



# ERNEST CHARLES LARGE: PIONEER IN PHYTOPATHOMETRY

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My abiding memory of E. C. Large is that of him at a foray of the British Mycological Society sitting at a bench in a students' laboratory, side by side with his wife, while they examined and drew specimens of the larger British fungi. On the bench is the basket they used for carrying the specimens collected during the day spent in woods or open country, and nearby is the microscope, complete with eyepiece micrometer, that Large used so much on the forays to measure spores and other structures. Also on the bench are the  $8 \times 5$  inch index cards on which he made what he described as engineering drawings of toadstools. On these occasions Large always called his wife Mrs. Large and she called him Mr. Large. It was only after reading his obituary that many of us realized his first names were Ernest Charles.

This picture of Large clearly brings to mind some of his characteristics and helps to justify the use of the word phytopathometry in the title of this article. He was much preoccupied with the necessity for making accurate measurements so that at forays he was intent on measuring spores and other structures of the larger fungi he collected. This, of course, was happening when most of us were trying to acquire and retain visual images of these fungi without much, if any, microscopic examination.

I first met Large in 1948, in Belfast, when he was attending his first foray organized by the British Mycological Society. As Local Secretary I had good opportunities of meeting those attending it. At this time, I had not realized that Large had become a plant pathologist by an unusual route, without having received any formal training in the subject. He really had

three interacting careers: engineer, writer, and plant pathologist. Although these careers are not clearly separated, it is desirable to consider them separately.

## PERSONAL DETAILS AND EDUCATION

E. C. Large was born on June 24, 1902, at Parsons Green, London. His early education was received in London at Clark's College, Putney, and later at St. Paul's School. He did not wish to follow his father's career in law and was apprenticed to an engineering firm, Gwynnes Pumps, at Hammersmith, London. At the same time (1919) he commenced studies as an internal evening student of the University of London at Battersea Polytechnic, and in 1924 obtained the Honours Degree of B.Sc. (Engineering). For the next four years he worked during the day as an engineer and in the evenings studied electrical engineering. Also at Battersea Polytechnic, he acted as a demonstrator to evening classes in mechanical engineering. He continued studies from 1936 to 1940 by attending evening classes at Chelsea Polytechnic, London, leading to the award of the Associateship of the Institute of Chemistry by examination. Later he became a Fellow of the Institute.

In 1930 Large married Gladys May Unwin, a London school teacher, who was then studying for her Dip. Lit. at King's College, London University. They had three children, Michael, Patrick, and Joanna. Large was very much a family man who talked frequently about his children. One of his colleagues recalls that he once told him how much it distressed him to be separated from his young children, and how strongly he disliked being away from home.

## ENGINEER

Utilizing his training at Hammersmith and Battersea Polytechnic, Large was appointed in 1928 to a research post in South Wales to work under Rudolf Leasing, the well-known specialist on coal and its products. With the onset of the economic slump, he became unemployed a year and a half later and decided to occupy himself, until employment prospects became brighter, by learning to write.

His year of "unemployment" ended, Large was appointed in 1930 as Engineer (and later as Manager) in the Colloidal Section of Einstein's Electro-Chemical Processes Ltd. at Acton, Middlesex, where he worked under Emil Hatschek, an eminent colloidal chemist. Hatschek developed a practical and inexpensive colloidal copper fungicide (British Patent No. 392,556 of 1931), later marketed under the trade name of Bouisol (10). Compared with Bordeaux and Burgundy mixtures, at that time much in use

as copper fungicides, Bouisol had the great advantage that the purchased liquid was merely added to the appropriate quantity of water in the spraying machine, so that the farmer did not have to undertake any other preparation of the fungicide. Large was to be closely associated with the use of Bouisol during the next 15 years.

Since Large was working at Acton in the early 1930s and was to become so closely associated with studies of potato blight, it may be recalled that one of Acton's more distinguished earlier residents was John Lindley. In 1845 Lindley announced the first occurrence of potato blight in England in the pages of the *Gardeners' Chronicle and Agricultural Gazette*. In this journal was also published later the memorable argument between Dr. Lindley and the Rev. M. J. Berkeley (1803–1889), a country parson in Northamptonshire, eminent for his knowledge of fungi, as to whether the mold that appeared on the diseased potato foliage was the cause or the result of the disease. Berkeley produced his revolutionary "fungal hypothesis" regarding the cause of potato blight, but this was vigorously opposed by Lindley. It has to be said that Berkeley produced the better argument, but he and Lindley agreed on the impossibility of controlling the disease at that time.

In the 1930s, Large was developing a dry bentonite-copper-oxychloride fungicide that could be used as a dust or for spraying (9, 10). Preece, who later worked with Large at the Plant Pathology Laboratory of the Ministry of Agriculture and Fisheries, Harpenden, described to me how Large told him he had invented this material as a fungicide and in the process of doing so had upset Mrs. Large by his use in the kitchen of smelly saucepans full of chemicals. Large reported (10) that the process of manufacturing this material was so simple that small quantities could be readily produced in an old enamel plate heated over a saucepan of water.

During Large's time with the Colloidal Products Section at Acton, it became necessary to test Bouisol and other products for fungicidal efficiency. This involved setting up field trials embracing a range of plant diseases and this was his introduction to plant pathology. He recorded that G. H. Pethybridge (1871–1948), Assistant Director of the Plant Pathology Laboratory of the Ministry of Agriculture at Harpenden, helpfully guided his approach to leading workers in the subject. William Brown (1888–1975) of the Imperial College of Science and Technology, London University, certainly planned an investigation for Large, carried out at the Field Station of the College by Aphra Wilson. Around this time, Miss Wilson also assisted Large in his biological studies.

In 1936, Boot's Pure Drug Company purchased the Colloidal Products Section and, although for a time Large was retained as a consultant, he became unemployed for the second time.

## WRITER

In 1936, as in his earlier days of unemployment, Large took up writing again and Mrs. Large continued in her post as a teacher. During the next year he wrote his first novel, *Sugar in the Air*, published by Jonathan Cape. This was largely autobiographical and some plant pathologists and mycologists of those days (including myself) derived amusement from speculating about the scientists and businessmen who might have provided the basis for some of the characters we were introduced to in the book. His second novel, *Asleep in the Afternoon*, published in 1938, had as its setting England immediately prior to the outbreak of the Second World War. Large's third novel, *Dawn in Andromeda*, published in 1956, was the result of writing on Sunday mornings in the midst of a very busy program of work on plant pathology. These three novels were extremely well received, one being a Book Society choice and another receiving a Book Society recommendation. The reviewer in the *Saturday Review of Literature* wrote, "A delight for its tensile prose *Sugar in the Air* is entertaining fiction throughout". The *New Yorker* described *Asleep in the Afternoon* as "highly entertaining, intelligent, penetrating, never whimsical". Reviewing *Dawn in Andromeda* in the *Transactions of the British Mycological Society*, P. H. Gregory (7) wrote, "Within the story is embedded a history of the origin and development of technology; a vivid recital of the major discoveries of prehistoric men and women, such as the kindling of fire, twisting of thread, brewing, smelting, breeding and selecting crop plants."

Large's daughter, Joanna Major, remembers her father's concern that when writing about new discoveries such as the kindling of fire, he should have proved that the essential operation could be successfully performed. She related how her father and his family experimented in a wood trying to make a fire without matches and, when unsuccessful, visited the Science Museum in London to learn more about the methods of fire making in the days of early man.

Large's best-known book, as far as plant pathologists are concerned, has undoubtedly been *The Advance of the Fungi*, also published by Cape, appearing in 1940 and later reprinted on at least three occasions by 1958. This book was written entirely during his second period of unemployment. In this work, Large aimed at producing a history, or as he described it the "story," of plant pathology, in simple language that would appeal to the general public as well as to those who were previously interested in this branch of science. Preece recounts that Large told him "he went daily to the British Museum and other libraries to read and write *The Advance of the Fungi* while Mrs. Large kept us alive by working." When the first

chapter was written and seen by the publishers they promptly accepted the book. In 1962, a paperback edition appeared in the USA.

*The Advance of the Fungi* had a most favorable reception. The Times Literary Supplement reviewer wrote, "Mr. E. C. Large has a couple of highly original novels to his credit, and he writes with such exuberance and wit, as well as enthusiasm for his subject, that the general reader who knows little about fungi, and cares less, could hardly fail to be entertained." A reviewer in *The Listener* stated "The interest of the reader is held by accounts of the influence of the fungi on social affairs, acute observations on the personalities and motives of scientific investigators and dramatic descriptions of attacks of crop-destroying fungi".

It should be remembered that at the time Large was writing *The Advance of the Fungi* he had not undertaken, or been involved in, any research in plant pathology other than the spraying experiments with the products that emerged from the Colloidal Products at Acton. Moreover, it is extremely likely that while engaged in the historical research and writing of that book, he was also writing his second novel. He was far from unemployed!

## PLANT PATHOLOGIST AND MYCOLOGIST

In 1941, during the early days of World War II, Large was appointed assistant to A. Beaumont, of Seale-Hayne Agricultural College, Newton Abbot, Devonshire. Beaumont was the Advisory Mycologist for South-West England in the Ministry of Agriculture and Fisheries and had been actively engaged in studies on the epidemiology of potato blight from 1929 to 1939. He had defined the critical conditions of temperature and humidity necessary for disease outbreaks to occur. Later, the occasions when these conditions were met for at least 48 h were referred to as Beaumont periods. The work that Large was to undertake in South-West England during the war years related to the control of potato blight by spraying and also to potato "seed" production.

Shortly after arrival at Seale-Hayne College, Large's first paper on potato blight was published (11). It was intended to provide information for farmers not familiar with potato growing and the control of blight. Publication of results from the spraying trials made by Beaumont and Large followed (1, 2).

In a short article (12) in 1943, Large summarized the results obtained by spraying potatoes with suspensions of metallic copper. In these trials he used Bordeaux mixture, cuprous oxide + bentonite and H-reduced copper + bentonite. Bentonite was employed to ensure good adhesion to the foliage as well as to stabilize the copper suspension (10). The metallic copper

sprays provided effective control but, on the whole, were not as effective as Bordeaux mixture. In this work Large made full use of the conclusions reached by a small group of British workers constituting a subcommittee of the British Mycological Society. This subcommittee set out to devise, test, and ultimately to recommend methods of measuring plant disease in the field (3, 21). From his data, Large (13) showed that curves obtained for the progress of foliage destruction by blight expressed as percentage of foliage destroyed, plotted on a time base, were sigmoid in shape. These sigmoid curves could be reduced to straight lines by probit transformation. At this stage of the work Large (13) appreciated that "the whole course of a blight epidemic could be completely described by giving the half-decay date and the slope of the probit foliage decay line".

In a brief paper, Gregory (8) pointed out that when Large (13) observed the sigmoid progress curve of potato blight, he clearly had no knowledge of the work of Fracker (6). The latter, in a remarkable but neglected paper, had used the Verhulst logistic growth curve originally developed for fitting to human population growth, to represent the increase of white pine blister rust (*Cronartium ribicola*) in American forests.

Large's daughter, Joanna, in some recollections of their home life about this period, recalls that in "father's room" there was a mahogany baby grand piano, with its lid usually closed and piled high with an interesting mixture of loose papers and drawing instruments. Littering the mantelpiece was a collection of test-tubes, bottles, and rulers, and also a blown glass model of *Phytophthora infestans*. I have no doubt that this model was made by W. A. R. Dillon Weston of the School of Agriculture, University of Cambridge, who specialized in creating such objects as a palliative for insomnia.

In 1946, at the end of World War II, the National Agricultural Advisory Service was established and Large was transferred from Seale-Hayne to Cambridge to work under Dillon Weston. Here he had opportunities of extending his knowledge of crop diseases.

In 1950 Large was brought to the Plant Pathology Laboratory, Harpenden, by W. C. Moore, who had been appointed director the previous year. His duties were to be twofold. Firstly, he was to set up a new section at the laboratory for plant disease and pest assessment work. Moore was determined that the previous qualitative recording of plant diseases in England and Wales should be extended to involve quantitative work. Secondly, Large was to edit a new journal *Plant Pathology*, the first number of which appeared in March, 1952, published by Her Majesty's Stationery Office. It was to appear quarterly and have a very wide scope. Certainly, Large was well qualified to undertake these tasks. At first his investigational work on plant disease measurement was tackled single-handed, but, in 1957, T. F.

Preece was appointed as a Scientific Officer and Valerie Church as an Assistant Experimental Officer in the section.

At this stage of his career, Large did all his own work, at least until Mrs. Church was trained to do things precisely as he wanted. Tom Preece recalls him as always having Indian ink on his hands and being extraordinarily careful about drawings. He brought an engineering approach to his work and at home he built various ingenious devices to assist his research. These ranged from a wall-mounted enlarger to a field microscope. Indeed he is remembered as often replying to questions with the answer, "I don't know anything about that, I'm an engineer." He always had a drawing board and tee square on his desk. As I write, I have before me a sheet of paper on which Large had produced detailed notes for Preece stating exactly how to make a drawing for a  $2 \times 2$  inch slide that could also be used for a figure in a paper to appear in *Plant Pathology*. The sketch is very clear with precise measurements indicated, the sizes of the Letraset stencils to be used for various purposes are specified, and no detail is overlooked. The comment "keep wording to a minimum" is included. He did not recognize Saturdays or Sundays as holidays, but spent hours arranging plates for publication or for use at meetings. He saw to it that, when necessary, papers he was editing for *Plant Pathology* were redrafted until they were satisfactory to him.

Shortly after arriving at Harpenden, Large demonstrated (14) how blight progress curves could be used to estimate probable loss of yield and what the likelihood was of haulm destruction by chemicals that proved efficient for prevention of tuber infection. With help from the Agricultural Branch of the Meteorological Office he investigated the possibilities of potato-blight forecasting throughout England and Wales, using the hourly observations of temperature and humidity made at about forty synoptic weather stations. In this study, the practical matter at issue was to determine to what extent warnings based on the occurrence of Beaumont periods at weather stations would be valid for potato-growing areas. The first reports of the results obtained (15, 18) showed that regional forecasts of the date-of-blight outbreaks could be made successfully in the seasons 1950-55. However, it was essential that the forecasts should be based on the observations from the network of stations as a whole, rather than on those made at individual stations, and also that information regarding the first outbreaks of the disease in a region be considered. This study, like the others on disease forecasting that followed, was a cooperative venture between Large and the Conference of Advisory Plant Pathologists, with Large compiling the data submitted. Results obtained in this study helped to determine the proper timing of spraying in blight years, but also minimized spraying in nonblight years when it could cause a loss in yield.



While at Harpenden Large cooperated in various studies of measurement of diseases other than potato blight. This collaboration involved the Conferences of Plant Pathologists, Grassland Officers and Crop Husbandry Officers of the National Agricultural Advisory Service, and also that of Officers of the Ministry of Food. In this way valuable information was obtained about the incidence of choke (*Epichloë typhina*) in cocksfoot seed crops, occurrence of eelworm damage to clover, incidence of *Verticillium* wilt in lucerne, and crop losses due to common scab (*Streptomyces* sp.) of potatoes. Arising from his interest in investigations of leaf diseases of cereals, Large (16) published a brief paper defining the course of growth of cereals. This was for many years one of the most quoted papers in biological science.

Large outlined his philosophy about measurement and forecasting of plant diseases in three published papers (17, 19, 20) and a book (4) written jointly with A. E. Cox. One of these papers (19) was his Presidential Address to the British Mycological Society. He was absolutely certain that the tactics of disease measurement must vary according to the nature of the disease and that no method can serve for all plant diseases. Nevertheless, there is a general strategy that he felt could be applicable to many diseases. This strategy involves: (a) a description of the morphology and development of the healthy crop plant; (b) a study of the course of the disease on plants in the field; (c) the preparation of a standard diagram or field key for the assessment of the disease, followed later by a simplified field key; (d) making field trials, over several years, and preparing progress curves for the disease using the field key, recording yields of plots with uncontrolled infection and of plots kept as free as possible from the disease by frequent spraying or otherwise; and (e) the choice, from study of progress curves for the disease in the field, of particular disease assessments that best define severity of attack and calibration of these assessments in terms of reduction of crop yield.

In 1963 Large retired from the Ministry of Agriculture and was awarded the O.B.E. In 1964 he and his wife made a lengthy visit to Australia where their son Michael had accepted a post as a radio astronomer. During this visit he spent a term as a Visiting Professor in Sydney University, where he was responsible for what, no doubt, was the first course given in phytopathometry. Much time in retirement was devoted to drawing and painting species of larger British fungi and providing names for these fungi. Thirty of his paintings appeared in Findlay's book *Wayside and Woodland Fungi* (5). During the last few years of his life he suffered long spells of illness during which he was cared for by his wife. He died in hospital on 25 August, 1976.

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