History of Electron Microscopy in North America

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For many attendees, the highlights of the 50th Anniversary Meeting of the Electron Microscopy Society in Boston last August centered around the historical theme which featured the presence of many of the very early workers in the field, often as past officers of the Society. The anniversary emphasis also included videotaped interviews with many of the pioneers by Sterling' Newberry, a special documentary volume also prepared by Sterling Newberry, a portrait gallery of past presidents and a "Microscopy - Then and Now" focus to the 1992 Presidential Symposium organized by Pat Calarco, the last of 50 Presidents to preside over EMSA.

One of the EM pioneers very much in evidence at Boston was John H. L. Watson who received a Ph.D. from the University of Toronto in 1943 for extensive research with the original TEM in North America and the design of a second generation, high performance, TEM. He is renouwned for composing the "EMSA Refrain" and rendering it on several memorable occasions and especially for closing the '92 Presidential Reception with a remarkable performance of songs and forward directed comments with his wife Francis as his accompanist. Dr. Watson reviewed "The Origins of Electron Microscopy in North America at the University of Toronto" in the Presidential Symposium and, in a lighter vein, "Recollections of the Masters" in the Technologists Forum. The abstract of his latter presentation is reproduced below with some inserts (italized) excepted from the text of his Presidential Symposium lecture.

IN THE BEGINNING THERE WERE ELECTRONS

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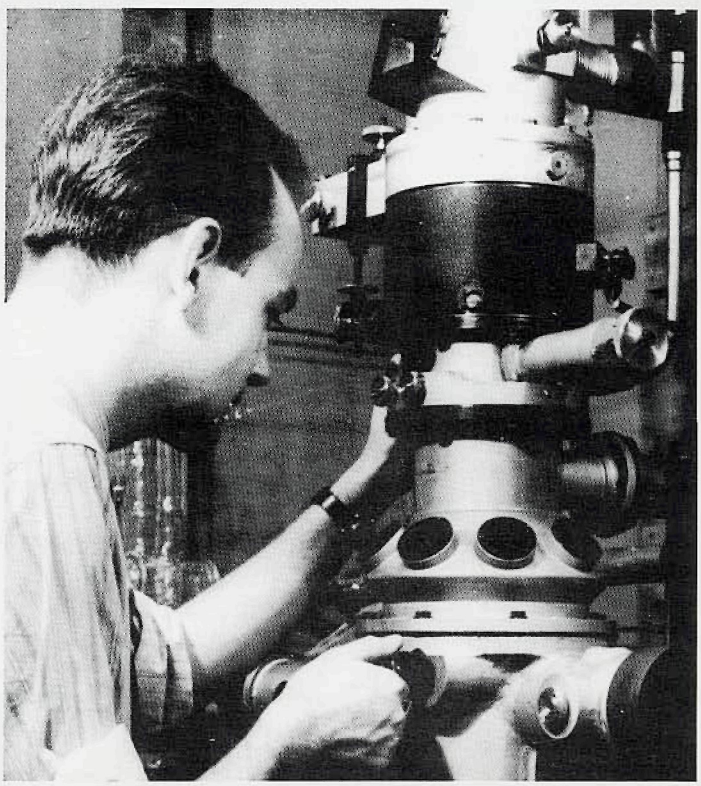
Electrons have undoubtedly been around since the beginning of time, but not until the first quarter of the twentieth century, following the work of deBroglie on the dual nature of the electron, Busch's hypothesis that an electron beam could be focussed by an axially symmetric magnetic field, and Davisson & Germer's and Thomson's independent demonstrations of electron diffraction, did microscopists take seriously the possibility of a microscope utilizing electrons and magnetic fields. The first attempts at building electron microscopes were made in Europe but the resolution of the often blurred and distorted electron images was not much better than that achieved by light microcopy, so that a general opposition to funding the development of electron microscopes began to emerge. In 1935, E. F. Burton, Chairman of the Department of Physics at the University of Toronto began a program of electron optical research - *Burton was clearly influenced by a German emigrant physicist, W. H. Kohl, a campus colleague and friend who was interested in the deflection of electron beams by magnetic and electric fields* - and set his graduate student Cecil E. Hall to build an emission microscope. *In his second year, Hall successfully completed a two-stage emission microscope with magnetic lenses and took photographs of the project. Hall's work at Toronto deserves special recognition because it was the basis for the construction of the 1938 transmission magnetic electron microscopy by James Hiller and Albert Prebus.* In 1937, Burton took a further step, with graduate students James Hillier and Albert Prebus, by building the first transmission magnetic electron microscope in North America, which was completed and successfully operated in April 1938. It had immediate resolution of 140 Å which was soon improved to 60 Å by use of a single-unit objective pole piece, and was of immediate practical application, producing the quality micrographs needed to eliminate all opposition to electron microscope development. *The instrument, designed and built by the two Canadian students was remarkable not only for the speed of its construction but for the facts 1) that it was applied immediately for practical purposes with resolution 10 to 30 times that of the light microscope, and 2) that it was the first such to be built and operated anyhwhere in the world.*

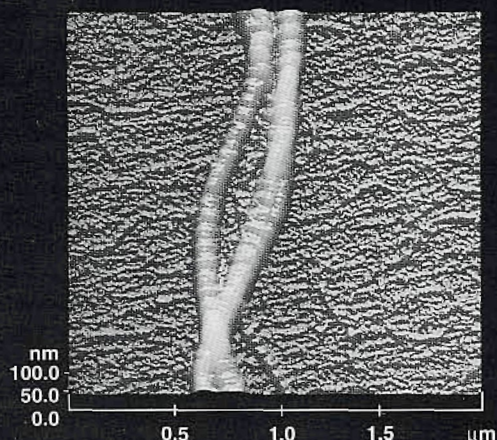
The six foot high column of the 1938 Toronto instrument was stacked in six sections, with lapped, vacuum-greased, metal-to-metal joints with a mercury diffusion pump backed by a Cenco Hyvac. The high tension system, consisting of a step-up transformer with half-wave rectifier was constant to a few volts in 50,000. Four standard 12-volt storage batteries in series, controlled by rheostats, supplied the lens currents. The cathode was heated by two 2-volt storage batteries. In the original instrument the electron gun was not self-biased. Concentric, soft-iron tubes shielded the beam in the critical region from objective to projector lens. Specimens were mounted upon a fragile film of collodion spread across a single hole bored in a metal disc. There were no air-locks and the camera contained only a single plate, so that a complete pump-down was necessary whenever a specimen was changed or a fresh plate introduced. All of these problems were minimized as time went on and eliminated in the design ot the 1944 Toronto electron microscope.

I used the 1938 instrument until the autumn of 1943. Hillier, Prebus and Ladd had each left the laboratory by 1940 and Dr. L. T. Newman and Dr. Beatrice Deacon had come on staff. Later Glen Ellis and, still later, Frank Boswell, Tom McLaughlan and R. S. Sennett with Dave Scott joined the Burton group in electron microscopy. I had left in 1943, returning briefly in the summer of 1944 to assist in setting up the 1944 model Toronto microscope, the design of which had been part of my 1943 thesis. Most work done with the '38 instrument was related to the World War II effort. The filtration efficiency of masks of many types was studied extensively, relating it to the particle sizes of particulates, the particles having been gathered on collodion films in a altered thermal precipitator. A whole array of substances both biological and physical was studied including polished glass, carbon blacks, diatoms, polishing powders, vacinnia virus, the vole, tubercle and typhoid bacilli and Rickettsia typhi. The effect of growing steptococcus hemolyticus in the presence of sulphathiazole was investigated. The soap components of lubricating greases and the helical nature of lime-based soaps were demonstrated and, well before the days of ultrathin sectioning, an attempt was made to visualize the fine structure of human, pathological tissue by examining tissue pieces macerated in a blender. Contiguous with these studies, the 1944 model Toronto electron microscope was designed and built. With it Boswell carried out precise determinations of lattice constants in small crystallites.

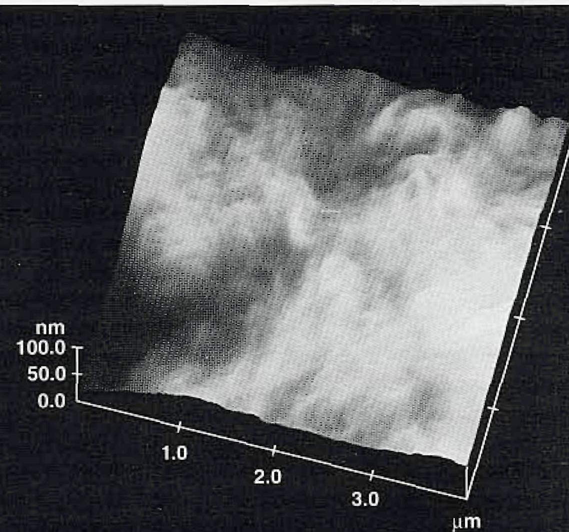


John H. L. Watson operating the 1944 Toronto microscope (circa 1944)

A Breakthrough in AFM Imaging of Soft Samples.



Type I Collagen Scanned in the TappingMode™ (patent pending) using the NanoScope Multimode AFM. Both the 70nm bands and the 30nm sub-bands are resolved in this uncoated sample. *Data: E. Chernoff of Indiana University-Purdue* University at Indianapolis, D. Chernoff of Advanced Surface Microscopy, Inc., and K. Kjoller of Digital Instruments.



Polyethylene Film Scanned in Air using the TappingMode™ of the NanoScope MultiMode AFM. Now soft, delicate samples like these can be scanned quickly and easily without the use of a fluid cell. *This is another example of our commitment to* meet our users' needs. Data: C. Boles of Digital Instruments.

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