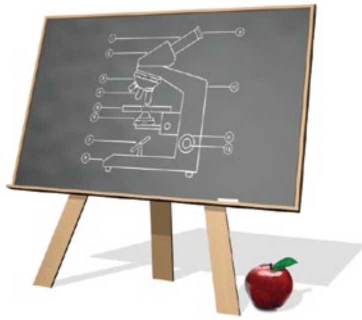
MicroscopyEducation

Empowering Pre-College Teachers Through Investigations of Micro- and Nano-Worlds



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Introduction

The microscopic world provides teachers with excellent opportunities to develop hands-on, inquiry-based curriculum, yet many K-12 educators lack the knowledge, equipment, and skills necessary to engage their students in these types of explorations. Through a Science Education Partnership Award (SEPA) from the National Center for Research Resources (NCRR), researchers at the University of Southern Maine (USM) are offering professional development activities designed to build skills in microbiology, immunology, nanotechnology, and microscopy—subjects that are notably underrepresented in the K-12 curriculum and in the undergraduate education of many teachers [1, 2]. Because these teachers lack formal microbiology training, the subject matter is often viewed as too dense, abstract, or inaccessible to be presented to pre-college students, despite the immensely important and fundamental roles microbes and viruses play in evolution, human health, and the ecology of all biomes on earth [3-6]. Microscopy is the essential gateway for making the invisible micro- and nano-scale worlds visible, accessible, and less abstract for students at all levels.

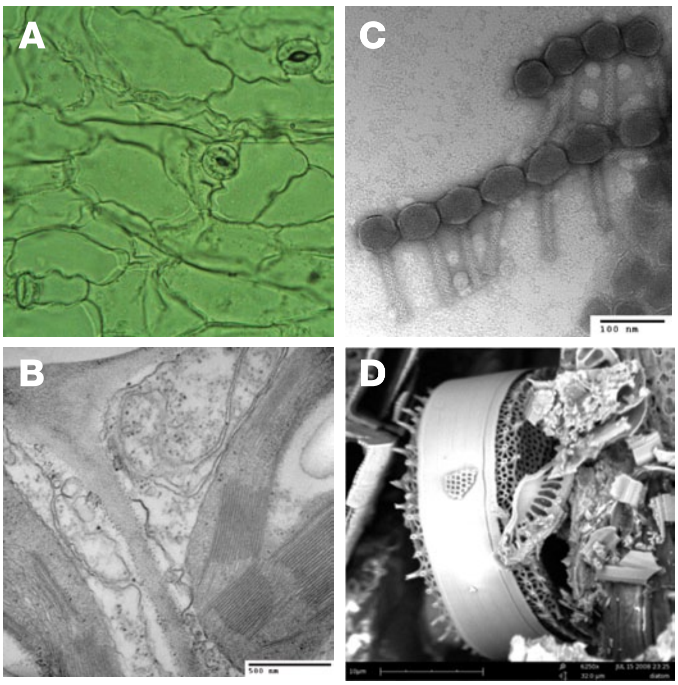

Figure 1: Light and electron micrographs acquired during the USM teacher professional development summer and academic year sessions. (A) Lettuce leaf by light microscopy showing stomata in the open and closed position upon the addition of a drop of saltwater (Image width = 300 µm). (B) TEM thin section of tomato leaf showing cell wall and chloroplast thylakoid layers. (C) TEM image of negatively stained bacteriophages (that infect *Eschericia coli*, strain C) isolated by teacher participants during the Fall 2008 session. (D) SEM of diatoms. Image acquired using the FEI Phenom during the 2008 teacher summer institute.

Micro- and Nano-Scale Explorations for K-12 Educators

Teacher professional development with the pervasive goal of making microbiology, virology, and micro- and nano-scale imaging accessible for K-12 classrooms is being pursued through two-week summer institutes and weekend academic year programs. In July 2008 the first "Micro- and Nano-space Explorations of Health and Disease" Summer Institute was held at USM. The 14 teachers of grades 3-8 who enrolled were targeted because these grade levels are critical for the development of scientific interests among the students, but teachers at these levels have few classroom microscopy resources and typically have insufficient training in their use. Emphasis during the summer institute was on curriculum development, outreach partnerships, and provision of a light microscope with digital image capture capability in each participant's classroom. To reveal the nano-scale during the professional development, the project incorporated extensive use of USM's transmission electron microscope (TEM). Sessions with the teachers involved specimen preparation for TEM (methods described below) and acquisition of images using the scope. Teachers viewed the stomata on lettuce leaf specimens with light microscopy as shown in Figure 1A and chloroplast ultrastructure in a tomato leaf with TEM as shown in Figure 1B. Viruses, particularly bacteriophages, as shown in Figure 1C, were also important specimens for the TEM work. We recently described elsewhere our partnership with high school educators to support classroom use of bacteriophage projects for instruction about viruses and molecular biology [7]. By arrangement with the FEI Company, a benchtop scanning electron microscope (SEM) was used by teachers to acquire images of diatomaceous earth, shown in Figure 1D. Initial teacher responses to both summer and academic year

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offerings have been highly positive. A future phase of the project will include the dissemination of project curriculum products and the integration of academic year programs for K-12 teachers into USM's academic offerings.

Materials and Methods For Transmission Electron Microscopy

Plant tissues were fixed for two hours in 3% glutaraldehyde in 0.1 M cacodylate buffer at pH 7.4. During the fixation, nitrogen gas was bubbled into the plant tissue samples. Tissue samples were rinsed with three changes of cold 0.1 M cacodylate—0.1 M sucrose buffer, 15 minutes per change, and post-fixed in cold 2% osmium tetroxide for 2 hours on ice. The specimens were subsequently washed for 15 minutes with 0.1 M cacodylate buffer. Plant tissue samples were then dehydrated through a series of cold ethanol: 30%, 50%, 70%, 80%, 90%, 100%. The 100% ethanol step was followed with one 30-minute change of cold (1:1) solution of 100% ethanol—propylene oxide. The dehydration series was completed with three changes of 100% propylene oxide at 4°C, 30 minutes per change. Plant tissues were infiltrated with a 2:1 mix of Spurr's resin—propylene oxide for 2 hours followed by two changes of 100% Spurr's resin for two hours each. Samples were polymerized at 65°C for at least 12 hours. Sections 60-80 nm thick were cut with an ultramicrotome and poststained with 2% uranyl acetate and lead citrate. Thin sections were observed using a TECNAI G2 Spirit BioTWIN TEM operating at 100 kV. Teacher participants observed the procedures but did not handle toxic reagents.

Outcomes and Future Goals

Each teacher cohort attending the summer sessions acquires more advanced skills in light microscopy and better understanding of the various types of microscopy. Consequently, they are able to make better use of existing microscopy resources in their schools and to take advantage of the full range of capabilities of their new microscope with built-in digital camera. Educators exit the workshop thinking more broadly about the applications of microscopy. Units in mathematics, life and physical sciences, and literacy created over the summer indicate that teachers see microscopes as tools to engage learners across the curriculum. After some initial classroom testing, these lessons will be made available to teachers worldwide on the supporting website. This program has extended and enhanced the educational outreach of our virology laboratory and TEM facility. Teacher workshop participants have been engaging researchers at our institution to advise on curriculum development, to present talks to their students, and to provide student tours of university laboratory and microscopy facilities. We look forward to augmenting our workshops to further inspire teachers' creative use of microscopy in their curriculum and to encourage regional pre-college educators to participate in additional formal university science courses that are increasingly being offered at times that permit in-service teachers to attend. Response to the project work indicates ample interest of educators in developing their scientific knowledge and skills and in discovering how to better incorporate microscopy into their curriculum.

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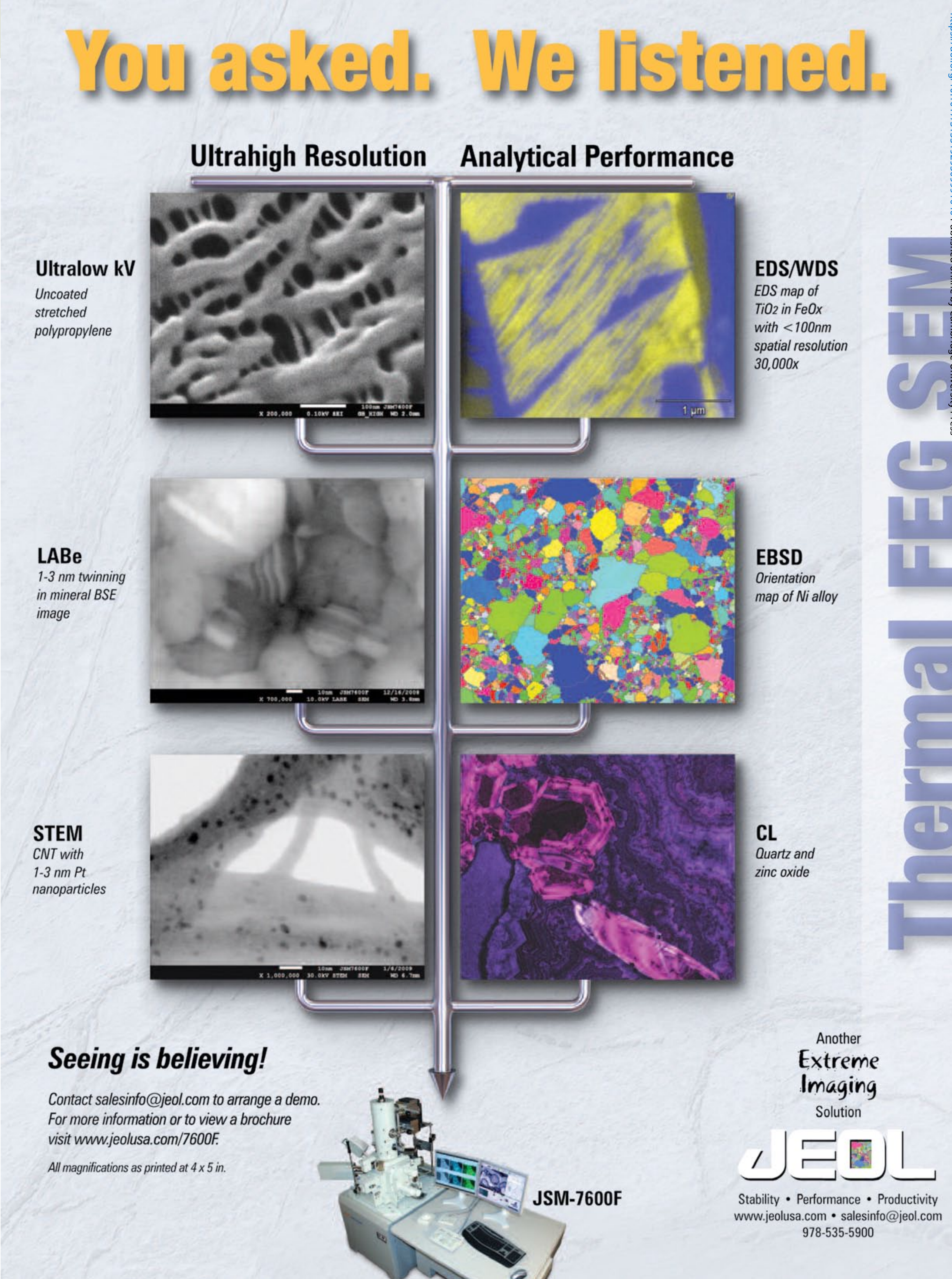
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