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mitotic division to produce eight nuclei. Each nucleus is then enveloped by a membrane system to delimit the ascospores. This method of ascospore formation is termed "free cell division" and is unique to the Ascomycetes. In most Ascomycetes the ascospores are forcibly ejected from the ascus when mature, but in some the wall of the ascus deliquesces, freeing the ascospores inside the ascocarp.

The Basidiomycetes differ from the Ascomycetes in one important characteristic: the sexual spores are borne externally on the cell in which nuclear fusion occurs, instead of internally. As in the Ascomycetes, sexual reproduction is initiated by the formation of specialized binucleate cells. These differ, depending upon the group under consideration. In the rusts and smuts, for example, which lack fruit-bodies, fusion takes place in teliospores that are produced by the fungus, and these teliospores then give rise to the basidia and basidiospores. Depending upon the species, meiosis may occur either in the teliospore or in the basidium. Typically only four basidiospores are produced per basidium, although in the smut fungi the number may be variable. In the rest of the Basidiomycetes the basidia form on or in a fruit-body (basidioma). The mushrooms produce their basidia in a layer, or hymenium, on the surface of thin gills on the undersurface of a cap or pileus, whereas in the bracket fungi the basidia line the inside of small pores. The basidia form at the tips of specialized binucleate hyphae on the surface of the gill or pore tissue. In both types of fruiting body (basidiomata) the four basidiospores are forcibly ejected from the basidium and fall down into the atmosphere, where air currents can distribute them.

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Thomas Allen Shalla is best known to plant pathology for his excellent teaching and mentoring skills and his research on plant virus–host interactions. Shalla developed several techniques to improve visualization of plant viruses with the electron microscope, including the use of ferritin-labeled antibodies for identification and localization of viruses within host cells. Shalla was widely recognized for his work on the structure of viral inclusion bodies and movement of viruses through plasmodesmata, the cytoplasmic connections between adjacent plant cells. Shalla is also known for organizing and directing a multidisciplinary and multiinstitutional task force that studied the biology and methods of controlling pear decline starting in 1960, which resulted in the virtual elimination of pear decline from California (1).

Photo courtesy of the Department of Plant Pathology, University of California–Davis.

Thomas Shalla was born May 7, 1933, in Grand Rapids, Nebraska. He graduated from Fort Collins Colorado High School in 1951 and received his B.S. in botany from Colorado State University in 1955. He received his Ph.D. in plant pathology from the University of California at Davis in 1959. Shalla spent six months in the military before becoming instructor and junior plant pathologist in the department of plant pathology at the University of California at Davis in 1959. Shalla became full-time professor by 1969 and spent the remainder of his career at the University of California at Davis.

Shalla belonged to several societies, including the American Association for the Advancement of Science and the American Phytopathological Society, to which he was elected fellow in 1974. He served on the editorial board of *Virology* beginning in 1969 and was editor of the journal from 1974 until his death.

Thomas Allen Shalla died May 13, 1983, in Kansas City, Kansas, while on sabbatical leave.

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SHIGOMETER

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The Shigometer is a battery-operated, lightweight field ohmmeter named after Dr. Alex L. Shigo. The meter was initially developed by Shigo and his collaborators as a means of detecting discolored and decayed wood

in living trees using a pulsed electric current (1). The same instrument was then used as a means of detecting variations in the growth rate of tree stems (2). Since that time, other applications of the Shigometer have been developed for assessing tree and forest health and wood product quality (3).

Basic operation of the Shigometer and its common applications are available in a handbook (4). The meter itself has undergone many changes since its introduction as a simple ohmmeter using a pulsed electric current. The meter has been digitized and reconfigured using a squarewave direct current. Similar instruments are now available in the United States and abroad. Each meter can be used with a variety of electrodes and accessories, such as battery-powered drills, to make contact with tree tissues. However, all the meters have in common the capacity to measure electrical resistance in thousands of ohms (kohm). When an electric current is passed through tree tissue that has a moisture continuum and a temperature above freezing, the resistance to the current is inversely proportional to the concentration of mobile ions in the tissue.

As wood becomes infected and the decay process begins, the concentration of mobile ions steadily increases and the resistivity of the wood correspondingly decreases (5). This allows a properly trained operator to distinguish infected, decaying wood from healthy, sound wood. Although the measurements are simple to make, the interpretation of complex patterns of measurements in trees, utility poles, wood in service, and other situations is not simple. Valid interpretation requires thorough knowledge of factors affecting the resistivity of wood. These factors are temperature, moisture, stage of maturation, and infections caused by a variety of microorganisms.

When using the Shigometer to detect wood-destroying infections in trees, utility poles, and other wood products in service, a small hole is drilled and a twisted wire electrode is inserted. Measurements of electrical resistance are taken at 1–2 cm intervals from the outer surface along a radius. The pattern of these measurements is then compared with known patterns for sound and decayed wood in both its early previsual stage and advanced visible stage. The diagnosis of an infection depends on the comparison with known patterns of decay-causing infections in trees and wood products. The position of the drill hole depends on a thorough knowledge of the relationship between external indicators of decay and the internal patterns of wood ionization produced by the spread of decay. The effects of moisture and temperature on the electrical measurements must be taken into account when patterns are compared, so that any necessary adjustments can be made for a proper diagnosis.

When using the Shigometer to detect differences in diameter growth of tree stems, a double-pinned moisture meter electrode is used. The pins are pushed in vertical orientation through the bark and vascular cambial zone into the outermost wood on one or more faces of a tree at 1.3 m aboveground during the growing season. Fast-growing trees have a more active, wider vascular cambial zone than slow-growing trees, which increases the mobile ion content and gives a lower electrical resistance (6). This inverse growth relationship can be used to track the productivity of forests, especially during periods of high stress such as caused by insect defoliation. However, the method must be applied with care because infected wood in the outermost part of the stem in declining trees may give a measurement indicative of rapid growth in slow-growing trees. As in the case of diagnosing wood infections, the operator must know when and where to measure as well as how to measure electrical resistance.

The key to proper use of the Shigometer is to know how biological ionization occurs and how to interpret resulting changes of resistivity. The Shigometer has been used (*1*) to distinguish between stands of productive and sound trees and stands of suppressed and infected trees, (*2*) to detect root-rot in plantations, and (*3*) to detect decay in utility poles and wood in service. The Shigometer can help managers assign risks and allocate treatments to reduce risks of loss.

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SIDEROPHORES

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Siderophores (from the Greek "iron carriers") are low molecular weight compounds that are produced by microorganisms under iron-limiting conditions, chelate the ferric ion (Fe^{3+}) with high specific activity, and serve as vehicles for the acquisition of iron from the environment. Transport of iron from the siderophore into the microbial cell is mediated by membrane receptor and transport systems that recognize specific iron-siderophore complexes (1,2). It is generally assumed that organisms have evolved these high-affinity iron uptake systems because the naturally abundant ferric ion is virtually insoluble in oxygenated environments at neutral or alkaline pH (at pH 7, Ksp of $Fe(OH)_3 = 10^{-17}$ M), and thus is almost unavailable for microbial growth.

Iron is an essential element for living organisms because of its two stable oxidation states (Fe^{2+} and Fe^{3+}), which act as cofactors in various oxidative-reductive enzymatic reactions. Iron can also be toxic due to its catalytic role in the generation of oxidizing radicals from superoxide and peroxide. When present in excess, iron is stored as ferritin complexes, which are not toxic to