host cells, to populations of cooperating host cells, to warring populations of host and parasite cells. These themes also transcend dramaturgical elements: from development of characters to relationships and dialogue among characters, to conflict and resolution in a storyline:

***1) Character development.*** The mammalian immune system comprises hundreds of millions of cells, of various types. Each type of cell has characteristic physical and functional traits that set it apart. For example, macrophages are large cells that eat parasites whole, whereas killer T cells are small, compact cells that poke holes in virus-infected cells. It is impossible to understand immunology without first understanding this array of cell types, or this cast of characters. In parallel, it is impossible to understand a play without understanding traits and motives of characters.

***2) Relationships.***  Skilled though cells are, the immune system can only achieve defense of the entire host via coordinated action amongst autonomous cells. Thus, relationships and communications among cells are crucial to the success of an immune response. Some communication is private between pairs of cells while other communications are broadcast widely (e.g., when molecular messages like cytokines are secreted into the bloodstream for circulation throughout the body). The content and volume of messages aid cooperation and chart the course of the response. Likewise, relationships among characters determine how they communicate, collaborate with or undermine each other, and chart the course of a play.

***3) Story.*** The strength and type of immune response determines whether the host clears infection or succumbs, the likelihood of tumor metastasis, etc. These health impacts of the immune system generate a lot of potential dramatic material – e.g., antagonism with parasites, cooperation with gut microbes, or the treachery of tumors.

*How has the seminar gone, and with what lessons learned that will benefit this scheme?*

Weekly writing assignments, weekly feedback from peers and faculty, weekly readings and viewings, and a clear step-by-step approach to constructing a classic “well-made play” (e.g., Egri) have proven highly effective. Our novice playwrights thereby generated 1 act plays of 3 scenes each, conveying aspects of the immunology and epidemiology of tapeworms, malaria, cytomegalovirus, and of course, SARS-CoV-2, among others. In each case, the immune cells and the parasites are embodied as human or humanoid characters that exhibit motives and traits that map well onto the biology. We have found that an evolutionary understanding of infectious agents – and thus the fact that obtaining transmission to the next host is a prime directive – has helped the students to become better biologists and better playwrights, as they capture the nuances of the different parasite life cycles in their plays.

For the proposed playwriting workshops, we will follow the same model, though accelerated to a daily pace and with a narrower range of infections to inspire the drama. Our lesson plans for the 2-week playwriting workshops will entail the following elements. First, we will offer daily instruction and discussion on the science (e.g., recognition, signalling and effector function and immune cell types with key roles in each; diversity of infectious agents; causes of varied duration and severity of infections). Next, we will view and discuss relevant dramatizations. We will also have daily writing sessions and feedback sessions. The writing assignments will begin with character sketches and then to move on to drafts of recognition, signaling and effector scenes, culminating in the resolution of an immune response (e.g., resistance, tolerance, and immune memory).

Ultimately, we will offer 3 focal examples for the workshop participants to write their plays about (COVID-19, gastrointestinal worms, and one other; likely either a herpesvirus or malaria). By the start of the second week, we will discuss key scientific points to convey to the audience.

Logistics: either in-person or virtual formats are possible.

**Timeline over the 3 years of the project:**

Each winter, secondary school teachers in humanities and sciences (1 from each subject per school? And 2 schools per city? = 12 workshoppers) will be selected to participate in a summer workshop.

Each spring, the writing seminar will be offered at Princeton. This will generate a steady source of student plays that might be performed. We will have many to choose from each year.

Each summer, Graham, Cressler and 2 consulting playwrights will teach the 2-week playwriting workshop. 8 hours/day, 20 June – 3 July or thereabouts

Each autumn, we will offer performances at the schools of the playwrights AND at 2 public libraries per city. That’s 4 performances per city, 12 performances total? Actors will be recruited locally. We have buy-in from the Lewis Center for the Arts, Princeton, the XYZ Theater Department, UN-Lincoln, and (a community college? Buntport?), Denver.

**Costs incurred annually:**

Honorarium for playwrights to co-teach workshop with Graham & Cressler:

2 playwrights x $3500 = 7K

Per diem for secondary school teachers to participate in the workshops:

12 secondary school teachers x $200/day x 10 days = 24K

Advertising, recruiting, and logistics – 1/8 admin time at PU at Lewis Center?

Payment for 5 actors in each of 3 cities to undertake 4 performances? Maybe we need to rely on student actors at PU and UN-L

Directing and staging, including costumes, will be provided by the institutions?