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### **Development of a Biophotonics Option within a Photonics Technology Degree Program**

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#### **Abstract**

Albuquerque Technical Vocational Institute (TVI) has developed a collaboration with the National Science Foundation (NSF) Center for Biophotonics Science and Technology (CBST) headquartered at the University of California, Davis in order to develop a transportable biophotonics curriculum for community colleges. A "Biophotonics Option" has been developed within the well-established Photonics Technology Degree program at TVI, centered on two elective courses ("Introduction to Biophotonics" and "Biophotonics Applications"). In addition, TVI is a part of the "Albuquerque Model" that involves exposure to photonics education from the middle school level through graduate education at the University of New Mexico.

#### **Keywords**

biophotonics, photonics, education

#### **Summary**

For the job market in the United States, a serious undersupply of workers is projected for jobs requiring an associate degree or equivalent advanced training (32% of 9th graders will enter an associate degree program, while 65% of the jobs require such training).<sup>1</sup> A similar shortfall has been specifically identified for photonics technicians (a shortfall of 24,000 as projected by the Center for High-Technology Materials, University of New Mexico). The field of "biophotonics" is emerging as an important subset of photonics.<sup>2</sup> From its inception, the Center for Biophotonics Science and Technology (CBST) at the University of California, Davis has included in its educational mission the training of a technician workforce for the field of biophotonics. Biophotonics can be defined as the science of generating and harnessing light to detect, image and manipulate biological materials. The term "biomedical optics" is often used as an alternative label. While the field is often associated with "lasers in medicine," CBST has tended to broadly define biophotonics to include the use of the full electromagnetic spectrum in studying biology as well as related medical applications. In exploring potential partner institutions for CBST, it became clear that one of the most mature photonics technician training programs in the USA is that at the Albuquerque Technical Vocational Institute (TVI). The administration and staff at TVI saw significant benefits from including a biophotonics option in the Photonics Technology degree program in order to enhance the career options for their graduates.

A Biophotonics Option has been developed within the long Photonics Technology degree program at TVI within a relatively brief two-year time span. Representatives of CBST and TVI first met to discuss areas of mutual interest in October 2003 at the Education and Training in

Optics and Photonics (ETOP) Conference in Tucson, Arizona. A formal Letter-of-Intent was signed between the two groups in February 2004 by Dennis Matthews, Director of CBST and Don Goodwin, Dean of what was then the Technologies Department at TVI. (As of July 1, 2005, Technologies was combined with Trades and Service Occupations to form the Division of Applied Technologies.) The Letter-of-Intent included an agreement that CBST and TVI would cooperate to assess the demand for technicians in the biophotonics field. In addition, TVI agreed to develop biophotonics courses appropriate for a Biophotonics Option with support from the resources and personnel of CBST. Various exchange visits between representatives of CBST and TVI were carried out through the remainder of 2004, culminating with the design of both the Biophotonics Option and specific courses for that option. A press event announcing the collaboration between CBST and TVI was held in Albuquerque, New Mexico in October 2004 and the first, prototype course on "biophotonics" was offered at TVI beginning in January 2005.

Albuquerque Technical Vocational Institute (TVI) is a progressive community college that promotes and provides higher education, skill development and workforce training relevant to contemporary needs. The largest and most comprehensive community college in New Mexico, TVI, along with the Sandia National Laboratories (SNL) and the US Department of Energy (DOE) through their outreach programs, has initiated a Photonics Academy that was modeled after the school's Advanced Manufacturing Academy. Although the collaboration between CBST and TVI has focused on the Technologies Department (now the Division of Advanced Technologies, which includes the Photonics Technology program), there is substantial potential for increased interaction with the Health Occupations Department (especially with its Biotechnology program) as evidenced by the fact that 30% of the students in the pilot biophotonics class during Spring 2005 were from that department.

At TVI, occupational training includes substantial hands-on skill building. The institution also provides associate degree opportunities in various fields, college transfer courses, preparatory classes, and basic skills classes for adults. The Photonics Academy is located on the Main Campus near downtown Albuquerque. (Three other campuses are located in various other areas of the greater Albuquerque region.)

The inauguration of the Science and Technology Center (STC) program at the National Science Foundation in 1987 represented a fundamental shift in scientific funding policy in the United States,<sup>3</sup> viz., a move from individual principal investigators to large, multi-investigator, multi-institutional centers. Well established by 2002, the STC program added six new centers, including the Center for Biophotonics Science and Technology (CBST) for which the University of California, Davis was the lead campus. Partner institutions included Lawrence Livermore National Laboratory, UC Berkeley, UC San Francisco, Alabama A&M University, Stanford University, University of Texas at San Antonio, Fisk University and Mills College. Roughly 100 researchers, including physical scientists, life scientists, physicians and engineers, are collaborating in this rapidly developing area of research. Applications of biophotonics range from using light to image or selectively treat tumors, to sequencing DNA and identifying single biomolecules within cells.

CBST is now in its fourth year of operation. Science and Technology Centers have typically operated for a ten-year period. Although the earliest STC's have now finished their NSF funding

cycles, many have been institutionalized as permanent research centers. There are currently thirteen STC's funded by NSF. The six STC's created in 2002 (including CBST) joined five STC's that were started in 2000. Two new STC's were added in 2005. A benefit of the community of STC's is networking and collaboration among different centers. The Center for Adaptive Optics, started in 2000 and headquartered at the University of California, Santa Cruz, has been an especially useful collaboration for CBST. Similarly, the annual meeting of the NSF Research Center Educators Network (NRCEN), a gathering of educational specialists from the various STC's and similar NSF-funded centers such as Engineering Research Centers (ERC) and Materials Research Science and Engineering Centers (MRSEC), is a highly effective forum for sharing best practices for educational programs.

The Photonics Technology Curriculum at TVI exposes students to four major areas: laser systems, electronics, optics, fiber optics, and electro-optics. A primary goal is to provide graduates with hands-on training in scientific procedures and applications utilizing lasers and fiber optics. The core of the Photonics Technology curriculum is a 38 credit hour certificate program. This certificate program can be taken during the first three terms of attendance at TVI. The 38 credit hour core is then followed in the fourth and fifth terms by an additional 40-41 credit hours of coursework to produce a total program of 78-79 credit hours leading to an associate degree. This curriculum is aided by a textbook developed by one of the instructors in the program.<sup>4</sup>

A Biophotonics Option has been developed within the Photonics Technology Curriculum at TVI. In the context of the overall curriculum, this option requires including the courses PHOT 227L (Introduction to Biophotonics) and PHOT 228L (Biophotonics Applications) from a list of technical electives. PHOT 227L (Introduction to Biophotonics) includes a biology review, along with coverage of light basics, geometric and wave optics, sensor fundamentals, and light/tissue interaction. The course is designed to be a balance of theory, laboratory experience (requiring a 100% passing grade on a laser safety examination before entering the laser laboratories), and internet research. PHOT 228L (Biophotonics Applications) covers bio-imaging, diagnostics, therapies, mental health, nano-biophotonics, biomedical ethics, and research protocol. A highlight of this course is a series of seminars from guest speakers who are experts in industry, medicine, and academia.

Students are expected to demonstrate basic competencies upon the successful completion of these courses. For example, upon completion of PHOT 227L (Introduction to Biophotonics), they should be able to explain the structure of DNA and its function, explain the structure of a cell, its components and functions, operate a low power laser safely, explain the difference between laser light and ordinary light, describe the rectilinear and wave propagation of light (including interference and diffraction), and explain how light interacts with living tissues via reflection, refraction, absorption, and scattering.

It should be noted that the Photonics Technology program at TVI is part of the "Albuquerque Model" of optics and photonics education. Strongly supported by the Sandia National Laboratories, the "Albuquerque Model" provides an educational lattice beginning with three middle schools in the Albuquerque area (Jimmy Carter, Harry Truman, and John Adams), West Mesa High School (which has a Photonics Academy), TVI for the associate degree in Photonics Technology, and the University of New Mexico for B.S. (tentatively planned for 2006), M.S., and

Ph.D. degrees in Optical Science and Engineering. Students can progress through this series of schools or exit to the workforce at any level from the high school to graduate degrees from the university. The collaboration with the University of California, Davis, as described in this paper, provides two additional options to students at TVI, viz. (a) a path to the biophotonics workforce directly from TVI and (b) transfer to an engineering or science program at UC Davis.

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