Ohio Science and Technology: A 200-Year Heritage of Discovery and Innovation [1,2]

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INTRODUCTION

Ohio was carved out of the wilderness of the Old Northwest Territory two centuries ago. As we now prepare to celebrate its Statehood Bicentenery, it is fitting that the Ohio Academy of Science look back over these past 200 years to reflect on Ohio's contribution to science and technology. These contributions manifest themselves in at least four ways: 1) natural features or events of scientific interest that have helped us understand principles and processes, 2) events or developments through human endeavor that have advanced science, 3) Ohio scientists and technologists who have left their mark on the world through the practice of their profession, and 4) historic sites that recall scientific and technological achievements. This paper will attempt to explore each of these avenues of contribution. A preliminary listing of contributions in each of these categories for the 88 Ohio counties is presented in an appendix[3]. Taken together, Ohio can point with pride to the total sum of its scientific discoveries and technological accomplishments, which lend proof to the axiom, "the science of today is the technology of tomorrow."

Resource Base

The geology and physical environment of Ohio are exceedingly advantageous to human settlement, in terms of providing places for habitation, livelihood, and recreation. The glacial advances which covered all but the southeastern third of the state with ice and large glacial lakes left a legacy of relatively smooth topography and rich soils—ideal for the development of agriculture once adequate drainage had been effected. One of the most monumental engineering tasks undertaken in Ohio was draining the ancient glacial lake bottoms (Black Swamp) of northwestern Ohio in the late 1800s. To the southeast, the unglaciated Allegheny Plateau was less suited for farming but the hills and valleys supported magnificent hardwood forests. The early settlers were also blessed with a variety of natural resources that fostered primitive industries in the late 1700s and early 1800s. Through the 19th century these frontier efforts developed into productive resource-based industries, including salt extraction, clay products manufacturing, iron ore smelting and steel-making, lumbering and wood products manufacturing, limestone and sandstone quarrying, sand and gravel extraction, coal mining, oil and gas drilling, glass-making, and water supply.

Ohio is also blessed with navigable waterways on its northern and southern borders, namely Lake Erie and the Ohio River. Historically, Lake Erie has served as an important transportation artery, conveying Indian canoes, schooners, passenger steamboats, ore carriers, commercial cargo ships, fishing vessels, and all types of recreational crafts. Likewise, the Ohio River was the great highway to the West and South, carrying Indian canoes, flatboats of settlers, keelboats of traders, steamboats, and modern towboats and barges which carry enormous tonnage of coal, oil, chemicals, and other bulk cargoes (Knepper 1989). Although the state has a paucity of natural lakes within its borders, Ohio is amply supplied with a dense network of rivers and streams, approximately 70,000 km in total length. These interior waterways were important conduits for early settlements and supplied the power for the first industries (Noble and Korsok 1975).

Early Settlement Period (late-1700s to early-1800s)

The Indian Wars in Ohio were ended in 1795 with the signing of the Treaty of Greene Ville by General Anthony Wayne and scores of Indian chiefs led by Little Turtle. The Treaty established a boundary line that opened eastern and southern Ohio to white settlers. Thus began the first safe immigration into the Northwest Territory that transformed wilderness into statehood in less than 20 years. One of the first needs was a road system to serve the burgeoning but widely separated population. The first major road building project in the Ohio Territory was a trail from Wheeling, VA, to Maysville, KY, authorized by Congress in 1796. Built by Ebenezer Zane

[1]Manuscript received 4 May 1996 and in revised form 1 November 1996.

[2]PRESIDENTIAL ADDRESS—Presented at the 105th Annual Meeting of The Ohio Academy of Science held at Malone College, Canton, OH, on 4 May 1996. Dr. Charles E. Herdendorf is the Past President of The Ohio Academy of Science and Emeritus Professor of Zoology at The Ohio State University. He joined The Ohio Academy of Science in 1961, and is now a Fellow and Life member. In 1991, he was a Centennial Honoree of the Academy. For eleven years he was Geologist and Lake Erie Section Head of the Division of Geological Survey, Ohio Department of Natural Resources. During his nearly 30 years at The Ohio State University, Dr. Herdendorf was the seventh Director of the Franz Theodore Stone Laboratory at Put-in-Bay, and the founding Director of the Center for Lake Erie Area Research and the Ohio Sea Grant Program. He also served on the faculties of Zoology, Geological Sciences, and Natural Resources, teaching courses in limnology, oceanography, marine biology, and wetlands ecology. The author of numerous publications, Dr. Herdendorf's research fields include Great Lakes geology and ecology, New Zealand estuaries, and deep-ocean environments. Dr. Herdendorf received his undergraduate education at Ohio University, followed by graduate work at Ohio University, Western Reserve University, University of California-Los Angeles, University of Maryland, and The Ohio State University (Ph.D. in Zoology).

[3]Because of the extensive length of the Appendix (118 pages including 186 references) the county-by-county listing of scientific sites, personages, and accomplishments is not printed herein although segments of the appendix were presented as part of Dr. Herdendorf's presidential address. Those readers who are interested in obtaining a copy of the Appendix should contact The Ohio Academy of Science office, 1500 West Third Avenue, Suite 223, Columbus, OH 43212 (1-800-OHIO-SCI). Copies are available at $15.00 plus postage and handling.

along the course of an old buffalo trace, it soon became known as Zane's Trace. Towns such as Zanesville, Lancaster, and Chillicothe sprang up along its route. In 1809, Congress set aside $12,000 for construction of the National Road from Cumberland, MD, through central Ohio. Construction of the National Road reached Ohio in 1825 where it followed Zane's Trace to Zanesville, then west to Columbus by 1833, and finally reached the Indiana Border in 1837—the only east-west thoroughfare across Ohio connecting the eastern seaboard with the western frontier. The National Road crossed Ohio's many rivers with picturesque covered wooden truss bridges and unique stone "S" bridges. Today, there are more that 42,000 public bridges over Ohio's streams (Vonada 1992).

Development Period (mid-1800s)

Important as roads were to the development of the state, the movement of large quantities of heavy freight required a water-borne transportation system. At the urging of Governor Ethan Allen Brown, in 1825 the Ohio Legislature created the Board of Canal Commissioners to oversee construction of a canal system for the state. The Ohio-Erie Canal was the first to be built (1825-1832), stretching nearly 500 km from Cleveland on Lake Erie, up the Cuyahoga Valley to Portage Summit at Akron, down the Tuscarawas Valley to Coshocton, southwestward across Licking Summit to the vicinity of Buckeye Lake, west to Lockbourne on the south side of Columbus, and down the Scioto Valley to Portsmouth on the Ohio River. For a fare of $6.18, a canal packet boat would carry a passenger from Lake Erie to the Ohio River in 80 hours (Knepper 1976). To serve the western half of the state, another canal was constructed from Toledo to Cincinnati—the Miami-Erie Canal (1825-1845). These main canals were supplemented by many "feeder" and "cross-cut" canals which eventually reached most regions of the state. The estimated cost of the canals was enormous, $6 million, which represented about 10% of the assessed valuation of all the taxable property in the state (Hood 1969). Even though the state never recovered enough in tolls to cover the construction costs, the economic and psychological benefits to Ohio and its citizens were indeed positive. The canals moved Ohio from a poor frontier to a leading industrial state. They were responsible for growth of existing cities and the establishment of new communities. Perhaps most importantly, the canals united Ohio politically, bringing together the diverse settlements into a cosmopolitan state (Frost and Nichols 1985).

Travelers on Ohio's canals could board steamboats on the Ohio River or Lake Erie for passage to New Orleans or New York and beyond. As well as passengers, the steamers carried vast quantities of grain, livestock, and other agricultural products. These romantic vessels were already plying the Western Rivers and the Great Lakes when the canal connections were completed. The *Orleans* steamed from Pittsburgh to Marietta, Cincinnati, and on to New Orleans in 1811, while seven years later the *Walk-in-the-Water* made her maiden voyage from Buffalo to Detroit with port calls at Cleveland and Sandusky. By the mid-1800s, the steamboat era was in full swing with steamers being produced at several Lake Erie and Ohio River ports. In the 1830s, Huron was the leading American shipbuilding port for steamboats on the Great Lakes. During the first 50 years of steam navigation on the Great Lakes, no less that 250 steamboats were built in 15 Ohio ports.

Both the canals and the steamboats were ultimately surpassed by the railroads whose tracks could reach formerly isolated areas of the state. The State Legislature granted the first railroad charter to the Mad River and Lake Erie Railroad in 1832, a company from Sandusky whose citizens were angered by being left out of the canal system. The first locomotive, *The Sandusky,* arrived in September 1835, tracks were laid to fit the engine, and the gauge was adopted by the Ohio Legislature as the standard for the state (Traylor 1990). The line was eventually connected to Cincinnati via Xenia in 1846, completing a cross-state route that would compete with the Miami-Erie Canal. By the beginning of the Civil War, Ohio led the nation with nearly 5,000 km of railroad track. The locomotive's whistle was the death knell for the canals which began a decline and eventual abandonment by the end of the century. In the early railroad years there was little uniformity of equipment, but as the Civil War approached, the Erie, Pennsylvania, New York Central, and Baltimore and Ohio lines emerged as the interstate systems. These systems gave a boost to Ohio commerce and reoriented trade routes in an east-west direction as compared to the north-south canals, which had major political consequences in consolidating the North in the decades before the Civil War (Knepper 1976). A century later, Ohio possessed 29 different railroads operating 16,000 km of track, and Toledo emerged as the third largest railway center in the nation (Heald 1961).

The establishment of a state-wide, efficient transportation network was vital to the increasingly specialized and sophisticated industries of the mid-1800s, particularly at a time when technological innovations were rapidly changing the world. Improved transportation of raw materials and products made it possible for Ohio companies to expand from local markets to regional and national ones. Technological innovations, demand for high-quality iron from steam engine and machinery manufacturers, and Ohio's transportation network made the iron industry the state's most heavily capitalized and the largest non-agricultural employer. The use of steam for blowing (blast furnaces) and the replacement of charcoal by coal (particularly coke) in the smelting process increased furnace output by nearly ten-fold. Dozens of furnaces were built in the Hocking Valley, Mahoning Valley, and Hanging Rock Iron Region. By 1850 Ohio ranked second only to Pennsylvania in production from its iron furnaces (Knepper 1976). Even at this early period of specialization, the diversity of Ohio's other industries was considerable. Prominent among Ohio manufactures were all types of clay products (pottery, fine chinaware, bricks, and tile), glassware, farm machinery, paper, soap, matches, furniture, carriages and wagons, tools and hardware, and machines that were used in the manufacture of other products.

Ohio has long been known for its attention to education and for its extraordinary number of colleges and universities. The first school in the Ohio Territory was opened in Schoenbrunn (1773) by Moravian missionary David Zeisberger for Indian children. The first Ohio academy for higher education (i.e., high school) was the Muskingum Academy at Marietta (1800). Land was reserved in the Ohio Company Grant (southeastern Ohio-1787) and the Symmes Purchase (southwestern Ohio-1796) for the support of colleges. Ohio University (chartered in 1804) developed out of the former, and Miami University (chartered in 1809) out of the latter. Kenyon College at Gambier (1824) and Western Reserve College at Hudson (1826) were the first independent, church-supported colleges in the state. Other early Ohio colleges include Marietta, Oberlin, Denison, St. Francis Xavier, Wittenberg, Capital, Otterbein, Baldwin-Wallace, Heidelberg, and Ohio Wesleyan. Ohio's Morrill Act (1862) land grant college, The Ohio State University, was founded in 1870 as the Ohio Agricultural and Mechanical College. Today, Ohio has one of the largest and most comprehensive higher education systems in the United States. It includes 13 state universities, 2 state medical schools, 10 community colleges, 13 technical colleges, 24 university regional campuses, 48 independent liberal arts colleges and universities, and at least 70 specialized independent colleges. Total enrollment in these institutions is more than 500,000 students, about 80% of which are in Ohio's public colleges and universities (Vonada 1992).

Formal medical education in Ohio started with Dr. Daniel Drake's school in Cincinnati which was chartered in 1819 as the Medical College of Ohio. In its first 15 years this school graduated 239 doctors. Drake was also instrumental in establishing the Cincinnati Medical College in 1835. Samuel D. Gross, Professor of anatomy at that school, published *Elements of Pathological Anatomy* (1839), the first systematic presentation on this subject in English. In northeastern Ohio, the distinguished scientist, Jared Kirtland, joined with colleagues to found the Cleveland Medical College (1843), while in Columbus the Starling Medical College was formed (1847). Thus by 1850 the state had four medical schools with an enrollment of 518 students (Knepper 1989). During this early period Dr. John Harris also opened the nation's first dental school at Bainbridge in southwestern Ross County (1828). Elsewhere in the state other medical schools appeared from time to time, but most of them were short-lived. An impediment to medical education in the mid-1800s was the legal prohibition of dissecting human cadavers. Professional grave robbers (resurrectionists) developed a thriving "underground" trade in newly interred bodies for the medical schools. The conflict between sentiment and science was partially reconciled in 1881 when the Ohio Legislature enacted the Anatomy Law permitting unclaimed bodies from public institutions to be used as anatomical subjects, but only under the supervision of a Professor of anatomy (Knepper 1989).

Ohio was the nation's premier agricultural state at the close of the Civil War and continued to reign until the emergence of the great western farms later in the 19th century. In 1880 there were nearly 250,000 farms in Ohio, and during the last quarter of the century agriculture continued to be Ohio's single most important industry, although by 1900 the value of Ohio's manufactured products far exceeded that of agriculture. As mechanization of the farm progressed, Ohio prospered as the leading manufacturer of farm machinery until the end of the century. Inventive Ohioans produced movers, reapers, seed drills, steel plows, cultivators, binders, and steam threshing machines. Through agricultural journals, state and county fairs, and organizations such as the Grange, farmers had access to improved techniques. In the mid-1860s the Ohio Legislature took advantage of the Morrill Land Grant College Act which provided for the sale of public lands for the purpose of establishing an agricultural and engineering college from the revenue (Ohio Agricultural and Mechanical College). The 4-H movement, the Ohio Agricultural Experiment Station at Wooster (now Ohio Agricultural Research and Development Center), and the Ohio Cooperative Extension Service with agents in every Ohio county were all outgrowths of this initiative. In 1887 the Board of Trustees decided that the college would be a comprehensive one with graduate research programs in many fields rather than being confined to agriculture and engineering, thus The Ohio State University was born.

Expansion Period (late-1800s to early-1900s)

Seven factors help to explain the phenomenal expansion that took place in Ohio during this period: 1) the region's richness in natural resources and waterpower, 2) a supply of cheap labor (Ohio's population nearly doubled between 1880 and 1920), 3) creative genius and inventiveness in solving technical and engineering problems, 4) imaginative and powerful industrial leaders, 5) a coast to coast distribution network that was provided by the railroads, 6) government that supported industrial growth, and 7) willing buyers of goods and services. Among the great Ohio inventors were Charles F. Brush, Thomas A. Edison, Martin Hall, Charles F. Kettering, Thomas Midglet, Jr., and Orville and Wilber Wright, while John D. Rockefeller, Marcus A. Hanna, Samuel L. Mather, Harvey S. Firestone, and Frank A. Seiberling exemplified the entrepreneurs. This was the Industrial Revolution that gave employment to hundreds of thousands of native and foreign-born Ohioans, raised their standard of living, and provided them with a galaxy of undreamed of conveniences and luxuries (Murdock 1988).

By the 1880s Ohio's manufacturing output had reached an annual value of $350 million, more than double that for farm products. Thus, the cities became the centers of technological advances. Cincinnati was still the major metropolis, but no longer was it known as "Porkopolis" as manufacturing (clothing, leather goods, furniture, carriages, books, and malt liquor) replaced meat packing as the major industry. However, Cincinnati was not well located with respect to sources of iron ore and coke, and could not compete with other Ohio cities for iron and steel industrialism. Strategically located between the southeastern Ohio coal fields and the Lake Superior ore deposits, Cleveland emerged as the state's heavy industry giant. By 1880 its population had reached 160,000 and,

owing to the leadership of John D. Rockefeller and his associates, Cleveland had become the greatest oil-refining center in the United States and the third ranking producer of iron and steel (Roseboom and Weisenburger 1967). By the turn of the century Cleveland surpassed Cincinnati as the state's major metropolis. Following Cleveland's lead, a number of other industrial cities were spawned in the Cuyahoga and Mahoning valleys, including Akron, Canton, and Youngstown. Akron became a world leader in cereal milling and rubber products, especially when the bicycle craze of the 1890s put Americans on rubber-tired wheels. During this period, industrial expansion was also profound in Dayton, Columbus, Toledo, and many other smaller cities in the state.

Ohio's industrial life flourished during this period because of its leadership role in several of the major growth industries of the time: 1) steel, 2) oil, 3) machinery, 4) automobiles, 5) rubber, 6) glass, 7) business machines, 8) agricultural implements, 9) paper, and 10) soap. Because new technology developed within the state had placed Ohio on the "ground floor" of these industries, its plants were new and process efficient, thus a competitive edge was assured. Cleveland profited most from this industrial expansion, particularly because of its position as a port on the Great Lakes waterway, its service by trunk-line railroads, and its nearness to raw materials (coal, limestone, and oil). Likewise, lake shipping and shipbuilding brought prosperity to a host of port towns such as Conneaut, Ashtabula, Fairport Harbor, Lorain, Huron, Sandusky, and Toledo.

Scientific initiatives in the early period of Ohio statehood came from a small but distinguished group of investigators (e.g., Daniel Drake, Jared Kirtland, Lucas Sullivant, and Charles Whittlesey) who had been born and educated in the East, and who brought their training and skills with them when they migrated to Ohio. By the late 19th century Ohio-born researchers were making significant scientific and technological advances in many fields. A large measure of these advances led to processes that kept Ohio in the vanguard of industrial development (Knepper 1989). At the same time, support for scientific and technical work was becoming more institutionalized as Ohio colleges and universities developed strong laboratories in the physical and natural sciences and established robust engineering curricula. For example, Albert A. Michelson, Professor of physics at the Case School of Applied Science and the first American to win the Noble Prize in physics (1907), teamed up with Edward W. Morley, Professor of chemistry at Western Reserve University, to conduct experiments that showed that the speed of light is unaffected by movements of the Earth through space (1887), disproving the "space ether concept" and paving the way for Albert Einstein's Theory of Relativity (1905). The pioneering work performed by this pair has come to be known as the Michelson-Morley experiments. Michelson was also the first scientist to accurately determine the speed of light (1881; revised in 1930), values that stood for nearly 90 years (Goetz 1991).

The Engineering Experiment Station at The Ohio State University was established in 1913 by the Ohio Legislature, "to make technical investigations and supply engineering data which will tend to increase the economy, efficiency, and safety of manufacturing, mineral, transportation, and other engineering and industrial enterprises of the state, and to promote the conservation and utilization of its resources." The Experiment Station carried out research associated with the development of the state's natural resources, sponsored by industry and government. In addition to the specialized equipment in the Station proper, the facilities of many science and engineering laboratories in campus departments were used to conduct research and testing projects (Smith 1950). In 1937 The Ohio State University established the Research Foundation to organize and administer research contracts sponsored by industry and government. The Foundation has been a significant factor in promoting close cooperation between the University and industrial sponsors, both in the training of students and in the furnishing of mutually valuable research service.

Modern Period (mid-1900s to late-1900s)

The second half of the 20th century saw widespread activity in scientific research within Ohio and reflected the state's progressive nature. The sites of this activity were the laboratories of industry, government agencies, private institutions, and the numerous colleges and universities within the state. By 1950 there were approximately 300 industrial research laboratories in the state, employing more than 33,000 persons. The distribution of the laboratories was Cleveland: 75; Cincinnati: 34; Toledo: 23; Columbus: 19; Akron: 17; Dayton: 17; and the remainder scattered throughout other industrial areas of the state (Smith 1950). Most were involved in chemical or metallurgical research, but other important fields of interest included research in food, rubber, ceramics, textiles, petroleum, agriculture, paper, fuels, aeronautics, graphic arts, mechanics, and electrical engineering. In 1950, based on membership in learned societies, the center of population for American scientists and technologists was a point in southwestern Ohio. By the middle of the century Battelle Memorial Institute in Columbus (a private, non-profit research center) had amassed a staff of 1,300 technologists who were conducting research in all phases of industrial science: including physics, chemistry, chemical engineering, agricultural engineering, graphic arts technology, fuels and combustion, ceramic technology, metallurgy, and related fields. Battelle played an important role in encouraging both large and small industries, as well as the government, to undertake applied research.

In addition to the Ohio Agricultural Research Station at Wooster and the Engineering Experiment Station and Research Foundation on the Columbus Campus of The Ohio State University, the mid-1900s saw many other Ohio institutions of higher learning engaged in important scientific and industrial research. The University of Toledo Research Foundation, founded in 1945, focused on studies for small industries in northwestern Ohio, particularly problems in food technology, sanitation, plastics, glass, organic chemistry, fuels, metallurgy,

and automotive engineering. Other university research centers at the time included several departments at the Case Institute of Technology; the Basic Science Research Laboratory of the University of Cincinnati; the Charles F. Kettering Foundation for the Study of Chlorophyll and Photosynthesis of Antioch College at Yellow Springs; the Bureau of Business Research at The Ohio State University; the Scripps Foundation for Research in Population Problems at Miami University; and the Franz Theodore Stone Institute of Hydrobiology of The Ohio State University at Put-in-Bay where research on the ecology of Lake Erie contributed much to the fisheries industry.

During and following World War II a number of large centers for governmental research were located in Ohio. The National Advisory Committee for Aeronautics (destined to become NASA) established one of its three laboratories in Cleveland (today's Lewis Research Center). Research at this laboratory specialized in airplane engines and propulsion problems. Early projects dealt with the probable performance of aircraft engines using nuclear energy. The Wright-Patterson Air Force Base, near Dayton, became the headquarters for the Air Materials Command and sustained large research programs in materials science and engineering. The US Atomic Energy Commission constructed laboratories at Miamisburg and Marion, both operated by the Monsanto Chemical Company. Additional research was also conducted at Battelle and The Ohio State University where a research reactor was constructed. The Taft Sanitary Engineering Center, operated by the Division of Sanitary Engineering, Office of the Surgeon General, was established at Cincinnati as a national center for the study of steam pollution. Government sponsored medical research was conducted at the state's major medical schools (The Ohio State University, Western Reserve University, and University of Cincinnati), including problems in clinical medicine, medical biology, and preventive medicine.

Ohio's industrial growth, as well as that of the entire nation, has always been closely linked to scientific and technological advancement. Ohio is a case study of how technological improvement fostered more sophisticated manufacturing processes and products. Recognizing this relationship, in 1985 the Ohio Legislature enacted a number of programs which subsidized cooperative research activities between industry and the state's academic community. One example of this effort combines the research capabilities of the University of Akron, Case Western Reserve University, and northeast Ohio industry in a program designed to make the Cuyahoga River Valley a "Polymer Valley" which would attract new industries to the region (Knepper 1989). Similar cooperative ventures are being experimented with throughout the state and point to the importance of a broad-based scientific research capability as Ohio industry evolves in the 21st century.

CONCLUSIONS

After delving into the record of Ohio's scientific contributions it became obvious that a corollary, or perhaps the converse, to this paper's focus was also true and deeply intertwined. As one views Ohio's scientific contributions it is clear that science has contributed greatly to the development of the state. Ohio's initial growth and development was based on the proximity of natural resources. As further development and regional expansion took place, transportation and communication networks became more important.

In his presidential address to the Ohio Academy of Science, Dr. Richard W. Janson noted that nearness to raw materials is of lesser importance than in the past because of major strides in transportation and distribution networks (Janson 1994). Thus, manufacturing facilities in the future will be more directly oriented on the basis of market information, intellectual property, and new technologies. For Ohio this means that increased, or even sustained, prosperity is inexorably linked to value that can be added to products produced in the state (value added by manufacturing: the difference between the cost of raw materials, plus their processing costs, and the cost of the finished product). In a competitive world, plants will readily relocate and firms will continually invest in new regions to take advantage of new markets or to gain access to better technology. Ohio must recognize that a strong, scientifically based research and development investment will lead to the technological innovations of the future. Recently, Dr. Janson stated, "We are a science-based economy. Science discoveries led to industrialism. There is not one company [in Ohio] that doesn't depend on science. Science-based innovations produce better products more economically," (*North Canton Free Press*, 26 November 1995).

The challenge for Ohio is clear—a renewed commitment to science education and increased support for technology development. However, in our present mode of "downsizing" it is difficult to initiate compelling new programs in science education and to find support for innovative ways of fostering technology development. If anything, the history of Ohio's proud science heritage has taught us that support of research will lead to new prosperity in the state's third century. In our present time of intense competition for resources, one thing that is sorely needed is a central planning effort for science and technology initiatives—a rallying point for debate, resolution, and implementation. I would envision the Ohio Academy of Science as a key player in reaching this goal.

LITERATURE CITED

Frost, S. L. and W. S. Nichols 1985 Ohio Water Firsts. Water Management Association of Ohio, Columbus, OH.

Goetz, P. W. (ed.) 1991 The New Encyclopaedia Britannica. Encyclopaedia Britannica Inc., Chicago, IL.

Heald, W. F. 1961 Ohio. *In*: J. M. Moore (ed.), Moore's Who Is Who in Ohio 1961. Moore's Who Is Who Publ., Los Angeles, CA. pp. 1-19.

Hood, M. G. 1969 Ohio Canal: 1825-1913. Ohio Historical Soc., Columbus, OH.

Janson, R. W. 1994 Interregional trade: Adjunct to innovation. Ohio J. Sci. 94(5): 124-133.

Knepper, G. W. 1976 An Ohio Portrait. Ohio Historical Soc., Columbus, OH.

___ 1989 Ohio and its People. Kent State University Press, Kent, OH.

Murdock, E. C. 1988 The Buckeye Empire: An Illustrated History of Ohio Enterprise. Windsor Publ., Northridge, CA.

Noble, A. G. and A. J. Korsok 1975 Ohio–An American Heartland. Ohio Dept. Natural Resources, Div. Geological Survey Bull. 65.
Roseboom, E. H. and F. P. Weisenburger 1967 A History of Ohio, 2nd Ed. Ohio Historical Soc., Columbus, OH.
Smith, G. H. (ed.) 1950 Ohio: An Empire within an Empire. Ohio Development and Publicity Commission, Columbus, OH.
Traylor, J. 1990 Ohio Pride: A Guide to Ohio Roadside History. Backroads Chronicles, Columbus, OH.
Vonada, D. 1992 The Ohio Almanac. Orange Frazer Press, Wilmington, OH.

ANNOUNCEMENT OF NOMINATIONS FOR THE HERBERT OSBORN AWARD

The Ohio Biological Survey is soliciting nominations for the 1997 Herbert Osborn Award. This annual award honors the founder of the Ohio Biological Survey and recognizes noteworthy accomplishments and service in the field of biology relating to the objectives of the Survey. Past recipients are Dr. J. Arthur Herrick, Dr. Henri Siebert, Dr. Charles King, Dr. Tom Cooperrider, Dr. Warren Wistendahl, and Dr. John Olive.

Nominations for the 1997 Award may include a listing of worthy achievements, bibliographies (when appropriate), and additional relevant information. The nomination should not exceed five pages.

The deadline for nominations is February 15, 1997. Send nominations to Professor Carl Hoagstrom, Chair, Osborn Award, Department of Biological Sciences, Ohio Northern University, Ada, Ohio 45810.