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I am fortunate indeed to be able to discuss with you, in juxtaposition, two of my greatest interests – science and the state of Minnesota. Although my experience in the latter (six years) is but a small fraction of my exposure to the former, it is obvious to me that the future of Minnesota will be determined to a marked degree by how well she can nurture and utilize science and technology. In a recent statement, Mr. J. Cameron Thomson, President of the Upper Midwest Research and Development Council, said, "The Upper Midwest Council determined early that the region's best opportunity for growth lay in concentrating on increased employment in the major growth industries, such as the scientific-technological field, and placing itself in a position to provide the skills required for those industries."

Such a conclusion, based upon economic research, must be of great interest to this audience and I wish to discuss with you some of its implications regarding the responsibilities and the future of Minnesota science. The Minnesota Academy of Science can and must play an important role in this future, representing as it does a very broad base of science teaching and utilization in the state.

As the trend from agriculture to urbanization continues throughout the country, Minnesota, along with other farm-oriented states, faces a major adjustment to a more manufacturing-oriented economy. Whereas, in 1950, about 23% of the Minnesota labor force was on the farm, today that percentage is estimated at about 12. This compares with a national average of about 5.5% During the 1950-60 decade, Minnesota farmers and farm labor decreased by 35%, but the labor force in manufacturing did not correspondingly increase. Instead, the increase went to clerical and service workers with a surprising 37% increase in professional and technical categories.

The point here is that Minnesota heavy manufacturing has not been increasing and by all predictions cannot be expected to increase substantially in the future. We are simply at a disadvantage in transportation, climate, and natural resources, insofar as heavy industry is concerned. Personally, I feel that this is perhaps fortunate since it confronts us with the necessity of developing along more sophisticated lines, which, in the final analysis, will keep this state a more desirable place in which to live.

But the development of sophisticated science-based and of advanced technologically-oriented industry is not an easy accomplishment. We are not alone in wishing to proceed along these lines. In fact, many other areas are proceeding along exactly these lines and for exactly the same reasons. In a recent issue of *Industrial Research*, Mr. Victor Danilov stated,

> Everywhere you turn, there are advertisements, brochures and signs proclaiming the merits of some area and offering sites for sale or lease. The juciest plum in this ever-widening competition is the research laboratory or science-oriented industry. In addition to the economic benefits they offer, science-based activities generally are nuisance free, more stable, staffed by professionals, and a decided advantage in attracting other laboratories and industries to the community.

Attempts to attract science-based industry take many forms. Many areas are establishing nonprofit research institutes. Recent additions to the growing list of such organizations are the Houston Research Institute, the Spindletop Research Institute in Kentucky, the Alabama Research Institute, the North Carolina Research Triangle Institute, and our own North Star Research and Development Institute. It is estimated that there are at least 91 research or industrial parks with scientific emphasis. A number of localities are offering strong tax inducements to new industry. These readily pay off in terms of financial benefit. The United States Chamber of Commerce estimates that a new plant, office or laboratory with 100 jobs brings to a community 100 households, 359 people, $710,000 in annual spending power, $331,000 in retail sales, and $229,000 in bank deposits. So the competition is going to be tough! In New York State, there are 1100 research laboratories with 30,000 scientists and engineers. In New Jersey, 625 laboratories with 23,000 scientists and engineers; in Illinois there are 500 laboratories with 25,000 scientists and engineers. These are impressive numbers and, from our standpoint, a little overwhelming.

Unfortunately, these commanding leads in science-orientation are difficult to overcome. For instance, the large recipients of funds for government research are Massachusetts, California, New York and Illinois, where there are already high concentrations of laboratories and scientists. Production contracts frequently follow the research contracts, and Minnesota finds herself a bit off the main stream in both.

The location of new government research laboratories

is another item of concern. Unfortunately, national security has been frequently sacrificed in favor of political expediency – as witness the outrageous concentration of government research in the Boston metropolitan area. However, no amount of political expediency can justify locating government laboratories in scientifically impoverished areas, and Boston is unquestionably a prime choice from the standpoint of scientific culture.

There is much that Minnesota can do to raise the level of her scientific culture. Perhaps our greatest asset is the University of Minnesota. This is a great university, but it can and must become greater since great universities are perhaps the most important single factor contributing to the desired scientific culture we must attain. Faculty salaries, while much improved, are still not entirely competitive. A recent bulletin issued by the University of Minnesota Alumni Association points out that of the Big Ten Universities, plus Chicago and California, Minnesota ranks tenth in salaries paid to full professors, eleventh in salaries paid associate professors, and at the bottom of the rung in salaries paid assistant professors and instructors. Since the eminence of a university depends upon its faculty, we cannot afford to risk losing our eminent professors to more affluent schools. In research volume, our university is in a middle position. Of the approximately $2 billion of research conducted or managed by academic institutions, our university conducts about $20 million. This compares with $29 million for Wisconsin, $40 million for Michigan, $130 million for Chicago, and $300 million for California. The latter two, of course, operate large research facilities for the Government. The "in house" research at Chicago is about $45 million. Among Big Ten universities, Minnesota ranks fourth in volume of research conducted. In common with most other universities, the great bulk of Minnesota's research funds come from the Federal Government – 78%. The University reports that all its 1400 research projects are basic in nature.

As a fundamental point of self-preservation and state progress, all Minnesotans should adopt the philosophy of making our university predominant in all areas but, especially, eminent in science and engineering. With special attention from the legislature, industry, organized labor, and all residents, this can be accomplished.

I have sometimes heard it said that Minnesota wastes money educating scientists since most of them leave the state for more lucrative outside opportunities. This so-called "brain drain" is viewed with alarm. While it is true that there may be a net outward migration of scientists and engineers from Minnesota, it is equally true that many scientists and engineers do move to Minnesota from other areas. For example, of the 157 scientists and engineers hired by my company for research positions in Minnesota within the last five years, 108 or 69% received their last degree in academic institutions outside Minnesota, and 91 or 58% had never lived in Minnesota prior to coming here for scientific or engineering work.

Another basic element of a state's scientific "culture" is the number, type and nature of its industrial-research laboratories. Minnesota is fortunate that a substantial number of its home-founded companies have grown to major national dimensions. Fortunately, although operating world-wide, these companies have chosen to keep all or much of their research in Minnesota. A recent series of articles by Harold Chucker, business news editor of the *Star and Tribune* revealed the following impressive facts:

1) 3M spent more than $35 million last year on R & D.
2) Honeywell spends $100 million per year on research and 1 in 5 of its employees is engaged in research.
3) Control Data spent $12 million or 10% of sales on research last year and expects to spend over $15 million this year. CD has more than 2,000 people engaged in R and D work, including an 8 million dollar government research program.
4) In the past 10 years Pillsbury has doubled the number of its research personnel and quadrupled the number with doctor of philosophy degrees. Its present research staff exceeds 250.
5) Cargill spends 8 to 10% of its pre-tax earnings on research.
6) General Mills spends $7 million per year to support the research program of about 600 scientists, engineers and technicians.
7) Archer Daniels Midland Co., spent nearly $2.5 million to support the research and engineering activities of its 200 research personnel.
8) International Milling Co., spends more than $1 million per year on research.
9) Economics Laboratory, Inc. has a research staff of more than 125 technical employees.

Altogether, I would estimate that these nine Minnesota founded and nurtured companies are now spending upwards of *$170 million* per year on research and development. This suggests that somewhere in the vicinity of 6000 scientists and engineers are employed in research by these nine companies. In addition, there are a number of other companies conducting industrial-research programs, e.g. Univac, Gould-National Batteries, Donaldson Co., Inc., Rosemount Engineering Co., G. T. Schjeldahl Company, and others.

Another important potential contributor to the science culture of Minnesota is the North Star Research and Development Institute. This project of the Upper Midwest Research and Development Council and the University of Minnesota is soundly financed, well managed, and of great future importance to Minnesota.

Summarizing what I have said to this point, I believe that Minnesota has many valuable assets that contribute positively to the kind of science culture that encourages science-based industry. However, we have no cause for complacency. There are others much bigger and perhaps better, making our task difficult and demanding.

In this environment and with these objectives one might well ask in what ways the Minnesota Academy of Science can contribute constructively to the State's science culture.

Just last week I was privileged to attend a conference at Wingspread, near Racine, Wisconsin, sponsored by the Upper Midwest Research and Development Council. Among the 80 persons present were representatives

of industry, education, and business from the ninth Federal Reserve district which comprises Montana, North Dakota, South Dakota, Minnesota, and parts of Michigan and Wisconsin. Included in the conference were three university presidents, many corporation executives, and many business and education leaders. Minnesota was amply represented since the Twin Cities area represents the economic "hub" of the region. During the conference, attention was focused upon the economic development of the region and problems that must be met in order for this region to grow in economic stature in the nation. The problems are formidable but can be solved if all concerned work intensively to do so. The general areas that have been studied by the Council and in which action programs were considered were agriculture, urban problems, industrial development, and education. I was particularly impressed by the central position of education in all areas considered. The so-called "culture" of the region can be developed along lines attractive to industry only if the education function is adequately furthered. This means proper consideration for elementary, secondary, technological, and higher education. In spite of recent progress there are still seven counties in Minnesota where less than one-half the adult population has achieved a high-school diploma. Many of our rural-area high schools are far below minimum size for efficient and adequate instruction. We can derive small comfort from the fact that Montana and the Dakotas have an even greater problem in this regard. This generally adverse situation existing in the less populated areas of our state is even more unfavorable insofar as science teaching is concerned.

Several years ago, the Minnesota Board of Education proposed, on a trial basis, a compulsory one-year science requirement for all high school students. This imposed such severe problems upon the smaller schools that after a short period the proposed requirement was abandoned. The Minnesota Academy of Science strongly urged the State Board to adopt the science requirement but could not prevail against the arguments of several organized teacher groups who were unwilling to face up to the problems involved. I would say that with that action Minnesota science culture lost some ground, and it is up to the Academy to continue its efforts to improve the stature of science training at the secondary school level. Hopefully, current advances in closed-circuit television and the new exciting telephone systems being developed can bring high level science training to all high schools at acceptable costs.

There are a variety of ways in which the Academy can continue to improve Minnesota's science culture. In many ways, it is currently contributing to the improvement of science teaching. Since a greater science culture is now a recognized economic asset to the future growth of the state, it seems to me that the Academy could well capitalize upon the current favorable climate and intensify its program of service to science teaching. For example, I wonder if the program of the Upper Midwest Research and Development Council, which has achieved national recognition and stature, could not be used as a powerful argument with the State legislature and with Federal agencies, such as the National Science Foundation, for increased funds for the Academy to carry on its many worthwhile programs.

The Minnesota Academy occupies a unique position in Minnesota science. It is, so far as I know, the only multidiscipline scientific society that effectively brings together all levels of Minnesota science. In the Academy we have those responsible for secondary-school science teaching, those responsible for college-level teaching and research, and a wide range of industrial and non-profit institutional scientists. Surely this association of eminent and dedicated scientists can do much to further the statewide objective of improved economic strength based upon science-oriented industry.

One function of the Minnesota Academy, which would appear to be in a particularly advantageous position, is the Industry-Education Board which is now functioning as a permanent committee of the Academy. The Industry-Education Board has sponsored several industry-education conferences, the most recent one at Moorhead two years ago. Additionally, the Board has supported other programs designed to improve liaison between the academic and industrial scientific communities and to further the science culture in the state. I believe that this Board can effectively support the action programs of the Upper Midwest Research and Development Council, and can in turn, be aided by the economic research programs of the Council. Perhaps the Board can serve the Council also in an advisory capacity representing, as it does, both the industrial and academic segments which are vital to successful development of science-based industry.

Another important Minnesota Academy contribution to the science culture of the state, is in stimulating interest in science careers among the youth. The Science Fair is a most worthwhile program in this regard, as is the Junior Academy itself. In spite of the tremendous opportunities awaiting the science graduate, enrollments in science and engineering courses are falling behind increases in the humanities and social sciences. This means that students are not being made sufficiently aware of those opportunities and many potentially great scientists are being lost to science. In particular, I think our young people need to understand that it does not require an I.Q. of 150 to be successful in science or engineering. Unfortunately, the popular press tends to glamorize the long-haired scientists who design computers, rockets and atomic devices. There is a somewhat more prosaic area of science to which properly-motivated average students can contribute, and no student who is willing to work need steer away from science and engineering courses because he fears their complexity. We generally regard as highly complicated things we know very little about. The Academy can do much to familiarize young students with the various scientific disciplines and the career opportunities existing in each.

Earlier in this discussion, I pointed out the extreme competition throughout the country for science-based industry. Minnesota has some advantages and some

disadvantages in this competition. If we are to be successful in improving our position, we must use all of our contributing assets to the greatest extent possible. This means building an even greater university and continuing support for the State's many fine colleges. It means broader and better science training at the secondary school level. It means greater participation and interest from our large and competent group of industrial scientists. It means a critical reexamination by the State Legislature of our industrial tax climate, and it means a great deal of selling by all of us of the merits of our State for science-based industry and for greater allocation of the Federal research and procurement dollar. Our "balance of trade" with the Federal government is unfavorable or at least it was in 1960. In that year, Minnesota paid $140 million more in taxes to the Federal Government than was received from the Federal Government in the form of expenditures. In California, Massachusetts and Texas there was a large and significant balance of Federal Government expenditures in excess of payments. One sure way to improve our balance of trade is to develop our scientific and technological eminence to a stature demanding greater consideration. To that end, the Minnesota Academy of Science can contribute much.

Learned Societies Around the World

Austria

Austrian Academy of Sciences and Letters (Osterreichische Akademie der Wissenshaften) in Vienna. Founded 1847. Two divisions: (a) mathematics and natural sciences; (b) historical-philosophical sciences. Members: eminent Austrian and foreign scientists and scholars. Austrians (university professors) may become full members; foreigners may be accepted only as corresponding members. Academy of Sciences maintains the Institute of Radium Research and Nuclear Physics (Institut fur Radium-forschung und Kernphysik) of the University of Vienna, as well as the Biological Station (Biologische Station) at Lunz and the Research Institute of Balneology (Balneologisches Forschungsinstitut) at Badgastein. Publications: Annual almanac, bulletin, proceedings of meetings, various memoranda, and scientific journals.

Emergency Association of Austrian Scientific Societies (Notring der Wissenschaftlichen Verbande Osterreichs) is the central organization of more than 140 scientific organizations. As an organization of mutual assistance for Austrian science and learning, it finances individual research workers and research projects by subsidies derived mainly from public funds.

Belgium

Royal Belgian Academy of Sciences, Arts and Fine Arts (Académie royale des sciences, des lettres et des beaux-arts de Belgique). Founded 1772. Two divisions: (a) natural sciences; and (2) fine arts. Owns large library. Publications: Bulletin, memoranda, and yearbook.

Royal Flemish Academy of Belgium for Sciences, Arts and Fine Arts (Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van Belgie). Publications: Reports, memoranda, and yearbook.

Further specialized academies and societies (some of distinguished reputation) which issue a large number of publications.

Canada

Royal Society of Canada, in Ottawa. Founded 1882. Divided into English-speaking and French-speaking sections for arts and social sciences, as well as natural science section. Members: most distinguished Canadian scientists and scholars.

Royal Canadian Academy of Arts, in Toronto. Founded 1880. Promotes and sponsors the fine arts.

Number of specialized societies that publish periodicals and journals.