from all levels convincingly demonstrates the great possibilities awaiting the refuse heap-potsherd stratigraphic method which, until the present, has rarely or never been successfully employed in Peru. In addition, one small tomb encountered adjacent to this cut yielded nearly one hundred excellent skeletons pertaining to the early Pachacamac-Interlocking period. These were removed by Dr. Newman and will be reported on by him. More recent work by Mr. Willey in the Chancay valley has added to this ceramic sequence. Here, at Cerro de Trinidad, he encountered several meters of consolidated refuse containing Chancay White-on-Red pottery beneath refuse containing Interlocking pottery styles. This was also confirmed by finding a large White-on-Red tomb under undisturbed floors of the Interlocking period. This discovery not only adds an earlier coastal type of ceramics to the Pachacamac sequence but also, on the basis of actual superimposition, reverses Uhle's and Kroeber's conclusions that White-on-Red ceramics were intrusive in Interlocking style tombs and were therefore later. Space is lacking to more than mention excavations already made or in progress yielding incised pottery of Early Ancon (or Coastal Chavin) type. This is the earliest ceramic type yet encountered in the general region and apparently represents a basic and wide-spread Peruvian culture. In certain aspects it approaches a truly Archaic level. Furthermore, certain evidences encountered suggest the presence on the central coast of a pre-ceramic culture, but these are as yet not entirely clear.

In coastal Chile, a pre-ceramic culture has long since been reported by Latcham and Uhle. Recent work by Junius Bird, supervisor of Project 4 (under the same directorship as Project 3), has objectively confirmed this fact and stratigraphically placed the horizon. In the Arica region, Mr. Bird has encountered several stratified sites which run the gamut from hunting peoples of lithic culture to agricultural peoples with pottery, weaving and metals. Not only is direct superimposition present, but it also appears possible to work out many details of development and diffusion regarding horticulture, domestication and technical advance. Work farther to the south in the vicinity of Taltal is now in progress. More detailed results will be reported at a later time.

In conclusion, it must be emphasized that the foregoing is a mere "work in progress" report and stands in need of some correction and much amplification. It is, however, already obvious that detailed stratigraphic excavations in Latin America are yielding rich theoretical results. One thing is certain and that is that there is no lack of stratified refuse deposits on the Peruvian, Chilean and adjacent coasts. It will take time, skill and much hard work to get their full story, but when we do the rich record of ruined city and gorgeous grave find will fall into order and assume cultural meaning within a historical frame. The discoverer of America was not Columbus nor did the European create those great agricultural and economic resources which revolutionized the post-Columbian world. There is much to be learned, both socially and economically, from the past and present achievements of the American Indian, and he would be provincial indeed who regarded such facts as merely academic. Thus, the work continues on a broad front with the close cooperation of North, Central and South American scientists. Its aim is a deeper knowledge and a better application of those vast human and ecologic resources which pertain to the western hemisphere but, in the future as in the past, will actually affect the entire world.

THE PROBLEMS OF AGING AND OF VASCULAR DISEASES[1]

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THE PROBLEM OF AGING

THE medical problem of aging is more concerned with prolonging the stamina of youth and middle age than with extending the lives of the aged. It is hoped that we may delay senility rather than prolong it. Although aging has numerous manifestations, such as loss of hair color, of muscular tone and of sex activity, the average individual is most concerned with two manifestations, namely, the progressive loss of physical and mental ability on the one hand and the rapidly increasing death rate with age on the other hand.

The increasing death rate appears to be the only manifestation of aging which, during adult life, shows wide changes that are subject to accurate measurement. A study of the mortality data brings out the great importance of the problem of aging. Human death rate is at a minimum at the age of ten when only one child in 800 dies each year. If the death rate remained at this level throughout the whole life span our life expectancy would be 550 years, instead of 63 years as at present. In reality our death rate

[1] Part of the material in this paper was presented at the Symposium on Aging at the American Chemical Society meetings in Atlantic City, September 9, 1941. The investigation has been aided by grants from W. R. Warner and Company and the John and Mary R. Markle Foundation.

increases 8 per cent. each year throughout the life span until the mortality among elderly people is very high.[2]

In Fig. 1 it may be seen that if in the United States in 1936 there had been only one death in 800 among

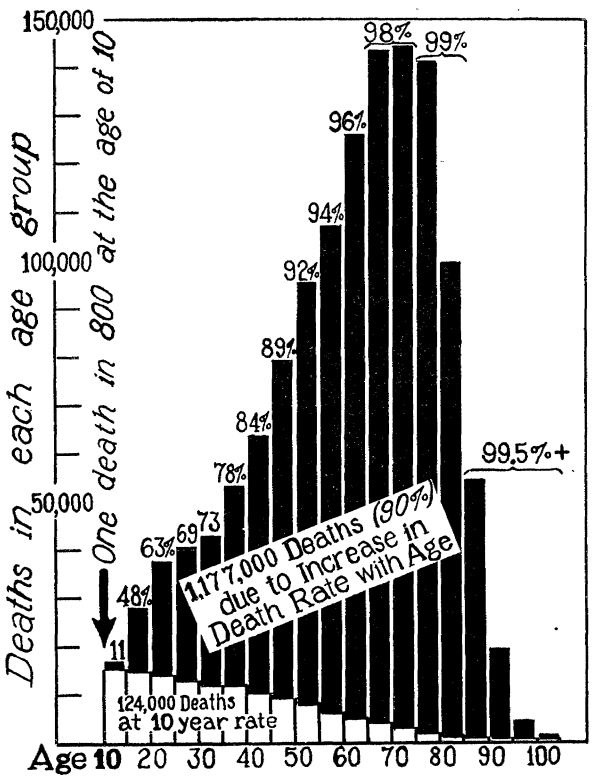

FIG. 1. A comparison of the deaths which occurred in the United States in 1936 with those which would have occurred if the death rate for all age groups had remained at the level found at the age of ten.

people of all ages above ten, there would have been only one tenth as many deaths as actually occurred. These are represented by the white columns at the bottom. The other 90 per cent. of the deaths, *over a million a year in the United States,* result from the increase in death rate with age. Even among people in their early twenties the majority of deaths are due to this increase in death rate with age. Many of these excess deaths may be attributed to the progressive loss of resistance to disease as a result of an underlying aging process.

In accounting for the enormous effect of age on death rate we must distinguish between the "aging process" and the random accumulation of pathological injuries (such as damage from acute infections, from tuberculosis, from silicosis or other industrial hazards, cirrhosis of the liver, nephritis and perhaps arteriosclerosis). Such random injuries should follow a linear relationship with age (except in so far as one injury may accentuate another) and, hence, can not account for the observed increase in death rate[3] which follows a logarithmic equation.[2]

We may therefore conclude that this decreasing resistance to disease is largely the result of *an underlying process of aging which involves the progressive alteration of vital physiological functions.* This "process of aging" may include such progressive changes as those occurring in the blood vessels (including thickening, distension, loss of elasticity or of capillary permeability), diminished vital capacity, changes in metabolism or of water balance or resistance to shock, alteration of endocrine glands and any "wearing out" of tissues or gradual accumulation of metabolic products.

Since loss of physical and mental ability is correlated with diminishing resistance to disease[2] it is to be expected that any amelioration of one manifestation of aging may be reflected in the other.

VASCULAR DISEASES

If we accept aging as our most important medical problem then our second most important problem is vascular diseases. With improved treatment of infections the vascular diseases are becoming increasingly important. In Table I it will be seen that in 1938 in the United States nearly 50 per cent. of the

[2] Henry S. Simms, SCIENCE, 91: 7, 1941. In this paper it is shown that the death rate at age t (for either total deaths or for individual diseases) follows the empirical equation $\log P_t - \log P_0 = kt$ where k indicates the rate of aging. Loss of ability follows the same equation.

[3] In so far as one injury may augment another, a logarithmic curve might be obtained; but it is questionable that such a mechanism can account for the 250 fold increase in total deaths between the ages of ten and ninety, or for the 2,000 to 10,000 fold increase in deaths from vascular diseases, without consideration of the aging changes in the blood vessels. Senile debility is correlated with senile mortality and may involve the same mechanism, yet it seems unlikely that progressive physical and mental debility result from accumulated injuries to the various organs rather than from progressive alterations in the circulatory and glandular systems, for example. A few elderly people, while showing no significant pathological damage, become disabled and die within the usual life span. If accumulated injuries were the cause of senile mortality we would expect occasional authentic cases of individuals living to astounding ages such as 150 years, but such is definitely not the case. It was shown by Brody (*Univ. of Mo. Agr. Exp. Sta. Res. Bull.* 105, 1927) that the mortality of drosophila also follows a logarithmic curve similar to that for humans but much steeper. It is difficult to imagine that within the short life span of these insects there is the opportunity for the accumulation of sufficient pathological injuries to produce a many-fold increase in the death rate. Delayed deaths, as in nephritis or cancer, also fail to explain the increased death rate, since the mortality from such diseases involves logarithmic aging curves which are merely displaced along the time axis according to the duration of the disease. Although some of the delayed deaths resulting from rheumatic fever are probably included in the black columns of Fig. 1 these should not account for any predominating portion of the increase in death rate.

TABLE I

RELATIVE IMPORTANCE OF THE VARIOUS PATHOLOGICAL CAUSES OF DEATH AFTER THE AGE OF TEN*
In each disease group, except pregnancy and childbirth, the majority of deaths may be attributed to the loss of resistance to the diseases as a result of aging

Disease or diseased organ	No. deaths	Per cent.
Cardiovascular-renal disease[4] (Heart and arteries 376,907; cerebral hemorrhage 111,073 and chronic nephritis 90,459)	578,439	48.
Infectious diseases (General infectious and parasitic diseases† 96,542; respiratory 75,691; other specified organs 25,739) ...	197,972	16.
Cancer and other tumors	154,551	13.
Accidents and violence	112,405	9.
Digestive system (except infections) ..	50,744	4.
Glands and nutriton	39,137	3.
Genito-urinary system (except chronic nephritis)	27,515	2.
Nervous system (except cerebral hemorrhage and infectious diseases) ..	11,350	1.
Pregnancy and childbirth	9,953	0.8
Blood and blood-forming organs	9,374	0.8
"Senility"	9,242	0.8
Ill defined and miscellaneous	17,713	1.5
	1,218,395	100.

* Rearranged from the United States Vital Statistics for 1938.

† Including 12,728 deaths (1 per cent.) from influenza and 1,952 deaths (0.16 per cent.) from other filterable viruses and rickettsia.

deaths after the age of ten involved diseases of the cardiovascular-renal system.[4] The importance of these diseases is far out of proportion to amount of research being done in this field or to the support received from foundations and research institutions.

Vascular diseases are more prevalent in later life because the death rate from them increases with age more rapidly than from other diseases[2] and because, being chronic, they produce a delayed death.

RESEARCH

Our present knowledge does not warrant a prediction as to the outcome of research on aging and on vascular diseases. There is no justification for the frequent assumption that these are inevitable or that nothing can be done about them. We have as much reason to hope for a retardation in the rate of aging as for a cure for hypertension, cancer, cirrhosis and other diseases which are extensively studied. It can be shown mathematically that whereas the elimination of all remaining infectious diseases would only slightly increase our life span, it would require only a small amelioration of the rate of aging to greatly delay the onset of senility and also extend the life span considerably.

A new method of attack has been developed in this laboratory. Healthy rats in various age groups were killed by a known and measurable cause, namely hemorrhage. The amount of bleeding required to produce death under standard conditions is determined and expressed as "grams of blood per 100 grams of body weight." It was found that 825-day-old rats died with 12 per cent. less hemorrhage than 100-day-old rats. With the aid of a distribution-summation curve these values were converted into probability of death from a given degree of hemorrhage (such as 3.6 per cent. bleeding). The older rats were found to have a probability of death 16 times greater than the younger rats and a plot of the values resembled the curve for spontaneous deaths of rats from disease.

Variations of this technique offer encouraging possibilities for determining the nature of the underlying aging process. Other needed research on aging includes the study of changes in blood vessels, in endocrine function, in metabolism, etc.

FINANCIAL NEEDS

The principal reason for the present neglect of the problems of aging and vascular diseases is not so much the difficulty in their solution as the difficulty in obtaining financial support. Much of the current medical research depends upon grants from the foundations. These foundations restrict themselves mainly to short-term grants, while the problems of aging and vascular diseases can not be adequately investigated by short grants which require quick dramatic results. In discussing grants from foundations, Dr. Alan Gregg, of the Rockefeller Foundation, wisely says,[5] "The good effects . . . are sadly qualified by the continuing preference for short-term grants instead of endowment or long-term support."

The adequate investigation of aging and vascular diseases requires endowments or long-term renewable grants because the study of these problems is handicapped by any demand for quick results. Furthermore, continuous animal colonies are needed to supply old animals and these must be supported for an indefinite number of years. It requires two and a half to three years to raise each old rat or mouse and a laboratory may use $2,500 to $5,000 worth of animals per year.

POSSIBLE SOURCES OF FUNDS

There are several ways in which this situation might be relieved. First, if new foundations are established they might manifest specific interest in aging, or they might adopt the policy of distributing their funds equitably in accordance with the relative importance of the problems without taboo on either long-term grants or on renewals. Second, the existing foundations might alter their policies to meet present needs, as advocated by Dr. Gregg. Third, endowments for

[4] In the "diseases of cardiovascular-renal system" are included arteriosclerosis, coronary diseases, cerebral hemorrhage, chronic nephritis and other diseases of the heart and arteries. This is similar to the grouping used by Dublin, "The Mortality from the Principal Cardiovascular-Renal Diseases," Metropolitan Life Insurance Co., N. Y.

[5] Alan Gregg, "The Furtherance of Medical Research," Yale University Press, New Haven, 1941.

research on aging and vascular diseases might be donated by foundations or by individuals to various medical schools and institutions. An annual income of $50,000 or $100,000 could well be used for this purpose by each medical school. Fourth, federal support is highly desirable, but its present program is quite inadequate. Fifth, popular subscription, which has aided treatment of tuberculosis and poliomyelitis, might yield support for medical research.

Some sources of funds for the study of aging and vascular diseases on a larger scale than is now possible is urgently needed and should be established in the immediate future.

SUMMARY

The increase in death rate with increasing age over that at the age of ten accounts for over a million deaths each year in the United States. To what extent these deaths are due to the aging process remains to be determined, but the progressive loss of resistance to nearly all diseases appears to play a large role even in youth and middle life. Since loss of resistance to disease, as well as loss of ability, seems to result from an underlying aging process we may look upon aging as constituting our greatest medical problem.

Second in importance to the aging problem is that of the vascular and renal diseases, since these are involved in nearly 50 per cent. of the deaths after the age of ten (in addition to the effect of aging).

Until more is known about aging and vascular diseases we are not justified in predicting what can or can not be done about them. A new experimental method in which healthy animals of different ages are killed by a known measurable cause offers possibilities for determining the nature of the aging process.

Our two outstanding medical problems are being neglected largely because of the lack of funds to support both the long-term research and the raising of old animals needed for adequate investigation in this field. New endowments as well as changes in the policies of existing foundations are urgently needed.

Supplementary Note: The war situation which has arisen since this paper was written does not lessen the urgent need for endowments in aid of research on aging and vascular diseases. The deaths from these causes, even among young and middle-aged people, will far exceed the war casualties. Diminished stamina after the age of 40 handicaps both our military and our productive capacity. Hence, continuous colonies of animals should be established immediately in order that old animals will be available for intensive research two or three years from now.

OBITUARY

CHARLES WILLIAM LINES, JR.

September, 1920–January, 1942

CHARLES W. LINES, JR., fellow in botany at the University of Wisconsin, died suddenly on January 9, in Oxford, Miss. (Hospital), as a result of injuries sustained in an automobile accident near there on January 3. He was enroute to Madison, Wisconsin, from Dallas, Texas, where he had attended the Christmas meetings of the American Association for the Advancement of Science as a representative of the Zeta Chapter of Phi Sigma.

He was born in Du Bois, Pa., September 24, 1920. After receiving public-school education at Du Bois, he entered Penn State, where he pursued a varied curriculum, graduating in botanical sciences in 1939. After one semester as a graduate student at Penn State, he went to the University of Wisconsin as a scholar in botany. He was made a fellow in botany for 1941–42.

Among the many accomplishments and endeavors which, despite his chronological youth, were many, his work at the University of Wisconsin was concerned mainly with physiology of fungi, while others, such as wild life conservation, plankton zoology, limnology, ecology, botanical taxonomy and physical chemistry, shared much of his eager interest and time.

He was a member of several scientific and honorary societies, among which were Phi Beta Kappa, Sigma Xi, Phi Sigma and the American Association for the Advancement of Science.

As a scientist Charles Lines was a conscientious, persevering and scholarly person. His future seemed pointed toward unbounded successes and scientific accomplishments. It is sad indeed to have to report the premature termination of such a promising career.

CLASSMATES AND FRIENDS

UNIVERSITY OF WISCONSIN

RECENT DEATHS

DR. ARTHUR MICHAEL, appointed professor of chemistry at Tufts College in 1881; professor of organic chemistry at Harvard University since 1912 and emeritus professor since 1936, died on February 8 in his eighty-ninth year.

DR. LAWRENCE J. HENDERSON, Abbott and James Lawrence professor of chemistry at Harvard University, died on February 10 at the age of sixty-four years.

DR. SAMUEL W. LAMBERT, formerly professor of clinical medicine and dean of the College of Physicians and Surgeons of Columbia University, died on February 9 at the age of eighty-two years.