This is a request for an RET supplement to the PI's NSF Award (CHE-1463724)

Part of the award consisted of a Broader Impacts program now entitled "SENSEible Science: Dyeing to do Chemistry." The program was originally called "Sensible Chemistry" and was targeted toward 1) Junior High Teacher Training, 2) Junior High Student Training, and 3) Organic Chemistry Day. Executing this within budget constraints proved to be impossible; the program was too ambitious, recruiting participants being a problem.

We next moved to an affiliation with an ongoing student opportunity at the University of Missouri known as "Summers at Mizzou," a program that brings in 4H students for various camp experiences.[1] Our advertisement, as it were, for this program is shown in Figure 1. As of June 2, 2016, only one participant had signed up for this particular camp. Earlier, the enrollment

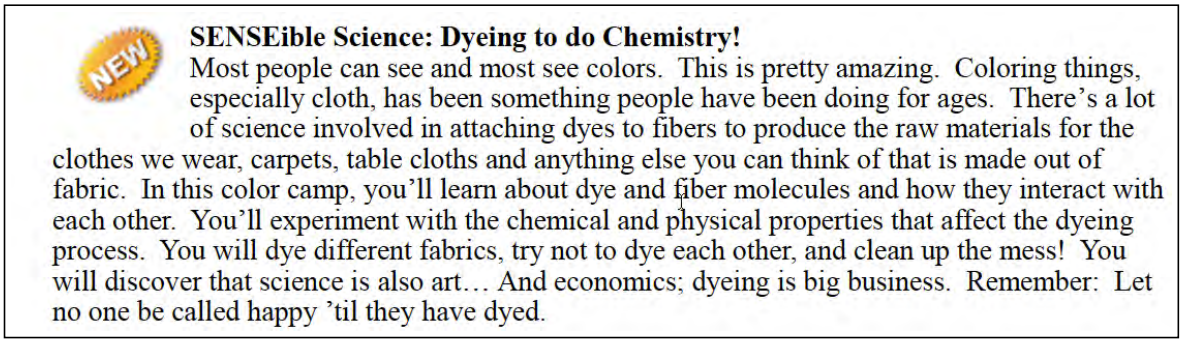

Figure 1

fluctuated between one and zero participants. Realizing that the entire Broader Impacts program might collapse, the PI made the decision to keep the idea alive, but to target local teachers to develop their knowledge of organic chemistry and give them laboratory experiences that could be used in their classrooms. A monetary incentive was proposed to encourage participation. As it stands at the present time, we have seven prospective participants; thus constituting a reasonable size for an outreach/development program of this type. The incentive portion of the program is a $1000 stipend for each participant. Therein lies most of the origin of this request for a supplement.

Table 1

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th></tr>
<tr><td>Time</td><td>7/11/16</td><td>7/12/16</td><td>7/13/16</td><td>7/14/16</td><td>7/15/16</td></tr>
<tr><td>9:00 AM</td><td>Lecture 1</td><td>Lecture 3</td><td>Guest Lecture</td><td>Lecture 4</td><td rowspan="3">Field Trip</td></tr>
<tr><td>10:00 AM</td><td>Lecture 2</td><td rowspan="2">Lab 2</td><td rowspan="2">Open Lab</td><td rowspan="2">Lab 5</td></tr>
<tr><td>11:00 AM</td><td>Lab Intro</td></tr>
<tr><td>12:00 PM</td><td>Lunch</td><td>Lunch</td><td>Lunch</td><td>Lunch</td><td>Lunch</td></tr>
<tr><td>1:30 PM</td><td rowspan="3">Lab 1</td><td rowspan="3">Lab 3</td><td rowspan="3">Lab 4</td><td rowspan="3">Lab 6</td><td>Lecture 5</td></tr>
<tr><td>2:00 PM</td><td>END</td></tr>
<tr><td>3:00 AM</td><td></td></tr>
<tr><td>4:00 PM</td><td>Discussion</td><td>Discussion</td><td>Discussion</td><td>Discussion</td><td></td></tr>
<tr><td>5:00 PM</td><td>END</td><td>END</td><td>END</td><td>END</td><td></td></tr>
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The evolving schedule for the program is summarized in Table 1. There will be five lectures delivered by the PI. The first will cover an introduction to organic chemistry, emphasizing structure, valence, three-dimensionality and intermolecular interactions. The second will deal with functional groups with some discussion of light and color. Lecture 3 will bring things together with

respect to fibers and dyes: structures, functional groups, interactions, light absorption and color. Lecture 4 will discuss the synthesis of indigo and the chemistry associated with its reduction and oxidation; light absorption will be included. Lecture 5 will be a general one on perceptions of chemistry in society, general ideas on what it takes to be a scientist or appreciate science, and how students need to be taught in a general sense so they can not only know facts, but make use of them in idea generation or problem-solving. There will be one guest lecture. Currently, we plan to have Hannah Reeves,[2] an artist who works with fibers and dyeing, discuss her art and her methods to discover new ways to use color and the dyeing process itself to speak to others through art.

Labs will be partially guided, but also exploratory in nature. Most of the labs are designed so that they can be easily translated into things done by high school students, with further emphasis on safety and minimization of waste streams that are beyond the capabilities of the schools involved. We want the teachers themselves to make discoveries when possible. The first lab will involve dyeing a variety of fibers as an entry to intermolecular interactions as the basis for why some fibers stick to dyes better than others. Effects of concentration, temperature, pH, and the presence or absence of functional groups will be explored. Lab 2 with be similar to lab 1, but in this variation, a mixture of dyes will be used to dye a small rectangle of 3 cloths. Our preliminary experiments indicated that the proper mixture of food coloring will lead to a "slice" of neapolitan ice cream (Figure 2). The teachers will explore this and try to make discoveries for themselves in terms of optimization, e.g., who can make the best looking "ice cream" (it is not trivial to make chocolate). In lab 3, we will compare the paper chromatography of simple dye mixture with reverse phase chromatography, the hypothesis being that orders of elution should switch for the two methods. We have not studied this at all and it is meant to be that way; we will not explain the hypothesis at the beginning of the lab. The results will dictate when we reveal what we thought should happen. We don't care whether our hypothesis is supported or not; we want to emphasize the "propose hypothesis, test hypothesis" idea. This will hopefully evoke discussion and ideas as to how to modify the experiment or vary it. Lab 4 will involve a natural dye, quercetin, further emphasizing intermolecular interactions and revealing that mordants, substances added to fibers to make them more attractive to dyes, not only serve as "linkers" between dyes and fibers but also modify the chromophores in dyes. In lab 5, we will attempt to apply a paste containing CR2000, a cationic ammonium species, to cotton. The paste should react with the cotton, if we get the chemistry right. As such, it should have a particular affinity for acidic (anionic) dyes. We will use this to achieve differential dyeing of cotton, such that the areas of cloth treated with our materials will take up an anionic (acidic) dye to a much greater extent than the untreated cotton. In lab 6 we will do a classic: the synthesis of indigo and its use via reduction/oxidation as a dye. This is a place to introduce mechanisms of reactions to the teachers, though we realize their experience in that intellectual realm of organic chemistry will be limited, save for perhaps those participants with advanced chemistry degrees.

Figure 2

We are planning a field trip to a natural dyer located in Columbia, Missouri to see her shop and engage in small scale dyeing, with less molecular rigor, but simple pleasure being the rule of the day during that experience, with learning taking place at the same time.[3]

The request for additional funds for this BI program is $8742. Each participant will receive $1000 for participation in the program and for promising to do two things: 1) write and submit a detailed evaluation of each part (lectures, labs…everything) of the program mentioning the good, the bad, and the ugly, so that we can use the information to improve the program and bask in the glory of anything well done; 2) inform the PI if and when they use anything directly or derived from the program, including student evaluations of the experience. All of the teachers involved are at schools within driving distance, so the PI will be, within constraints imposed by university duties, available for consultation in the teacher's classroom. Finally, we are going to use this program to build ongoing relationships with high school chemistry teachers to encourage student participation in research projects in the PI's lab or labs of his colleagues. This will be easy for students residing in Columbia. Additionally, this program will begin to lay the groundwork for an REHSS-Research Experience for High School Students-an idea that we are just beginning to formulate as an outreach program that might be BI or might be a stand-alone endeavor in which the entire chemistry department can participate.

We are asking for an additional $500 to cover lunch expenses for the group and fees for the field trip as well as $646 dollars for a student assistant who has already helped immensely in exploring the chemistry to be used in the BI experience. Fees for the field trip amount to $250. Supplies will come from the PI's supply budget.

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1. http://4h.missouri.edu/summersmizzou
2 http://www.moval.edu/Morris_Gallery/bios/2012-13/hannah_reeves.php
3 http://www.hillcreekfiberstudio.com/