

# THE SCANNING ELECTRON MICROSCOPE REVEALS A NEW WORLD OF AGRICULTURE

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The light microscope, originally developed in the mid-1600's, has been steadily improved to its present level of technical sophistication. During the present century countless applications have been made of the light microscope to agricultural research.

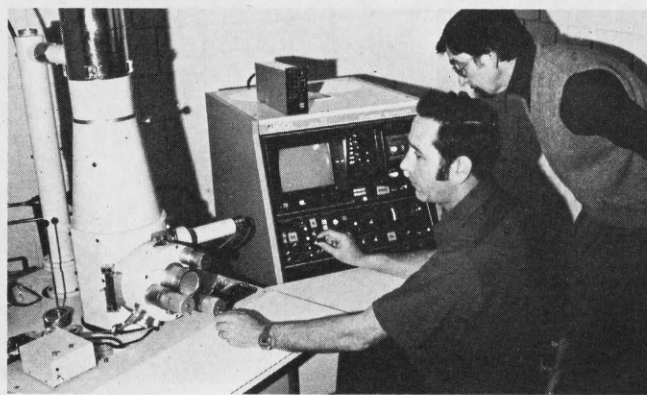
In contrast, the electron microscope has reached a high level of technical capability and a wide range of application within three decades of its initial development. Electron microscopy provides visual access to structures in a region between the cellular and the molecular level. In this essentially unexplored region lie the answers to many of the fundamental problems of the life sciences. The electron microscope has become an essential tool in our understanding of cellular structure and function. Light microscopy is still an invaluable source of data and is routinely used to supplement electron microscopy. Light microscopy, however, is severely limited by functional magnifications of 1200 X and resolutions rarely better than 2000 Å<sup>1</sup>. Thus, light microscopy does not permit the detailed examination of cell surfaces, cell organelles and membranes.

The transmission electron microscope permits the examination of biological tissues at very high magnifications (100,000 X or greater) with a resolution of 7 Å or less. The magnification and resolution capabilities of the transmission electron microscope permit examination of individual cell organelles and membranes. The thin sectioning required in sample preparation results in images that are essentially two dimensional, as are those obtained with the light microscope.

Because of the great depth and three-dimensional quality of the image obtained with the scanning electron microscope the results can be easily interpreted. The scanning electron microscope can reveal details of surfaces (not restricted to biological samples) not obtainable with other instruments. Details of less than 70 Å can be resolved with a depth focus approximately 500 X greater than that of an optical microscope of equivalent magnification. Magnifications on the scanning electron microscope range from 10 X to over 100,000 X.

<sup>1</sup>Å = 1/250,000,000 of an inch

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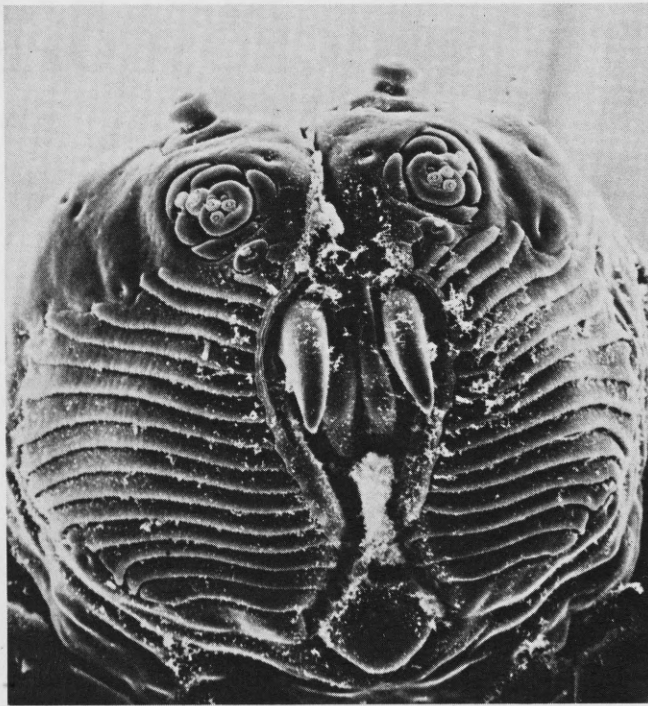


Drs. Freeman and Littlefield working with the scanning electron microscope.

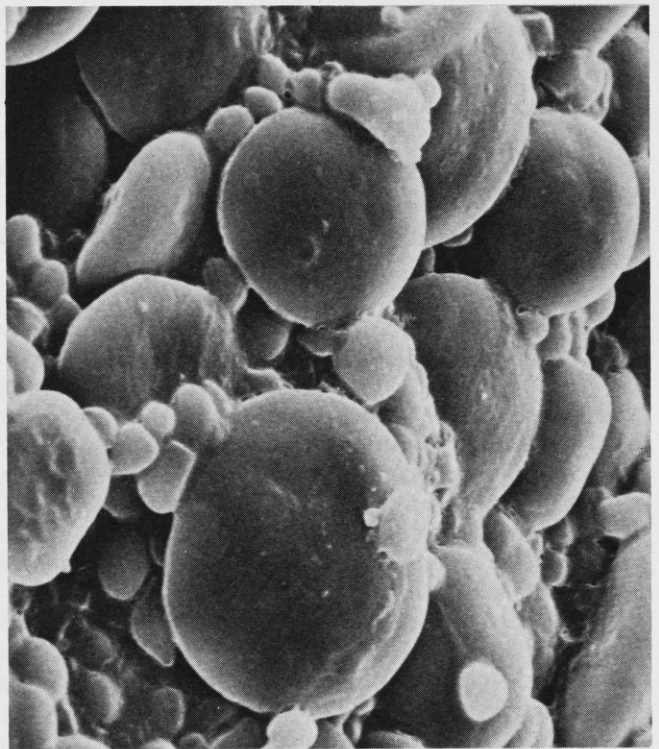
The scanning electron microscope produces photographs by scanning the surface of a specimen with a small electron beam. The electronic signals produced by the interaction of the specimen and the electron beam are used to form a visual image on a small television screen. This image is then recorded on photographic film. In addition to surface structures the instrument can be used to study the internal structures of plants and animals. Scanning electron microscopy can also be used to detect surface luminescence, surface composition, crystallography, and surface conductivity.

Sample preparation varies with the type of specimen to be examined. Certain types of hard biological samples such as insect surfaces, bone, teeth, pollen, spores, wood and seeds may be examined with little or no preparation. Softer biological materials must be killed and fixed to preserve their cellular characteristics. Following fixation the samples must be completely dehydrated and covered with a thin layer of a highly conductive metal, usually gold.

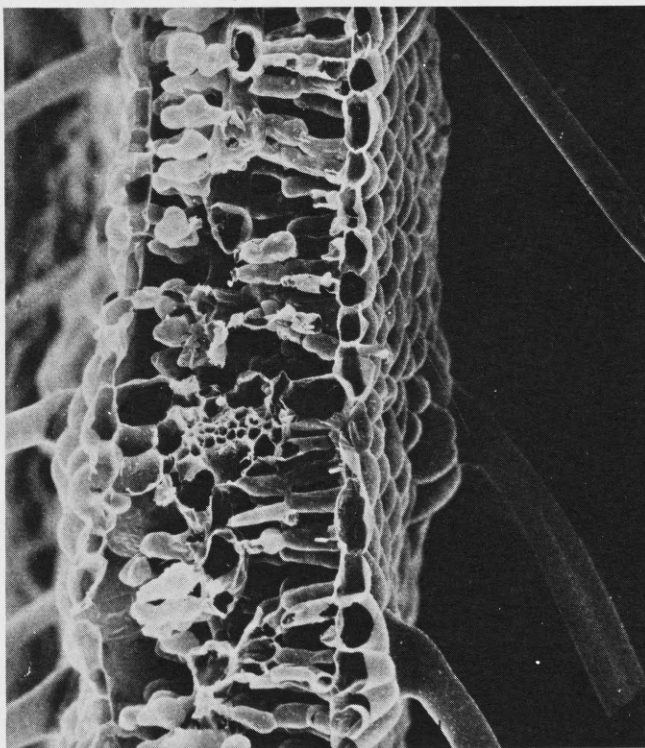
The electron microscope laboratory at NDSU is a university facility and cooperates with researchers studying a wide variety of agricultural problems. The laboratory has both transmission and scanning electron microscopes and the necessary ancillary equipment. The photographs shown are examples from some of the many agricultural research projects at NDSU in which the scanning electron microscope is utilized as a research tool. They are kindly provided by project leaders in the departments of Agronomy, Bacteriology, Botany, Cereal Chemistry and Technology, Entomology, Plant Pathology, and Soil Science.



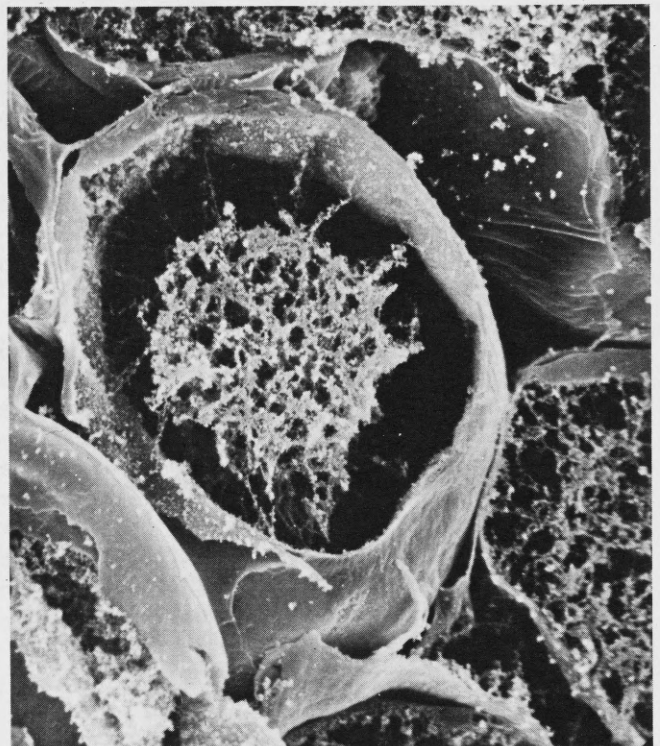
Face view of sugarbeet root maggot. Magnification 430 X. Project #ND 1521. Sugarbeet Insects. Entomology Department.



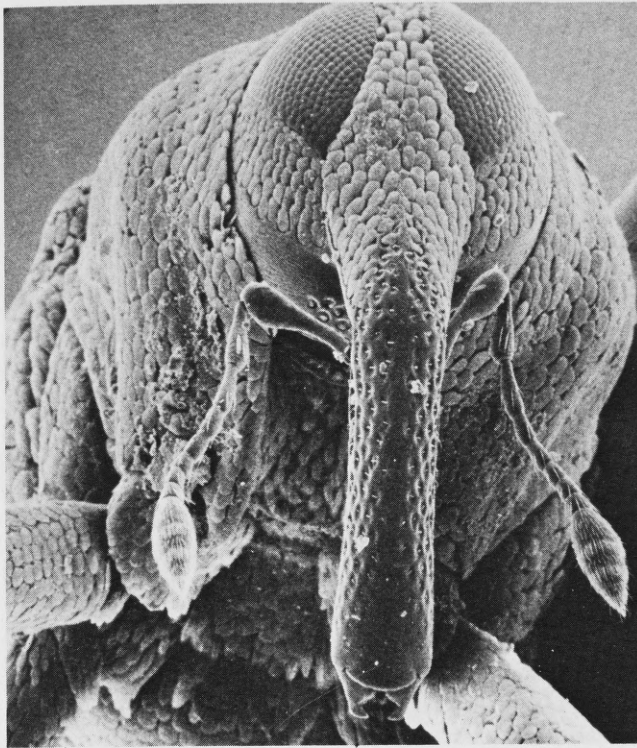
Starch grains of uncooked spaghetti. Magnification 1700 X. Project #ND 2004 Durum Quality Research. Department of Cereal Chemistry and Technology.



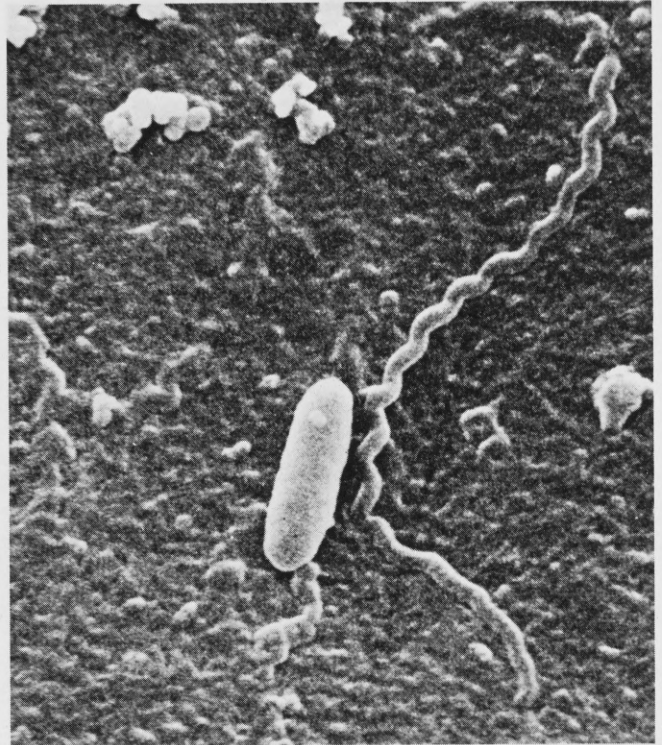
Cross section of a soybean leaf showing internal cellular characteristics and surface structures. Magnification 240 X. Project #ND 2543 Micronutrients and Plant Growth. Soils Department.



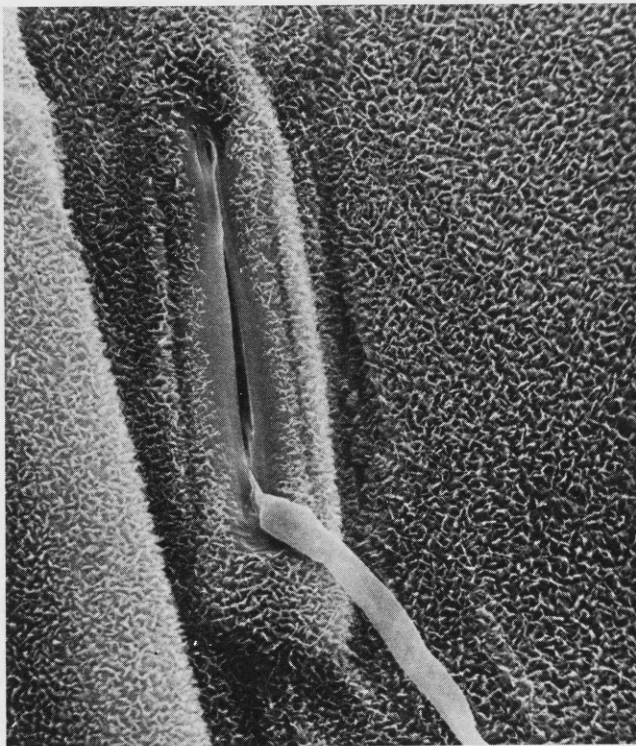
Cross section of a wheat leaf cell showing cell wall and cellular contents. Magnification 3300 X. Project #ND 1919 Cellular Photosynthetic Processes. Botany Department.



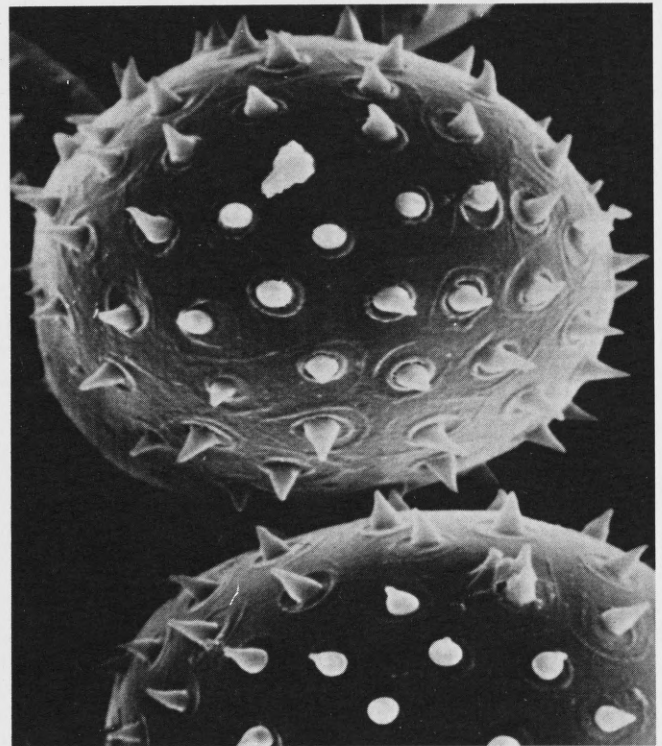
Sunflower stem weevil. Magnification 60 X. Project #3502 and 1519. Department of Entomology and USDA Metabolism and Radiation Research Laboratory.



Bacteria from Sheyenne River sediment. Magnification 13,300 X. Project #ND 1815 Pathogens in river and lagoon sediments. Department of Bacteriology.



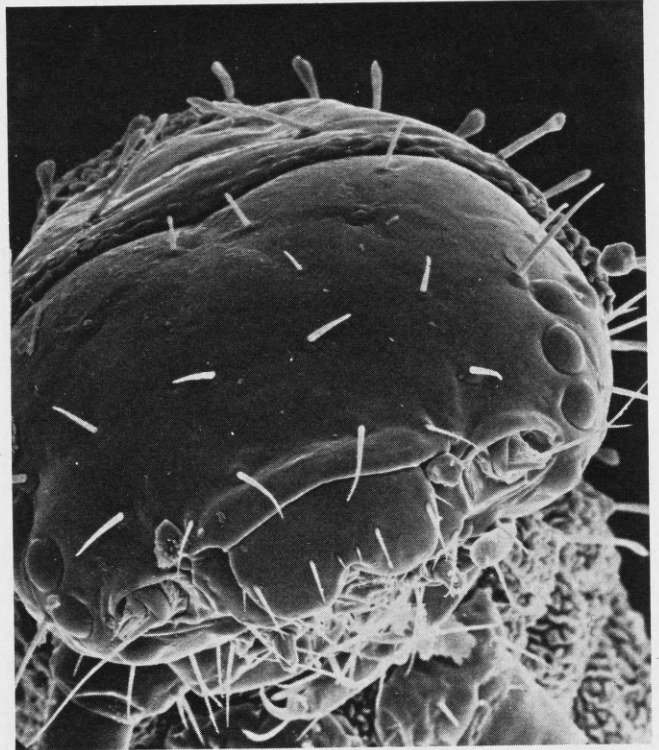
Fungal hypha penetrating stoma of wheat leaf. Magnification 2,400 X. Project #ND 2317 Cereal Foliar Pathogens. Plant Pathology Department.



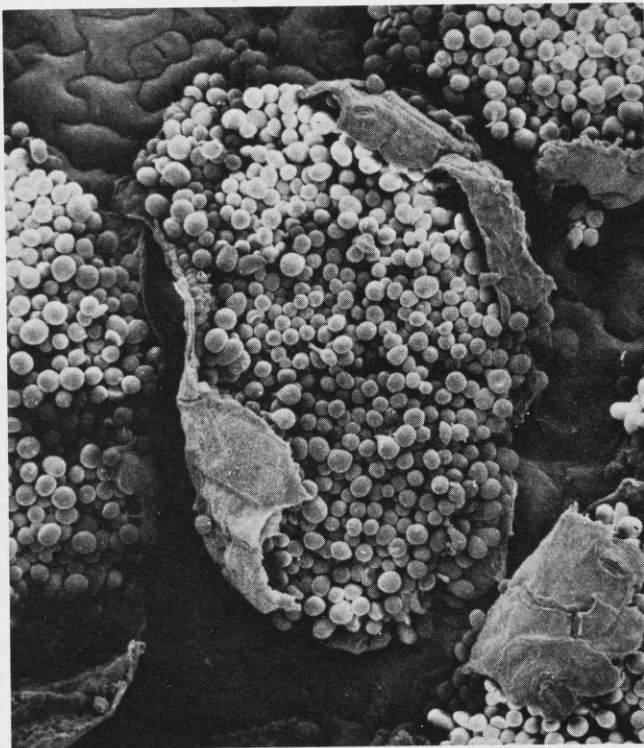
Urediospores of bean rust fungus. Magnification 5,000 X. Project #ND 2314 Bean Rust. Plant Pathology Department.



Starch grains in the endosperm of sweet corn. Magnification 650 X. Project #ND 01606 Corn Improvement. Agronomy Department.



Face view of dark-sided cutworm. Magnification 370 X. Project #ND 1521 Sugarbeet Insects. Entomology Department.



Pustule of flax rust fungus containing urediospores. Magnification 190 X. Project #2313 Flax Rust Histology. Plant Pathology Department.



Aecia of cedar-apple rust fungus on apple leaf. Magnification 110 X. Plant Pathology Department.