Connecting Biology Teachers and Students with Living Invertebrates

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During the past 28 years, while trying to balance traditional research and teaching duties within a large university, I frequently pondered these questions: *Can more be done to inspire students in biology? Is biology education too often a 'spectator sport'? If so, why, and what can be done?* My intuitions and my colleagues seemed to provide affirmative answers to the first two questions, but I felt I was in no position to effect any change. Then, in 1993, an opportunity arose that changed my thinking. By necessity, I was compelled to shift from a 'pondering' to a 'practical' mode, as I assumed the risk and role as a co-director (co-PI) of a funded project supported by the Howard Hughes Medical Institute. The overall aim of the project was to improve undergraduate biology education at my institution. My main role in the project was to implement an educational outreach phase in which I proposed to create and lead summer workshops (*i.e.*, total-immersion courses) for biology teachers. The venue for these residential, hands-on workshops was Iowa Lakeside Laboratory, a previously under-utilized biology field station in NW Iowa. [see: **http://www.lakesidelab.org**] Themes for the proposed workshops were familiar ones that matched my research background -- namely, invertebrate biology and neurobiology.

What followed from that first workshop, in 1993, was a series of personally rewarding and professionally transforming experiences in educational outreach that continue to evolve. Through funded and expanded workshop initiatives that continue today (see acknowledgements), I have sought to connect (or re-connect) participating teachers with the *living, natural world of invertebrates* in both field and lab settings. Teachers often acknowledge the special powers that invertebrates possess to engage student interest and stimulate curiosity. So, together as colleagues, we have developed ways to more effectively and creatively utilize them for biology classroom investigation, at all levels.
Such efforts have gradually led me to believe that meaningful interaction of teachers and their students with a wide range of living, behaving organisms not only enhances their biology education in general but it is ultimately crucial for promoting ecological awareness and preserving biodiversity. Thus, I am now deeply committed to the notion that hands-on connections with living organisms, especially invertebrates, ought to play a key role in general biology education at all levels. And, I have strived, in my own fashion, to create and propagate such concepts and connections in the following ways:

1) Instructing residential workshops for biology teachers. The teacher workshops that I developed in invertebrate biology at Iowa Lakeside Laboratory, in 1993, served as a springboard for my subsequent involvements in educational outreach. The most notable of these was an invitation to instruct for one week at the 1996 Woodrow Wilson Foundation summer institute in neurobiology held at Princeton University. This residential institute, led by Dr. Donald Cronkite, engaged 50 outstanding high school biology teachers from throughout the U.S. It proved to be the most challenging and inspiring outreach opportunity that I have undertaken.

2) Presentations and publications with biology education associations. Since 1995, I have made efforts to regularly and freely present or co-present new ideas for laboratory investigations to many

efforts to regularly and freely present or co-present new ideas for laboratory investigations to many highly enthusiastic and supportive secondary and college-level educators who attend hands-on workshop sessions at NABT and ABLE (Association for Biology Laboratory Education). Manuscripts derived from some of these presentations were subsequently published in journals associated with these organizations. Thus, I have no intention of retiring, while leaving behind innovative ideas for lab gadgetry or student inquiry, which otherwise might rest solely within the dusty archives of a teaching lab for my successor to discover or discard. I consider such publication as a professional obligation, as well as an opportunity for making a unique educational legacy. In recent years, new and rewarding opportunities followed, such as invitations to lead workshops at state teachers' organizations in Delaware (DABT), New Jersey (BTANJ), Kansas (KATS), and Iowa (IAS/ISTA).

3) Blending blackworms and biology. Many biologists have 'pet' organisms they use in research or teaching. A 'pet organism' that I began using in research about 15 years ago is *Lumbriculus variegatus*. These are freshwater oligochaetes, also known as blackworms. Soon after completing several research projects, I began to imagine, develop, and share an assortment of original classroom applications of these worms for high school and college-level biology. Now, blackworms are commonly used in high school and college biology labs. They are easily cultured in the lab and highly amenable for both structured and open-ended student investigations, such as studies of segment regeneration, circulatory physiology, locomotion, neurophysiology, and toxicology (Drewes, 1996a,b, 1999a,b,c). Regenerated worms, with new head and tail segments, form from very small body fragments. The worms exhibit unique forms of locomotor reflexes (helical swimming and body reversal). Blood pulsations, and effects of drugs/toxins may be determined without restraint or dissection. All-or-none action potentials from giant nerve fibers are easily recorded from intact, freely moving worms. The worms are readily eaten by a wide array of invertebrate predators. Thus, teachers find these organisms versatile because various features of their biology may be integrated into course units on ecology, behavior, development, physiology, or biodiversity. Students never cease to be fascinated by them.

4) Distance mentoring of student research. Connections created by outreach activities have naturally led to requests from students (mostly middle school and high school) seeking advice or guidance in their research. Over the last six years, I have served as a 'distance mentor' for research projects by more than 60 students from 25 states. Typically, their projects involve studies of segment regeneration, locomotor behavior, or ecotoxicity effects in oligochaete worms (*Lumbriculus variegatus).* Surprisingly, mentoring has not proven to be a 'time sink' because student engagement in independent research tends to be a very self-selective process. That is, students most likely to repeatedly request mentor support are usually thoughtful, non-procrastinating students who are apt to achieve some measure of research success. In contrast, students who are least likely to make repeated requests tend to be those who send an urgent (but futile) email request for support just before their project deadline. Although one does not always get feedback about project outcomes, many students have notified me of their successes in regional, national or international science fair competitions. Several have won college scholarships.

***5) Clearing house for teaching materials*.** "Necessity is the mother of invention," especially when attempting to develop quick-and-easy, "low-tech" ways to inexpensively use invertebrates for hands-on classroom activities and experiments. Through synergistic interactions with teachers at workshops, I have refined and shared an array of new materials, gadgets, and write-ups that facilitate collection, handling, viewing, and investigations with invertebrates. My web pages list materials that I mail, free-of-charge, upon request [see: **http://www.eeob.iastate.edu/faculty/DrewesC/htdocs**]. Each year, I fulfill hundreds of requests for write-ups, materials, and samples from students and teachers at all

education levels. As an additional educational resource, I currently maintain a so-called "*Invertebrate Cloning, Culture, and Adoption Service"* consisting of sexually and asexually reproducing lab cultures of a wide variety of invertebrates (*e.g*., blackworms, other oligochaetes, leeches, daphnids, snails, limpets, hydra, nematodes, etc.). I freely provide schools and colleges with living specimens when I visit classes or when teachers visit me.

Other types of educational outreach initiatives in which I have engaged include direction of teachers' projects in my research lab during summers
and development of human electrophysiology recording kits that are loaned to schools. Two new and exciting outreach-related initiatives that I would eventually like to pursue are (a) development of scholarship and recognition programs for college students who are preparing to be biology teachers and (b) "start-up" packages of classroom support for new biology teachers.

During spring 2001, I had the privilege and opportunity to share ideas regarding "educational linkages" with participants at a conference, entitled: "*Forging a Link*." [see**:** **http://hope.edu/pr/releases/showpr.cgi?page=0001/science.21Feb2001**] Conference attendees consisted of a selected set of high school and biology teachers from across the U.S., all of whom were somehow involved in developing educational partnerships and linkages. Through such opportunities, I have increased my appreciation of the exceptionally varied and fulfilling ways that university faculty can make self-styled and significant contributions through linkages of all types. To the extent that we do not concern ourselves with continually creating and maintaining such linkages, I believe we place at risk the sustainability and credibility of the educational and research enterprises of science.

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