Undergraduate and High School students interested in Chemical Engineering test the effects of Phytochemicals on Cancer cell lines

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Introduction

Opportunities for students to conduct investigations in science and engineering laboratories are important in science education and can promote interest in science among youth [1, 2, 3, 4]. When students participate in laboratory-based investigations, they develop procedural knowledge, psychomotor skills and sensory awareness and they are more likely to earn baccalaureate degrees [5, 6]. Additionally, it is our opinion that exposure to the practice and culture of conducting research is important for non-science majors as part of a well-rounded education.

Research experience can be regarded as essential for undergraduates majoring in science or engineering to be competitive candidates for entrance into graduate programs and/or into the workforce [7]. Additionally, universities are including intensive biology components in chemical engineering curricula and offering students opportunities to learn biological and biochemical processes using hands-on experiments. Chemical engineering students with a strong foundation in the biological sciences tend to be well prepared for careers in the food, biotechnology and pharmaceutical industries, among others [8].

The Institute for Science Education and Science Communication (Science Institute) in the Department of Science and Mathematics at Columbia College Chicago (CCC) has a long history of providing summer laboratory internships in molecular biology for high school students [9]. The Science Institute's laboratories also offer opportunities for research experience for undergraduate students (including non-science majors). The Science Institute aims to provide all groups with hands-on laboratory experience in the biological sciences, to provide a venue for students and program participants to nurture their interest in science and technology, and to offer an introduction to the practice of conducting scientific investigations in an academic environment.

Recent investigations in the Science Institute's molecular biology laboratory have focused on testing the effects of selected phytochemicals (chemicals derived from plants) on cancer cell proliferation and cell cycle regulation. Phytochemical characterization and processing for the purpose of the treatment of disease is a rapidly growing field of chemical engineering [10]. This account will describe the overall structure of the research opportunities offered within the Science Institute's laboratories, the cancer cell lines and phytochemicals tested and the outcomes of the experiment, focusing on the work conducted by a student in a chemical engineering

program. These experiments could be adapted by other molecular biology laboratories or for the classroom in order to provide students with experience in these fields.

Program Description

Molecular biology project questions were founded in published research characterizing the properties of phytochemicals that may treat or even prevent cancer. Projects were carefully designed so that they are scientifically relevant, but within the scope and skill of the students conducting them. Students were given several opportunities to ask for one-on-one clarification from the lead instructor of particular points of difficulty. While in the laboratory, students reviewed the eukaryotic cell cycle, the scientific method and peer review and the fundamental components of a sound scientific experiment, emphasizing the importance of appropriate positive and negative controls. Students were introduced to cell signaling pathways and how aberrations in these can lead to cancer and how cell biology research is conducted using established cell lines as models. Students were also encouraged to consider how natural products can be characterized and developed for various applications. Students learned molecular biology techniques including DNA extraction, mammalian tissue culture, Western blot analysis, using a particle counter, Crystal Violet staining, and Immunocytochemistry.

The structure and duration of the laboratory experience depended on the availability and the educational backgrounds and interests of the students. For example, several students from Marketing, Television, Fiction Writing and other non-science majors taking courses in the life sciences worked for 90 minutes, in groups of three, outside of class time to complete a collaborative investigation that they then presented in their respective formal classes. The sample student investigation below was conducted by one chemical engineering student in an unpaid internship of approximately 50 hours over three months.

Sample student investigation

A sample student investigation includes testing the effects of the phytochemical curcumin on PC-3 prostate cancer cell growth and proliferation. PC-3 cells are a prostate cancer cell line that harbors a mutation in the tumor suppressor p53. The tumor suppressor p53 is mutated or deleted in over 50% of cancers [11]. Curcumin is a phytochemical extracted from turmeric and it has been shown to have several anti-cell proliferation properties and potential anti-cancer properties. Mechanistically, curcumin has been found to inhibit the division of colon cancer cells by suppressing the gene expression of critical cell cycle regulators such as cyclinD1 and EGFR [12]. Additionally, curcumin has been shown to increase the expression of the negative cell cycle regulator p21Waf1/Cip1 in human glioma cells and in selected prostate cancer cells lines [13].

Data agree with published accounts showing that curcumin limits the proliferation of PC-3 cells in a dose-dependent fashion. Preliminary Western blot data, however, do not show any difference in p21Waf/Cip1 expression, conflicting with published reports. Students will continue to contribute to the understanding of how curcumin limits cell division through p53-independent mechanisms, by comparing the gene expression of other key cell cycle regulators in untreated versus PC-3 cells treated with varying concentrations of curcumin.

Other Investigations

Other projects conducted by students investigated the effects of the phytochemicals genistein and daidzein on the proliferation, survival and cell signaling of PC-3 prostate cancer cells and A549 and H1299 lung cancer cell lines. These cell lines were found to be appropriate for these investigations because they are easy to maintain in culture for an extended period of time (upwards of six weeks), are adherent, stain well with Crystal Violet, and respond well to the phytochemical treatments. H1299 and A549 are also ideal for introducing experiments that test the effects of a treatment in p53-dependent and p53-independent cell contexts [14].

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