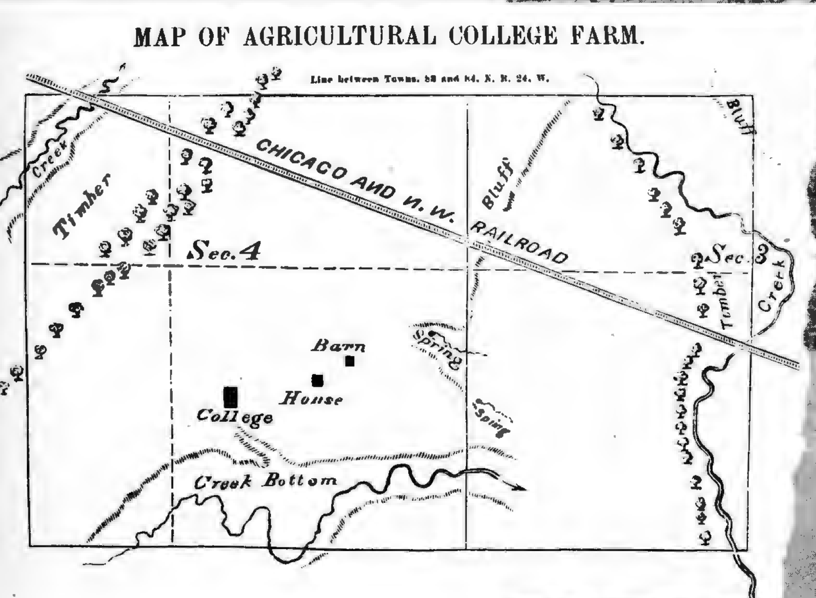
Commemorative Papers
From the

Iowa State College Centennial

A PIONEER CAMPUS



NOW

A LIVING TRADITION

Commemorative Papers
From the
Iowa State College Centennial

WITH HONOR TO THE PAST . . . WITH VISION FOR THE FUTURE . . .

1858
CENTENNIAL
1958

IOWA STATE COLLEGE

Commemorative Papers From the

Iowa State College Centennial

- Founders' Day Convocation
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THE ACADEMIC SYMPOSIA, March 23, 24, 25, 1958

Introduction

IOWA STATE COLLEGE *in 1958 celebrated the Centennial of its founding. The act which created the College was passed by the Seventh General Assembly of Iowa, and signed by Governor Ralph P. Lowe, March 22, 1858.*

The Centennial observance consisted of four main parts. On March 22, 1958, a convocation was held in the College Armory, to which the public was invited. In the academic procession to the convocation were representatives of the other Land-Grant Colleges and Iowa four-year colleges and universities, as well as several other Midwestern state universities; representatives of learned societies covering the various disciplines of the College; members of the Faculty Council and the Administrative Board and Department Heads, representatives of the student body and of the alumni classes.

Following the Convocation there was a luncheon for invited guests in Memorial Union.

On the next three days a series of academic symposia *within the various disciplines of the College was held at Memorial Union.*

Third phase of the Centennial was at the student Veishea festival and open house in May, when themes of the exhibits and the parade were keyed to the Centennial.

The final major event was the June Commencement when activities in connection with graduation and alumni events centered around Centennial matters.

This volume records the words of the chief speakers at the March 22 ceremonies and the academic symposia which followed.

FOUNDERS' DAY PROGRAM

Saturday, March 22, 1958

9:30 a.m. Academic Procession to College Armory
CONVOCATION IN COLLEGE ARMORY
DR. JAMES H. HILTON,
President of Iowa State College, presiding

9:30 a.m. Prelude

10:00 a.m. Processional—Grand Triumphal March . *Guilmant*
Singing of "America," led by TOLBERT MACRAE
Invocation: THE REV. LEROY S. BURROUGHS

Greetings:
HERSCHEL C. LOVELESS,
Governor of the State of Iowa
HARRY H. HAGEMANN,
President of the Iowa State Board of Regents

Conferring of Honorary Degrees

Address:
DR. JAMES L. MORRILL
President of the University of Minnesota
"The Unchanging Challenge—Lest We Forget"

Benediction

Recessional—International Accord . . *Golman*
(Music by the Iowa State College Concert Band under direction of Frank Piersol.)

1:00 p.m. LUNCHEON IN MEMORIAL UNION
DR. JAMES H. JENSEN,
Provost of Iowa State College, presiding

Invocation: THE REV. G. S. NICHOLS

Address:
DR. VIRGIL M. HANCHER,
President of the State University of Iowa
"Higher Education in Iowa"

DR. HILTON—"Closing Comments"

The Centennial
Founders' Day Convocation

The Hon. Herschel C. Loveless
Governor of the State of Iowa

Welcome

IT IS A DISTINCT PLEASURE as well as a privilege for me, as Governor of the State of Iowa, to extend an official welcome to the distinguished visitors and friends of the Iowa State College on this occasion. The state of Iowa is honored by your participation with us in the observance of the 100th anniversary of the establishment of this institution.

It is entirely fitting and proper, as we mark the first century of service by Iowa State College, to pause and evaluate the accomplishments of the College and to renew our determination that it shall continue to contribute to the welfare of the people of Iowa, the nation, and indeed the world.

During the past century, Iowa State College has achieved many distinctions. It was the first institution in the nation to comply with the provisions of the Morrill Act establishing it as a land-grant college; the College was also the first land-grant college to be coeducational, and the first institution of higher education to provide courses in home economics for college credit.

I could cite a long list of instances in which the College has achieved pre-eminence. But more important than these has been the basic philosophy underlying the establishment and operation of the College. Very early a wise board of trustees recognized that the success of the institution depended more on the character, ability, and leadership of its faculty than upon any other set of factors. So long as priority is given to the quality of the men and women who teach and carry on the research and extension activities of this institution, we need not be concerned for its continued excellence.

In the legislative deliberations which led to the establishment of Iowa State College, our forefathers wisely provided for an institution of higher education which was especially adapted to the young and dynamic democracy in which it was to operate. In a very special sense, the State College was established for the working class of people – the farmers, the mechanics, the artisans, and the manufacturers of Iowa. By providing basic courses in the sciences and the arts, as well as practical training in the application of these principles, Iowa State College has made a unique contribution to the development of Iowa and our nation.

But the College has been more than a vocational training institution. From a very early date it has contributed to a richer life for the citizens of this state through its activities in the broader academic areas. It is a mark of great promise that Iowa State College has – down through the years – successfully achieved balance in its program for the training of our young people.

The policies which have guided the program at Iowa

State College have also been characterized by a very healthy awareness of the need to modify teaching, research, and extension programs, in response to changing needs of our people. In coming years, when the speed of social and technical change will be accelerated, it will be vitally important to maintain this flexibility. The spectacular innovations which we have witnessed since the end of World War II are striking evidence of the rapidity with which new fields of endeavor are opened, and established areas of activity decline in relative significance.

For example, the new agricultural adjustment program has been made necessary by undreamed of advances in the technology of production. We must now match these increases in productivity with new and expanded markets, new methods of processing and distributing agricultural products, and the revitalization of our rural communities. In this task, as in those which it has faced in the first century, I know I express the confidence of the people of Iowa when I say that we know the College will find a way.

In conclusion, I should again like to extend a most cordial welcome to President Morrill and to other distinguished guests. We hope your visit in Iowa will be pleasant and that you will gain inspiration from the review of the first century of Iowa State College.

Harry H. Hagemann
President of the State
Board of Regents

Remarks

I HAVE THE HONOR to bring you greetings from the Board of Regents on this very special occasion — the Centennial of Iowa State College — which marks 100 years of distinguished service to the state of Iowa, to the nation, and to the world.

There are reasons to rejoice and be grateful for what has been achieved without forgetting the needs ahead.

Iowa State now has an enrollment of 9,000 to 10,000, and by 1970 the enrollment will exceed 16,000. Now is the time to take inventory, to take a good look around, and see where we are and where we are going.

The big question is: Will Iowa meet the challenge and continue to provide opportunity for higher education regardless of social and economic status? There are no easy solutions and there are many critical needs.

A few of these needs are:

1. The library of Iowa State College was built in the '20's

to accommodate an enrollment of less than half of the present enrollment.

2. Even now the present classroom space is over-taxed.
3. Wartime temporary barracks have worn out.
4. Buildings for research are urgently needed.

And there are many other pressing needs.

This is your College — an excellent faculty, a fine student body, a generous alumni body — all interested in this College. The future of Iowa State College depends upon you — your continued support and interest and your aggressive leadership.

I congratulate all of you on this Iowa State Centennial.

James L. Morrill
President,
University of Minnesota

The Unchanging Challenge—Lest We Forget

I AM VERY GRATEFUL to President Hilton, not only for the kindness of his introduction, but more especially for the honor and privilege of participating in this significant Centennial celebration by his invitation. We have served together, he and I, to my own profit and instruction, in the work of the American Association of Land-Grant Colleges and State Universities, whose cordial greetings and congratulations I have been designated officially to bring to this distinguished occasion; in the Midwest Universities Research Association; and in other shared assignments.

My warm regard and high respect for President Hilton bring the remembrance of his two immediate predecessors, Dr. Charles E. Friley and Dr. Raymond M. Hughes, whose friendship and association I was likewise privileged to enjoy — dating back more than 30 years in the case of Dr. Hughes whom I came to know and admire during his presidency of Miami University in Ohio, my native state.

Both of these, devoted leaders in their day and time, let me likewise salute with sincere regard and esteem.

Our minds turn back in an event such as this, and rightly so, even though the proud record of this institution's accomplishments during its first century "is but a prologue to what lies ahead," as President Hilton has written. The Earl of Birkenhead, high steward of Oxford, once prayed the gods in an earlier day for "one endowment, one precious gift: the bump of veneration." I am mindful of that prayer today.

How curious the contrast between institutions and individuals! – the institution so proud of its years, the individual almost apprehensive as his birthdays continue to come.

The difference, I suppose, is in the faith of educational institutions, among all others, that their indispensible task is never done; that they must go forward eternally, yet looking back, on such an occasion as this, to keep sure and straight the line of march.

Each of our colleges and universities is inspired by its own history and traditions. I must confess to envy of the Iowa State "firsts" in its fascinating "Chronology of Important Events of the First 100 Years" which President Hilton sent me. Iowa, the first state to accept the provisions of the Land-Grant Act of 1862; this institution the pioneer of agricultural engineering as a profession and the first to establish an "experimental kitchen for home economics;" likewise the first veterinary medical school in a state-supported college; your Earle D. Ross the first authoritative historian of the land-grant system – the list is outstanding and impressive, indeed.

And that ancient "Victory Bell" of yours — the like of which we need so sorely in Minnesota athletics just now! Like several other land-grant colleges, you have a "Morrill Hall." There is none such at Minnesota, although sometime there may be if our University continues its custom of naming a building after each of its retired or deceased presidents.

Even so, the name at Minnesota could not carry the deserved honor, as it does here, of the revered author of the Land-Grant Act. It would have another meaning at Minnesota, if a suggestion I've made is accepted. We're going to build a new Chemical Storehouse on our campus. Because of the ever-present danger of an explosion in such a structure, it is being designed with one weak wall which would blow out instantly to relieve the pressure on its inmates in the event of such an accident. What with the way things happen to college presidents sometimes, it occurred to me "Morrill Hall" might be a good name for it.

* * *

The Unchanging Challenge — Lest We Forget!

It is vital in the climate of this Centennial, surely, drawing strength from the past, facing forward to the future. Our time seems a specially changing and confusing one. But this is nothing new in the history of American higher education, which has come upon crises before, and, in the land-grant instance above all others, has evolved to respond to the nation's needs.

Ten years ago, at the beginning of the post-war period, the implications of which now so much more seriously surround us, I tried to discern the larger meaning of the historic land-grant challenge.

"Institutions are society's organized response to the needs of the time in the period of their establishment," I remember writing at that time. "The varying types of colleges and universities bear witness, historically, to this truth," I wrote — and then went on to say:

"In all the long tradition of higher education, ancient and modern, in the Western World, the land-grant college has been unique. It created what has been described as 'the most comprehensive system of scientific, technical and practical higher education the world has ever known.' American university research was an adaptation of the German genius. Commitment to the liberal arts (with the American invention of the four-year liberal arts college) was the heritage of the medieval universities and the Renaissance, transmitted to our shores through Oxford and Cambridge.

"America's needs were new and different, practical and urgently immediate to meet the requirements of an expanding democratic and economic order. They required a wider curriculum and a more democratic widening of educational opportunity. The land-grant institution provided the needed response:

"Not only 'liberal' but 'practical' education. Not only the traditional scholastic and professional subjects in the combined land-grant state universities, but workaday agriculture and the mechanic arts brought into the academic environment — gaining dignity and academic acceptance and the methodology of science and scholarship thereby, contributing the challenge of *useful* relevance to a concept of culture too remote from the problems of daily life and work.

"Education not only for men but equally for women. The opportunity of learning, not just for a well-to-do or intellectual elite but for *all* who must carry the burdens of citizenship and productive service in a great and growing nation.

"These," I said then and would now repeat, "have been the goals of the 'land-grant idea,' richly realized, changing the whole character of American higher education, enriching the strength of the democratic ideal."

And 10 years ago I raised the question which seems to me today ever more significant than then:

"Has the land-grant college any longer a special function — other than in agriculture, perhaps? Has it still the opportunity to pioneer? Because of widespread acceptance and imitation of the land-grant idea and philosophy, have our institutions fulfilled the ancient admonition to find themselves by losing themselves? Do we still have the opportunity and the need for leadership, the land-grant leadership that historically was 'unique, distinct and indispensable?' "

The pendulum swings: for every action, a reaction; for most trends, a counter-trend.

You remember the trends that brought our institutions into being: the rise of Jacksonian democracy, with what our latest land-grant historian, Dr. Edward D. Eddy, Jr., has called the "political credo" of "the supreme worth and dignity of the individual" and the plea of old Jonathan Turner of Illinois in the 1850's for a "Common Man's Educational Bill of Rights."

Along with these, as Dr. Eddy says, "across the country the free school movement had begun," and "in this period, too, came the important assumption that education was a *public* obligation."

Do you discern counter-trends today in the spurious hysteria over the Soviet satellites with its overwhelming emphasis on science and technology which a good many politicians with no previously evinced interest in educational support are now competing to capitalize — the counter-trend, in the face of inevitably rising costs which will be required to continue the provision for widespread educational opportunity for the larger numbers of American youth and to face up educationally through teaching and research to the incredible post-war explosion of knowledge — the counter-trend, arising from these exigencies toward enforced tuition increases in the public institutions?

The trend toward more restrictive admissions? The idea that, after all, "mass education" has been a mistake and that quality and quantity in American higher education are incompatibles? The actual notion, revived in some quarters, that the time has come for a partial retreat to the ancient academic tradition of the "ivory tower" — argued more especially just now in the demand for secondary school reforms?

Science and technology, to be sure, have been mainstays of the land-grant program, but our job has always been more than that. It has been all these years the mandate of the Land-Grant Act "to promote" — without excluding other scientific and classical studies (beyond agriculture and the mechanic arts, and including military tactics) — "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

That mission has been accomplished magnificently, and its challenge is unchanging! More than half of all World War II officers for the nation's defense, for example, were commissioned through the land-grant R.O.T.C.'s.

In 1955 — the latest statistics I could locate — 38.4 percent of all doctoral degrees awarded in the social sciences by all American institutions were granted by the land-grant colleges and universities; 26 percent of all the doctorates in English; 30 percent of all those in the fine arts; 20 percent of all those in foreign languages, modern and classical.

Far more than a third of all students in land-grant institutions are enrolled in the colleges and divisions of liberal arts and sciences, as they should be in a society with its need of skills and leadership in all "the several pursuits and professions of life."

The current craze for just more scientists and technologists worries me, I must confess — remembering so well that less than 10 years ago government statisticians warned us we were training too many. The more so, with business and industrial employment still declining and our memories of the unemployed engineers in the 1930's.

Today the fastest-rising enrollments in most of our institutions are in science and engineering, as you know. Dr. Ralph F. Berdie of our Minnesota staff testified recently before a Congressional committee:

"In 1930," he told the Congress, "the American population was 123 million. In 1950 it was 151 million, an increase of 23 percent. In those same 20 years the number of undergraduates earning the bachelor's degree in engineering increased 575 percent! In 1930 we had only 12,000 scientists in this country with Ph.D.'s. Twenty years later, as compared with a 23 percent increase in population, we had 39,000 Ph.D. scientists — an increase of 225 percent."

But this country needs more than scientists and engineers. It needs all kinds of educated citizens. Striking indeed is the measure of what generous higher educational opportunity has meant to qualified American youth trained for all "the several pursuits and professions of life." As between the periods 1926–30 and 1946–50, with its population increase of a little over 20 percent, the numbers of bachelor's degrees given by all the colleges and universities of the country increased from 551,000 to 1,421,000 — an increase of 158 percent.

It was the "land-grant idea" that long since had opened the doors! — the idea which former President Edmund J. James of Illinois declared to be "the beginning of one of the most comprehensive, far-reaching. . . schemes for the endowment of higher education ever adopted by any civilized nation."

No American college or university of importance and integrity, unless forced by failure of financial support, will abandon the "idea of excellence" or the "pursuit of the first-rate" in the effort to serve larger numbers. They will cling to standards and strive to upgrade them.

But the land-grant colleges especially will remember, too, the words of one of the "giants" of their tradition, Dr. William Oxley Thompson, the beloved president of the Ohio State University in my undergraduate days who served for 10 years as president and chairman of the Executive Committee of the Land-Grant Association.

"The tendency. . . to operate an institution for the sake of maintaining standards is all wrong as I see it," he said somewhat testily one time when the charge of low standards was hurled against the "cow colleges" in the earlier days. "An institution," he said, "is to be operated for the good it can do; for the people it can serve; for the science it can promote; and for the civilization it can advance."

That purpose, too, we will not abandon without peril!

Actually, "the true greatness of American higher education is held aloft on the two pillars of quality and quantity," President C. W. de Kiewiet of the privately-supported University of Rochester (well-remembered, I am sure, as a distinguished former teacher and historian at your sister State University of Iowa) told an American Council on Education audience not long ago.

Dr. de Kiewiet went further to warn against any imitation by this country of the restrictive and selective philosophy of higher education in Great Britain and the Continental countries. The infiltration of communism in French political life and of socialism in British liberal politics he attributed in significant measure to the disappointment and sense of frustration among the youth of those nations, deprived of the opportunity for advanced education, without hope of finding a place in society suited to their talents.

"What is missing in those countries," he said, "is the acceptance by universities of a proper responsibility to help in the training of the student of good but not (necessarily) first-rate ability. The ordinary American graduate, not the first-class man who is headed for the top professions, but the rank-and-file student, is the foundation upon which American industry is built. . . The American system of education from top to bottom is the costliest in the world. It *is* wasteful of time and money, but as a great solvent which smooths out incompatible social differences — and as a principal architect of national coherence — time and money have been cheap prices to pay."

But this matter of money is critical for the citizens and taxpayers of our states, we fully realize. For our institutions this will be, increasingly, a time of test and trial in our Congress and the state legislatures. It will also test the understanding of our people; their understanding of the indispensably productive meaning of higher education in the American social and economic order; the meaning of 100 years of Iowa investment in the land-grant enterprise.

President Eisenhower's Committee on Education Beyond the High School has spelled out the hard fact that the present three-quarters of one percent of the nation's gross national product for the current annual support of higher education won't do the job for the predicted doubled enrollments 10 or 12 years hence. The Committee has said to the American people that unless we are to retreat from the American guaranty of educational opportunity, there is no escape from a higher priority in private giving and public expenditure for higher education: a higher percentage of the gross national product.

What with a presently reduced agricultural and industrial economy, the tendency of some state legislatures to expect or enforce higher tuitions in the publicly-supported institutions is understandable. But we need the reminder that vast expenditures for federal and state scholarships, which in some measure I believe to be socially sound, will require still greater institutional costs, because in neither the public nor private institutions can tuition be made to cover the costs of teaching, research and required new capital outlay for the oncoming larger numbers.

And we need everlastingly to remember that the greatest and the primary factor in making higher educational opportunity widely available "has been that the people have built and maintained public colleges and universities in every state which young people can attend at comparatively low cost," as our Land-Grant Association Executive Secretary, Mr. Russell I. Thackrey, wrote recently.

The land-grant challenge is unchanging. It is the new and varied response which we must discern and contrive in the changing educational scene. No large aim is ever fully accomplished. Persistence in old patterns — however valid and resourceful in their day — is never sufficient for a future which all too soon becomes the pressing present. This, surely, is the land-grant lesson we have long since learned.

Truly there will be no retreat to any "ivory tower" of the kind inhabited by that ancient Oxford don who proclaimed that the worth of knowledge lies in the degree of its uselessness. Rather, we shall continue to believe that "education is the acquisition of the art of the *utilization* of knowledge" and that essentially "culture should be for action, and knowledge for use," as the philosopher Whitehead said.

And surely we shall not draw back from the fight for the same chance for our children and their children that the youth of this generation enjoy.

The continuing shift from rural to urban and industrial occupations inevitably will shift our earlier aims and service. The enormous impact of science and technology may require more scientists and engineers for the national defense. But even more, I deeply believe, it calls for a clearer interpretation of their meaning socially and politically, in the democratic process of decision-making for peace or war. It calls for a closure of the cleavage between science and the humanities which is of such concern in British higher education, for example, and which in this moment of overemphasis could become critical in our own country.

The trend toward intense specialization in every kind of subject matter, the increasing abandonment of "general education," so called, of which earlier we had such great hope — these are more evident than at any time in my own experience. In part they account for what has been called "the flight from the undergraduate," the discouraging divorce of science from the humane values taught in a meaningful social context at the undergraduate level.

Our institutions are challenged, and are responding generously and patriotically, to the wider dimensions of international relations, and that is an encouraging example of flexibility. More than half of the American colleges and universities engaged in technical assistance and training in foreign countries, sponsored by the federal International Cooperation Administration, are land-grant institutions which manage far more than half of the staffs and expenditures overseas involved. This is understandable, considering how vital to the underdeveloped countries is the upgrading of their agricultural and industrial resources and what the land-grant example of teaching, research and extension has meant to our own.

The by-products of international understanding with its prospect for a more peaceable and prosperous world are incalculable. Here, too, our institutions have risen to meet the new and broader challenge of their time.

It is this flexibility of response to national and international needs that has been the land-grant heritage, and its hostage to a larger destiny. It is the unperishable identity of our tradition.

Let me quote to you the testimony of a discerning observer:

"Great as the contribution of the land-grant institutions has been in the past three generations, I venture two predictions. First, it is inevitable that in the immediate and continuing future the responsibilities and scope of these institutions are going to be immeasurably larger than they ever have been — not only actually but also in relation to the other segments of our over-all educational system.

"Second, if the land-grant institutions should fail, quantitatively or qualitatively, to play to the full the role which destiny is assigning them, I doubt that we will have a free society and a democratic form of government in the United States a century hence."

The speaker I have quoted is a native son of Iowa, the perceptive publisher of our newspapers in Minneapolis, Mr. John Cowles, speaking at the Pennsylvania State University Centennial.

* * *

Our land-grant colleges are no longer a group apart from the great and larger company of splendid institutions, public and private, with whom we share the burden of the day, we fully understand. Together, as partners with these, we paint the glorious picture of "a whole land aglow with colleges and universities, like a field with the campfires of an army on the march," in former Harvard President Abbott Lawrence Lowell's inspiring phrase.

We are but one current in the broad mainstream of this country's higher education, but it is a current deep and strong. Our identity in the years ahead will be — as uniquely as it has been historically — an identity of purpose and service. It will be the precious purpose implicit in our heritage.

All honor to the Founders on this day! — those pioneers who saw so clearly the challenge to build for a better day. From that unending commitment surely we are not relieved today, despite the progress of a century.

And when we build, as John Ruskin once wrote immortally, "let us think that we build forever. Let it be such work as *our* descendants will thank us for.

"And let us think, as we lay stone on stone, a time is to come when these stones are held sacred because our hands have touched them — and that men will say, as they look upon the labor and wrought substance of them — see, this our fathers did for us!"

Recipients of Honorary Degrees

JAMES LEWIS MORRILL
educational statesman, journalist

ROBERT EARLE BUCHANAN
scientist, administrator

JOHN WALTER COVERDALE
agriculturist, civic leader

GERTRUDE MARY COX
statistician, teacher

EDWARD BERTRAM EVANS
veterinarian, agricultural educator

THEODORE V. HOUSER
business executive, humanitarian

HERBERT HENRY KILDEE
educator, livestock authority

ALLAN BLAIR KLINE
agricultural leader, farmer

BETH BAILEY MCLEAN
home economist, business woman

GEORGE WADDEL SNEDECOR
statistician, teacher

FRED RAY WHITE
highway engineer, servant of Iowa

Centennial Founders' Day Luncheon

March 22, 1958

Virgil M. Hancher
President,
State University of Iowa

Higher Education in Iowa

ON THIS OCCASION I have the honor and the privilege of bringing felicitations and best wishes to the Iowa State College from the American Council on Education, the Association of American Universities, the Association of Iowa College Presidents, and my alma mater, the State University of Iowa.

It is no small thing for an institution of higher learning to be founded on the open prairies of Iowa and within the space of 100 years to reach a position of national and international distinction in the fields of science and technology. Such a record of accomplishment in one brief century of existence leads one to speculate what this institution will be, indeed what all of our institutions will be, when this newly-settled land shall be as old as Oxford or Paris or Bologna or Rome or Athens.

We feel instinctively that we live in a time of decision, in a time when new forces are impinging upon us whose effect cannot be clearly calculated — the impact of expanding populations, the acceleration of travel and communication, the astounding growth of new knowledge, the potential of atomic energy and space machines. We feel instinctively, and I believe rightly, that the decisions which we are now making, and which we must make in the decades immediately ahead, will have profound effect upon the future of our state and of our nation.

The decisions to be made in higher education are no less fateful than those in other fields. We have a dual system of publicly controlled and privately controlled higher education in the United States. In recent decades approximately one-half the students beyond the high school have been in privately controlled colleges and universities and one-half in publicly controlled colleges and universities. However, the percentages and relationships vary from section to section of our country. Along the eastern seaboard, private colleges and universities were first established, and they early achieved preeminence in scholarship, numbers, and reputation. On the Pacific Coast, publicly controlled higher education achieved predominance through a combination of overwhelming numbers and high scholarship.

As so often happens, we in Iowa occupy a middle ground. Our oldest public and private institutions were established about a century ago. Our youngest are very new. We have approximately 50 institutions for general collegiate and university purposes beyond the high school, having a combined enrollment of approximately 47,000 students. The three state-supported four-year institutions enroll slightly more than 23,000 students; the four-year private colleges enroll nearly 19,000; the eight private junior colleges enroll about 2,400; and the sixteen public junior colleges enroll about 2,500 students. Not only are we fortunate in having a fair distribution of enrollments between the public and the private institutions; we are fortunate, also, in having both public and private institutions that rank high among the colleges and universities of the nation.

This happy state of affairs, however, is no cause for self-congratulation and complacency. There are clouds on the horizon — no larger than a man's hand — which may not portend a change of weather, but which we would be ill-advised to ignore. We live in a state which for more than 25 years has been more dependent than most states upon the national prosperity for its own well-being. It has not been master of its own economic fate. It has too frequently been dependent on policies determined in Washington with all the consequences to morale that such dependency implies. Iowa is a state which is in economic transition. The small unit farm has become an anachronism in an age of mechanical farming. Farming has become, if not Big Business, at least bigger business, and the modern, successful farmer is a capitalist on an equal and sometimes a larger scale than the town or city businessman. But the increase in farm size and the mechanization of processes means the displacement of human beings and the end of a way of life for those displaced. Such adjustments are painful whether they take place in India and Pakistan or whether they take place in Rolfe or Cherokee or Harlan or Marengo or West Liberty. And a society in flux, a society in process of rapid change, stands in danger of resort to unwise and desperate and impetuous choices and remedies. We need to keep these risks in mind as we consider the future of higher education in Iowa.

In common with most states we face the promise and problems of increasing enrollment in colleges and universities. They are less acute with us than with California and other states with exploding population; but nonetheless, the colleges and universities of Iowa, as well as the people who are their constituencies, will be called upon to meet the challenge of increasing numbers, as well as the increasingly rigorous intellectual demands of a vastly complex and rapidly changing society. How are these demands and challenges to be met? What guiding principles should be followed in meeting our needs? It would seem to me to be of the first importance that we assure the intellectual strength and eminence of our existing colleges and universities, both public and private, before we establish new ones. Gresham's Law says that bad money tends to drive out good money. Unfortunately, that law has its educational corollaries. Poor high schools tend to reduce the standards of good high schools. Poor high schools tend to reduce the standards of colleges and universities. Poor colleges and universities tend to reduce the standards of high-ranking colleges and universities. In this time of crisis, our emphasis should be on high standards and quality performance. This means no diminution in the intellectual strength and eminence of our existing colleges and universities. We need to put first things first.

A second guiding principle is that no new institutions for higher education should be established until it is first demonstrated that there is need for them — that they have a natural constituency not now served by an existing college or university to assure an enrollment and a financial base adequate to guarantee high standards of scholarship and performance. We have institutions in Iowa which compare with the best in the land. Unhappily, others have been established less on the basis of existing needs than upon hopes for future development. When these hopes were disappointed, the institutions were left without a natural constituency to provide either enrollment or support. The history of those institutions has been one of heart-breaking endeavor and unrealized hopes.

We need not and we must not repeat that experience in future decades. We must not leave our descendents the collegiate equivalent of the "one-room school." There are few communities in Iowa where a high school graduate is more than 25 miles from some college or university. There are few communities in Iowa (and even fewer without a college) which could meet the minimum standards imposed by the state of California for the establishment of a junior college. Those minimum standards are an anticipated average daily attendance of 400 students and a district with a tax base of $100,000,000. The solutions applicable to states with rapidly expanding urban population have little relevance to an agricultural state lacking great urban centers. While it is true that expensive education is not invariably good education, it is true that good education is usually expensive, and it is never cheap. Cheapness and shoddiness are always dangerously close together. For this state, therefore, the guiding principle and first concern should be the strengthening of its existing institutions, both private and public.

In the context of higher education in Iowa, it is the function of the three publicly-supported institutions of higher learning to complement, rather than supplant, the other institutions in the state. Our three institutions attempt to provide a coordinated system of higher education — with teacher training predominant at the Iowa

State Teachers College; with the liberal arts and sciences, graduate study, and certain professions at the State University; with science and technology, the allied applied arts and sciences, graduate study, and certain other professions at the Iowa State College.

All of us, I am certain, will join in acclaiming the eminence of the Iowa State College on the 100th anniversary of its founding. In 1953 I had the good fortune to attend the 50th anniversary celebration of the Long Ashton Research Station of the University of Bristol. Great figures in agriculture were there from England, Scotland, Wales, Ireland, and more distant parts of the Commonwealth. All knew the Iowa State College and its work, and many had visited here. Their tributes — and those from many other parts of the world — can well be cause for satisfaction to all who have played a part in building the national and international reputation of this institution, but I venture to believe that these tributes will be no idle satisfaction to the Iowa State College, but rather a challenge for even greater accomplishment in the next 100 years.

James H. Hilton
President,
Iowa State College

Closing Remarks

AND SO WE COME to the end of today's program commemorating the first century of Iowa State College.

On behalf of our faculty and students, I wish to express to you, our guests, who have made this day such a delightful occasion for us, our sincere thanks.

This College has been fortunate to be in a state where higher education receives serious attention as evidenced by the excellent group of sister Iowa colleges and universities, all of whom are represented here today. We are proud to be a part of such a distinguished family, and to share with its members the duties and responsibilities which citizens of Iowa and elsewhere have placed upon them. It is our sincere wish that we may continue to work together, as we have in the past, in the education of our young people, the discovery of new knowledge, and in service to all citizens.

To you, President Morrill, and to President Hancher our very *special* thanks for making our Centennial birthday so meaningful. We shall forever be grateful to both of you. The many kind things you have said about our institution will strengthen, for all of us, the faith in our mission as a land-grant college.

Ideas and ideals determine to a large degree the stature of a college or a university. None has been more important to Iowa State than the principle laid down by the Governor's Committee appointed to select the first faculty nearly a century ago.

> On the character and ability of its faculty will the character and success of the institution depend more than upon all other circumstances taken together. Buildings, cabinets, libraries, and rich endowments will be in vain if the living agents, the professors, be not men of ripe attainments, fine culture, and eminent teaching powers.

On this great truth, generations of Iowa State College administrators have based their programs.

Now the College begins its second century of service. We of the faculty, alumni groups, and student body pledge continued adherence to the moral and spiritual character, the integrity, and the high standards of scholarship which have gained world-wide respect for Iowa State. To live up to the promise of the future there can be no retreating from these basic principles. Indeed, they must be strengthened at every opportunity.

From time to time institutions, like individuals, must pass through critical periods as they grow and mature and move from one situation to another. As we enter the second century we are determined to be realistic in our approach to the needs of our times. We will strive unceasingly for that combination of technical training, broad education, and humanitarian philosophy which will best equip men and women to build tomorrow's world. Our graduates and our faculty can give meaning and continuity to changes which might otherwise seem unrelated and without purpose.

Iowa State College was born of change, and it will continue to alter its thinking and its methods to meet those problems which are still ahead of us. It seems entirely possible that the transformation of the next 100 years may dwarf those of the past century. But Iowa State's purpose will remain unchanged. The motto "Science With Practice for Service of Mankind" will be just as worthy for the College 100 years from now as it was 100 years ago and as it is today.

It is our hope and prayer that the service and contributions of Iowa State College during the next century may be greater and more far-reaching to an ever-increasing number of people, not only in Iowa but throughout the world, than during the first century of its existence.

The Academic Symposia
March 23, 24, 25, 1958

William G. Pollard

Executive Director of Oak Ridge Institute of Nuclear Studies, and Priest-in-Charge of Saint Francis Episcopal Church, Norris, Tennessee

Science As Community

IT IS INDEED a great privilege to be called upon to give the opening address of the Academic Symposia commemorating the Centennial of the founding of Iowa State College. The land-grant college is one of the truly great ideas in education, and Iowa State over the past 100 years has pioneered the conversion of this idea into the significant actuality which we all know today. Not only is it the first institution to participate in the benefits of the Morrill Act, but ever since then it has opened up paths for other institutions to follow by making evident practical ways in which Senator Morrill's vision could be realized in concrete educational processes. In a very real sense the Centennial of Iowa State is also the Centennial of the land-grant idea in American education. When seen in this perspective, the present symposia acquire a place of such importance and significance that an invitation to participate in it is not only an honor but a most important challenge.

The role given me by the committee which planned the symposia was that of portraying the integration of science and faith in past and future social development. This is indeed a tremendous assignment, and I shall only be able to approach it in this one lecture from a single vantage point. Yet it is clearly central to the vision which must inspire Iowa State and her sister institutions as they enter the second century of the development of the land-grant idea. During the first century they have, to a greater extent than any other kind of institution, brought science down to the level of the common man and placed it in his service. At the same time they have carried out this task with a student population which, to a greater extent than that of any other institution, has been energized and supported by that sturdy Christian faith of the common American man and woman on which the greatness of America has been built. Even if not explicitly planned to do so, science and faith have in fact worked hand in hand to produce the rich and manifold contributions of the land-grant college to the social development of this country.

In the conclusion of his recent book on the land-grant idea in Amerian education, Dr. Eddy summarized this idea in the following way:

> Born out of America's worship of education, the land-grant colleges strengthened that worship. Partially through their efforts, higher education came to be regarded as not so much a luxury as a national necessity. Before long, America had taken for granted the assumption that each individual, regardless of his economic or social status, should be given the opportunity to develop his innate abilities to the ultimate benefit not only to himself but to the nation. Each man was worth educating as a person and as a citizen in keeping with the Judeo-Christian and democratic belief in his dignity and worth.[1]

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[1] Edward D. Eddy, Jr., *Colleges for Our Land and Time,* Harper and Brothers, New York, 1957, p. 285.

Thus the land-grant college, which in its program is so much concerned with science, is in its ideal equally concerned with faith and firmly rooted in the Judeo-Christian heritage of Western civilization. Yet at the same time science and religion are today widely believed to be inimical to each other, and there is in fact much actual tension between them in contemporary thought. Quite clearly, therefore, a discussion of these two areas of human thought and endeavor is appropriate and even central to the occasion which we are celebrating.

Wherever science and religion are discussed, it is usually the subject matter or factual content of each which is contrasted. Or, on occasion, it may be the techniques, methods, or basis for validation of truth in the two fields which is contrasted. Since my ordination several years ago, I have been under pressure to speak and write on these vitally important issues out of my own experience. For some time my response to such pressures followed this usual pattern of concern with the factual and conceptual content of the two fields. I would strive to perceive the unity and coherence between the theoretical picture of reality as I had come to know it through science, and that which I had come to know through theology. Or else I would strive to understand and express the differences in the ways in which truth may be established and reality known in physics and in Christianity.

In all of this activity, however, I experienced a growing sense of dissatisfaction with such approaches. Something important was clearly being overlooked. It was not a matter of lack of success or of failure to deal meaningfully or significantly with the issues involved. On the contrary, I sometimes was able to achieve what seemed to me some real insights into the structure of a knotty problem which had been worrying me and to have the satisfaction of discovering that others found my resolution of it meaningful and illuminating. The real trouble lay elsewhere. Mainly it consisted in the recognition of the seemingly unavoidable circumstance that both I and my hearers were standing apart from our discourse, and viewing it in a detached way from our several vantage points. Each one could agree or disagree, be interested or bored, enthusiastic or antagonistic, without its making a great deal of difference. The subject under consideration was a thing apart, and the difficulty was that there was no obvious or essential way in which it really had to do with any of us. What then about my mode of response to the pressure upon me to speak out of my joint *experience* first as a physicist and later as a priest of the Church? Could any amount of discourse about the contrasting subject matter of physics and Christian theology ever really get at what was evidently being demanded from me?

One clue to the problem raised by such questions came to me early, although I did not then understand its full implications. This was the simple fact that all of my writing and speaking on science and religion came well after my full involvement in and commitment to the Church. None of it could possibly have been undertaken by me at all until, in a sense, it was already too late for me to have done anything about it. Christian theology is something which can be fruitfully engaged in only by already fully-committed Christians. This, however, was not in any sense new to my experience. It had previously been just the same way with physics. By the time my first paper in physics was published in The *Physical Review,* I had already sometime since become a fully involved and committed physicist. To be sure, I was young and inexperienced in the field and it was not then clear either to me, my professors, or my fellow student physicists whether I would turn out to be a good or only a mediocre physicist. But by then it had become quite clear both to me and to them that, for better or for worse, I was already one of them.

A thought such as this naturally leads to the question of how it is that anyone becomes either a physicist or a Christian in the first place. The common notion, I suppose, is that one first learns all about the subjects of physics or Christianity, their factual matter, content, methods, and ways of knowing, and then on the basis of all this knowledge decides whether or not one wishes to become a physicist or a Christian. But I am convinced that this widespread popular impression is completely erroneous. I do not really know or understand the process which led me as a young man to become interested in physics and soon to decide that I wanted to be a physicist. But whatever this process was, it was not based on a knowledge of physics. On the contrary, I am convinced that until I had made that decision, I could not even begin to really learn physics. In the same way the process which led me into full involvement in the Church is equally mysterious to me. It certainly was not the result of an exhaustive study of Christianity. Indeed it is now clear to me that only after I had made such a decision did I have a secure enough platform on which to stand to make it possible for me to grapple at all meaningfully or fruitfully with tough theological questions. This, however, is just another way of expressing the central theological affirmation that it is by grace, not works, that one becomes a Christian. To this affirmation I would add that it was also, in a completely analogous way, by grace, not knowledge, that I became a physicist.

This early clue received its needed impetus and clarification from a lecture given by my close friend and associate, Dean Harold K. Schilling of Pennsylvania State University, during a Danforth Foundation seminar for college teachers of science which we jointly conducted several years ago. In this lecture he developed the idea of physics, or for that matter of any science, as community rather than subject. As I listened to his remarkably clear and cogent development of this idea, I realized with considerable excitement that here was the key I had been groping for to the problem which had been gnawing at me. With full acknowledgment of my indebtedness to Dean Schilling for many of the insights and ideas which I have borrowed from him, it is this theme which I propose to explore with you today in the light of my own experience as an active member of two communities of inquiry and understanding: physics and the Church.

There are a number of ways in which it may be seen that any science is much more distinctively a human community than it is a body of subject matter or a particular methodology. One way is to try to formulate an adequate and satisfactory definition of a given science in terms of its subject matter. This must somehow be attempted at the beginning of an introductory course in the science. The students who have registered for it expect to be told at the outset what the subject is about. The instructor, however, in trying to formulate some adequate statement for meeting this natural and apparently quite proper need generally finds himself in difficulty. How, for example, can a boundary be staked out in the natural world which will clearly and adequately distinguished physics from chemistry? The deeper one goes into this task the more difficult and complex it is seen to be. Every definition of either subject which recommends itself is soon seen to have numerous loopholes. The fields overlap each other and the boundaries continually shift with new progress in each science. Many who have faced up to this problem have in the end suggested in desperation that the best definition of physics is that it consists of everything done by physicists. From the standpoint of physics as subject matter this definition is facetious, but from the standpoint of physics as community it is profound.

In actual practice little effort or interest is expended on such definitions. In time as the course goes on the students will come to acquire a feel for what physics is. In part this comes from the content of the textbook, lectures, experiments, and examinations as the course unfolds. But this is only in part. Even more important is the character and structure of the life which goes on inside the physics building or the chemistry building. Each is distinctive and recognizable. Although it may be difficult to tell the difference between physics and chemistry as subjects, there is no trouble at all when it comes to telling the difference between a physicist and a chemist. They are clearly members of two different, distinct, and contrasting communities. The student, along with the rest of the university, comes to think of physics as that which goes on in the physics building, whereas chemistry takes place in the chemistry building.

Another way to see science as community is to consider the history of each science. When we do this what immediately stands out is the unity and coherence of the men and women who have been engaged in it. Physics, for example, has changed radically in subject matter content over the years. First it was interested in the laws of motion of bodies; later with the properties of substances, heat, energy, and light. Then in the last half of the last century, electricity and magnetism were the dominant interests. With the discovery of the electron the center of interest turned to atoms and molecules, and more recently to atomic nuclei. Now the growing family of strange unstable particles produced at ultra-high energies is the center of interest. None of the early physicists could possibly have foreseen the course of this path of inquiry. Yet physicists today can still read the papers of Newton, Joule, Hamilton, Faraday, and Lorenz and feel at home with them. Whatever the subject under investigation, the peculiar combination of attitudes, values, judgment, and discipline which uniquely pervades the community of physics is recognizably present. These are clearly kindred spirits and fellow physicists, even though the content of physics has become for us something vastly different than it was for them.

Ancient Greece produced a few isolated instances of genius, such as Democritus and Archimedes, who investigated physical problems. But it did not produce physics. Only when such isolated individual sparks caught fire and spread so as to draw men into a communal enterprise did what we know now as physics emerge. When this happened, a community came into being possessed of a unique power of inquiry into nature. Its members were seized with this power and shared in the dynamic vitality and enthusiasm of it. The spirit of this community has been the same ever since in spite of the way in which the objects of its inquiries have continuously changed and spread. It has throughout commanded from its members a common loyalty, imposed upon them a common discipline, and conferred upon them common rewards and satisfactions. So too it has been with the other sciences which have emerged in the last few centuries. Each owed its birth to the formation of a special community of inquiry peculiar to itself. One man is not enough, no matter what his genius. Only when others catch his fire and his vision and join him to labor in a common quest for understanding does a science come into being.

The same aspect can be seen in the educational process by which each science reproduces itself and maintains itself from one generation to another. This process is very different in nature and character from what is commonly supposed. Many people look upon science as a sort of vast impersonal mechanism which people can be trained to operate as they would a lathe or a locomotive. It is thought to be a self-correcting procedure which automatically generates infallible information about nature by the application to phenomena of a mechanical process known as "the scientific method." Nothing could be further from the truth about science as it is known from the inside to those who live it and do it. Education in a science is a gradual process of incorporation into a community. The process, to be effective, must expose the student to the spirit of the community so that he becomes infected by it. He must, of course, master a large body of factual material and acquire many specialized instrumental and intellectual skills. But much more than this, he must somehow come to share the characteristic viewpoint and attitude toward phenomena of his science. Through intimate continued contact with his professors, he discovers how they react to the frustrations and ambiguities of research, becomes aware of the sources of their confidence in the ultimate fruitfulness of their enterprise, and learns how to subject himself to the rigorous discipline which the enterprise entails. He must hear too about the great personalities in his science, and this must include not only their scientific achievements but also tales and yarns about their foibles, personal peculiarities, and escapades as well. Gradually he comes to share in the sense of adventure, the excitement of discovery, and the hope in triumphs to come which energize the community. Ultimately he reaches the point at which both he and his professors recognize that he has become one of them. He is a physicist, or chemist, or psychologist. Not only does he feel himself to be one, but when he goes to a professional meeting he finds that others instinctively respond to him as such. He has been incorporated into the community.

Those who look on scientific education as a purely mechanical process of imparting information and skills often fail to see the importance of research and to argue in favor of dispensing with the thesis requirement. But when we think of graduate education as incorporation into a community, this matter emerges in a different light. For it is only in research that the student can be confronted directly with nature on his own and, under the watchful guidance of his professors, discover whether he too really can possess the intuitions and ingenuity, the discipline, and the confidence and faith which give the community its power to grapple with nature and emerge with new understandings. It is only in carrying out research on his own that the student can feel, and others can realize, that he has indeed become himself one of them, a full participant in the life and power of the community.

These examples will perhaps serve to make it clear what I have in mind when I speak of "science as community." The idea is summed up cogently and effectively by Dean Schilling: "Science is communal. The science community has the usual attributes that characterize other kinds of communities. It has its own ideals and characteristic way of life;

standards, mores and conventions; language and jargon, signs and symbols; professional ethics and moral code; authority, controls and sanctions; institutions and organizations, means of communication and publications; creeds and beliefs, orthodoxies and heresies; politics, pressure groups and maneuverings; schools of thought, divisions and schisms; personal loyalties and rallying cries, jealousies and hatreds; fads, fashions, and fancies."[2]

A number of the contrasts which are frequently made between science and religion are seen to be either wrong or irrelevant as soon as the true nature of science as community is recognized. Consider, for example, the common assertion that anyone can demonstrate the truths of science for himself, but the tenets of religion have to be accepted blindly on faith. Anyone who has ever taught a science knows how few people there are who can really demonstrate a scientific truth to their own satisfaction. How many, for example, can demonstrate to their own inner satisfaction that the acceleration due to gravity is 32 feet per second per second? A long, hard educational process is required during which a person must freely submit himself to a rigorous discipline and ardently desire and believe in its outcome before he can acquire for himself the power to demonstrate the truths of science to his own satisfaction. Indeed this process is none other than that which we have just described as the process of incorporation into the community. Only by becoming a physicist can he possess for himself the capacity to demonstrate the truths of physics to his own satisfaction. But this indeed is precisely the same case with Christianity. The Church too is a community whose distinctive life and unique

[2] H. K. Schilling, chapter in preparation for *Teacher Education and Religion,* project publication.

power of understanding can only be shared by those who have subjected themselves to the full process of incorporation into that community. Only those who have really done so can know the profound truths to which she bears witness. Only Christians can demonstrate the truths of Christianity to their own satisfaction.

The truth of this simple fact can be seen by considering the problem of popularizing science. There is a radical difference in communication when I as a physicist present a paper to fellow physicists at a meeting of the American Physical Society, and when I give a popular lecture on some aspect of modern physics to a general audience. In the former case a minimum of words suffices for a maximum of communication. Nothing can compare with the high level of appreciation which such an audience has to offer for a really good piece of work well done, nor with the incisive and penetrating criticism which it exercises in response to poor work. But in the latter case no amount of ingenuity or care can achieve any real sense of having really put across the point. Most particularly it is quite impossible to convey to a general audience the peculiar mixture of tentativeness and confidence which physicists instinctively feel about the knowledge they have gained. This situation is, however, in my experience not confined to science. In exactly the same way I experience the same contrast when I speak concerning the Faith to, on the one hand, a group of fellow clergy or theologians, or, on the other, give a lecture on Christianity to a random academic audience. Such experiences have convinced me that the only way to really know the truth of physics is to become a physicist, and the only way to really know the truth of Christianity is to become a fully-committed Christian.

This last point suggests another contrast which is frequently made, namely, that science deals with public knowledge, while on the other hand religion is confined to private, subjective knowledge. This again reflects not so much an insight into the proper nature of either, as it does a prejudice peculiar to the twentieth century cultural context. It is true that when I give a popular lecture as a physicist, I can count on having an audience which is completely sold in advance on the validity, importance, and undeniable truth of the enterprise of physics as a whole. Moreover, the idea that I might speak of a private physics of my own would not even occur to them. I have never yet been called upon by a modern audience to defend myself or explain what possessed me to embrace physics. It is equally true that whenever I give a popular lecture on a theological topic, I can count on having an audience equally convinced in advance that religion, although possibly proper, respectable, and even admirable, is nevertheless a private peculiarity of individual people and therefore essentially unreal and invalid. Here the idea of a catholic faith which is the common public witness of the whole body of the faithful through the ages is alien to contemporary ways of thinking about Christianity. I can almost always count on being called upon by puzzled people to explain what possessed me to embrace such a faith with the degree of seriousness implied by my taking Holy Orders.

In this sense it is true that in the twentieth century science is public knowledge, and religion is private. But it has often struck me that, had God given it to me to live in the sixth century or even the twelfth instead of the twentieth, the situation would have been exactly reversed. Then when I spoke on Christianity my audience would have been convinced in advance of the complete validity and universal truth of what I represented, and it would have seemed completely natural that I should want to be a priest of the Church. On the other hand, if I then spoke as a physicist no one would have thought it important or real, and it would have seemed quite unaccountable that a man should throw himself whole-heartedly and zestfully into such an enterprise. In the sixth century Christianity would have represented public knowledge and science would have been called private knowledge.

Another way in which these two fields are frequently contrasted is the assertion that science is based on facts whereas religion must be taken on faith. Such an assertion is quite as untrue from the standpoint of the basis on fact as it is from that of the dependence on faith. In the first place I can bear witness from my own experience that I had just as much sheer factual material to learn and digest in my preparation for Holy Orders as I did in obtaining my doctorate in physics. The range of subject matter from modern Biblical scholarship, through church history and liturgics, to moral and dogmatic theology represents a most extensive factual base upon which Christianity rests. It requires prolonged and disciplined effort to achieve a thorough grounding in Christianity.

Faith, on the other hand, is just as essential an element of science as it is of Christianity. This is perhaps a much more difficult point to grasp adequately than the other. The reason, I believe, is the common misconception of science which regards it as a self-regulating mechanism which automatically produces information when the crank of scientific method is turned. Very little faith would, of course, be required for the operation of such a mechanism. But science, as we have seen, is not at all that kind of affair. The investigator confronting nature directly finds nothing resembling the smooth, ordered, lawful behavior depicted by the textbooks. What he finds instead is, in Conant's apt phrase, the downright "cussedness of nature." A crucial experiment successfully performed is a major achievement which only fellow scientists who themselves have met nature face to face can fully appreciate. Scientific research is a tough and unrelenting business. Only those who enjoy a firm and unshakable faith in the ultimate intelligibility of the chaotic torrent of phenomena in terms of underlying laws and universal principles can possibly stand up under it and carry through with it successfully. Often students discover when they leave the textbook stage and try to grapple with nature directly that they simply cannot believe that they can derive anything orderly and dependable and sure from their experiments. When this happens all they can do is change fields. Without such an abiding faith, it is simply not possible to become a part of the community. The acquisition of such a faith is the prime requisite for the process of incorporation into the science community which we described earlier.

It is a mistake to think of apparatus smoothly grinding out data in accordance with the regularity and dependability of natural law. The common experience with apparatus is rather that one could only conclude that it was under the control of gremlins bent on defeating the experimenter. The inexperienced may even develop a psychological block against making a run on even very fine apparatus for fear that it will not really work for them. In contrast there is a wonderfully inspiring quality about the really competent investigator in the sure and confident way in which he can throw a piece of apparatus together, get the bugs out of it with an intuitive feel for them of the most extraordinary sort, and soon have it working and giving data which surely reveal hidden and unsuspected regularities in nature. He is light-hearted and confident about his work and can approach the laboratory with an air of sure mastery which is wonderful to behold. The faith on which this confidence rests is clearly a gift which others may catch from him as they would an infection, but which otherwise cannot in any way be mechanically taught as one might teach a subject or a technique. But this is precisely the reason why physics is in its essence much more a community than it is a subject.

It is much the same with that community of the faithful in Christ called the Church. The world as we experience it directly does not seem at all the kind of world which the Christian God would create and govern. In the torrent of events in which we are all caught up there is such a mixture of evil, misery, cruelty, and injustice that disbelief in the Christian assertions about the nature of the reality which lies at the heart of events is easy. Yet here, too, faith in the God of goodness, mercy, and love — and of wrath and judgment too — who has revealed Himself in Christ, is the prime requisite for incorporation into the Christian community. To those within this community who have been given such a faith, the world takes on a different aspect and is seen with new eyes. It provides them with a firm foundation on which to stand and a fresh vantage point from which to look out upon events. Just as the faith which is essential to the fruitful pursuit of scientific inquiry endows one with the power to uncover and make manifest an underlying order and regularity behind the surface turbulence of events which subjects them to the rule of universal law, so also does the faith which is essential to the fruitful pursuit of the Christian life endow one with the power to know and respond to the hand of God behind the same events which subject them to the rule of His providence and judgment.

One of the assertions in Dean Schilling's description of the characteristics of the science community which I have found to cause the greatest resentment is that this community has its own creeds and beliefs, orthodoxies and heresies. Let us see in what way this is true of science. In my own field of physics it is a common experience to receive privately published papers which develop all kinds of strange and bizarre theories about everything from the electron to the universe as a whole. When I was a professor at the University of Tennessee, the department kept such communications in a "quack file." To the non-physicist they have as bona fide a ring as a paper in the *Physical Review*. But to physicists they are immediately recognized as fundamentally different. They constitute in the strict sense of the word unorthodox or heretical physics. In subtle ways impossible to describe clearly to the world at large, they violate everything which has given the physics community power to slowly and painfully acquire real and dependable insights into the nature of things. They are lone wolf enterprises unchecked by the discipline of the community and unsupported by an essential loyalty to the enterprise of physics as a whole. Most often the authors of these papers are completely oblivious to these elements and suffer from a deep sense of persecution. They cannot see why their theories have not been given an equal hearing with those of accepted physicists. They cannot understand why the community consistently and repeatedly rejects them.

Orthodoxy and heresy are words which have acquired bad connotations in modern ears. As a result their nature and meaning has been widely misunderstood. Every community must have them in order to be a community at all. Even a street-corner gang has a collection of crucial loyalties, values, beliefs, and standards which represent orthodox behavior for members of the gang. A heretic who fails to share any of these and rebels against the communal requirement of assent to them must be expelled from the gang. If he is not, the gang will soon disintegrate and disperse. So too with both science and the Church. There are certain essential attitudes, loyalties, convictions, and devotions without which either community would lose its special source of power, vitality, and integrity. These represent the orthodoxy of the community. These are really crucial to the health and welfare of the community. If it fails to preserve them, it will degenerate into a mere institution or organization, powerless and ineffectual.

Every science has had its heretics. For the most part, as in the case of Christianity, they dry up and disappear, being powerless to attract others into their fold. Science is not yet old enough to have produced many heretical offshoots with power to grow into significant schismatic bodies. But this was true of the Church too. It was only in the fourth, fifth, and sixth centuries that the great Arian, Nestorian, and Monophysite heresies arose. There are, however, two very apt examples of such scientific heretical movements today. One is represented by the osteopaths as a schismatic heretical body attached to orthodox medicine, and the other is the science of parapsychology devoted to the investigation of the so-called psi-phenomena which is a heresy of orthodox psychology. A study of either of these two contemporary movements can be very illuminating in revealing the true character of heresy in general. For example, the long struggle waged by the osteopaths in state legislatures to achieve legal equality with medical physicians has many parallels in the legislative history of the struggle for religious toleration. In the case of parapsychology, it would be most illuminating to those who like to think of science as an impersonal mechanism which automatically follows wherever the evidence takes it, to study the reaction of orthodox psychology to this field of investigation.[3] A number of leading psychologists in writing on the subject clearly indicate that their objections to telepathy and other psi-phenomena are based on something deeper than mere statistical evidence, so that even if the evidence were proved statistically sound and unimpeachable they still would not believe it.

All of this has a bearing on the widespread notion that religion necessarily imposes a rigid straight jacket on the intellect in contrast to science which is intellectually free and unhampered by any authority. In my own experience of incorporation into both communities, such a notion is completely false. In both cases it was necessary first to accept and willingly conform to the discipline of the community and to respond to its authority before the community could bestow upon me its power of liberating the intellect to carry out really fruitful inquiry. The tendency is to completely underrate the toughness and difficulty of really fruitful intellectual activity in either science or theology. Without a firm foundation on which to stand, one simply cannot grapple with experience in the tough and sturdy way which is required for real understanding. But such a platform cannot be had apart from the discipline and authority of

[3] A study of the group of articles in the January 6, 1956, issue of *Science* (Vol. 123, pp. 7-20) will be found most instructive in this connection.

the community. A completely free intellect operating in a lone and isolated self cut free from every tie which binds into community is an impotent thing tossed to and fro by every wind and wave. I could not even begin to do physics until I had given myself fully and freely to physics. Neither could I begin to do theology until I had given myself fully and freely to Christ in His Church.

The authority and discipline which every community exercises over its members represents at once the primary source of its power and vitality and at the same time its most fearful danger. When the community is dynamic, vigorous, and full of vitality, its authority and discipline are so gladly and spontaneously accepted by its members that they are scarcely conscious of it. This is the case with science today, and it has been the case with the Church in all of its past periods of greatness. The vitality, genius, and brilliance of the intellectual activity of the Church during the fourth and fifth centuries matches that of theoretical physics in the nineteenth and twentieth. If one wishes to really understand authority, discipline, dogma, and orthodoxy in the Church in a way which brings out their necessary character and fruitfulness, one must turn to such a period in Her life as that.

The nineteenth century enlightenment had a corrosive effect on the Church, and we are just beginning to emerge from the deadness and sterility which resulted. The great difficulty in talking about Christianity today is that it is this nineteenth century image and vision of the Church which is predominant in the minds of contemporary audiences. When the power and vitality is sapped out of any community so that there is left behind only an empty institutional shell, the imposition of its authority and discipline and the maintenance of its dogma and orthodoxy does become an evil and obnoxious thing, stultifying the intellect and imprisoning the soul. But it is then no solution to simply discard all these elements, for to do so will only leave the community powerless to bestow any powers or capacities at all upon its members.

I trust that this brief review of the elements of science as community may have served to introduce to you an essential aspect of science, and of Christianity too, which is widely ignored and neglected in many contemporary discussions of science and religion. The factual and conceptual content of each of these fields is certainly important and relevant. Indeed, the resolution of the tensions and conflicts between these two bodies of knowledge is perhaps the primary intellectual and scholarly task and challenge of our time. Moreover, it is a task of such difficulty and magnitude that several generations of dedicated effort by the best minds we have to offer may be required for its completion. The point of my remarks here has not been to underrate or gloss over in any way the importance or relevance of this task. But at the same time I am convinced that the task simply cannot be carried out at all if we continue to ignore the surprisingly close analogies between the two communities of inquiry and understanding by which these subject matter contents have been produced. My plea is simply that one must recognize first, before even starting on the task of content resolution, that in its most essential and elemental nature science *is* community and Christianity *is* Christ and His Church. If I have succeeded in even suggesting the possibility of the truth of this assertion in this brief address, I will have achieved my objective.

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Biology in the Atomic Age

FIRST I WISH to bring the greetings from my own university, now a bit snowbound, but I trust still active. There are perhaps some creaks and groans because we have celebrated our 300th birthday, and I am delighted to see you so active, so eager, on your 100th birthday.

I am very glad to have this opportunity to talk with you about biology, taking it in its broad sense in the atomic age, because Iowa State College played a very large part in bringing about the atomic age. I recall the small building, now torn down, where the uranium for the first atomic reaction on a large scale was manufactured. It was the sole source of purified uranium for a considerable period. One of the things the last war brought home was that the advances in science are made not in the arsenals of the nations, but rather in the universities of the nations. For the technical advances made acute in the framework of war, one needs the results of the skilled, patient, careful exploration of the unknown. That occurs primarily in the universities. As one sees the changing pattern of the atomic age, one is struck by the rapidity of change. At Hiroshima and Nagasaki it was demonstrated clearly that it was 3,000 times as cheap and easy to destroy as to build — reversing a trend in warfare that had been steadily reaching a more and more costly peak from the days the first two cave men decided to argue over who would get the larger share of the animal that they were carving up.

With this major break-through, which came about by a series of very rapid steps, we were precipitated into a period where the advancement of science became almost incredible. Even the imagination of Jules Verne had not adequately visualized satellites circling about our earth and giving us information as to the conditions of space, making it possible for us to talk seriously about problems of space travel.

Just as it is very difficult to see where the next advance will come, one recalls that the crude experiments of Lord Rutherford less than 40 years ago have led to the transmutation of elements, incidentally just the reverse of the goal of alchemists in the Middle Ages. Instead of transmuting mercury into gold, they transmuted a few of the atoms of gold into mercury, but opened up thereby the chance for the development of the whole field of understanding of the structure of the atom and the ways of utilizing the energy of the atom.

Biology in the atomic age is perhaps distinguished by this matter of having extraordinarily effective tools of amazing accuracy and speed. It is also faced with problems that are brought about by our changing environment — chiefly environmental radiation. These two factors, perhaps more than any other, affected the course of research in biology since the atom has become readily available and since man has been able, on a large scale, to bring about changes in his environment. Let's take the first. The ability to distinguish and trace quickly individual atoms has made possible unravelling skeins of intermediate metabolism, has even made possible the recognition of intermediary compounds that we didn't know existed because of the fact that they had relatively short lives in the biological change and because they were difficult of analysis. The tracer atom made it possible to recognize these with a rapidity that had never happened before. I recall in my own laboratory how proud I was when we were able to make a determination of phosphorus in microgram quantities. This was a major achievement and took three to four days' work. Now, with radioactive phosphorus, one is concerned not with microgram quantities but with millionths of microgram quantities, and the determination is down to fifteen or twenty minutes' time.

For the first time, then, we have a way of very rapidly learning what is going on — and not only learning what is going on by breaking down and analyzing substances, but learning what is doing on while those substances are still in their original and active form. The speed with which many biological syntheses are accomplished — even the most complex such as protein synthesis — has proved surprisingly fast, a matter of minutes in many instances. I am sure that Dr. Spedding has been somewhat envious, in his field, of what bacteria or protozoa or more complex organisms can do. This extraordinary ability of biological processes to work with great rapidity, even when very complex, had been suspected but not fully appreciated until the pathways could be followed with the atom.

It is interesting to realize that these atomic tools which are now quite a matter of course in many laboratories are nonetheless relatively new. The first distribution of isotopes on any reasonable scale came about in 1946. Now thousands of shipments are made annually from various laboratories, and work is going on with them in all parts of the world — in India, South Africa, Germany, Russia, as well as in the United States. And a very large share of this world-wide revolution in biologic thought and biologic approach owes its very existence to the pioneer work that was done by Dr. Spedding and his group here at Iowa State College.

One of the things that we have been able to do by virtue of having these various tools available in biology is to understand how molecules combine and separate, recombining within our own bodies as well as within the plants and animals on whose lives our own are so dependent. We've learned that even structures that we thought of as comparatively stable, such as teeth and bones, are unstable to an extraordinary degree and take a significant part in the daily metabolic activity of the body.

One of the instances where time is also brought into play in relation to biology in a rather interesting way is through the use of carbon 14. Dr. Libby's observations permitted analysis of small amounts of carbon 14 and brought out the fact that any biologic matter, while it is alive, is in equilibrium with carbon 14 in its environment. The fact that it ceases to be in equilibrium with the carbon 14 of its environment when it dies has been an extraordinary tool in determining the age of things under 25,000 or 30,000 years. For example, it has been possible to date with accuracy the grass sandals that were found in the caves of Oregon and were made about 14,000 years ago. It has been possible to check on the accuracy of the tree calendar that tells us much about the ecology of the southwestern portion of our country, in particular in the past, and throws light on the present trends. Sometimes this has proved disconcerting. For example, on checking the age of one of the mummies in the museum at the University of Chicago, it was found that a ringer had been worked in which was only 125 years old instead of belonging in the dynasty of the Pharaohs.

Another use of time has been to go back to the other scale — the very long-lived isotopes such as uranium — where one thinks in hundreds of thousands of years. And this has enabled us to get a much clearer understanding of geological time. One of the things that has happened with the use of the tracer atom to open up these various biological processes is the possibility of understanding much more clearly what goes on in the aging process of various metabolic diseases. When I first became interested in diabetes as a disease process, for example, it was necessary to measure the amount of sugar, protein, or fat that went into the patient, to measure the amount of oxygen that he consumed, the amount of sugar that he spilled in his urine, in order to estimate what was happening. We got about as sound an idea as one gets from watching the trucks go into a factory and the product that comes out of the factory. But just as a while ago the Coca-Cola Company and others began to put plate glass windows in their bottling works so that you could see what was really going on, so the tracer atom has enabled us to open up and follow the biological processes and to determine just how the metabolism was carried on, just where it was going wrong, and to learn much more accurately what to do about it.

In addition to learning a great deal about the normal functioning of man and animals, numerous pathways have been opened up for us in the diagnostic field. We can detect changes in the thyroid gland, for example, in man and animals, by the use of radioactive iodine that we never could have detected in any other way. And there are many other advances in human medicine and veterinary medicine, thanks to the availability of these materials.

The use of the tracer atoms, of course, is not limited to an individual man or plant or animal, but can be used to a tremendous degree in ecologic studies or in quickly checking the distribution of a fungicide or insecticide. And on an even larger scale one finds that oceanographers can learn a great deal about the life of plankton, a great deal about the food change, in relation to fishes of importance, a great deal about the currents by virtue of having large amounts of waste products or radioactive isotopes with which to trace. Probably more advancement has been made in the field of meteorology as a result of radioactive fallout from atomic tests than could have been brought about in any other way. They had one crude tracer, to be sure, when Mt. Krakatao exploded in the 1880's and put millions of tons of dust in the atmosphere. But this was difficult to trace with accuracy, and only the brilliant red sunsets of some Remington paintings are left as a reminder of this period. There is some information that was gained in the days of the Dust Bowl when the particles of known soil character could be traced for long distances. Sands of the Sahara have been tracked up into Turkey and the Crimea. But the motion of major air masses and the understanding of these really came about only when we had great masses of radioisotopes in the form of ashes of atomic explosions available to trace them.

There has been one area of disappointment thus far in the use of radioactive materials in biology and medicine.

We have not found any striking cures. There is nothing that corresponds to the discovery of the sulfa drugs or the antibiotics in the field of therapy. And while the field is yet young, it still looks as though we would make a number of significant but relatively minor advances. We have to look more to the research potentials of the radioisotopes than to the actual utilization of them in the treatment of disease. And it appears the radioactive isotope is at its best as a research or a diagnostic rather than a therapeutic tool.

The other side of the coin is the problem of potential changes that may be brought about in our environment by the atomic age. And these are already manifold. Radioactive wastes in fallout from atomic explosions are a factor in this. Sometimes the changes are simply related to changes not radioactive in themselves but brought about by radioactivity. For example, at the Hanford Works of the Atomic Energy Commission, our major problem is not in relation to the radioactivity and the wastes from the Hanford Works, but rather in the fact that in cooling the atomic piles we raise the temperature of the Columbia River enough so that it is just borderline for the salmon runs there. And in order to preserve the salmon industry in that river it has been necessary to take extraordinary precautions with regard to temperature control. One of the problems that we have close to home is that the Yankee Atomic Company is putting a reactor in western Massachusetts at the headwaters of one of the best trout streams of the area. This stream will be warmed up by some 10 degrees by the operation of the plant, and there is a question as to whether the present trout will do as well as they have in the past.

So there is a considerable range of these problems, not only atomic but others as well. There is the problem of waste disposal that needs to be thought of, because in any atomic reaction there are ashes just as there are the ashes of an oxidizing reaction of coal and wood. And these ashes are radioactive, hence a problem. In a country as vast as ours, with the broad expanses of barren areas, waste disposal does not provide a problem for us. It is more of a problem in such thickly settled areas with limited expanse as the United Kingdom, for example.

At the present time all foreseeable atomic wastes can be handled in this country either by burial or by safe sea disposal. Of course, the ideal answer to waste disposal is to do just what the packers have been able to do with hogs, to have the waste become of value so it ceases to exist as a waste problem. This can very likely be brought about in certain of the components of atomic wastes, perhaps not in relation to others. Still another environmental factor is that with the increased use of reactors — the increased transportation of materials for reactors or coming from reactors — the hazards of accidents also must be weighed. In the reactor the fuel elements are so arranged that even with a very serious accident an atomic explosion is virtually impossible. I asked a very competent theoretical physicist to give me a guess on this, and he said about one chance in three hundred billion. And that is on the order of chance of another star messing up the solar system.

On the other hand, there are other potential hazards not so serious but nonetheless annoying, such as the accident in the United Kingdom which you may have read about where I^{131} escaped from the accidental burning of fuel elements in the pile. Fortunately, because they were alert to the problem, there was no injury to man. But as the material settled out (and iodine changes very easily from a gas to a solid), it settled out on the forage pastures down wind. And some of it was carried not only through England but even to the Continent. Its path was checked as far as the Iron Curtain.

Closer by, there was enough in the pasture so that the cows grazing there picked up the radioactive iodine, incorporated it into their milk, and excreted it in the milk. As the result of this, some of the milk from adjacent milksheds had to be condemned, more for public relations reasons than any other until the radioactivity had lessened with the passage of time. It would have been perfectly feasible to have held the material for a few half-lives and soon it would have become completely harmless, but they were a little afraid of the public relations effect of this. It is like a number of things we know are perfectly safe but not always appealing from another sense. Once something has been bad we are very apt to continue to assume it to be bad.

Another thing that is changing in our environment with regard to radioactivity is the fallout from atomic weapon tests. As yet this is relatively insignificant although its effect is world-wide to an extent that is not generally appreciated. If one takes snow from the antarctic ice cap and melts it, one finds radioactive strontium. And because of its somewhat longer half-life, it is regarded as a chief danger and we check for this more carefully than for other elements. To give you a rough idea of how carefully this checking has been done from various portions of the world, something like over a half million analyses have been made. So we do quite well on the distribution of radioactive fallout, the amount of the chemical concentration, and the radioactivity. There is rather more concentratation in our latitude between 30 and 50 degrees north than elsewhere because this happens to be along the wind path that relates to both our tests and the

Russian tests. The southern latitudes have somewhat less. There has been gradual stratospheric diffusion from the tests in the northern hemisphere and also some supply from the tests of the United Kingdom which are carried on near Australia, as you know.

Now since this radioactive strontium can exchange with calcium and bone and acts just like calcium, and since even at low levels in mice it may cause the development of bone tumors or possibly leukemia by irradiating the bone, a tremendous amount of research has been carried out. And we have a number of analyses of this level in human bones. The evidence indicates that the uptake in human bones is not at a dangerous level and, in fact, is well under the dose regarded as acceptable for occupational exposures. It is of interest to stop and think that every one of us undoubtedly has a number of atoms of radioactive strontium incorporated at the present time, and then to think that this material could not exist until the atomic age occurred. This is fairly new material and yet every person, every animal on the face of the earth as far as we know, probably has at least some radioactive strontium in it. It gives an indication of how environment can be changed in these days. The radiation thus received from radioactive fallout is about one-fiftieth of the amount the average adult in this country has received from medical and public health applications, that is, chest surveys, the use of X-rays, and is much less less significant in increasing one's exposure to radiation than would be moving from Ames to Denver or Salt Lake City. Nonetheless, since it is a widespread man-made source, the level of environmental radiation has been, and will continue to have to be, extensively studied. As a matter of fact, we know a great deal more about the potential danger from radioactivity than we do about the potential danger from automobile exhaust fumes.

One of the most amusing things that I have seen recently was a parody of one of Linus Pauling's articles on the hazards of radiation adapted to the use of coal. The parody pointed out that this was an extraordinarily dangerous substance because when ignited it could not always be controlled and there would be great destruction of property and lives from fire; there would be carbon monoxide gas produced; there would be any number of chemicals produced; it was very hard to handle because it could heat things up to hundreds or even up to about one thousand degrees centigrade, and this was going to be rough on metals that it came in contact with. One wondered if all these things had been said and widely debated publicly when coal first began to be mined, that perhaps there might not have been some degree of public anxiety as there is today in regard to use of atomic energy.

One of the reasons that we need to study radiation very carefully in our environment is that radiation is an important source of mutations. It is assumed by the geneticists that a fraction, or some say almost all, of the mutations now present in the human race have been brought about by the action of radiation from the natural background — the cosmic radiation, the radiation from the radioactive potassium and radium in our own bodies, the radium that is frequently found in drinking water, and so on. And it is quite possible that these have played a significant part in bringing about the mutations that have gradually led man from his primitive state, by a process of elimination of the unfit or unadaptable, up to the present time.

One of the things that particularly concerns us today is that the process of selection is not working as effectively as it has in the past. When the time was that the patient who developed diabetes on the basis of heredity died before having children, there wasn't a major heredity problem. But with better treatment of diabetics we are keeping the genes of those individuals who are carriers active in the pool of the race and hence have the likelihood of many more diabetics in future generations, and so it goes.

The geneticists say we should go very slowly and carefully with anything that is apt to bring about radiation mutation. This is seen perhaps most vividly in contrasting what one knows about obtaining better breeds of plants by radiation and about obtaining better breeds of animals. The plant geneticist can irradiate tremendous numbers of seeds and broadcast them over acres and then can watch for those plants that are doing the things he would like to have them do. As a crude example of this, a number of years ago about half a bushel of peanuts was shoveled into the atomic reactor at Oak Ridge and these were heavily irradiated. Then they were planted in North Carolina. Some of them failed to come up, some of them were pretty unhappy, spindly plants. Others proved to have increased yields, or produced a much larger peanut. Others were resistant to blight, others resistant to drouth, and by selection from these it was possible to obtain improvement in the type of peanuts and rapidly get this up to a level where it would have commercial importance. Now with animals one can't do that. You can't handle as large a number. Imagine trying to irradiate cattle at random and breeding a few million cattle, trying to pick out the good ones that you wanted. It just isn't a practical approach. So, in general, for the plant geneticists, radiation is a useful and practical tool. For the animal geneticists and human geneticists we have to assume that in general, mutations prove to be bad rather than good.

Perhaps the most valuable aspect of atomic energy in the field of genetics has been entirely a side product — the stimulation of large-scale genetic work — research that would not otherwise have been carried out. We have, right here at Iowa State under Dr. Gowen, a very important project in genetics related to the radiation problem. We have at Oak Ridge now, I think, about a quarter of a million mice that have been involved in the experiments on genetics there. We have experiments on dogs going on in different parts of the country. Similar experiments are being carried on in different parts of the world and must be carried on so that we will know what the problems of good and bad are. We are somewhat in the situation that Adam and Eve were in. We have the apple, and the question is how far to bite into it in relation to the good or evil that it may bring.

Now, in the course of the discussion of this problem of our changing environment incident to the utilization of atomic energy, some very useful facts have been presented, some things that purport to be facts but are not, and a great many emotional viewpoints. You probably have noticed in any argument that the further one gets away from the fact, the warmer the argument becomes, and this is true in this field as well as in others. One of the very fortunate things is that we have a period of time in which we can choose what we should do in order to find out the good things that are available for us and to find out what the hazards are and how we may control them.

One point that is of importance to us is to know what the social burden of these environmental changes may be. Is it going to be an overwhelming one? Is it going to be a significant one? Mutations cannot be predicted with accuracy as to number or as to type. But we can make a rough estimate of the probable number of mutations in man at the present time. And we can make the assumption that doubling that number would not place too serious a social burden on the earth's population. This amount of radiation that would double mutations has been called the "doubling dose" and is regarded as an amount of radiation which, in the light of present knowledge, man should not exceed. The value of this doubling dose is a matter of speculation. The estimates run from very low to as high as 400r, with 10r as a probable low limit and 30 to 50r as the rather likely level.

Now what is an r? It is an arbitrary unit of radiation. It is an abbreviation for roentgen. My wrist watch has a radioactive dial. And that radioactive dial is constantly irradiating the skin of my wrist while I wear it. And in the average time that I wear it, approximately 16 hours a day, the skin underneath gets the same permissible dose that would be safe to give my entire body. That is three-tenths of a roentgen for a week. This is a safe level of radiation as far as systemic effects are concerned; it is a level of radiation that might have some genetic effects.

However, there is another point that we must remember in relation to the genetic effects. This is that the effects may be apparent in the first or the second generation, but that many generations must pass before equilibrium is reached. This is fortunate with man because the present levels of radiation, due either to weapon testing or industrial utilization of atomic energy, are very low, and therefore we have time to sample the good and evil potentials of atomic energy — to choose wisely, I hope, between them.

Cecilia Payne-Gaposchkin

Chairman of the Department of Astronomy, Harvard University

New Light on Cosmic History

THE PRESENT ERA is one of new approaches to the universe. Astronomy has been revolutionized during the past decade. Perhaps the most remarkable change has come from the newly developed ability to receive radio signals from outer space. The mysterious "cosmic static" of a couple of decades ago has blossomed into the new science of radio astronomy, whose telescopes are measured in feet where the optical instrument is measured in inches. It is not an idle dream that the radio telescope will soon reach to greater distances than have been probed by the study of the light of stars and stellar systems.

Another new approach is of still more recent date: it is less than a year since the first man-made satellite was launched into space. But the satellite is not yet a fully astronomical tool. At present it is looking inward, not outward; it is primarily a means of studying geophysics. When satellite astronomy does look outward, the astronomical consequences can hardly be foreseen. But that day is still in the future.

The new approaches are not confined to techniques. The whole system of ideas concerning the universe is in a state of flux; the whole emphasis in our cosmic picture is changing.

It has been said that there have been three eras in modern astronomy. The first, which dates back less than two centuries, was concerned with the great stellar system in which we live — the Milky Way system. The stars were counted, and their positions were surveyed; their motions were measured, and many attempts were made to discern structure in the great system of stars. Gradually it dawned on astronomers that our Milky Way system has limits, and then it appeared that we are not unique — our own Milky Way is only one of many, separated by vast empty spaces. Only now are we beginning to realize how many Milky Way systems, or galaxies, there are — not hundreds or thousands, but thousands of millions, extending to the utmost limit that our telescopes have been able to reach.

The study of the Milky Way was essentially an era of map-making. The next great stage came when the stars were recognized as individuals with special, identifiable properties of their own. Some are hundreds of times the size of the sun, some are proportionately smaller; some have surface temperatures a hundred times the sun's, some are so cool that they barely shine. The star as an individual has dominated the first half of the present century, and we have learned to find out not only their superficial properties, but even to analyze their chemical composition. The results are surprising: most stars are of very nearly the same materials, and in nearly the same proportions. Hydrogen, the simplest of the atoms, dominates the composition of the universe: it has been said that stars "are made of hydrogen, with a smell of other elements."

Today we have taken a further step: not content with recognizing an amazing variety among the population of the heavens, we have begun to ask the question: What makes them differ? Have they always been as they are today? What was their past history, and what will be their future? These are the questions that dominate astronomy today. It might be thought that these questions can never lead to more than fruitless speculations, but remember that only a hundred and fifty years ago a famous philosopher stated that one thing we can be very sure of is that we shall never know what the stars are made of. Famous last words! I wish I could present you with the details of the quantitative analysis of the sun's atmosphere, and the beautiful, intricate evidence on which it is based.

Two roads have converged to give us our present knowledge of the development of stars. I prefer not to call it "evolution," because that word has come to have a special biological use, which is not transferable to cosmic processes. The first was the recognition of families of stars; the second, the understanding of what keeps the stars shining, a problem that had puzzled astronomers and physicists for three-quarters of a century.

Our own Milky Way system contains about a hundred thousand million stars — many of them, of course, too faint or too distant to be seen, but the number can be stated with some confidence. Those that can be studied reveal a surprising tendency to occur in groups. The majority of the stars have at least one companion, a physically associated body in orbital motion around it. Many of these groups are multiple, like the bright star Castor which has six components, and the famous "Trapezium" in the Orion nebula, which seems to have eight. The very nearest of the stars is a triple system. And we can feel sure that these multiple stars have always been associated together since their beginning; the stars, though numerous, are so far apart that a chance capture is out of the question.

Even more striking than the double and multiple stars are the star clusters. Everyone who knows the sky is familiar with the Pleiades — the "seven stars in the sky" that are visible to a keen eye. A telescope shows that this cluster contains far more than the seven bright stars, indeed it has hundreds of members. The Hyades, not far from the Pleiades in the sky, is another cluster well known to the stargazer; here again there are hundreds of members in addition to the small number visible to the unaided eye. There are thousands of such clusters, and many more, faint and distant, remain to be discovered. If a double star has no chance of being an accidental association, how much less likely is a star cluster to be one!

If star clusters and double stars are not chance groupings, but have been together from the first, we can draw an inescapable conclusion: they were born together of the same materials and at the same time, or very nearly so. This is the basic fact that underlies the modern study of stellar development.

The stars of the Pleiades cover a large range of brightness; some are much brighter than our sun, and they are found to range all the way to stars much fainter. When these various members of the Pleiades family are studied with care, their individual properties determined, and their sizes and temperatures measured, they are found to be arranged in a very orderly progression. The brightest are the largest and the hottest, and their sizes and temperatures are uniformly graded downward as we pass from brighter to fainter. The members of the cluster were born together and have developed in company. Why, then, are they so different? The answer to this question was provided by the second discovery that has ushered in the new era of astronomy — the discovery of the food of the stars.

Speculation has succeeded speculation on the question of what keeps the stars shining. Specifically, how has the sun maintained a virtually unchanged output of heat and light during geological time? Mere combustion would be hopelessly inadequate. The idea that the sun might be releasing gravitational energy in the form of heat, and contracting as it did so, while it improved matters over the combustion theory, was still insufficiently prolific. When radioactivity was discovered, and the release of energy from the nuclei of atoms was seen to be possible, speculation began to play with the idea that the stars might be subsisting on the energy of their own atoms. It was less than twenty years ago that these speculations gave way to convincing theories. At nearly the same time, Hans Bethe and C. F. von Weizsäcker showed how stars could release energy from their own hydrogen atoms under the very high pressures and temperatures in their interiors. The food of the sun was shown to be hydrogen, simplest and commonest of all the elements, and the supply of energy was seen to be adequate within our luminary for a long time to come. There is little doubt that the stars in the Pleiades are similarly fed.

If stars shine by consuming their own internal hydrogen, it is clear that their careers must be limited by the amount of hydrogen available. It was therefore a matter of great interest to determine how fast they are using up this essential material. There is a very simple way of finding this out: the amount of hydrogen used is proportional to the amount of light given out.

Stars give out light at very different rates, which is the reason why they differ so much in brightness. The brighter members of the Pleiades are giving out far more light than their fainter brothers. But are they all equally well supplied with food? Have the brighter ones, perhaps, more hydrogen within them than the fainter ones?

On this point the evidence, also, is very convincing. As stars are mainly made of hydrogen, the amounts of available food that they possess must be proportional to their masses. And, although the masses of the stars in the Pleiades cannot be measured, we are confident that they resemble the masses of many other stars that can be measured (because they belong to close double-star systems whose mutual gravitation can be determined). The study of such stars leads to the striking conclusion that a star's light output is not proportional to its mass, but goes up much faster — nearly as the *cube* of its mass. The light output of a star of a hundred times the sun's mass would be about a million times as great as the sun's. So the more massive star must use up a million times as much hydrogen in a given time. Since it has a hundred times as much hydrogen to start with, such a star is "living" at a rate 1,000,000/100, or 10,000 times that of the sun. We cannot escape the conclusion that it can last 1/10,000 times as long.

Now we take a close look at the physical properties of the stars in the Pleiades. When a star is beginning to come to the end of its hydrogen resources, we can predict what will happen to it: it will begin to draw on new sources of energy, and will grow in size and fall in temperature. Some of the very brightest stars in the Pleiades show unmistakable marks that this process has begun, whereas the fainter ones, like the sun, still have ample supplies. By knowing the characteristic mass of a star like those that begin to show signs of departing from the sunlike pattern, we can calculate how long they have been shining. And this enables us to assign an age to the Pleiades cluster — an age that is about ten million years.

Large as this time is, it is small compared to the probable age of the sun — perhaps five thousand million years. The Pleiades, however, is old compared to some other clusters that we know. The great double cluster in Perseus is little more than a million years old; and the group of stars that shine through the meshes of the Lagoon Nebula in Sagittarius is perhaps five hundred thousand years old, younger than the datable life upon our own planet!

There are clusters older than the Pleiades; the Hyades contains some stars that have departed very far from the sunlike pattern, and this cluster is perhaps ten times the age of the Pleiades. There are still older clusters, inconspicuous in the sky, but dear to astronomers, "NGC 752" and "Messier 67," for instance (known only by the numbers assigned to them in catalogues), the latter being perhaps 5,000-million years old, as old as the stellar system itself.

How, you may ask, do we know the age of our stellar system? We date it by the oldest objects in it, and corroborate the date from our studies of the energy sources of the sun itself (about 5,000-million years old) and the geological estimates of the age of the earth, which are not much smaller.

The oldest objects that we know in the stellar system are clusters, but clusters of a very different kind from the Pleiades. Whereas the clusters we have spoken of have hundreds of stars in them, these old clusters have populations of hundreds of thousands, if not millions, of stars. They are known as the "globular clusters" because they look like globes of stars, which they probably are.

Globular clusters show development patterns that confirm and supplement the patterns shown by the galactic clusters, though they are different in important and striking ways. These clusters can be dated in much the same way as the Pleiades-like clusters, and they all turn out to be nearly of the same great age, about 5,000-million years, perhaps rather more.

What makes them differ from the Pleiades-like clusters? Probably they are of different composition, and contain more hydrogen and less of the heavy elements. We ascribe the difference to their greater age: they were formed at a time when the star-generating clouds consisted mainly, perhaps entirely, of hydrogen.

How, then, did the Pleiades-like clusters come to be formed from materials of different chemical composition? We now believe that these clusters are a second generation in stellar development. As stars consume their hydrogen, they form other, heavier elements; first helium, later oxygen, neon, and finally the metals. Many of the heavy, luminous stars become unstable and explode, scattering these products of their digestive processes into space. The clouds of material thus formed are able to form again into stars and clusters of stars — very likely all stars are born in clusters, and some of them get lost as the cluster ages. Thus, the younger stars, the second-generation stars, are of different chemical composition from the primitive stars, and their course of development is somewhat different. The difference is reflected in the pattern of physical properties that is displayed by the members of a cluster like the Pleiades.

The new outlook in astronomy has led to a complete transformation of ideas. Today we look out at the stars and star clusters that make up the Milky Way system and recognize that they span a vast variety of ages: some infant groups are less than a million years old, the oldest that we know are five thousand million years of age. The static universe of yesterday has been transformed into a picture of perpetual change, development and rejuvenation. The stellar system known to astronomers — even the bright stars visible to the casual observer — has changed immensely since life first walked the earth. And yet this conclusion is a triumph of *ideas* — the idea that groups of stars are of the same age and origin, and the idea that stars sustain themselves by consuming their own substance. We have yet to observe, *directly,* any change in a single star that can be ascribed to development. The coming era of astronomy will look for such changes; and I have little doubt that the astronomers of tomorrow will find them.

Theodore V. Houser
Chairman of the Board of Directors, Sears, Roebuck and Company

Today's Challenge to People's Capitalism

IT HAS BECOME the fashion to have centennial celebrations here in the Midwest. I have just come from Chicago where the YMCA is having a great centennial rally this weekend. These anniversaries are significant benchmarks in the development of this part of the country. Probably nowhere in the world has 100 years wrought such a transformation as in this area. We have gone from a wilderness to great metropolitan cities, from raw prairie to the most productive and efficient farms of the world.

I need not say how honored I feel in talking to an audience assembled in honor of our great institution, which serves so well to illustrate the dynamic character of the Midwest. It seems to me to be one of those few times when one is justified in looking back in order to size up why and how we have come to our present state of development and also to look forward, if possible, to see if there are any threats to the continuation of this onward march.

It is difficult to find a word which adequately describes the social-economic system of our country. It is capitalistic, yes, but very different — even fundamentally different — from capitalism as practiced in other parts of the world. As a matter of fact, about three years ago President Eisenhower asked the Advertising Council to develop a term that would adequately describe the distinctive type of social and economic organization of this country. The name ultimately adopted was "People's Capitalism." Since the selection of that name, the Council has been actively engaged in explaining and publicizing "People's Capitalism" both in this country and abroad.

Let us first define the elements of "People's Capitalism" that differentiate it from capitalism as practiced in other parts of the world, primarily in Europe. I would list the following as being the essentials of the American system:

1. Wages as high and hours of work as low as productivity will permit, resulting in the development of the worker as a consumer.
2. The application of scientific research, engineering, managerial skill, and capital investment to increase productivity per hour of work.
3. Competitive society with the consumer free to buy what he will, where he will, and with industry competing for the customer's favor through the production of goods that are more desirable or less costly.
4. Recognition of growth as a national characteristic and the realization that this growth comes from better plants, better machines, better-trained workers, better products.
5. Essential to this concept of growth is the principle of modest profits with increasing turnover of capital rather than a limitation of volume through large unit profits.

This latter point implies the obsolescence of equipment before it is worn out, if more efficient and productive equipment is available, and this in turn requires a constant reinvestment of a sizable portion of profits to provide for expansion and improvement.

Our American system had its genesis in the industrial revolution that started abroad, principally in England, in the latter half of the 18th century. In retrospect it seems extremely significant to our development that the political revolution that established us as a nation occurred at a time when a fundamental economic revolution was also taking place. This unique combination of events has had a profound effect on the direction and pace of our development.

You will recall that the spinning jenny was invented in 1764. The invention of the steam engine and particularly its adaptation to rotary power, the power loom, discoveries that permitted coal instead of charcoal to be used in the making of steel — all of these events occurring in a 35-year period — had a revolutionary effect on the advanced nations of the day. They were significant because of the greatly increased productivity which followed, and because of the flexibility which they permitted in the location of producing units.

Now let's look at some of the effects of the industrial revolution. Turning first to Europe where the effects were first felt, we find that the new economic order was based on the production of goods by workers employed at a minimum wage for the longest possible hours of work and that this was made possible by a continuing over-supply of applicants. There was a control of marketing through a system of cartels, based upon collective industry agreement as to production volume and division of markets. Equipment was used for the longest possible time, limited by the physical life of machines and buildings. Profits were largely withdrawn from the operation for the direct benefit of the owners. It was reasoned that capital for additional plants could only come from a limited owner class, and thus a rationalization was devised for a large profit margin.

The industrial revolution provided a new way to create wealth and was an economic revolution, not a social revolution, for the social organization was a direct carry-over from that which had existed before. The relationship between owner and worker was the same as had existed between the military officer and the common soldier or between the person of title and the commoner. These great revolutionary inventions did not touch with improvement the lives of the great masses of people.

The best witness to the spectacular ability of the industrial revolution to produce new wealth without benefiting the masses is the criticisms and attacks directed at the newly emerging capitalistic system as it was being practiced in Europe. For the masses who worked long hours in shops and factories at great danger to health and life itself, one could seriously question whether they were not better off in their former simple, close-to-the-earth manner of living. Let's take a brief look at what some of the observers of this social order had to say.

Adam Smith, the patron saint of capitalism, wrote in 1776: "No society can surely be flourishing and happy, of which the far greater part of the members are poor and miserable." Smith went on to say: "Masters are always and everywhere in a sort of tacit, but constant and uniform combination, not to raise the wages of labor above their actual rate. . . . We seldom, indeed, hear of this combination, because it is the usual, and one might say, the natural state of things which nobody ever hears of. Masters too sometimes enter into particular combinations to sink the wages of labor even below this rate."

Some 70 years later in 1845, Friedrich Engels, in drawing up his bill of particulars against capitalism could still say, in commenting on the English economic scene: "The great towns are chiefly inhabited by working people. . . . These workers have no property whatsoever of their own and live wholly upon wages, which usually go from hand to mouth. Society. . . does not trouble itself about them; leaves them to care for themselves and their families, yet supplies them no means of doing this in an efficient and permanent manner. . . the human being, the worker is regarded in manufacture as a piece of capital for the use of which the manufacturer pays interest in the form of wages."

Other commentators, while critical of the system as it then operated, were more conscious of the possibilities for a better life that it offered. Thus an early French economist, Jean Charles de Sismondi, wrote in 1819: "The immediate effect of machinery is to throw some of the workers out of employment, to increase the competition of others, and so to lower the wages of all. This results in diminished consumption and a slackening of demand. . . "

". . . It is not the perfection of machinery that is the real calamity, but the unjust distribution of the goods produced. The more we are able to increase the quantity of goods produced with a given quantity of labor, the more we ought to increase our comforts or our leisure. . . ." and, ". . . To increase the sale of the produce of industry and labor of man, it is not the income of the rich but the income of the poor that must be increased. It is their wages that must be increased, for the poor are the only purchasers who can add greatly to the extent of the market."

Robert Owen, a remarkable genius of early English industry, was even more perceptive, seeing both the problem and the solution. He said: "It is the want of a more profitable market that alone checks the successful and otherwise beneficial industry of the working classes. The markets of the world are created solely by the remuneration allowed by the industry of the working classes, and those markets are more or less extended and profitable in proportion as these classes are well or ill remunerated for this labor. But the existing arrangements of society will not permit the laborer to be remunerated for his industry, and in consequence all markets fail."

And finally John Stuart Mill, who made a vital separation between the ability of the new economy to produce wealth and the distribution of that wealth. He saw that the proper combination of capital, labor, and land would produce wealth in any setting, but that the distribution of such wealth was not an economic matter but a social matter. He foresaw the possibilities of the unprecedented productivity of industry. "Hitherto it is questionable if all the mechanical inventions yet made have lightened the day's toil of any human being. They have enabled a greater population to live the same life of drudgery and imprisonment and an increased number of manufacturers and others to make fortunes. They have increased the comforts of the middle classes. But they have not yet begun to effect those great changes in human destiny, which it is in their nature and in their futurity to accomplish."

This then was the European scene at the time this country came into being. Important inventions were available to us on which to build an industrial base. We had a continent to be settled. We had rich natural resources of a type in demand by the world of the day. The task of building roads and later railroads, communication systems, and a banking system faced the nation and contributed to a psychology of growth and expansion and individual opportunity. We had built into our very political structure a regard for the rights of the individual unique in all history. We must remember that the history of mankind is in large part the story of man's struggle to be free of the caprice, the power, and authority of the individual tyrant, despot, or dictator. The majority had struggled for recognition and had achieved it, but it remained for this country to establish the rights of the individual or a minority against the power of the majority in certain specific areas of human conduct. Thus, politically, there was recognition of the rights and dignity of the individual imbedded in our national psychology from the beginning. From a social standpoint it was accepted that no individual person had to stay in the social and economic level in which he was born. The American society was one in which the individual, through ability and willingness to work, could advance himself. While at any given moment there were definable economic levels comparable to those found in other nations, these levels were constantly changing so far as their composition by specific individuals was concerned. This country had the political, social, and economic climate for a departure from the accepted pattern of the industrial age as it developed abroad.

However, despite the completely different potential, in the main our older industrial areas copied European principles of capitalism which remained pretty much the order of the day up to the latter part of the 19th century. By this time the pattern of economic development and its impact on the social order of the day were such as to cause concern in many quarters. Even the Catholic Church, which today takes such an unqualified stand against communism, was at that time equally positive in condemning capitalism as practiced. In 1891 Pope Leo XIII, in the Encyclical Rerum Rovarum, recognized and summarized the conflict of the times. He wrote: "We clearly see, and on this there is general agreement, that some opportune remedy must be found quickly for the misery and wretchedness pressing so unjustly on the majority of the working class. . . a small number of very rich men have been able to lay upon the teeming masses of the laboring poor a yoke little better than that of slavery itself. There is no fear that solicitude. . . by the administration . . . will be harmful to any interest; on the contrary, it will be to the advantage of all; for it cannot but be good for the commonwealth to shield from misery those on whom it so largely depends for the things that it needs."

The question was thus posed, how could the faults of capitalism be corrected while preserving the system? In the Encyclical, the Pope went on to say: "Justice. . . demands that the interest of the working classes should be carefully watched over by the administration, so that they who contribute so largely to the advantage of the community may themselves share in the benefits which they create — that being housed, clothed and bodily fit, they may find their life less hard and more endurable. It follows that whatever shall appear to prove conducive to the well-being of those who work should obtain favorable consideration. There is no fear that solicitude of this kind will be harmful to any interest; on the contrary, it will be to the advantage of all; for it cannot but be good for the commonwealth to shield from misery those on whom it so largely depends for the things that it needs."

In this country it was obvious by 1890 that the growth of business and industrial enterprises and their economic power had reached a point where some type of regulation was necessary. This was done through the mechanism of the Sherman Anti-Trust Act, which has come to have a greater influence on the American industrial system than any other legislation. This law provided that "every contract, combination in the form of trust — or conspiracy in restraint of trade. . . is declared illegal." And that "every person who shall monopolize — or combine or conspire with any other person — to monopolize any parts of the trade or commerce — shall be deemed guilty of a misdemeanor."

The Sherman Act was supplemented in 1914 by two other acts, the Clayton Act and the Federal Trade Commission Act. The Clayton Act further defined the original intent of the Sherman Act and prohibited the organization of cartels, division of markets, and rigging of prices on the basic premise that if competition were free from restraint, more of the fruits of labor would accrue in the form of lower prices to the benefit of the consumer. The Federal Trade Commission Act stated that "unfair methods of competition in commerce and unfair or deceptive acts or practices in commerce are declared unlawful."

As a result of these legislative acts, by 1914 we had created a political climate for economic growth that was destined to give this growth a character completely different from that of foreign economics. But while the political basis existed for change of direction, the issue of wages, prices, and profits remained unanswered and the conventional view was still held that, while the standard of living of the masses could be improved through a better wage system, the result would be a losing of the profits that were essential to provide the capital for further economic growth and facilities required by the nation.

However, in 1914 there occurred a major economic break-through. Henry Ford announced a revolutionary eight-hour working day and a $5.00 a day basic wage. Even if we judge this effort only in terms of dollars and cents it was revolutionary, for it occurred at a time when the average industrial worker was paid $11.00 for a 49-hour work week. But its real significance lies in the fact that Mr. Ford had caught the vision of what applied science and engineering could do in increasing productivity, thus opening the way for a new concept of wages and working hours which would eventually make the worker group a greater consumer of its own product. This change in economic concept, plus directives establishing the political ground rules have resulted in the development of the basic principles that distinguish "People's Capitalism" so markedly from the European capitalistic order.

What has been the impact, on individuals and society as a whole, of this new concept of capitalism operating in a unique political climate? Using 1914 as a base year, since that year marks the application of Henry Ford's theories and the beginning of "People's Capitalism," the average wage level of the industrial worker has gone up 544 percent, while the prices of those things comprising his standard of living have increased only 180 percent. While this tremendous increase in wage levels was occurring, the average work week went from 48 hours to 41 hours.

This dramatic increase in wage levels has given the average worker a high degree of discretionary buying power which has not only been used to improve the workers' standard of living, but also supports a wide range of cultural, social, educational, and religious activities. The number of those engaged in the arts has increased 200 percent, although the total civilian work force has gone up only 40 percent. About $2 billion are contributed annually by the public and corporations to health and welfare agencies. Another $5 billion accumulates each year for unemployment compensation, hospital and medical care when needed, and for pension purposes. There has been a 300 percent increase in the number of charity, welfare, and religious workers. The number of hospital beds in proportion to the population has doubled, and hospitals are staffed by three times the proportionate number of nurses. Church membership has increased more than 120 percent, compared to a population increase of 55 percent; colleges, too, have had some share of the greater wealth in the hands of the public and business, as is indicated by a 400 percent increase in the number of faculty members, and this increase was made necessary in part by the fact that 34 percent of the college age group attend college now as compared to 18 percent in 1914.

Let's mention some of the more important situations which face us now but which were relatively unimportant before the last war.

First, the so-called cold war and all of its implications. It absorbs 10½ percent of our economic effort and has reached, since 1946, as high as 14 percent. It reaches into the fabric of our whole economic system. Can we carry this on and yet preserve, in all respects, the political, social, and business practices of peace time?

During a war we expect greater centralization of authority, over many aspects of life, by government. Democratic processes are too slow when urgent needs must be met. We are keeping the normal peacetime balance of power between the three branches of government, when undoubtedly there are demands to be met which require a faster tempo than is permitted by legislative processes. At the same time, there is no war, with its actual operations of success or failure, to serve as a check on more complete executive autonomy. One does not see how Congress can keep up with science and technology, as applied to defense material, or with the everchanging political and economic affairs all over the world. At the same time, if it gives the Executive Department and the Defense Department rather complete autonomy to carry on as they see best, as would be done in actual war, the whole operation becomes shrouded in secrecy and there are no war incidents to tell how well the job is being done. This whole defense problem projects the federal government into questions of education, scientific research, school construction, foreign commerce, grants-in-aid, and atomic development as well as complex relations with industry.

This problem presents a real dilemma and has a direct bearing on our whole society. In fact, if we are to have defense expenditures at the present level for many years, as many people believe, then we must think through the best way of organizing for such purpose. On one hand we want to have the efficiency of direct competent authority, but on the other hand we want to preserve to the fullest possible extent the fundamentals of a free but competitive society.

The concept of a free competitive society which the wise leaders of the past had in mind when our Constitution, Bill of Rights, and later when our anti-trust laws were formed, assumed competition between sellers in a market or competition between buyers in a market. The charter of a constitutional government expressed in its original documents provided rights to property, a wide scope of individual liberty, and the three essentials for freedom in any economy, namely, free movement of people, property, and money. When referring to competition of buyers or sellers they were not thinking primarily of individual persons. The corporation, as a form of organized effort, was the medium by which the production and distribution of necessary goods and services was to be performed. Competition was, per se, competition between one group of people comprising owner and workers against another similar group. The anti-trust laws sought primarily to maintain conditions wherein corporations competed with each other for the customers' favor.

Against this background let us look at the development of industry-wide union organizations. First of all, this new element has created a horizontal division in many of these vertical groups contending with each other. On one hand, in each corporation is a group with some understanding and appreciation of what is involved in a commercial competitive situation. They understand the importance of product design, of continuing research and engineering development, of financial controls, and of marketing, sales policies, advertising, distributor and dealer relations, personnel and public relations, competitive costs, and efficient plant equipment. On the other hand there is the group of organized workers, belonging to a union which often embraces the workers of the competing firms in that industry, where leaders have little appreciation or interest in the problems of effective competition. The worker is subjected to opposing loyalties. As a mature individual possessing judgment and a sense of values, he undoubtedly takes some pride in the success of the enterprise in which he plays a part. At the same time he is constantly exhorted to put his loyalty to a class above that to his employer.

A new force has entered the picture which seeks only the average and collective improvement of a large number of organized workers. The older concept of economic classes whose composition changed as the more able moved on up in station and responsibility is being supplanted by a tendency toward a permanent stratification. The European capitalistic concept of fixed classes is being re-created here, year by year, by those who seek the improvement of workers rather than by those in power seeking to hold the worker down. The worker looks to his union representative for economic improvement rather than to his own individual initiative and ability. Seniority and job classification alone distinguish one worker from the next. One cannot help but wonder if something is not in the process of disappearing from the American scene which heretofore played such a great part in our national development, i.e., individual ambition, application to the job, self-reliance, and the desire to get ahead.

I am not saying that the organization of labor is under question. Human nature being what it is, quarrels and dissension regarding the division of property and money are not uncommon among people — families, partnerships, and heirs, as well as employee-employer groups. The record is full of many employers who have treated their employees fairly and generously even though unorganized. On the other hand there are the many cases where lack of consideration and fairness would be the rule without the economic strength of employee organization. It is only when the industry-wide union, with its membership made up of the workers of competing members of the industry, faces a single firm that we have a situation that is a marked change from that contemplated when our anti-monopoly laws were written. It seems inescapable that some changes regarding industry-wide unions must be made if we are to retain the essentials of the capitalistic system which have brought us so far.

"People's Capitalism" is also faced with the problem of assimilating and incorporating into its functioning the incredible scientific break-throughs on many fronts. While the press dramatizes satellites and atomic power applications, everyday intricate equipment, often electronically controlled, is being installed in industry. Automation is no different from what has occurred all during our economic history of applying scientific and engineering talent toward increasing productive output per hour. Its development has grown out of technological advances in a number of areas necessary to cope with the scale of modern industrial operations. We hear much about the effect of automation on opportunities for employment. I think the experience of the telephone company best illustrates what actually happens in practice. The dial telephone is probably a more extreme form of automation than is likely to occur in industry in general. Instead of throwing operators out of jobs, their number is now nearly doubled. By the same token, however, if the present volume of telephone traffic had to be handled by manual switchboards, I am told that even if every able-bodied adult woman in this country were drafted to serve as a telephone operator, there still would not be enough operators to take care of today's volume of calls.

What is the effect of all this on the social and economic organization of the future? For one thing, it seems inevitable to put a premium on size. It takes sheer size to carry on the research and experimental work for such developments, and it takes size to make efficient use of such productive but costly equipment. It will have to be recognized that the large corporation is essential to an efficient and successful industrial economy. Political attacks on large corporations, simply because they are large, should not be popular. Only their conduct should be questioned, and conduct is not a product of size. How else are we to compete with Russian state corporations, with their unlimited funds for science and research, unless we use to the fullest the great institutions which have grown and prospered as a result of the free choice of American citizens when purchasing their products.

Corporate management will more and more come to be in the hands of those who sense the quasi-public character of the large corporations in this new setting. As the number and size of larger corporations increase, their requirements in the way of specialized services also increase, and the opportunity for the small individual businessman may be more in the way of serving them and less in direct competition of product. This is a trend already in effect.

However, in reviewing what has happened since the war, we seem to run into at least one major hurdle. I refer to the subject of inflation, which has been bothering thoughtful people despite the events of the last few months and the short-term outlook. That there is such a thing is illustrated by the fact that over-all prices have increased since 1947 at an annual rate of 23 percent. This means the value of the dollar has shrunk accordingly. What new forces are at work, in the system we are discussing, to cause this problem? Since the war the government here and elsewhere has become increasingly aware of its power to influence economic conditions. For example, we have the Full Employment Act of 1946, which places the government directly in a position of responsibility for so-called full employment. Another new ingredient is the growth in size and economic power of organized labor.

Inflation is normally thought to be intimately associated with the supply of money and the amount of civilian goods produced. During the inflation, which occurred here and elsewhere as a result of the war effort, the supply of money increased, because of war costs, much faster than did the amount of goods for civilian purchase. Since the war, however, the amount of goods available for purchase has increased faster than the money supply. For instance, during this same period the total physical output of goods and services on a constant basis increased 44 percent, but the total money supply increased only 23 percent, and yet prices increased 26 percent. Therefore we must look to other causes for this persistent pressure toward higher prices.

One cause is the wage policy of organized labor and its power to enforce such a policy. In part, this power stems from the high level of defense expenditures which created, up to a few months ago, an extremely tight labor market through the diversion of many people to the armed forces, defense plants, and government employment in general. But in addition, unlike the earlier days of "People's Capitalism" when the benefits of technology were divided between the worker in the form of higher wages, the consumer in terms of lower prices, and the owner in terms of profits, we have a wage policy which diverts to labor alone the full benefit of increased productive ability.

It seems axiomatic that the only way in which a group of people, such as comprises our total economy, can have more goods each is to have more goods produced and in greater proportion than the growth of population. Modern science has shown us how this can be done. If wage level increases were not in excess of over-all productive improvement, the basic laws which created our competitive society would insure that competition would prevent prices from rising over any extended term. But if certain industries where applied technology does result in a constant increase in productivity are required by coercion to increase wage rates in excess of such improvement in individual output, then that industry must perforce require higher prices to offset the excessive wage increases. At a time of full employment, the example set by wage changes in these key industries is carried over to others where comparable improvement is not possible and, despite the intense competition, there is an irresistible trend to higher prices for their products, be they tangible goods or services.

There is an unequal distribution of the effect of inflation, with the workers in key industries not feeling the effects at all because wages are kept ahead of prices, and the brunt being borne to an increasing degree by those industries where wages lag further and further behind prices, until we finally come to those people on pensions or annuities who feel the full weight of this inequity. Thus the efforts of the wise statesmen, who turned our capitalism into a highly competitive system, are nullified by the power of labor in so far as equitable distribution to all people is concerned.

In the long run, not even union members, whose leadership year after year gains for them wage increases well in excess of what is warranted by increased productivity, are immune to the effects of inflation. Despite the fact that their current income keeps them ahead of inflation, the funds that are set aside for retirement benefits are being subjected to drastic erosion from inflation. For example, I mentioned earlier that the U. S. dollar has depreciated at an average rate of 2.3 percent per year since 1947; however, during 1956 and 1957 the consumer price index rose 6 percent. At this rate we are experiencing a doubling of prices every 19 years. If our present trend continues, money now being paid into pension funds by workers in the median age bracket of our work force will have lost 50 percent of its value by the time those workers retire. If an effort is made to maintain present wages, and at the same time increase payments to pension funds to gain protection from the effect of inflation, then the process of deterioration will simply be speeded up.

Government intervention when a downturn in economic activity occurs is another inflationary force to be considered. It should be recognized that in adjustment periods such as 1949 and 1954, as well as the one we are now experiencing, time is necessary to bring about a correction of the excesses which developed during the preceeding boom. While government should continue to pursue vigorously its accepted role of fiscal and monetary management, including money and credit supply, it must be kept in mind that natural forces are working to restore the balance. In 1954 these forces were recognized as being adequate and were given time to prove their effectiveness. Government actions in times such as these have a direct bearing on inflation. Each period of acceleration in business activity naturally leads to a strengthening of prices. If natural forces are not permitted to correct previous price rises because of government intervention through expenditures for non-economic purposes, then the next upswing must start from a higher price base. Thus the stage is set for even greater inflation as the economy moves into the succeeding period of growth and a further strengthening of prices.

It is certainly not appropriate in this talk to define the application of these observations to the current recessionary period. It unquestionably differs from the two periods of recession since the war in that this time it follows a great capital goods boom in contrast to the build-up of excessive inventories as previously. I merely counsel against precipitate actions by government in the way of direct expenditures which might not be considered advisable under normal conditions. At the same time, actions of a monetary and fiscal character, which will accelerate the normal forces of adjustment, are appropriate and in fact vital. It is important to recognize that our progress has never followed the pattern of an ascending straight line, nor has it been due to the idea that somewhere and somehow government must immediately correct any deviation.

Thus a new array of forces, which have not existed before, are affecting what we have called "People's Capitalism." The system has amazing vitality — it has withstood the tendency to substitute government direction for individual initiative during the '30's. During the '40's it provided equipment necessary for the war effort, and since the war has compiled a tremendous record of expansion, whether measured by living standards or defense standards. While we have a tradition of change and adjustment, the changes which occur should be measured against principles which are unchanging, and chief among these I would name that greatest asset of all, individual freedom and initiative. If new concepts and new forces which are introduced into our economy and society are judged by their effect on individual freedom and initiative, then these important principles can be as great a safeguard for our future as they have been for our past.

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Some American Agricultural Policies and Their Impact on Foreign Relations

AMERICAN AGRICULTURE, a modern wonder of the world, is still in trouble. During a century of scientific and technological advancement, it has attained so high a level of proficiency that it continues, on a diminishing acreage and with a decreasing number of farmers, to produce far in excess of the increasing demand of a rapidly expanding national population. Despite all efforts to curtail this abundance, production remains aloft, farmers' income shrinks, and the government goes on purchasing and storing surpluses against a time when by some means they may be disposed of somewhere. So a cry persists throughout this blessed land calling for somebody to do something to "put right" the greatest agriculture in a world not yet well fed.

To that cry, as always, America is responsive. As always, there is the prospect of additional legislation, the formulation of further policies, the promulgation of new rules and regulations, and the prosecution of such programs as afford promise of betterment of agriculture and rural living, consistent with the general welfare. Such ready response to the farm problem, in whatever form it has arisen, has helped to make American agriculture great. It has also contributed enormously to the weight of the farm problem now bending America's back.

The shape and magnitude of America's farm problem has varied with the circumstances confronting successive generations of farmers. It has not always commanded the intensity of interest reached during the last 40 years; nor has the focus of that interest played so directly as now on the economic aspects of the problem. Formerly, public interest lay chiefly in the expansion of agriculture and its adjustment to recurring technological change. In recent years, primary interest has revolved around price-cost relationships, acreage allotments, marketing quotas, and other facets of intricate procedures aimed at the attainment of parity.

The shifts of public interest pursuant to problem changes have resulted in successive legislative actions and policy determinations which have tended to be cumulative. So in today's farm problem we discern a combined effect of several policies, each rooted in relevant legislation, which are of great importance to our agriculture but which are not clearly aligned to common objectives.

This situation, since it complicates our farm problem, invites mature consideration and frank expression of honest opinion. It is serious enough even if it could be looked upon as of domestic concern only; but it is of much wider concern. It has an impact on our relations with other countries on either side of the Iron Curtain.

Some of our policies are regarded favorably by other nations, e.g., those we have observed consistently in promoting agricultural education, research and extension, and various regulatory, economic, and statistical services. These are being emulated widely in the world; indeed, their adaptation in many different governmental structures is being largely financed by the United States under contracts negotiated with land-grant colleges or universities in cooperation with recipient countries.

Other of our policies, on the other hand, are regarded unfavorably even by some friendly nations. This is true particularly with respect to policies aimed at surplus control or disposal. By those nations which also hold surpluses, our huge stocks are viewed as a constant threat to international trade in the commodities involved. These nations are less fearful of straight-forward competition in the trade channels than they are of the subsidies by which America may underwrite her "competitive" transactions.

Deficit countries, able to buy in the channels of trade, understandably are alert to the advantages of a buyers' market, and they are not disposed to discourage competition among nations holding surpluses. When a deficit country takes advantage of a buyers' market the international repercussions sometimes are pronounced, as I learned in late 1954 in the Far East. Rice-holding countries, such as Burma, were complaining that the United States had invaded the Japanese market. Actually Japan explained that she had bought where she could get the kind of rice she wanted at the price she could afford to pay. But that plausible explanation failed to allay resentment at our alleged invasion.

Nations not holding surpluses and not able to shop with dollars, even in a buyers' market, welcome with some reservation the provisions of our Public Law 480. This law permits nations qualifying under its provisions, to buy our surpluses with their own currencies, the amount paid us to be held as a "counter-part fund" for use in furthering our programs within the respective countries. By this method it would seem that America gets rid of surpluses and at the same time advances its programs, but it is not quite that simple. To me it appears as a transaction comparable to one in which I get merchandise "free" for coupons or trading stamps for which in some mysterious manner I have already spent money. Similarly, the American taxpayer, having bought the surplus commodities, trades them for less valuable counter-part funds which, like the coupons and stamps, can be "redeemed" only at specified counters, in this case the countries of origin. Having had to deal in about 40 different currencies, I naturally wonder about the ways in which counter-part funds are expended and about how much better off anybody is after they are spent. But, I believe that Public Law 480 is sufficiently meritorious to warrant attempts to extend its application.

Countries unable to purchase our commodities with even their own poor currencies are willing to accept gratis allotments. Some will accept such allotments under almost any condition America wishes to impose, whereas others are reluctant if acceptance involves binding obligations to the United States in either cold or hot war. And there is always the question of who pays the freight. Free goods are not useful if you cannot afford to transport them to points of consumption.

The concensus of comments I have heard in my travels generally favors the United States as a nation making a sincere effort to do a tough job well. I have noted also the more extreme reactions, varying all the way from complete acceptance of *anything* America has done to outright damnation of *everything* she has done.

Most nations, regardless of whether they are selling, buying, or just receiving agricultural commodities, see the conflict in our policies — to increase productivity at home and abroad, on the one hand, and to restrict production at home on the other.

There is reason to feel that the net effect of that conflict is to confuse ourselves, baffle our friends, lay ourselves open to the subleties of unfriendly nations, and leave the in-between nations bewildered.

America therefore must face up to a stern fact: Her magnificent agriculture is not "right" either at home or abroad. So she is obliged to continue her quest for a remedy to satisfy that incessant cry, although she knows by sad and costly experience that a remedy is neither easily prescribed nor readily fulfilled.

In her further quest for a remedy, America would do well, I believe, if she would take a hard look at *all* of her agricultural policies as they have come down through the years, not only those directed at surpluses. Surplus policies continue in the limelight and are likely to occupy it for some time yet; but actually they have not had, are not having, and are not apt to have any more profound effect on American agriculture or in reference to our foreign relations than other policies which have been observed by this country for 100 years or more.

Even a cursory examination would show our policies to be as varied as they are numerous. They are also complex. Their objectives generally are sound. But they lack the cohesion that would maximize effectiveness and minimize confusion. They lack also clarity of over-all purpose, which needs to be made plain if we are to have better understanding of what, really, we are attempting to do, and if we would extend that understanding to other nations. Finally, our agricultural policies need to be seen more plainly in relation to our diplomatic, military, and commercial policies which, under the stress of international events, often command consideration not always inclusive of our agricultural goals and commitments.

To keep her agriculture in the sound position that is essential to strength in her national economy, America's review of her policies needs to be realistic and tough — but amenable, at the same time, to compromise. For, as is so often the case in human affairs, the most earnest endeavor ends somewhere between the practical and the ideal, between principle and expediency. No other end would seem probable to a man who has spent as many years as I have in the atmosphere of bureaucracy.

During an appearance I once made before an appropriation committee of the United States Senate, I was in the exceptionally rare position of a bureaucrat seeking not more but actually less money. The Bureau of the Budget had welcomed my recommended reduction and the House committee had not said it was opposed; so I was a bit confident of achievement as I faced the Senate committee. But that confidence faded fast when a member condemned my recommendation as not acceptable to his constituency. My explanation that the proposed reduction would be applied in several states, not his alone, only created further trouble for me. Finally, after having gone off the record for an extended discussion, the chairman simply and clearly summarized the outcome. "This committee," he said to me, "is in full accord with your argument, which makes sense, but it's poor politics." The wisdom of that conclusion was underscored a few days later by a stack of telegrams representing the adverse attitude of every community in the United States that could have been in any way affected by my proposed saving. Needless to say, the appropriation act ignored my recommendation, and I was obliged to continue to operate facilities which in my judgment had outlived their usefulness.

My career has afforded me the privilege of serving under several different secretaries of agriculture, not all of the same political faith. I have seen each of them come to his office, seemingly determined to take the kinks out of agriculture and put it "right." Certainly his party had pledged itself to do just that, and he had been chosen to carry out the party's promises. Insofar as my association with each secretary permits me to judge, I should say that each in his turn did about everything that anyone in that man-killing job could have done.

In his struggle to console the forces in front of him — the Congress, farm organizations, various commodity, breed, and industrial associations, consumers and other groups — he had to depend in very large measure upon the forces back of him — the career employees, the bureaucrats if you prefer, or the public servants if you would be gracious. These backstop forces persisted in laying before him facts for which there could be no substitute. No secretary has escaped them. I suspect that each has been impressed by the volume of fact at his disposal and by its unending flow toward him. He must have seen in those data also much of what had been seen by his predecessors; it could not be otherwise, for facts do not change as they accrue. Yet each secretary, in his hour of decision, has had to take into account not only the facts before him but the politics of the moment, or risk being sunk – on the Hill or in the Husting.

Alone in the same spot, I think any one of us would have concluded that until sounder bases are provided as guides to further legislation, policies, and programs, proposed remedies for the ills of agriculture are likely to be imbalanced concoctions of fact, opinion, and expediency. I would expect them to achieve the same end as my ill-fated recommendation for a budget reduction. They might make sense but still not make the grade in politics.

Ever sounder bases are in the making and in time will serve to guide more wisely our economic, social, and political adjustment to technological progress. But we have not yet acquired the bases needed, and our lack should be in mind as we look over our policies.

That look, moreover, must see not only the policies of primary concern domestically; it must see also our policies affecting foreign relations. Both types and their interplay have helped to bring American agriculture to its present position. So, in seeking realistic ways in which to strengthen that position at home, it would be unwise to omit consideration of the high ideals inspired by America in a frightened world as she progressively assumed, or had thrust upon her, steadily increasing responsibilities in international leadership: the earth-girdling declaration of the Four Freedoms, for example; America's daring initiative in bringing about before the end of World War II concerted effort among the then United Nations to preserve and magnify the lofty ideals of democracy; and then America's "bold, new" program of technical cooperation and economic development aimed at mutual security.

But even if we train our camera upon policies reasonably within our range of vision, to get a true picture we need a variety of specially ground lenses capable, first, of encompassing in a single exposure the whole depth and breadth of our history and, second, of portraying against that background the heritage, the body, and the soul of this living, changing, organic something which we call agriculture. Then its ailment would become more apparent, diagnosis could be more exact, and a remedy more certain.

Lacking such equipment, we are obliged, as it were, to resort to a series of aerial photographs, the assembly and interpretation of which, I assure you, is not to be accomplished within the fast-expiring limit of my allotted time. The best I can do is to point to some which I believe to be worthy of inclusion in more comprehensive studies.

I would point to the existence in this hemisphere of ancient cultures whose influence on our agriculture has been infinitely greater than is commonly recognized. They gave us corn, for example, and potatoes and tobacco; and their farming practices and irrigation structures have conditioned our own. I would point, too, to some stakes driven during our colonial era, which set the course of national development and projected our agricultural expansion. Then came events which gave us independence and launched on an orbit encircling the globe the basic concepts of democracy.

Very soon thereafter, occupying a domain continental in scope, America in her youth possessed unmatched natural resources with potentialities beyond her imagination. To exploit those resources she encouraged immigration and opened her ports to people of many different origins, of varied skills, but with a common goal — realization of the opportunities and the freedom our democracy held out to them. With those people came seed, and plants, and livestock, and farm practices, and the "know how" which enabled some of them to settle wild land and tame it. Others of them turned to the development of industry, the extension of transportation lines, the improvement of means of communication, the foundation of towns and cities, the substructure of commerce. They with their successors constitute the warp and the woof of the fabric from which has been cut the agricultural-industrial pattern of America. But our progress was not accomplished, certainly not in the beginning, without the financial assistance of some of our mother countries or of private investors within those countries who were convinced of our future.

I would point to early agricultural societies in which through open discussion the multiplying difficulties encountered by farmers were delineated and, where necessary, drawn to the attention of governing authorities. Most authorities in those days lived in the states and territories instead of the national capital. Several states, including Iowa, were in fact leading the federal government in wrestling with the farm problem of a century ago. At that time it entailed a rising need for a type of education better suited to the requirement of farmers and workers in industry than the classical type conventionally available only to the learned professions.

National policies based on Congressional acts of 1862 invite special consideration. The Land-Grant Act, gestating in the minds of thoughtful men for a generation before legislation gave it life, set in motion an educational policy, later fortified and extended by supplemental acts, which has remained at the heart of agricultural advancement in this country. By an enabling act, Congress in 1862 also created the United States Department of Agriculture, thus raising agriculture to cabinet rank and setting in motion activities which, largely in cooperation with the states and territories, have contributed to the enormity of agricultural production. The Homestead Act, designed to encourage land settlement and home ownership, impelled production and provided an operational base for progressively increasing production consistent with advancing technology.

Accompanying the development of the land-grant institutions and the federal department was the growth of state and territorial departments or commissions of agriculture. From the activities of all of these agencies has come a state-federal program of agricultural education, research, and regulation that is acclaimed in many other countries. This is not a national program in the sense of being planned and directed by a central authority. Rather it is a cooperative, nation-wide program of farm and home services to every community — services taken largely for granted in America but sadly lacking in many other countries.

Farmer organizations, carrying torches lit by the older agricultural societies and torches which they themselves have lit, have kept alert to expanding knowledge and advancing technology, pushed for adoption of constructive policies where pushing was necessary, and applied brakes when action threatened to out-run wisdom. The farmer organizations are perhaps no closer together than our armed forces in the Pentagon, but the force of their joint action when they rally to a common cause is a force to be respected, as it has been on a good many occasions.

Segments of industry have become ever more important components of agriculture as it has outgrown the confines of the farm fence. These segments are the bases of supplies of farm machinery, fertilizers, agricultural chemicals, biologics, and transportation and communication services. It would be impossible even to approximate the role of these and other segments of industry in making possible the attainment of the high level of productivity now characterizing American agriculture. We can hope that industry may be equally effective in meeting the difficulties of distribution.

While looking at industry's role in agriculture, I would not overlook Main Street with its commercial institutions, its banks, its professional services, its gas stations, and its appliance centers. Here is the farmer's primary market and, we should not forget, the place where he joins the ranks of ultimate consumers. Here he receives his money, and here he spends it. Along Main Street is to be found, also, a powerful lobby which has had a voice in many an action defining policies affecting agriculture. I am inclined to feel that the voice of Main Street will help to determine the life and level of future support prices.

I would call attention to our long-established policy of exploring the world for seeds and plants of promise in this country. In consequence of what Americans did before Columbus arrived, and of what they have done since, it is reasonable to believe that three-fourths of our principal crops, virtually all of our breeds of livestock, and many of the techniques we employ in agriculture have origins beyond the borders of the United States. Production of each of the crops now in surplus in this country has been greatly advanced by the materials and techniques we have sought, introduced, and established. The same can be said of other crops not in surplus, as the soybean and forage crops found commonly in our grasslands, which are important to the livestock industries, including dairying, whose products are in surplus.

The policies toward which I have thus far directed attention are among our older policies. Prior to 1912 they were just about the only policies we had. Yet they were contributing steadily to an improving husbandry by an intelligent, literate farm population.

In the relative calm which had pervaded the farm atmosphere up to that time, Iowa's "Tama Jim" Wilson had served comfortably as Secretary of Agriculture for 12 consecutive years. He was my first Secretary. I recall my first glimpse of him:

> It was exactly noon of a mild day in mid-October, 1910. Both hands on the clock in the tower of the old post office building were straight up. A polished open carriage stood before the old, red administration building. Two well-groomed horses, in equally well-groomed harnesses, were restive but still responsive to the clucking of a liveried driver who sat erect, eyes forward. Then, as if by unvarying custom, Secretary "Tama Jim" appeared. He wore a Prince Albert and a high hat which made his white beard the more conspicuous. He traversed the terrace between the front door and the waiting carriage. He stepped into the carriage and sat alone. The driver spoke gently to the horses, and the Secretary was on his way to lunch.

Those were the horse-and-buggy days of the Department, attuned to the tempo of the times. But that tempo, as we have since learned the hard way, was as the calm before a storm.

The true origin of the storm by which American agriculture has been beset since those peaceful days may never be known. It probably arose, like hurricane Hazel and her sisters, at some distant point and then moved in upon us. With no storm-warning service at that time, we were left to sense the approaching storm only when a presidential election swept into the White House a valiant advocate of "The New Freedom."

With some friends, I had been privileged to visit the governor in his office in Trenton when he was still only mentioned as a possible candidate in the forthcoming election. He asked us questions about the Far West, with which we were familiar, but he did not do us the honor of telling us anything about the type of man he would name as secretary of agriculture in the event that the champion of "The New Freedom" should eventually be elected.

The man he later named Secretary had a strong bent for economics, and it wasn't long before the old Department had a "new look." We soon had the beginnings of a Bureau of Agricultural Economics; agricultural extension services began nation-wide performance; farmer cooperatives took on new life; statistical and economic services were enhanced. "The New Freedom" had sponsored the debut of Miss Social Science and made plain the intention of making her the life partner of Mr. Natural Science who, until then, had lived in blissful bachelorhood. And it was at that time, according to some of my old colleagues, that the storm broke. Since then, they claim, *the* farm problem has been constantly in America's economic, social, and political laps — first in one, then in another, and sometimes in all three at the same time.

The new look of the federal department was reflected also in the countenances of all associated agencies, institutions, and societies, including the land-grant colleges and universities. But we had scarcely become accustomed to it before the rumblings of World War I prompted defense measures which threw the reconstructed administrative machinery into high gear, and we were soon in an accelerated program of production. The economics of agriculture were submerged in war measures when at last America took her place as a combatant, and her farmers were called upon further to increase production despite the drain on manpower made by the armed forces.

American agriculture's success during that war was more than an important aid to victory; it demonstrated its peacetime potential. That could have warned us of impending trouble, but we were happy with the Armistice and the prospect of making the world safe for democracy through the still a-borning League of Nations. That prospect foundered tragically when the United States, in its first real test of world leadership for peace, refused to ratify the Charter to which Wilson had pinned his faith in our future.

The technical knock-out America dealt the League was not without its effect on the home folks who still yearned for the tranquility they had fought to achieve; and this country was not prepared for the plight in which agriculture was enmeshed within three years after the Armistice. Government responded, nevertheless, and there was a scramble to provide legislation and define policies again to "put right" the agriculture which so recently had demonstrated its might.

Those unhappy days presaged the lagging but inevitable financial crumple of the 1930's which ushered in the hopeful New Deal. Its unprecedented remedial measures Congress promptly endorsed, and served notice on a watchful world of the length to which America was prepared to go on behalf of its agriculture.

Despite all measures adopted and earnestly prosecuted in those turbulent years, however, America still had her farm problem. Efforts to hold farm supply in line with market demand, even the more drastic efforts, were in large part futile. The momentum of technology continued unabated, and mechanization extended. The productivity of agriculture was steadily enhanced and reached heights to be exceeded only by the all-out effort later demanded by World War II. Those record years of production magnified anew the impending hassle with distribution which could have been acute about the time America dropped her atom bombs. But it was postponed because of war in Korea. Then we got into the middle of the delayed hassle and have been in it ever since.

The farm problem as we face it today is complicated by much more than the astounding productivity of American agriculture. For during World War II America had become magnanimous toward her allies. She opened wide her windows and doors and invited them to help themselves to just about everything we had to offer. Some of us occupying responsible positions wondered, at the time, how far we should go in upholding that policy. I remember that I was given indefinite instructions to be circumspect but not to oppose entrance to our laboratories by any of our then allies.

To what extent America at that time contributed to science in the Soviet Republics as we have now come to recognize it, I would not presume to say. But I believe we then disclosed to the world an agriculture geared to science and advancing technology which commanded respect as well as interest. We stimulated the hope and ambition of other nations, and held out to the people of nations still to be born the prospect of their becoming able to make fuller and more intelligent use of their resources, as they hoped might soon be their war-won right.

The hope thus aroused was given a still greater boost in 1943, while the war was still hot, by America's sponsorship of the first world conference on food and agriculture. The final report of that conference shows America leading 37 other nations — the United Nations, in fact — into a battle against hunger and want, dedicated to the cause of satisfying the nutritional requirements and raising the level of living of all people.

That battle is still on. Membership of the Food and Agricultural Organization has increased to 74 nations, more than a score of which have come into existence since World War II. Each nation has a single vote, its official delegate usually is the secretary or minister of agriculture, or his designee, and each delegate usually takes with him to FAO conferences a delegation, varying in size from one to a score or more members. The United States' delegation usually is among the largest and includes, besides technical advisers in agriculture, economics, fisheries, forestry, and nutrition, representatives of the State Department, the Congress, and the farm organizations. Americans are to be seen also among several of the numerous nongovernmental bodies ranged in seats reserved for official observers.

Through its delegation at conferences and its representation on the Council and standing advisory committees, the United States has been an active participant in the formulation and review of FAO's program, fiscal policies, and administrative procedures. She currently bears a third of the cost of the organization's regular program, which is at the percentage level she has sought to achieve and seeks to maintain in her support of the specialized agencies and of the United Nations Organization itself. The United States bears an even larger percentage of the United Nations Fund for Technical Assistance, from which FAO receives an allotment about equal to the amount voted by the Conference.

Not content to be a participant in the international programs initiated by the New Deal, the United States early in the Fair Deal launched a "bold, new program" of its own. This program, by contributing to the UN Technical Assistance Fund, to that extent strengthened the international programs; but, basically, it is a bilateral program between the United States and individual friendly countries — part of a broader United States program of economic development and mutual security.

Other nations have borne their pro rata share of the costs of the international agencies; some, such as the Commonwealth nations, have also continued additional programs, as under the Colombo Plan; and others have bilateral programs. In the meantime, the Soviet Republics and some satellites have entered the world picture with programs of their own to supplement what they are supporting through the United Nations. The most recent arrival in the arena is Israel.

Still older programs than any supported by public funds have been continued by religious and philanthropic organizations; and great foundations have now extended their activities to widely separated parts of the world.

In this total global movement, policies of the United States, to be most effective, must take account of policies adopted by other countries and by various agencies dedicated to the achievement of common goals through international cooperation. That all effort directed at common goals should be coordinated internationally as well as nationally and locally is taken for granted; and I believe efforts at coordination are made just as seriously at the international level as at any other and with as much effect. One of the heavy costs of democracy, at home and abroad, pertains to coordination or the lack of it. But the cost of it is still trivial compared to that paid where freedom and individual initiative are lacking.

The two-world concept, which unfortunately now permeates most human affairs, has created rivalry in the field of technical assistance and economic development as much as in the field of missiles and space ships. And recipient nations, finding themselves between the two great forces in that rivalry, either are afraid to favor one side over the other, or they coyly play both sides against the middle.

This is a situation of which neither side in the cold war can be proud and about which no in-between nation can be happy. The dire consequence of its continuance could be a retreat from the high plane of cooperation for mutual benefit back to the plane of national isolation. And hundreds of millions of people would accept almost any other alternative.

Hence the United States, having gone as far as it has in initiating and espousing programs aimed at agricultural betterment in the world as well as at home, has a vital decision to make: Whether to continue on or turn back. She cannot "just stand there."

If America needs a multi-lens camera to provide a picture of how her agriculture got where it is, she needs perhaps still more elaborate and efficient equipment to point the way ahead. She does not have such equipment, and is not likely to have it, so she must reach her decision by human means, taking due account of recognizable alternatives.

She could withdraw from the international scene of which agriculture comprises so large a part. But her withdrawal could not be graceful, nor to her own advantage. She would disappoint her strongest allies, shatter the hope of many another friendly nation, and surrender to a rival world the leadership she has maintained, no matter how tenuously, for more than a decade. She would deny to her agriculture at home not only the potential of wider world-markets, but the privilege of sharing her abundance to help insure better health and well-being among all people. The possibility of this country's taking a decision to withdraw, therefore, is beyond my range of vision.

Conversely, she can continue to lead the free world toward agricultural betterment and, by her example, perhaps exert a similar influence on the rest of the world. This decision, which I favor, would be to her credit among all nations and to her advantage at home. But it must denote a position of positive, friendly cooperation, make clear its high purpose, and make plain a determination to align all policies in support of that purpose.

I would favor also more positive leadership by the United States in exploring with other nations every possible means of accomplishing better distribution of the products of an advancing agriculture. Such exploration, I would hope, could be undertaken by nations not merely as traders holding or seeking stocks and disposed only to dicker for advantage, but as responsible sovereignties seeking, among themselves and on behalf of others not represented at the council table, the kind of peace and well-being which, I venture to believe, may still be found in a bag of grain, a bale of cotton, a pound of butter, or a good cigar.

* * *

America today is in a much better position than formerly to exercise positive leadership. A dozen years ago very few Americans had been off-shore, except in the armed forces, which had other purposes in mind than the improvement of agriculture. Most of our experience lay in limited foreign agricultural service. And when we moved full-scale into the foreign field we were not well prepared for the load we had confidently undertaken to carry. We had to learn by experience, sometimes painful and humiliating, the ways of people, their cultural backgrounds, their aspirations, and the extent to which and by what methods we might be helpful to them and they to us. And we had to learn that the road to happiness in association with them was not to be paved with our money, our "know how," and our vim and vigor. We had to learn that some of our best friends are not always willing to let us do what we think is best for them. We have learned those lessons, and our earlier mistakes are not likely to recur. Thousands of Americans now are prepared to pursue, far more intelligently than before, the goals which have not changed and the benefits which are still to be attained.

Our cooperation should seek mutual benefits in the basic sciences as they are being developed in the world, for they are important to the future of agriculture. Essentially the same basic sciences that are involved in current efforts to perfect missiles and satellites are fundamental in our quest for answers to unknowns still beclouding the phenomena with which agriculture is obliged to live.

I have been made conscious, by wide travel in more than half the nations of the world, of an intangible but discernible something that seems to distinguish between governments and people. Too often, I fear, our attention is directed or drawn toward a few men who temporarily head governments rather than toward the lasting millions who are governed. Governors come and go and governments change, whereas the masses of people governed remain to continue combatting their difficulties which often have been rendered still more complex by misgovernment. Those masses continue to hope for peace and for success in the use of the natural resources upon which they must largely depend. And among those masses only are the ideals of democracy in a free world to be realized. It is there that the brotherhood of man must live if it is to live at all.

Look at Egypt, for example. What was done in 1902 and subsequently to build the existing Aswan Dam in the lower Nile and to perfect the water distribution system, benefited the Egyptian people immeasurably, without reference to whether their ruler was a Farouk or a Nasser. The success of that dam has convinced them that they need another and still higher dam upstream in order to make available similar benefits to a now much larger population. The need, I believe every informed man will agree, is urgent. But there is still much uncertainty as to whether a new dam will be built and if so when, by what means, and from what source. The rivalry between two worlds holds the development in abeyance. Similar situations are to be found in the Jordan Valley, in Kashmir, and in other places too numerous to spawn optimism.

There is great need in the world for understanding of the restiveness engendered among people upon whom such delaying actions are imposed by governing forces disposed more to dicker than to deliver. What, those people may well inquire, is the difference between delaying actions imposed by self-government and those formerly imposed by colonialism? Being still denied the water they urgently require, what, for example, have the Egyptians gained by their revolt against Farouk except to get Nasser and a changed form of government? And if people in that position come to believe that the change has not been productive of the good they crave, then may they risk still further change? If so, is the change to be sought in the free or in the communist world?

We may well ponder a further question before leaving the Nile Valley: Who is going to pay the greater cost of the determination by Western powers to withdraw from the proposed scheme of financing the needed high dam — the people of Egypt or the people of the West? I can only venture a layman's opinion that, in the long run, withdrawal will cost the West more in the Near East alone than the dam project would have cost to finance in toto.

It is not surprising that in Egypt and in other parts of the world where people are similarly disappointed, or for other reasons are equally dissatisfied with the continuance of surmountable barriers to progress, a voice from the masses reminds the American of what the people of his own country once did to bring about conditions conducive to greater national stature. And the thoughtful American, so reminded, has something to ponder.

His pondering leads to a sincere belief that American agriculture, still in its late teens, can attain full maturity only by accepting courageously and positively the responsibilities of the leadership America has assumed. Other nations see in our production achievements a pattern for them to follow and in our distribution difficulties a task for them to share, if invited wholeheartedly to do so.

But, says the skeptic, if we should go on utilizing our full productive capacity and encouraging other nations to do likewise, and if we should in the next decade find better ways to distribute the increased production, where would that get us? I can only express profound faith in such a future — faith that we would be living in a better world, with a much larger percentage of a much larger population much better fed and clothed and housed.

And in the meantime? What we may do may be even more costly in dollars than what we have done for agriculture, but much less costly than what we are doing and may have to do in the race for missiles and space ships that could deny the world the peace that a prosperous agriculture could win.

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Education and Bio-cultural Evolution

IF WE are to look at ourselves and our problems in proper perspective, we ought occasionally to review our present position in the grand scheme of things. How did we come to be? Where are we going? And what are we going to have to say about it? I know of no more suitable occasion to reflect on such questions than this centennial celebration of the establishment of a great institution of scholarship.

► MAN'S PLACE IN THE UNIVERSE

Man is the product of at least a thousand million years of organic evolution. Just how many we do not know. As Doctor Payne-Gaposchkin has already explained in this series of talks, we do not know the age of the universe with any precision. And we do not know how it came to be in the first place. We do now that it is at least five thousand million years of age and probably much more. If, as Professor Fred Hoyle and others believe, there has always been and always will be continuous creation of the primordial stuff of the universe, which is hydrogen, the universe may be without beginning and without end.

However this may be, we do know that the universe is a place of continuous change. Stars are born. They grow cold with age. And they are born again. Clearly we are but a very, very small part of the whole. But from our own viewpoint, we are an important part. We are a part of the magnificent evolutionary process by which the universe began and by which it will continue into the unknowable future.

Astronomers, nuclear physicists, and biologists are coming more and more to believe that evolution is a continuous process that began with the universe and that goes on and on with no sharp breaks. In one sense, man's evolution began when the universe began. How long he will continue we cannot know. And whether the life on earth, of which man is a small but very significant part, is unique, or perhaps exists as well in strange and unknown forms on some of the members of the planetary systems which may belong to a thousand million other suns, we as yet have no way of knowing.

► EVOLUTION BEFORE LIFE

The evolution that began way back in the beginning — five thousand million years, ten thousand million years ago, or even at the very beginning of time — is believed to have taken place, and to be continuing today, according to a sequence somewhat as follows: Hydrogen burns to helium. Vast quantities of energy are released. This is the energy by which stars emit light. Helium atoms fuse to give beryllium-eight, a form of this element that exists only at temperatures enormously higher than those on earth. Beryllium-eight captures helium nuclei to form carbon nuclei and these fuse with helium to give oxygen. Neutron capture is another part of the mechanism by which elements evolve. Nuclear physicists are beginning to understand how, in such ways, the elements we know today came into being in the past and are being constantly produced today in many parts of the universe.

Elements interact to form molecules. Five thousand million years ago, give or take a thousand million years or so, when the crust of the earth was solid, there presumably existed in its atmosphere many kinds of simple molecules. There was molecular hydrogen, H_2; water, H_2O; ammonia, NH_3; and methane, CH_4. The latter is an important constituent of cooking gas. But free oxygen, O_2, so abundant in the air we breathe, is believed by many to have been absent in the atmosphere of the primitive earth.

Physical chemists are able to say with confidence that in an atmosphere of the kind postulated to have existed on the earth at this stage, and with sources of energy such as those believed to be present, chemical reactions of many kinds will go on and that they will give rise to molecules like some of those of which we are built. First clearly pointed out by Professor Harold Urey, this notion was put to the test of experiment by one of his students, Doctor Stanley Miller. Hydrogen, water, ammonia, and methane, placed in a tube through which an electric discharge, somewhat like natural lightning, is passed, will give rise to several amino acids exactly like those from which we build proteins.

Stanley Miller's experiment — an experiment so simple a high school student could repeat it — was an eloquent demonstration of the fact that when conditions become right, "organic" molecules of the kind that occur in all living organisms will arise spontaneously and inevitably. Since the "right" conditions can reasonably be assumed to have existed on the earth of a few thousand million years ago, we are permitted to believe that organic molecules must have been formed in great abundance and in great variety.

Our understanding of how this molecular stage of evolution could have taken place has been significantly extended in recent years by Professor Sidney Fox, now at the University of Florida at Tallahassee, and whom many of you know as a former faculty member at Iowa State College. Among other things he has shown that molecules of biological importance — amino acids and others — are formed under simple conditions of high temperature that surely must have existed on the surface of the earth during the early stages of its evolution. His work has strengthened our conviction that a great many such complex organic molecules must have arisen by the many reactions that must have gone on just as the reactions planned by an organic chemist must go on when he subjects the reacting materials to the proper environment.

► "LIVING" MOLECULES

To those who have thought about the processes by which organic molecules arise in the absence of life by chemical reactions that can be reproduced, it no longer seems mysterious and unimaginable that somewhere, sometime in the eons that existed before life came into being on earth, a molecule arose with two entirely new properties that gave it life or made it possible for life to evolve from it. This is an old hypothesis. Charles Darwin suggested it a hundred years ago. The English geneticist-biochemist-mathematician Haldane gave it credence. The Russian biochemist Oparin wrote a book about it some twenty years ago. It is now a widely accepted view.

But what are these two novel properties? They are, first, the ability to reproduce or replicate by directing the coming together of simpler molecules and, second, the property of mutation without loss of replicability.

Do these attributes confer life on a molecule? Many students of biology would say yes. Others say no. It all depends on how one defines life and this is arbitary and must ever remain so. The definition I prefer has the virtue of simplicity and objectivity.

Molecules with these two properties are well known today. They are the deoxyribonucleic acids, in the shorthand of science designated DNA. They are long, double chain-like molecules in which specifically paired nucleotide sub-units hold the two chains together. Replication is believed to involve separation of the paired complementary chains with each single chain then serving as a template to gather the nucleotides with which to construct a partner. In this way a double chain directs the synthesis of two new double daughter chains, one half of each being derived from the parental double chain.

Mutability without loss of ability to replicate is possible because the order of nucleotide pairs has nothing to do with replication. Thus the sequence of nucleotide pairs may be altered through errors in replication and the mutant molecules so produced will replicate the new order with no decrease in precision. DNA molecules are the hereditary material of all cellular forms and of some viruses. They may reasonably be assumed to have descended from ancestral DNA molecules that were the beginning of organic evolution.

► THE STAGES OF ORGANIC EVOLUTION

How could a replicating and mutable molecule like DNA have given rise to more complex systems by an orderly process of evolution? We believe that modern biology is beginning to understand the process in principle even though the details may be enormously complex. Let me outline in a very general way what some biologists think the main steps might have been.

Perhaps one of the earliest evolutionary advances was the acquisition of protective protein coats by the postulated primitive DNA molecules. The result would be a system very much like some of the present-day viruses.

Viruses are multiplied only in living host cells — presumably because only there are found the required nucleotide building blocks and the energy necessary for the process of replication. We know as a result of recent work that in some viruses the protein coats can be removed and discarded without destroying the ability of the nucleic acid cores to enter suitable host cells and there replicate and direct the synthesis of new coats of protein like those discarded and unlike those normally made by the host.

In these early stages of evolution there were of course no living host cells in which these postulated primitive virus-like systems could have multiplied. But such host cells were presumably unnecessary, for the building blocks required for replication were produced by pre-life chemical reactions.

There is of course no sure way of knowing that DNA or a closely similar kind of replicating mutable molecule was ancestral to more complex living systems. It seems to many chemists and biologists to be one of the more plausible of several lines of speculation. I shall therefore accept it as a working hypothesis in the discussion that follows.

► MULTIMOLECULAR SYSTEMS

Let us suppose that relatively simple systems of DNA with their protein coats underwent mutational changes in which the sequence of nucleotide pairs became altered by addition, subtraction, substitution, or rearrangement. Each such new arrangement of DNA that was not less successful in survival than its ancestral form presumably acquired a new protein coat. This view assumes that the sequence of amino acids in the coat is determined by the sequence of units in the DNA core. The great majority of new protein coats would be expected to serve no function other than simple protection. But if, through mutation of a DNA core, a new protein were to arise capable of catalyzing a chemical reaction useful to the system, the mutant form would be preferentially replicated. Suppose the ancestral form were slowed down in reproduction because of shortage of one of the four required nucleotides, and the new form were able to catalyze a reaction by which the limiting nucleotide could be formed from a precursor not in short supply. Obviously the new form would tend to replace the old form by simple natural selection. If now a second mutant form were to arise with a protein coat capable of catalyzing a reaction by which a second limiting building block could be made from its precursor, the two mutant forms could form a partnership by which they could carry out two desirable synthetic reactions. They would then be a kind of two-unit system.

By continuing this process of mutation and aggregation, multimolecular systems would be expected to evolve, capable of catalyzing as many synthetic chemical reactions as there were units in the system. Each of the steps in this process of evolution would depend on a useful mutation in a single unit of DNA associated with a single catalytically specific protein coat.

Of course the probability of a particular mutation being useful in the above sense would be very small. But since all those that were not useful would be lost in competition, and since time was abundant in these early days of evolution, large numbers of mutations serving useful purposes would be expected eventually to arise.

This hypothesis, which so simply accounts for the origin of biosynthetic capabilities through mutation and natural selection, was first clearly formulated by Professor Norman H. Horowitz.

► CELLULAR AUTONOMY

Given sufficient time—and perhaps a thousand million years or so were needed—a succession of many thousands of advantageous single mutational steps would give rise to a completely autonomous system like the single-celled green alga of today. Such a system is capable of carrying out all of the chemical reactions by which its component molecules are synthesized from simple inorganic substances such as carbon dioxide, water, phosphates, nitrates, and sulfates. Green plants, of course, utilize light energy in building up the complex organic molecules that are their substance. Such complete autonomy probably requires the ability to carry out many thousands of separate chemical reactions and an elaborate intracellular organization. The number of reactions that a green alga must carry out is probably not less by more than an order of magnitude than the number required by a system as complex as man. In other words, the time span required for a green alga to evolve from the first beginnings of life on earth is almost certainly very much greater than that required for man to evolve from a unicellular form.

► MULTICELLULAR ORGANISMS

Unicellular organisms gave rise to many-celled forms through aggregation and differentiation of cells. The latter consists in division of labor among cells, which made possible the evolution of land plants and animals.

In the animal line of descent there arose cells specialized for carrying messages from one part of the body to another. These evolved into the nervous system, which has achieved its highest degree of specialization in man. It makes possible memory, reason, and communication. The high development of these capabilities in man is the key to his uniqueness. They are the basis of the cultural inheritance by which our species supplements the mechanical biological inheritance that so largely limits our pre-human ancestors.

Before continuing a discussion of cultural inheritance, I should like to return to a further consideration of the remarkable replicating mutable DNA molecules that are responsible for organic evolution. We have known their structure for only about five years. This understanding is surely one of the outstanding achievements of biology of the twentieth century.

► THE GENE

The DNA molecules in the nuclei of our cells are presumed to be direct descendants of the similarly constructed molecules of primitive life. On this view the units of DNA whose protective protein coats served catalytic functions in the pre-cellular stages of evolution were the ancestors of our genes.

I shall illustrate what we mean by a gene or functional unit of DNA by means of a substance called phenylthiocarbamide (PTC). This is tasteless to about three out of ten persons and very disagreeably bitter to the remaining seven. It is easily administered in the form of small strips of filter paper that have been dipped in a one percent solution of PTC in acetone and dried.

Persons who taste PTC differ from those who do not by a gene, which is presumed to be a segment of DNA made up of perhaps 1,000 nucleotides. This segment of DNA exists in two known forms. One may be said to contain the coded message "I can now taste PTC." The alternative form carries the message "I cannot taste PTC."

In each cell of the body there are two genes of this kind. They are descendants of the two genes of the same kind that were contained in the fertilized egg from which all cells of the body came. One was contributed to the fertilized egg by the mother, the other by the father via the sperm.

There are therefore three kinds of persons: those with two taster forms of the gene, those with two non-taster forms, and a third type in which there is one of each kind. They are respectively pure tasters, pure non-tasters, and hybrid tasters of PTC.

The fact that persons who have both messages in each cell are tasters, tells us that the taster form of the gene is dominant and that the non-taster form is recessive.

The inheritance of taste reaction to PTC is simple. Each fertilized egg begins development with two messages, one from each parent. At every body cell division thereafter exact replicas of the two messages are formed and transmitted to daughter cells. Knowing this, it is easy to formulate the rules of inheritance for taste reaction.

How is the message spelled out? The answer is in the sequence of the four nucleotide pairs of which the gene material—the DNA—is built. There are thus four symbols in the molecular code that is the material substance of our biological heredity.

How is the replication of the message accomplished at cell division? We believe we know. The DNA molecule consists of two parallel chains each constructed of nucleotides. The two are weakly bonded together through their nucleotides in such a way that the units in one chain are complementary to those in the other. Thus if a sequence of four units in a segment of one chain is 1 - 2 - 3 - 4, the corresponding segment in the partner will have the sequence 2 - 1 - 4 - 3. The corresponding double segment could then be represented in the following way:

—1—2—3—4—

.. ..

—2—1—4—3—

During replication the bonds that hold the two chains together, represented by double dots, are broken and the halves of the double molecule separate. Each half molecule then fits to itself new nucleotides in such a way that it reconstructs a new complementary half. Thus, where there was originally one double molecule, there are now two identical double molecules carrying the same information.

With every cell division all the genes of the nucleus—10,000 to 100,000 of them—replicate in this same way.

Collectively these many genes are the directions for making a person from a fertilized egg cell. Some ten tons of food, a proper environment, and some fifteen or so years are required to complete the process.

The message for taste reaction to PTC is a trivial one in the sense that there seems to be no advantage whatever in being able to taste PTC—or in not being able to do so. But other messages are not trivial. One kind specifies how the protein part of the hemoglobin molecule is built. It determines the precise order in which 600 amino acid building blocks are linked together to make normal hemoglobin. Another determines that a reaction necessary for normal intelligence will take place. Dozens of such messages or genes are known in man, and there remain thousands to be investigated.

The total complement of genes may include 10,000 to 100,000 kinds. In all they may be made up of as many as 200,000,000 nucleotide pairs. Francis Crick of Cambridge University has estimated that the total DNA in the nucleus of a single human egg cell is equivalent in information content to that of 1,000 good-sized library books. This is another way of saying the directions for making a person from an egg cell, the necessary food material, and a proper environment, would fill 1,000 volumes if written out in the English language.

► MUTATION

With every cell division the total genetic information is replicated. The precision with which this is accomplished is remarkably high. For each functional unit or gene such as the one concerned in hemoglobin specificity, there is probably about one chance in a million of a mistake being made per reproductive generation—from egg to egg or sperm. This involves many replications, perhaps as many as 20 to 50. The frequency of mutation is not known with any degree of accuracy for human genes. In fact, mutation frequencies for individual genes are difficult to measure in the most favorable experimental organisms. The value given is therefore a rough approximation. It may be as high as one in 10,000 per generation for some genes, or may be lower than one in 100,000,000.

Most gene mutations are unfavorable. This is known through observations on experimental plants and animals and is also to be expected *a priori*. A consideration of the gene that is concerned with the structure of the protein of hemoglobin will make it clear why this is so. There are approximately 600 amino acids in a single hemoglobin molecule. Out of the astronomically large number of ways these could be arranged in the two identical polypeptide chains that make up this protein, only a very few, perhaps only one, are normal hemoglobin. The normal molecule is made according to the information coded in the normal form of a gene. If this information is modified by chance mutation, there are obviously many more ways to make hemoglobin protein less efficient than there are to make it more so, or to leave it functionally unaltered. Therefore it follows that the great majority of gene mutations will lead to a less fit organism.

► SELECTIVE ELIMINATION OF DELETERIOUS GENE MUTATIONS

Since the DNA of a mutated gene is as faithfully replicated as that of a normal form of that gene, and since the probability of a second random mutation restoring the original form of the gene is vanishingly small, it follows that deleterious genes will accumulate with time if not eliminated. Under genetic equilibrium they will be eliminated at the same rate at which they occur by mutation. The elimination normally occurs by natural selection—by individuals carrying mutant genes failing to reproduce or reproducing at a lower rate than the average for the population. Such elimination has been designated "genetic death" by Professor H. J. Muller. It may occur in early embryonic stages and be scarcely noticeable. It may take the form of complete or partial sterility. Or in certain instances it may consist in postnatal premature death of individuals carrying the deleterious gene. These types of eliminations may occur either in individuals *hybrid* for the gene in question, or *pure* for it.

If there are 10,000 kinds of genes per cell and each mutates with a probability of one in a million per generation, there will be about 10,000/1,000,000 (which is one per hundred) eggs and sperms per generation that will carry new mutations. Eliminations through natural selection will have to occur at this same rate—the equivalent of one genetic death per hundred individuals per generation—to counterbalance this mutation rate.

► RADIATION-INDUCED MUTATION

All forms of high energy radiation increase the probability of mutation in the genes exposed to it. That is why geneticists are so concerned about exposure of the germ cells to such radiation.

Over the range of exposures from that giving the lowest measurable increase in mutation rate to that increasing it by a factor of 20 or 30, increase in mutation rate is directly proportional to exposure. Since there is no recovery, the effect of many small exposures will be cumulative.

A reasonable estimate for the exposure to X-rays necessary to double the natural mutation rate is about thirty r units per reproductive generation. That is a 100 percent increase. One-tenth of an r unit per generation, the value given for present levels of fallout, would increase the normal mutation rate by about one-third of one percent. Due to uncertainties in the assumptions made in arriving at this percentage increase from fallout, it might be too high or too low by several times. It might well be as high as a one percent increase.

A one percent increase in mutation must be counterbalanced by an equal increase in elimination of deleterious genes. This may seem like a small percentage increase in the number of genetic deaths. It is. But in terms of world population it could well be equivalent to 200,000 genetic deaths per generation.

From a genetic point of view, it is obviously desirable to reduce radiation exposure of people who have not completed reproduction to the lowest possible levels. This is true whether the radiation comes from nuclear weapons tests, medical X-rays, peacetime reactors, or from other sources. Nuclear weapons testing poses special ethical and moral questions because the fallout is not usually confined but is world-wide in extent, falling on peoples who have no choice in the matter.

Medical radiation for diagnostic and therapeutic purposes must also be put in a special category because the benefit derived greatly exceeds the small harm it does if it is administered only when necessary and with all due care.

► FAVORABLE MUTATIONS

Since geneticists say natural selection of favorable gene mutations is responsible for positive evolution, it is natural to ask the question, "Why is it not advantageous to increase the mutation rate in man, thereby increasing the number of favorable mutations available for his future evolution?" The answer is simple. The favorable mutations may well be increased in number by a general augmentation of mutation rate. But there is already so much unused genetic diversity in the human species—so many favorable genes that are not now preferentially multiplied—that an increase in their production through an over-all raising of the level of mutation would almost surely be insignificant in comparison. Secondly, such an increase in favorable mutations would have to be paid for by an increased number of genetic deaths that would result from the accompanying increase in deleterious mutations. Finally, even if society were prepared to preferentially multiply such additional favorable mutations through positive eugenic measures, which we are not, there is no known way of detecting more than a very insignificant number of them.

► MORE ABOUT CULTURAL INHERITANCE

Let us return to a further consideration of the uniqueness of man that results from the high degree to which his nervous system is developed. Our memories exceed by far those of other species. We are able to reassociate ideas and thus to carry out complex and abstract reasoning. All these capabilities underlie the new methods of communication that our species has evolved. Speech, music, and art are important parts of our communication techniques. Writing and printing are more recent extensions.

Memory, reason, and communication provide means of transmitting information from one generation to another that are most important supplements to transmission of information by way of genetic material. They are the basis of cultural inheritance, which only man has developed to any significant degree.

These new ways of supplementing mechanical biological inheritance in a manner that is cumulative from one generation to the next has made possible the development of religions, art, music, agriculture, technology, and, finally, science. All of these make up the human culture that is constantly being added to and revised by an evolutionary process not unlike organic evolution. More successful cultures replace less successful ones by a kind of natural selection.

Science is one of the newest and certainly one of the most rapidly developing components of our culture. Five thousand years ago it scarcely existed. Twenty-five hundred years or so ago man first began to ask intelligent questions about the earth and the universe: what they are, how they came to be, and how they operate. More important, he began in systematic ways to search for the answers to such questions.

Slowly at first, and then at an ever increasing rate, answers were found, organized, and communicated from person to person and from generation to generation by extrabiological inheritance.

The difference between biological inheritance through the transmission of information in the form of molecular code and by cultural inheritance can be simply illustrated by comparing the web of a spider and the house of a man. The spider inherits coded information from its parents, and this it translates into a web of a design characteristic of the species of spider. The chain of events between hereditary information coded in DNA and the design of the web may defy our present understanding, but we can be reasonably sure the spider carries out the process through the blind instinctive pattern of behavior that is the mechanical translation of the molecular code. The spider cannot "learn" to make a different web. Nor, if this were possible, could the information learned be transmitted to the offspring by any means of communication about which we now know.

Contrast the man. He builds a house by following directions communicated by his fellow man. In the process he thinks of modifications and tries them out. If they result in improvements, he remembers and passes on directions for the new house to his fellow men and to the next generation. Thus the houses of men evolve through cumulative cultural inheritance that, although rooted in biological inheritance, is supplementary to it. All the religions, arts, technologies, and sciences that make up human culture are transmitted in this new way that man alone has evolved.

► SCIENCE A PART OF CULTURE

Science is a recent addition to human culture. It has now become a very large part of the total and is presently growing more rapidly than any other component. Like all other parts, it is inseparable, indispensable to the whole. That is why we are so insistent that no person today can be liberally educated and well informed without having acquired some understanding of science. And I should like to emphasize that understanding is needed, not mere accumulation of information about science. The facts of all science are far beyond the capacity of any single individual to know. But many of the important basic concepts and principles of science can be understood by any intelligent person willing to make the necessary effort.

Like the rest of culture, science is continuously undergoing evolutionary change. So too are its interactions with the other parts. The religion of yesterday may be in direct conflict with the science of today. But the successful religion of today cannot conflict with the science of today. If it did, it could not long remain successful. Like science, religions too must evolve. There is no sensible reason why these two important aspects of human culture cannot evolve harmoniously through mutual interaction.

► SCIENCE AND TECHNOLOGY

Technology antedated modern science by many millennia. But as science evolved and grew, technology came more and more to depend on it, until today the two are so intricately interwoven that they are often confused. They are not the same. Agriculture, medicine, and engineering may apply science, but they are not themselves science. Sputniks, Explorers, and Vanguards are dramatic demonstrations of the applications of science, but neither are they science. Science is made up of ideas and concepts, confirmable by observation and experiment, about the universe and all its parts. It is not a collection of machines or things such as radios, nuclear reactors, and satellites.

The technology that today is so largely fed by science is also a part of human culture of ever increasing importance. Agriculture, utilization of raw materials in industry, and development of new sources of energy have made possible great increases in human food supplies, which in turn have permitted unprecedented population growth.

► POPULATION AND WAR

With increased numbers of people to house and feed, technology has had to advance at an equal rate. As Doctor Philip Cardon has so clearly pointed out in an earlier talk, economic, political, and social problems have multiplied rapidly. The production and distribution of food has by no means been accomplished on a satisfactory world-wide basis.

Unequal distribution of natural resources, including agricultural land and energy supplies, is a basic and major cause of war. Surely lasting peace cannot be attained until we have somehow succeeded in sensibly relating populations and resources.

► HOPE THROUGH EDUCATION

It is difficult to see how final solutions to these many problems can be found without a general increase in educational levels throughout the world. In a sense education serves the same purpose in cultural inheritance as do DNA molecules in biological inheritance. Education is the means by which the culture of one generation is transmitted to the next. It is the basis for the cumulative increase in knowledge and wisdom. Only through education can we learn how better to use the increasing resources of modern science and technology. And only in this way can there be general understanding of the interrelations to be desired among the several components of human culture — science and technology of course included.

In an ideal free and democratic society of the kind for which so many of us hope and strive—the people's capitalism of Theodore Houser—intelligent and wise decisions will depend increasingly on an understanding of science by the representatives of the people and by the people who elect those representatives.

One of the problems of a free society is that we find it difficult to raise the general level of education rapidly. We tend to change slowly. As a result it may sometimes appear that a totalitarian system has advantages. In such a system it can be decreed that the educational level must be raised—that there must be more general understanding of science and its social implications. I believe this is a short term advantage, for a high level of general education is pretty likely to be incompatible with a totalitarian system.

It is perhaps not out of the question that the several formulas by which nations are governed will slowly converge as educational levels are raised and reason tends to replace emotion in national affairs. The biologist would call this convergent evolution of social systems. We should certainly not close our eyes to this possibility. Perhaps there are ways by which the process can be accelerated.

In any event it is clear that we had better get on with doing a better job of education. If we fail to move rapidly enough, there is a real danger that our system—our people's capitalism—will be out-evolved by a competitive system. If this happens, it will become a pretty meaningless question whether or not we were right. The judgment of evolution is harsh.

What should we do and how? Before attempting to answer that, I should like to emphasize that our system of education is a pretty good one, a fact that we should not forget in looking for improvements.

Do we put too little emphasis on intellectual development? Does our national sense of values need revision? There are those who would answer yes to these questions. There are those who say with considerable justification that our teachers are not sufficiently respected in the communities in which they live and work. They are poorly paid. They tend not to have sufficient understanding of the subject matter they teach. These things are all interrelated.

If these criticisms are just, who is to blame? All of us are. Society as a whole is. You and I are. Professional educators must share the blame. Scientists have made few constructive efforts to improve the teaching of science in elementary and high schools. How many academic people encourage their superior students to go into high school teaching? Parents could do more to help. School boards have not always acted with all the wisdom of which they are capable. Citizens in general have not distinguished themselves in showing intelligent concern about needed improvements in the system.

Pointing the finger of blame will not solve the problem. All of us must get busy with positive moves toward improvement. Schools need more adequate support. Perhaps the present basis of support, largely through local real estate taxes, needs fundamental change. We must insist on better-qualified teachers. This will mean better salaries and more regard for the profession of teaching. We must encourage respect for knowledge and understanding among our children. We must teach them by example that intellectual achievement is something worth working for. All of these things we can do if we will but put our minds to it.

There is a weakness in our system that has, I believe, developed through lack of understanding of the true meaning of democracy in education. Despite the statements of our founding fathers, we know that we are not all created equal. Democracy in an educational system should provide every member of society with an opportunity to make maximum use of his or her inherent abilities. In our enthusiasm for education of the masses, and it is a highly desirable enthusiasm, we have too often neglected those outstandingly able individuals who are capable of going far beyond the average. We are not sufficiently aware of the fact that many fewer than one in 100 individuals of this generation will be responsible for far more than 99 percent of the cultural progress that will significantly affect the next generation. We can scarcely overestimate the importance of doing more to see that the talents of these exceptional individuals are given the fullest opportunity to develop and are used to maximum effectiveness by society.

► MAN'S FUTURE

The future of man is without limit. All of the problems we have mentioned can be solved. Populations can be controlled and they must be, both quantitatively and qualitatively, for otherwise we will surely continue to have misery and hunger and wars. We see sources of the raw materials and the energy that will be needed for the abundant life of all members of a population held within reasonable bounds.

Man has it within his power to control his own evolutionary future, both biologically and culturally. We now have the knowledge with which we can and do direct the biological evolution of the plants we cultivate and the animals we domesticate. In the same way, we are capable of guiding our own genetic future. This must not be done in the primitive manner of the early eugenists. It will require wisdom of a kind we do not yet possess, but it can be done.

This is "the challenge of man's future." It is the challenge this generation—and the next and the next—must face. We must face it with knowledge and wisdom, with resolution and courage.

REFERENCES

Note: The following list of references does not pretend to be exhaustive. It is given because it may serve to guide the interested reader to a few recent popular treatments of the material covered in this lecture. The ideas expressed are not new; these literature citations will enable the reader to explore their origins if he desires to do so.

Auerbach, Charlotte. Genetics in the Atomic Age. 106 pages. Fairlawn, N. J.: Essential Books, Inc., 1956.
Beck, William S. Modern Science and the Nature of Life. 302 pages. New York: Harcourt, Brace and Co., 1957.
Brown, Harrison. The Challenge of Man's Future. 290 pages. New York: Viking Press, 1954.
Brown, Harrison, Bonner, James, and Weir, John. The Next Hundred Years. 193 pages. New York: Viking Press, 1957.
Darwin, Charles G. The Next Million Years. 210 pages. London: Rupert Hart-Davis, 1952.
Dobzhansky, Theodosius. The Biological Basis of Human Freedom. 139 pages. New York: Columbia University Press, 1956.
Fox, Sidney W. Evolution of Protein Molecules and the Thermal Synthesis of Biochemical Substances. American Scientist 44:347-59, 1956.
Muller, H. J. Life. Science 121:1-9. 1955.
Rush, J. H. The Dawn of Life. 262 pages. New York: Hanover House, 1957.

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Concluding Remarks*

A CENTURY is a long time when viewed from the standpoint of an individual — but only a fleeting moment in the span of time.

Iowa State College in the first century of its existence has grown and expanded into vast areas of research and education in an attempt to meet the needs of our ever growing, ever expanding and ever demanding society. In this era of challenging change it is not easy to keep our balance as we move from one problem to another.

* * *

In setting up the program celebrating our first centennial, it seemed appropriate to invite to our campus distinguished scholars, scientists and industrial leaders who could interpret some of the biological, chemical, social and economic changes which have taken place, to evaluate the present and to point up the potentialities of the future.

* Given at the close of the last symposia on Tuesday afternoon, March 25, 1958, by President James H. Hilton.

Emphasis has been placed on the moral and spiritual values, social, political and economic values, and scientific values.

I am sure these distinguished people have strengthened the confidence of our mission as a research and educational institution, and inspired us to accomplish even greater things in the years ahead. I am sure all of them have given us a better understanding and a clearer perspective of the important issues of the present and opened up new vistas for the future.

And so as we close our centennial celebration, I hope the program has fulfilled the hopes and wishes of the faculty and the community. Our sincere thanks to all of our speakers who have made this centennial such a memorable occasion.