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Alaska Science Conference: Dr. H. Bentley Glass

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A man's voice jokes about University of Alaska Fairbanks' reindeer that were let out and it's not sure if they have been retrieved. The guests are served reindeer soup. He wonders if the good attendance is caused by the reindeer stew.

He introduces people at the table: Al George is mentioned, he says that the president of AAAS [American Association of Advancement of Science] is not present but in his place there's the administrative assistant of Division of Social, Economic and Government Research, Jim Scott. Then there's Irma Duncan, a research chemist from Arctic Health Research Laboratory; [unclear] executive director of Alaska Legal Services Corporation of Anchorage, William A. Jacobs; the conference chairman Victor Fisher who is the director of their research institute; John Borbridge Jr., president of the Central Council of Tlingit and Haida Indians of Alaska; president of the center for community change in Washington D.C., Mr. Jack Conway; George Rogers from Institute of Social, Economic and Government Research of UAF; Ms. Susan [Unclear], the executive secretary of [unclear]; and Professor Norman Chance from Department of Anthropology University of Connecticut; Mr. Richard Hill from Inuvik Research Laboratory from Northwest Territories. Mr. Hill has [unclear] immediate past president of Alaska Division of the AAAS.

5:44 As [unclear] to the conferences of that sort, the chairman has a few announcements to make, and the speaker asks Mr. Fischer to speak. Fischer announces a meeting of AAAS that will be held even if some of the proceedings are still going on. They have [unclear] the president of American Association of Advancement of Science. It's a national organization. To the best of Fisher's knowledge, that's the first time they have had the president of AAAS at a meeting of Alaska division.

Dr. Bentley Glass, the president of AAAS, is here today and will be a luncheon speaker. He's a distinguished biologist and an academic vice president of the state university of New York at Stonybrook, NY. He's been in numerous international scientific committees. He's the past president of American association of University Professors. He's in the American Association of Naturalists, American Institute of Biological Sciences, Biological Abstracts, and American Society of Human Genetics, and he has produced over 200 published articles. He welcomes Bentley Glass to speak.

9:18 Glass thanks President Wood and addresses the audience. He says that the conference in Alaska is one of the best AAAS meetings he's ever attended. In April of "this year" the AAAS got together to have a small meeting in Colorado, to which a dozen people from each of the associations were invited and there were about a dozen people representing other associations and nations. The subject of the conference was science in the future and the purpose was to discuss what kind of work AAAS was going to do in the world.

11:03 Glass was asked to introduce the conference and he did so by reversing the theme of the conference, and he is doing that by talking about future of science. He is going to summarize his paper to the audience.

What the previous lunch's speaker said about the exponential change in society and in science itself, present the theme from which Glass's presentation will take off. The overwhelming growth of science during the century, and the dramatic changes in technology have produced changes in all aspects of the life of modern man. Some of the changes have happened in higher education, which worries the educators.

Glass will briefly sketch the growth of science during the past century and a half because he thinks that looking at past trends is important for understanding the future.

There have been some limiting factors that are now coming to play, and there's urgent need for technological assessment and the intimate relation between science in 21st Century and the nature of society in education at that time.

13:33 In 1820, Europe was recovering from Napoleonic debacle and in America, Louisiana was purchased and USA was worried about limiting European influence. [The state of India, Australia and Africa are presented.] Travel was scarcely more frequent than in Roman times, and it was still largely dependent on horses and sailing boats. It took 6 days to travel from New York to Washington and a letter that was carried by postal relays took 3 days.

The first railroads were being built in England but the steam locomotives were in their infancy. Stagecoach was, at the time, as fast and as economical. Highways were as bad as in Roman times. First steamship crossed the ocean in 1819, and it only used auxiliary steam power and portable paddles to use in addition to sails, and it took 29 days and 11 hours for the crossing, while an all-wooden sailing ship required only 20 days and the record was 13 days and 11 hours. There was no telegraph, telephone, or radio.

16:56 Except for the early steam engines, the sources of power hadn't changed from the ancient times. There was no electric power or lighting, and illumination at night was reliant on natural oils, olive oil and whale oil. Household heating was shifting from coal and wood fire to use of more efficient iron stoves. Sanitation was not better than in Roman times, and possibly even worse.

There was high infant mortality and frequent epidemics but germs or parasites hadn't been found yet. Malaria wasn't associated with mosquitoes or plague with rats and fleas. Only avoiding direct contact with people with disease was recognized as important. Nutritional deficiencies often went unnoticed although the importance of having fresh fruit for prevention of scurvy in sailors was discovered.

In Spain, the average life-expectancy was under 30 years and in England and in USA it was under 40 years. There was no immunization except for an immunization against small pox, surgery was performed without anesthesia, and most operations were followed by infections and death due to lack of antiseptics. The population of the world was about 1 billion persons and it was rapidly growing in Europe.

18:38 The science was limited to Western Europe with minor participation from Russia, United States and elsewhere. There were perhaps 1,000 people in the world who thought of themselves as natural scientists. There were no major scientific journals.

He might have also chosen the year 1920 to illustrate that the change is exponential. In many ways, the year 1920 is more similar to 1820 than to year 1970.

Thinking about world population, it has risen from 1 billion in 1820 to 1.8 billion in 1920, and in 1970, it was 3.6 billion people. The average life expectancy has also grown in United States. The gains represent rise in the use of antibiotics and other drugs, and better nutrition that has reduced infant and childhood mortality.

21:18 They could compare transportation, entertainment and lots of other aspects of modern life in 1920 to that of 1970, and it’s hard to realize that only 50 years before, they had no commercial airplane travel anywhere in the world, no reliable long distance telephone service, radio broadcasts, movies, or television. The increase in science and technological work has also been exponential but with even faster rate than the growth of population or the increase in life expectancy.

The number of scientific journals has increased by a factor of 10 every half century from 1750s to present times. As Derek [Unclear] from Yale University noted, abstract journals came into existence in about 1830 when the number of journals reached 300 and it was no longer feasible for polymaths to read and digest them all, and hence summaries became important. Since that date, the number of abstracts in a journal has followed the same rules of increase as primary journals, a 10-fold increase in every half a century.

23:14 The increases in scientific journals reflects the number of scientific papers that present results of original research. It is probable that at least 600, 000 papers that report original research are published each year. This reflects the number of working scientists in any given time. For every 3 or 3.5 papers, there’s one scientist. Scientists have also been exponentially growing in numbers in past 150 years. The number of scientists, engineers and technicians doubles every 13 years.

The professional category of scientists, technologists now constitute 20% of the entire professional group in the labor force. There will be an upper limit to those numbers.

27:35 In United States, the population is doubling in approximately 70 year intervals, while scientists and technologists double at more exponential rate. The total population must stabilize in near decades.

The proportion of scientists in labor force indicates growth in science, but there seems to be a limit. A college education is seen as minimum requirement and very few people who fall in the lower half of the normal distribution of intelligence have sufficient capability to successfully complete a college class. They may set a limit for professional competence to include a limit of 50% of the total labor force.

At present rate of expansion, the professional and technical group has slowly increased from 2.8% of the total labor force in 1870 to over 11% at the present time. Even an increase of 20% in professional persons in 1971 to 1980 would permit only a 75% increase in the numbers of scientists and technologists. The examination of statistics shows clearly that the present increase in growth of science can't continue but for very few additional years, perhaps a decade. Exponential growth must halt.

30:00 Relative rapid increases in a number of scientists must soon end but the absolute numbers will still be great. It must keep pace with the total increase of population that is likely to reach a saturation point.

The nations that are most highly developed technologically are quite dependent on their economy upon improvement of technology, at rate of 6-7% a year. The growth in technology is dependent on increases in their scientific understanding and basic knowledge and if that ceases to grow, there's the question of if the economy will continue to grow at 6-7% per year.

Research costs are increasing far more rapidly than scientific manpower or productivity. They must cope with inflation and problems of increasing economy and with the increasing cost of expensive equipment that scientists must use if they want to work at the forefront of knowledge.

32:04 Some spokesmen of science have optimistically advocated for 15% increase annually in support of basic science. Such people should do their arithmetics better but such an increase is in exponential rate, and 15% increase can't continue for more than a few doubling times of 4.7 years without consuming the entire GNP. The 2 billion dollars of annual support for basic science in USA would in 24 years, with 15% yearly increase, equal the present defense budget, Vietnam War included. What seems to be needed, and what is lacking in present science policy, is a full-scale study of the relation of growth in science to technological improvement to population size and rate of population increase.

Studies of population growth are one of exponential growth with saturation. Inevitably, in the world of finite space and resources, population growth is eventually curtailed. Several types of scenarios may follow: The [unclear] rate might be maintained indefinitely, provided that limiting conditions restrict further increases. More commonly, there's negative feedback from presence of maximum numbers. In a limited space, the waste products tend to accumulate and have toxic effects on population, which will lead to decrease in population.

35:04 The growth of science behaves like a growing population of animals or micro-organisms, and there are 5 limiting factors that are worthy of study.

The first of the factors is the sheer volume of scientific information. For a scientist to be informed about even his own special field is almost impossible. Glass has been informed that many Soviet scientists spend ½ of each day studying literature. Phenomenal speed reader can cover as many as 50 articles in ½ day especially with abstracts and in a year, one could cover 12,500 articles. That's barely 10^{th} of the amount of articles in biology or chemistry and less than the output in most active specialties in the fields.

Most American scientists are at the opposite extreme. They surrender to the impossible and no longer read very much even in their own fields of work. They scan journals and read an occasional article in full, but for the most part, they rely on word-of-mouth and hence there are invisible colleges that meet annually and in which the membership is informal but open only to the elect. Their special purpose is to enable free discussion.

37:42 One of Glass' own study from 1958 showed that in all academic fields, scientists learned about important papers through hearsay or through chance. The invisible college is one of exclusion. The accustomed channels of publication are too slow and too gorged with old and new information to be used effectively. They are drowning in a sea of paper.

The second limiting factor in growth of science is closely allied to first one, and that is the increasing specialization of scientists who have to increasingly concentrate on a manageable area if they want to understand it sufficiently in order to carry on further successful investigation. That tendency has long been noted and it has become intensified as the number of scientists increases.

Francis Bacon divided scientists into two classes: The pioneers who dig and mine, and the smiths who refine and hammer. In 20th Century, they have produced enormous number of pioneers but very few smiths. Yet, the smiths construct the great unifying theories such as the periodic table or the electromagnetic theory and so on. It is well-recognized that most scientific breakthroughs come about when the techniques and concepts of differing fields are brought together. The increasing narrowness of specialization can reduce the probability of that happening.

Too many scientists can only see straight ahead in their narrow fields. The scientists might have to look at what has been previously discovered.

40:53 The third limiting factor is the rapid rate of educational obsolescence which is imposed upon the people by scientific and technological change. In about 8 years, the education in science must be thoroughly renewed. If applied science and change in the character of human society are subject to a doubling time of 30 years, then all the curricula should be remade completely within that period. Their schools and universities, however, continue to plan for having education crammed into first 20-25 years of person’s life. There must be life-long learning.

The effects are most dramatically seen in teaching positions. People must become life-long learners and be granted the time and financial support to undertake renewal in their education. The typical sabbatical comes at too great of an interval for social and technological changes. The regular cycle of mandatory leave that is regarded as a part of one’s mandatory duty and is paid for is essential.

43:00 Finally, the colleges and universities have to revise their programs to provide for renewal of education for professional people or some new institution must fill the gap.

Glass thinks that also lawyers and representatives in government need periodical retraining because in age of science, decisions must be made concerning social patterns and technological changes.

The fourth limiting factor in growth of science is that there are long-term side effects in introducing insufficiently tested technological development into social and political economy. The hope for immediate gain clouds peoples understanding of consequences and low motives may produce disaster.

Examples: The curtailment of infectious disease leads to population explosion, transportation produces smog, denser population generates water pollution, stress, and unrest in urban centers. As peoples of the world become aware of the destruction of their environment, they become to realize the loss of natural beauty. It seems natural that they will rise against forces that they feel are responsible.

45:20 Glass predicts more massive resistance to technological change, and growing hostility. The fifth and perhaps final limiting factor in growth of science is the psychological resistance and restricted support of a population that is inadequately educated to understand science and militantly opposed to it because of its identification with the technological annihilation of the environment.

Those consequences are only avoided by foresight and effort on the part of the scientific community itself. Glass has come to the conclusion that what each country needs more than anything else is a new type of agency to study the long term side-effects of new technological development before they are permitted into social organization.

Many recent economic, environmental and medical emergencies could have been avoided by applying the knowledge that people already possess, or by making some further tests. There was so need for the recent environmental crises.

47:24 Man is a social animal living in a complex environment and they have ignored the balance between nature and population. The demise of older civilizations is now being repeated in a world-wide scale. Glass mentions a few economic catastrophes and talks about the effects of dams.

50:44 Environmental scientists today insist that whole systems approach be taken to any technological assessments. The biological, psychological and socio-cultural aspects must be introduced in analysis, as well as long-range economic aspects that can’t be ignored in seeking immediate economic gain.

They need national agencies that can do systems analysis of how scientific and technological advancements affect people, to plan for people’s wellbeing, and guide development so that it will be for the long-term benefit and not for short-term gain.

International agencies must be created to deal with problems in worldwide scope, like DDT and pollution of seas.

53:19 Without some scientific analysis and foresight in charting the future, man courts disaster. In just 150 years, and mostly in the past 50 years, science and technology have brought changes in life. Science is supposed to be in service of life, but never have the social problems seemed so critical.

Science has created a new world but man is the same as they have been for a hundred thousand years. Save for the accumulated knowledge and other change, man remains the same in his emotions and thoughts than the first man. Man has made a world that is rapidly changing.

Science is a quest for truth for an individual scientist but it's also a social process that has a history and a future.

57:05 They need to start thinking science as service and stress the hope for the future. The growing hostility toward science has its roots in conflicting values but there is no conflict between instrument and the spirit. In future, scientists need to recognize their dependence on the society that funds their work and that the society too wants to benefit from science.

[End of the recording.]