Last of the Great Potterers

Would it be possible today for one inspired individual to make major contributions across a range of different scientific specialties?

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As a swan song (goodbye, readers!), I thought this month I would discuss one of my little-known scientific heroes. In doing so, I shall be looking backwards but also forwards to 2020, the centenary of his richly deserved but rarely celebrated Nobel Prize.

The man’s name was August Krogh, one of the last of the great scientific potterers—that remarkable galaxy of men (yes, they were predominantly men) who poked about in numerous areas of science and, apparently effortlessly, made historic contributions in all of them. Krogh was a contemporary of the English geneticist J. B. S. Haldane, perhaps the best-known potterer of all time. While Haldane was writing major papers on enzyme kinetics, blood groups, antigen-antibody reactions, population dynamics, evolution, and other often-unrelated topics, Krogh was pioneering important work in fields such as human physiology, marine biology, nutrition, botany, cell biology, histology, and biochemistry.

August Krogh seems to have been a competent but unremarkable schoolboy at Grenaa in Jutland (now comprising the continental part of Denmark and the northern portion of Germany), and said in later life that his real education took place outside of school time. He was a dedicated boy scientist, studying insects and spiders, making novel apparatus, and spending considerable time in the field botanizing and zoologizing. After a false start, when he enlisted in the navy, he went in 1893 to study physiology under Christian Bohr at the University of Copenhagen.

Immediately, Krogh began making important, original contributions to science. While studying the way in which mosquito larvae regulate their buoyancy, as a fish uses its swim bladder, he invented a new and highly sensitive method for analyzing air bubbles. He then applied the concepts and techniques of physics to a wide variety of biological problems—including the rising of sap in plant stems, the swelling of plant cells, and changes of pressure in animal body fluids. He soon became highly critical of other biologists who lacked the knowledge, dexterity, or inclination to apply physics in biological research. Krogh was, of course, right in his criticism. To a large extent, plant and animal physiology progressed by using just the sort of methods he was then pioneering.

Krogh gained his doctorate in 1903 for research in which he established that the frog takes up oxygen mainly through the lungs, but loses carbon dioxide by diffusion through the skin. In 1905, the year he married, he became interested in a controversy then raging as to whether human respiration was an active or passive process. He devised a micro-aerotonometer to measure gaseous exchange between a single bubble of air and the blood flowing around it. Using this device, he and his wife Marie discovered that arterial oxygen pressure was always below that in alveolar air, so that simple diffusion was sufficient to account for oxygen transfer. Thus they demolished the prevailing theory—that lung cells actively secreted oxygen into the bloodstream. Until that time, the secretion theory had been supported enthusiastically by Krogh’s chief, Bohr, and in Britain by J. S. Haldane—J. B. S.’s father and an outstanding authority in the field.

Before starting this classical work, Krogh had taken time off to join a scientific expedition to northern Greenland, where he investigated the metabolism of Arctic animals. Now, having finished the research, he went back to the Isle of Disko to study the nutrition of Eskimos in relation to their metabolism. Despite the severe climate, and dismal facilities for research, he did important work and began to lay the foundations for a new experimental approach to the physiology of exercise. The methods he evolved were
adopted later for worldwide surveys by the Health Organization of the old League of Nations, forerunner of the WHO.

Polishing off the research for which he later received a Nobel prize—showing, by a unique blend of elegant experiment and ingenious mathematics, how the capillaries respond to a need for increased blood—he then moved on to a wide variety of other matters. He invented the electromagnetic bicycle ergometer for studying exercise, and a highly sensitive means of weighing the subject; the “tilting spirometer,” a uniquely sensitive apparatus for gas analysis; new techniques for observing living tissues under the microscope; histological methods; the nitrous oxide method of measuring circulation rate; equipment for measuring the osmotic pressure of human blood; a wristwatch-type “micro climatograph” measuring temperature and humidity; and an instrument for monitoring oxygen consumption by insects.

The extraordinarily polymathic Krogh was also the first researcher to suggest the “sodium pump” that carries ions across cell membranes. He discovered that living things obey van’t Hoff’s Law, used isotopes (as early as 1935) to investigate the permeability of skin in aquatic animals, established the relative amount of energy the body liberates from fat and carbohydrate, and pioneered studies on the metabolic role of insulin. Moreover, he wrote about his work in superb, economical prose.

As regards insulin, August Krogh, were he still alive today, would be fascinated to learn of successive developments over the decades in methods of producing ever more potent, safer, and more appropriate forms of the hormone for the treatment of diabetes, culminating in today’s manufacture of genetically modified human insulin in bacteria. Shortly after insulin was discovered, in 1922, he and his wife Marie obtained a small supply which they used in their own studies. Marie herself had type 2 diabetes, and one of her patients suffered from the type 1 version of the condition. Their work led to the foundation of Nordiskinsulin Laboratorium, which made the hormone by ethanol extraction from pig pancreas—at a cost lower than anywhere else in the world.

Since Krogh died in 1949, polymathic potters have largely disappeared from the science scene. Why? Blameworthy on some occasions is premature specialization at school, which can place intelligent people on tramlines of increasingly narrow and irrevocable commitment. The chemistry teacher, mindful of a school’s greater glory, impels a young pupil with good marks in chemistry towards a degree course in chemistry. The teacher does so regardless of the student’s broader aptitudes and interests, which he or she tends not to notice, and regardless of the eventual utility of a degree in chemistry. Later, an equally well-meaning tutor assumes without question that because the graduate gained a good degree, with outstanding marks in physical chemistry, this must lead to research in physical chemistry. The cycle is complete 20 years later when a career is crowned with a chair of physical chemistry.

That is part of the story. Equal blame must attach to those grant-awarding bodies, heads of research departments, and the like, who invariably suspect the polymath and interpret versatility as shallowness of mind. Predictably, they will reject as a dilettante an individual with dozens of original but variegated ideas to their credit, and take on instead the plodder or single-minded enthusiast. Funding agencies that tend to favour “mission-oriented” rather than “curiosity-oriented” programs are especially suspect from this perspective.

All this, too, at a time when everyone acknowledges the importance of multi-, inter-, and cross-disciplinary research. We need to remember the ancient aphorism that “Talent does what it can. Genius does what it must.”