SCIENCE

VOL. 95 — FRIDAY, JANUARY 2, 1942 — No. 2453

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. — Garrison, N. Y.

New York City: Grand Central Terminal

Annual Subscription, $6.00 — Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary in the Smithsonian Institution Building, Washington, D. C.

INDIVIDUALITY AND SCIENCE[1]

By Dr. ALBERT FRANCIS BLAKESLEE

COLD SPRING HARBOR, N. Y.

THE presidency of the American Association for the Advancement of Science is both an honor and a punishment. The first year the president has merely to preside and look intelligent, or as intelligent as possible, at a plenary session of the association. The second year he has the punishment of a Binet test in a formal address before a formidable audience of his peers and peeresses.

Some of the former presidential addresses of the association have given a review of the research activities of the speaker; some have discussed the broader aspects of science. I shall attempt to combine these two methods and after briefly discussing some investigations in which I have had a share, shall say something of the relations which science may have to human welfare.

In looking over my past research activities, the one idea which impresses me most is the individual diversity among the living organisms which I have used as objects of study. Our first published investigations had to do with a group of lower fungi which can be included in the name of Bread Molds. Among these we discovered that growths which looked alike might differ in sex and in a wide range of chemical responses.

Another example of cryptic chemical differences

[1] Address of the retiring president of the American Association for the Advancement of Science, Dallas, Texas, December 29, 1941.

was furnished by the black-eyed Susan (*Rudbeckia hirta*). Two races which had yellow instead of purple cones we found could be distinguished by use of strong potash solutions. The treatment turned the cones of one race black and those of the other red.

These examples have to do with innate differences between individuals. Let us consider some examples of differences in which the environment appears to be the controlling factor. One variety of corn has red kernels at the ends of the ears where they are exposed to the sun but white kernels where they are covered. Both the red and the white kernels when planted, however, gave the same kind of offspring. What was inherited was the capacity to become red in a light environment and white in a dark environment. Another example of the interaction between the innate constitution and an environmental factor is furnished by the pink hydrangea. My wife happens to prefer them blue. It was a simple matter to satisfy her color preference by feeding them iron. There is no reason to believe that the change in flower color from pink to blue had any effect upon the innate nature of the plant.

I used to ask my students to find two apple leaves which were alike. They would start in with enthusiasm, but soon would come to realize that two leaves exactly alike could not be found if one used as a simple criterion of identity the possibility of having the two leaves match with all their indentations when one was superimposed upon the other. I would point out that the general pattern of the apple leaf in distinction from that of an oak, for example, was due primarily to its hereditary constitution but that the wide variations in size and shape of leaves and the arrangement of teeth on their edges were modifications of the pattern induced by differences in the environment such as the position of the developing leaf in relation to light and shade, vigor of the twig, its position in the developing bud and other possible factors in internal environment. The original Baldwin apple tree has been extensively multiplied by grafting. It remains the same tree with the same hereditary constitution but has produced an enormous number of leaves. It is safe to say that no two of these leaves have ever been exactly alike if in addition to external features we take into consideration also the finer structures such as number, form and arrangement of their cells.

With these considerations in mind it is not difficult to realize that probably no two trees in orchard or forest can ever be exactly alike, since in addition to the modifications brought about by variations in environment we have the modifications brought about by differences in hereditary constitution.

In the jimson-weed, the plant with which I am most familiar, many striking examples could be given of the interaction of environment and heredity. Often the effects of each are similar.

We are interested in a recent hereditary mutation which has similar effects on the plant to those brought about by the environmental influence of a virus which we had earlier called *quercina*. Both the quercina virus and the quercina gene cause the elimination of spines from the capsules, the elongation of the stigmatic surface on the pistil, the erosion of leaf margins and the change from a tubular corolla to one with separate petals. The quercina condition has special interest from the view-point of the possible similarity in nature or mode of action between virus particles and genes. It is mentioned here, however, as another example of the fact that both environment and hereditary factors as primary causes may bring about similar effects.

Although we can influence the character of organisms through the environment, it is generally believed that we have no control over their heredity. This is not entirely true.

Records this month on seedlings of jimson-weed which had grown from seeds buried for 39 years in soil at the U. S. Department of Agriculture in Arlington seem to be showing an increased rate of mutations. We can not predict the exact types of hereditary changes that will be induced by aging and other stimuli. In some cases in the jimson-weed, however, we have used mutated chromosomes with which to synthesize new pure-breeding types with predicted characteristics. By attention to the total number of their chromosomes we have reduced their ability to hybridize with their parental types and hence feel justified in calling them synthesized new species.

By one method we have succeeded in exercising conscious control over heredity and are able to predict with reasonable accuracy the characteristics of the new types induced through doubling their chromosome number by means of colchicine. In our own and other laboratories new species have been produced by doubling the chromosome number of sterile species hybrids, and new species are known to have been produced by this method in nature.

I shall give one illustration from animals. In white Leghorn poultry, yellow pigment may be present in the earlobes and legs. When a bird is laying heavily the yellow disappears. Several years ago we showed a close connection between the amount of yellow pigment and a bird's past laying record. This color test has become a practical method of selecting good layers for breeders. Heavy laying is not the only environmental factor which will decrease the amount of yellow. Lack of green food and sickness have similar effects. Hereditary factors also have an influence upon the pigmentation, since in the English Orpington breed, for example, yellow is absent from the body fat. Here again heredity and environment induce similar end results.

In many biological problems affecting human beings, science has had to look to botanists to lead the way. I need to remind you only of the original discovery of the mechanism of heredity by Mendel from his work on garden peas and its later independent rediscovery by three botanists. My interest in human individuality came from my experience with plants. It all started from a botanical problem in 1917 when we were trying to classify the colors of a segregating pedigree of Verbenas. A particular pink-flowered form was very fragrant to me but had absolutely no odor to my assistant. On the other hand, a certain red-flowered Verbena was fragrant to him but not to me. Some of the people in our laboratories agreed with me and some with my assistant. Only a very few found fragrance in both kinds of flowers.

Phenyl-thio-carbamide, which may be abbreviated to P.T.C., is a good reagent with which to show innate differences between people. Some of those we have tested need to have the solutions of P.T.C. more than 8,000 times as strong as others in order to taste it. The inability to taste the commercial crystals is inherited like blue eyes as a Mendelian recessive character, but different grades of taste acuteness have also been shown to be inherited. Numerous tests with other substances only emphasize the wide differences between people in their taste reactions. Some may remember the taste tests at the Richmond meeting when members of the association were asked to vote as to what the real taste of mannose is. They could not agree. Some voted tasteless, some bitter, some sweet and some voted sour or salt or some combinations of these tastes.

There are some interesting after-tastes. Over half the people after eating globe artichokes find the water tastes sweet, and tobacco smoke tastes sweet to some but not to all after the mouth has been rinsed with a solution of copper sulfate.

To the majority of people there are four primary tastes: sweet, sour, bitter and salt. A considerable number, however, we have found can not distinguish bitter from sour. To them quinine and vinegar taste alike. When these substances are weak they may be called sour and when they are strong bitter, but the taste is the same except for strength.

The individual reactions of taste are dependent primarily upon innate hereditary factors and the environment appears of relatively little importance. With smell the condition is quite the opposite. Probably even wider innate differences exist between people in their acuteness of smell than of taste, but environmental factors in abundance prevent the full expression of these hereditary differences. Thus age is a potent factor progressively dulling the sense of smell. A considerable number of people have lost their sense of smell entirely. Temporary conditions of a person, such as a cold in the head, may adversely affect his ability to smell. After being exposed to an odor for a time it becomes no longer perceptible. Olfactory fatigue apparently may be produced even by concentrations too weak to be detected. This is probably the explanation of asphyxiation of people by gradually increasing concentrations of gas which they never detected.

The sense of smell does not play as important a role in man as in many of the lower animals in bringing us information about the external world. There are not a negligible number of people, however, who can distinguish different individuals by odor in the same way in which dogs can distinguish individuals by scent alone. This power is more frequent in children but is often retained into adult life when it is generally concealed on account of the social taboo against speaking of personal odors. Several parents have informed me that certain of their children when young by smelling a handkerchief they had picked up could tell to which member of the family it belonged, but this ability had been lost after they had grown up.

It is possible to learn something about the emotional response to sensory reactions. At a talk given a year ago before the Lancaster branch of the American Association for the Advancement of Science one half of the audience was supplied with powdered kaolin with a weak concentration of cuminol (0.33 per cent.) and the rest of the audience had kaolin in which the concentration was ten times as strong. Reactions of each person who could detect the odor were recorded as to whether it was pleasant, indifferent or unpleasant. When the odor was weak more found it pleasant than unpleasant, but when the odor was strong the reactions were reversed and more found it unpleasant than pleasant. (See Table 1.) This test, as well as other observations, demonstrates that strong odors

TABLE 1

TESTS OF CUMINOL POWDERS*
LANCASTER, PA., JANUARY 30, 1941
Cuminol dilute (0.33 per cent. in Kaolin)

Odor	Absent	Pleasant	Indifferent	Unpleasant	Total number
Males	6.03	31.90	47.41	14.66	116
Females ...	6.36	21.82	50.91	20.91	110
Totals	14	61	111	40	226
Per cent.	6.19	26.99	49.12	17.70	
Cuminol concentrated (3.3 per cent. in Kaolin)					
Males	2.92	24.09	35.77	37.23	137
Females ...	2.94	9.80	28.43	58.82	102
Totals	7	43	78	111	239
Per cent.	2.93	17.99	32.64	46.44	

* Individual reactions to odors are given in percentages.

tend to be disliked. It should not be forgotten, however, that what is weak to one may be strong to another because of innate differences and also because of environmental factors.

Of greatest influence upon our likes or dislikes for a given odor appear to be the pleasurable or unpleasurable associations which have been built up around it. We apparently ourselves once assisted in the development of an unpleasant association. In an early test of cuminol we had made the concentration much too strong, and the majority of the subjects disliked it. A few days later we tested the same persons with a very weak concentration. Several said, "Oh, that's the same as the awful smell you gave us before" and immediately called it unpleasant. Apparently some at least of these subjects had established an unpleasant association with the odor of cuminol when it was presented to them in strong concentration but would have considered it pleasant, or at least indifferent, if they had smelled it for the first time in a weak concentration. The likes and dislikes expressed for weak concentrations of cuminol may be due to associations with objects which are believed to give off similar odors. A wide variety of answers have been given to the question: What does cuminol smell like? They range from roses and citrus rind on the pleasurable side through caraway seeds to bedbugs and perspiration. The fact that one does not himself consider unpleasant those odors which are purely personal is an argument for the contention that there is no odor, aside from its strength and associations, which is intrinsically either pleasant or unpleasant.

Associations are especially powerful with the sense of smell, but they exist with all the senses. So long as we live we are building up associations and developing our personality through reactions with our environment which express themselves in likes and dislikes. Likes and dislikes are important determiners of our behavior.

The examples just given of the influence of heredity and environment have been taken from the senses of taste and smell. All the other senses are similarly subject to internal and external influence. I need only mention the innate differences in musical discrimination disclosed by Seashore and the progressive decrease, under the environmental influence of age, in the pitch or number of sound vibrations one can distinguish at a given intensity. There are a host of other responses which contribute to human individuality. Among these are the blood groups, the natural and acquired susceptibilities and immunities to disease and chemical substances, the allergies and the reactions to hormones and vitamins. The Binet and other mental tests have disclosed great differences between individuals in mental equipment.

It will be granted no doubt that there are great differences between people in their sensory judgments regarding the world in which they live and that these differences are influenced in varying degree by factors of both heredity and environment. Is this true of man's mental and spiritual judgments? I believe it is even more so. A few simple examples may be given.

At the end of the Lancaster meeting already referred to, the audience was asked to select the best title among five which had been suggested for the lecture just given. It might be thought that since all had

TABLE 2

VOTES FOR TITLES IN RELATION TO POSITION ON BALLOT
LANCASTER, PA., JANUARY 30, 1941

	Titles	Position on Ballot*					Total votes	Per cent. of total	Rank
		1st	2nd	3rd	4th	5th			
Males	Why people differ	2.08 A	5.26 E	5.26 D	7.69 C	9.26 B	15	6.02	4
	Differences between people in taste and smell	44.44 B	70.83 A	63.16 E	59.65 D	69.23 C	152	61.04	1
	What makes differences in personality	1.92 C	14.81 B	6.25 A	5.26 E	8.77 D	19	7.63	3
	Demonstrations of heredity and environment	3.51 D	3.85 C	11.11 B	4.17 A	2.63 E	13	5.22	5
	Why each person lives in a different world	23.68 E	22.81 D	17.31 C	20.37 B	16.67 A	50	20.08	2
	Total number	37	59	45	53	55	249	99.99	
	Per cent.	14.86	23.69	18.07	21.29	22.09	100.00		
Females	Why people differ	8.70 A	2.17 E	10.53 D	9.30 C	8.57 B	16	7.69	3
	Differences between people in taste and smell	62.86 B	47.83 A	65.22 E	57.89 D	60.47 C	122	58.65	1
	What makes differences in personality	4.65 C	.... B	10.87 A	4.35 E	7.89 D	12	5.77	4
	Demonstrations of heredity and environment	5.26 D	 C	5.71 B	6.52 A	10.87 E	12	5.77	4
	Why each person lives in a different world	17.39 E	18.42 D	25.58 C	22.86 B	26.09 A	46	22.12	2
	Total number	38	30	52	39	49	208	100.00	
	Per cent.	18.27	14.42	25.00	18.75	23.56	100.00		

* Five titles were listed in different orders on five ballots A to E.
Numbers under each position are percentages of votes cast for given title on the ballot indicated by letter at right of figure.
Males: Ballot A was voted 48 times; B, 54 times; C, 52 times; D, 57 times; E, 38 times.
Females: Ballot A was voted 46 times; B, 35 times; C, 43 times; D, 38 times; E, 46 times.

heard the same lecture, there would have been considerable unanimity in preference. This was not the case, however. Though two titles had more votes than the others, each of the five titles was preferred by a considerable number. Here again we may be reasonably sure that factors of both heredity and environment did influence the mental judgments regarding the best title.

Unbeknown to the audience, the titles were in different orders on five different kinds of ballots which were shuffled before distribution. The records clearly show that there was no advantage so far as number of votes secured was concerned in having a title come first on the ballot. (For records see Table 2.)

A similar experiment with the same set of shuffled titles was earlier tried after a talk on taste and smell before an audience of 270 students at the Farmingdale Institute of Applied Agriculture on Long Island. Perhaps because the lecture, as well as the audience, was somewhat different, the percentages of votes cast for the various titles was considerably different from those in Lancaster. The position on the ballot, however, again did not seem to have any material effect on the voting. A different psychology might conceivably be involved in voting on questions in a referendum from that in voting for candidates in an election.

With the expectation of being able to show that position of candidates on a ballot would have no influence with a group of intelligent voters I next tried an experiment with scientists.

Under the authorization of the Executive Committee of the Association, a study is being made, in cooperation with Dr. Sewall Wright, of the effect of position of candidates' names on this year's preferential ballot for president of our association. There were four types of ballots sent out from the Washington office after they were properly shuffled. In one the names were arranged alphabetically; in the others the names were arranged at random, except for the first and last places for which names were selected on account of their high standing in last year's balloting.

We hope to publish a statistical analysis of the data at an early date. In the meantime, however, it will suffice to present some provisional conclusions from our arithmetical tabulation of the ballots received up to November 28th. (See Table 3.)

In all cases the percentage of votes for a candidate on the ballot in which his name came first or second was in excess of the average percentage he received on the other ballots. Other positions appear to have had little effect on the voting. If we use the excess in votes for a candidate in first or second place over his average in other positions as an index of the number of people who would not have voted for him if he had had a less desirable place on the ballot, then the percentage of votes due to preferred position on a given ballot range from 14.3 to 45.7 per cent. This would mean that between 3 and 4 per cent. or over 150 of the 4,000 members of the association who voted may have been influenced by the order of names on the ballot. (A biometrically more reliable measure of position effect on the ballots we hope to discuss in our joint paper, but it seems justifiable to use the suggested

TABLE 3

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
TABULATION OF BALLOTS FOR PRESIDENT, NOVEMBER 28, 1941
SELECTED NAMES TO SHOW POSITION EFFECT
F = Name *first* on ballot. S = Name *second* on ballot. L = Name *last* on ballot.

Nominee	Ballot 1	Ballot 2	Ballot 3	Ballot 4	Totals	Average excluding F or S	Estimated per cent. due to position
A	200 F	147	158 L	143	648		
Per cent. ..	18.85	14.73	15.94	14.80	16.14	15.16	19.58
F	38	59 F	40	36	173		
Per cent. ..	3.58	5.91	4.04	3.73	4.31	3.78	36.04
V	29 L	30	57 F	35	151		
Per cent. ..	2.73	3.01	5.75	3.62	3.76	3.12	45.74
Q	89	81 L	83	94 F	347		
Per cent. ..	8.39	8.12	8.38	9.73	8.64	8.30	14.70
B	91 S	65	73	79	308		
Per cent. ..	8.58	6.51	7.37	8.18	7.67	7.35	14.34
N	57	60 S	43	47	207		
Per cent. ..	5.37	6.01	4.34	4.87	5.15	4.86	19.13
L	58	73	72 S	50	253		
Per cent. ..	5.47	7.31	7.27	5.18	6.30	5.99	17.61
G	39	36	35	53 S	163		
Per cent. ..	3.68	3.61	3.53	5.49	4.06	3.61	34.24
O	30	35	31	31	127		
Per cent. ..	2.83	3.51	3.13	3.21	3.16		
Totals	1061	998	991	966	4016		
Per cent. ..	26.42	24.85	24.68	24.05	100.00		

provisional measure to point the trend of influence of position.)

To show that the position on ballot may possibly be of practical importance, we may compare the votes for two candidates who belong to the same section of the association and who would be generally considered rather closely comparable in age and in experience and eminence in both research and administration. The man whose name came first on one of the ballots stood two ranks ahead of the other candidate in total votes received. When, however, our correction was applied for his preferred position on the single ballot, he ranked one grade below the other candidate.

The fact that every one of the 22 candidates received a considerable number of votes is itself an indication of wide diversity in judgments of the voters. This may be attributed to differences in the fields of science represented and in the familiarity with the work of the various candidates. The balance between these environmental influences undoubtedly has a hereditary basis. That so many scientists should be influenced by such a trivial environmental difference as whether a candidate's name comes in the first two places or later in the ballot was unexpected. Those so influenced perhaps had a hereditary constitution different from the other voters. The results of the balloting of the American Association for the Advancement of Science show at least that we are not a class apart, uninfluenced by hereditary and environmental factors which sway the judgments of other people.

The Supreme Court of the United States is composed of outstanding minds. Their honesty is unquestioned and they are freed from even the unconscious pressure of political expediency. Here, if anywhere, we should expect unanimity. The Supreme Court, however, from its early history has rendered numerous decisions by a divided vote and in many instances, including some of the most important cases, by a majority of only one. With its broadly changed complexion since early New Deal days, one might expect less diversity in judgment at the present time. This does not seem to be the case judging from a last month's news report of the first two decision days of the present term. Within two weeks there were brought in three 5-to-4 and two 6-to-3 decisions. None of the justices during this time had failed to enter at least one dissent and all except two had more. We can not here attempt to analyze the elements in these differences in judgments. Such blanket terms as liberal and conservative suggest the influence of innate disposition and also of such environmental factors as advancing age. If we remember our experiments with taste and smell we may agree that judgments of drinkers regarding the taste of beer and judgments of the Supreme Court regarding issues of law can not help differing because men both are born different and have differences thrust upon them by their environment.

Differences in expression in art, music and literature can likewise be attributed to influences of heredity and environment. I have personally been interested in studying the manner in which trees have been used in art. Styles in method of representation are evident, but the artists differ in the way in which trees appeal to them. Some are interested in individual trees, others in groups. Some prefer trees in the foreground, others in the background or in the middle distance. There are differences also in the species of trees which different artists like best.

We have given examples of differences in plants and animals such that no two individuals are exactly alike and have classified the causes of these differences into the interacting factors of heredity and environment. We have shown that both heredity and environment are likewise responsible for the diversities in man, not only in his physical structure and sensory reactions but also in his mental and moral judgments. Every thought and act of our lives is influenced by these two factors. Man has used his knowledge of heredity and environment to mold plants and animals to his personal advantage. Can this be done with man himself? To some extent, yes, but the way is not so clear.

I know of no adequate evidence that man to-day is a better animal physically or mentally than at the dawn of history. While man's biological evolution during these five thousand years and more has seemed to lag, and at the present time has appeared to many to have been thrown into reverse, man's environment has changed markedly even within our own lives. Conscious control of human heredity, though a desired goal, will at best be slow even if our genetic knowledge were adequate for the task. Changing man's environment gives promise of more rapid betterment of human individuals, and in this effort we are far from reaching diminishing returns.

But the facts of individuality and the relative influence of heredity and environment upon personality must be carefully estimated in any rational campaign for permanent social betterment. Such knowledge has power to revolutionize our ideals and practice in social and religious justice, charity and education, methods of legislation and forms of government. Methods of education, for example, have been severely criticized for mass regulations which fail to take adequate account of individual excellences. Pedagogy has been called a racket, a pressure group which has forced legislation more in the interest of the pedagogical profession than in the interest of the individual students. Schools of education are accused of padding their curriculum in an attempt to compete in standing with other disciplines, and doctorates in education are considered inferior to those in other departments. This is strong language and may not be justified, but we have heard it repeatedly. Some of the criticisms are undoubtedly due to the difficulties inherent in the study of any subject in which variables are many and difficult to control. Similar criticisms come from the so-called exact sciences, mathematics, physics and chemistry, against the difficult, less exact biological sciences, botany and zoology, and some would even deny the name of science to those most difficult studies of man's social behavior. For years the educational world has been struggling with the problem of how best to deal with the increasingly recognized differences in mental ability, differences which, like those we have found in taste reactions, are of two kinds: a difference between general marked ability and general mediocrity and a difference between ability in certain lines such as mathematics, science, art or literature.

I recently wrote to the sixteen living past presidents of our association and asked them if they could satisfy the enclosed New York State requirements for teaching in the state secondary schools. Not one of the past presidents of the American Association for the Advancement of Science would be allowed to teach science in a New York high school without further preparation since none had taken the required instruction which included such subjects as the psychology, history, philosophy, principles and practice of education. One past president properly remarked that not all presidents would have been good secondary school teachers. It is a fact, however, that more than a quarter have had secondary school teaching experience, but could not now qualify under present requirements. This is not at the present time a serious deprivation of the freedom of these men, but some believe the state methods of selecting teachers place undue emphasis upon relatively unimportant requirements. Some educators have told us that in the balance between method and subject-matter they believed the pendulum had swung too far toward method.

Blanket regulations may make for ease of administration, but too great uniformity may preclude the assets of individuality. Uniform laws throughout the states would have certain advantages, but they might not be equally well adjusted to local environments and might prevent profitable experiments in local government. The increased means of communication throughout the world appear a mixed blessing. They tend to standardize our thoughts and behavior in a common mold but at the same time to decrease the material expressions of individuality available for social evolution through natural selection.

In the Imperial Valley of California some years ago the cantaloupe industry was on the point of ruin because of a fungus disease for which no adequate remedy was known. The problem was solved by bringing a gene for disease-resistance into the stock through hybridization with an inferior race from India. If only one variety had been grown throughout the world we would probably not now have the pleasure of eating cantaloupe for breakfast. Thus the cultivation of a single variety which is a high yielder may be of immediate advantage, but if grown exclusively it may cause the irreplaceable loss of genes of great value which are now combined in less desirable varieties.

Opposition to totalitarianism is not merely because it attacks man's rights but also because it suppresses his personality. Individuality is the kernel of democracy, the biological basis of the struggle for freedom. When we fight for individuality we fight on the side of nature. Recognition of individuality and all that it implies especially concerns us as scientists. Even if science were again persecuted and driven under cover, as it was in the middle ages, there would still be some brave inquiring minds. But science can not flourish without freedom of thought and its expression.

Why do I emphasize the value of individuality to science? Because I believe science is the great hope of mankind.

In speaking of science and scientists it should be clear I am not confining attention to the professionals. Whoever by observation or experimentation is responsible for increased knowledge of the world in which we live is a servant of science and contributes to the welfare of mankind. In this connection it is appropriate to mention that in colonial times keen observers had discovered the causal connection between barberry bushes and infestations of wheat rust and had passed laws in Massachusetts for the eradication of barberries long before botanists learned that a necessary stage in the life cycle of this rust is confined to the barberry.

Science is under fire for the suffering brought about by its applications, especially in the present war. Science is in no position to disavow its responsibilities in the problems of peace and war. As in epidemics of disease due to the ignorance of medicine we need not less but more medical knowledge, so in seeking a cure for the scourge of war we need not less but more science. The remedy we trust may ultimately be found by that most difficult of all biological sciences—the study of motives and human behavior. Science can reply to its critics that the applications of science are merely tools which men with good or bad motives use for their good or evil ends. The same can be said of printing. Even if we admit the responsibility of science for deaths due to its applications we will find that its applications have brought about even greater savings of life. The legend to a reproduction of the title page of Jenner's paper on vaccination published in 1798 reads: "The application of the facts presented in this paper has probably saved more lives than the total of all lives lost in war." The statement is easy to believe, since it has been estimated by Haggard that in the 100 years preceding Jenner's paper, sixty million people in Europe died of smallpox.

In war itself science has not been alone destructive, as may be seen from figures supplied by the Surgeon General's office regarding the annual death rate per thousand in the United States Army for the Mexican War, the Civil War and the first World War. Deaths due to battle injuries increased from 15 per thousand for the Mexican War through 33 for the Civil War to 53 for the World War. The death rate due to disease, however, decreased from 110 through 65 to 19 for the World War. The net result is that the total death rate actually declined, from 125 in the Mexican War through 98 in the Civil War to 72 per thousand in the World War. It is a satisfaction to feel that though implements of war have increased in destructiveness, those who are fighting to preserve our free way of life may not be subjected to greater risks than our forefathers assumed when they too fought for their country.

It can hardly be emphasized too strongly that it is not man's material comforts nor even the alleviation of his physical pains which are the greatest gifts of science to mankind. Science has freed men's minds. Foremost among liberating ideas is the belief that there is order and law in the universe and that this order can be discovered by questioning nature herself. Such belief was rare in the middle ages when processes of nature were generally attributed to supernatural causes: winds and storms to demons, comets and epidemics to the wrath of the Almighty toward a sinful world, and investigations of nature were persecuted by both church and state as Satanic magic and sacrilegious questioning of the acts of God. The Copernican theory widened our physical horizons and showed our earth a tiny speck in a universe of worlds. The theory of evolution brought a unity to our ideas of the organic world. The discovery of the mechanism of inheritance allowed an evaluation of the contributions of heredity and environment to the personality of individuals. The experimental method with adequate controls is the most valuable tool science has yet developed. Its understanding and use in daily life would mean more than all the scientific facts that schools can teach.

Science has helped to free man's soul. It has broadened the horizons of religion and given it a new point of view away from the old intolerant, materialistic theology when men sought their own salvation from selfish hope of heaven or fear of hell and persecuted or even killed those who did not conform to the authority of orthodox beliefs. Elimination of such incumbrances has left to religion a freer field for the cultivation of its great spiritual values. In this shrunken world all mankind are neighbors and our benefactions have had a world-wide view.

Science has banished much of ignorance and superstitution, but much remains. Recently in New York's Pennsylvania Station I purchased seven different magazines on astrology. One of them, and this not the best seller according to my newsdealer, I found had a monthly paid circulation of over 132,000 copies. (The circulation of our journal SCIENCE is about 15,000.) The readers of these astrological journals are part of our democracy and help to form the policies of our government. Other examples need not be given to show that the scientific method has not yet saturated our land.

If we consider past efforts to better mankind, it is clear that good intentions are untrustworthy criteria of service to humanity. The biblical criterion "By their fruits ye shall know them"—is biologically sound doctrine and still the best test. The attempts to suppress independent thought and study of nature in the middle ages, and up to the not distant past in our own country, were inspired by noble motives, but they put civilization back by many centuries. The crusaders had a lofty purpose but a trivial objective:—the capture of an empty tomb, with all too slight appreciation of the teachings of Him whom the tomb had held. The net result was unnecessary suffering and death even among a group of children who became involved.

Love of our neighbor is one of the loftiest ideals of the Christian faith. Sympathy and kindness toward those in need we can never do without—for our own sakes as well as for those who are helped. But charity covers a multitude of misplaced aims. It may attack symptoms merely rather than the cause of the ills to which it ministers and thus delay their cure.

During the plague of the seventeenth century when 25 million people or a quarter of the population of Europe died of this dread disease, there were doubtless, as there should have been, hospitals and other organized efforts to minister to the sick and dying. We can imagine the scant attention that would have been then paid a request for a grant for a scientific study of the life habits of such creatures as rats, fleas and the wriggling animalcules which Leeuwenhoek discovered at about this time in drops of putrid water. And yet our knowledge of rats, fleas and bacteria is one reason why centuries later pest hospitals are not found in London and we no longer dread the plague.

The illustration given is an example of the unsuspected value of knowledge in apparently unrelated fields. Many other examples could be given of the service of science to human welfare, a service which is often indirect. The ancients used human sacrifices to ensure bountiful harvests. Now we use commercial fertilizers for this purpose and find them more efficient. In the old days people fought yellow fever and smallpox by church rites and religious processions. Now we fight these diseases by killing mosquitoes and by vaccination. Formerly thousands of people were executed on the ground that they were witches. Science has proved that witchcraft does not exist. It would be difficult to give from history as striking examples of success in direct efforts to improve the condition of mankind without the aid of science.

Knowledge is power also in our efforts toward human betterment. We must learn the facts about the environment in which we live if we wish to adjust ourself into harmony with it. Efforts against nature are doomed to failure despite high motives. It is for this reason we believe that in a rational program for human betterment science—the free search for truth—is in the long run the best investment. If what I have said is true, it lays upon us all, both scientist and layman, a responsibility for the advancement of science, free and unhindered as a service to mankind. Think where we would have been now if in the dark ages men like Copernicus, Galileo, Albertus Magnus, Roger and Francis Bacon among other inquiring minds had been able to carry on their scientific investigations in an atmosphere of intellectual freedom. Our most difficult sciences might now have reached the stage occupied by biology, for example, and we might already have found a remedy for our present sick civilization.

How can science best be fostered? I need offer only a few suggestions.

Science in common with all intellectual pursuits needs tolerance, freedom from restraint and a recognition of the value of individuality. Men differ widely in their capacities for research. A great need therefore in the advancement of science, as of other intellectual endeavors, is to devise means for discovering the exceptional abilities at an early age and giving such abilities exceptional opportunities in order that their span of effective service with its social values may be prolonged.

The public, whom science serves, knows all too little what science really means. The magic and gadgetry of scientific applications rather than the methods and ideals of science make the great appeal. And yet the ideals and methods would help society reach judgments on the basis of ascertained facts rather than through emotional appeal and personal profit and would transform our daily lives if universally applied. Think what a change would come if our representatives in legislative halls should open each session with the prayer of Huxley: "God give me strength to face a fact though it slay me"—and really mean it.

A common comment of a layman after visiting a laboratory and having research explained to him is "what great patience scientists must have." The real thought appears to be how can reasonably intelligent men, as scientists seem to be, be content to spend time in such trivial and uninteresting details. The layman seems to feel as he might in watching a small child picking up little white pebbles laboriously one by one and putting them into a bucket and then taking them out again one by one in the same painstaking manner. And yet this same layman sees reason in taking a stick and whacking a diminutive white ball over a field, alone or in company with others, and each time he gets it into a little sunken bucket he takes it out again and whacks it to another bucket of the same dimensions. And when he has finally repeated this process 18 times he calls it an afternoon well employed and spends the evening telling his colleagues how he did it—provided he can find any colleagues who prefer to listen rather than to tell how they themselves whacked their own little white balls into 18 little sunken buckets. Or he may have to tell his story about what he did with his little white ball and the little sunken buckets to his patient wife, who can't get away. Science as well as golf is a sport to those who play the game and there is a chance of some bit of human value when the game is done.

In the promotion of human welfare through the advancement of science, scientists and the public have a common interest and may have a common share. I believe our association is especially adapted to furthering these common interests and could profitably undertake a study looking toward the development of a more effective program that would serve the aims of scientist and layman alike.

In this country as nowhere else patrons of art, literature and science have made investments in human good. The yields in benefits secured have varied much but sometimes have been slight because the investments have been unsound. We trust that those of philanthropic intent who wish to promote human welfare through the methods of science will subject their donations to as careful checks as they would a financial investment in order to ensure a profitable yield in the way of scientific dividends. A newly established National Science Fund is in position to serve as a clearing house for advice on the probable scientific dividends which may be expected from investments in science.

Although we do, each of us, live in different and more or less separate worlds of our own, I trust we shall ultimately be able to acquire a social organization as orderly as the constellations of other worlds. In our fight for individuality and freedom in this war and in the peace to come, I do not despair. The experimental method has demonstrated we must use force without stint to show that freedom and political morality as well as personal honesty really pay. We still cherish the faith that the free search for truth by the methods of science has power to rebuild the world and will prevail.

OBITUARY

ERNEST EVERETT JUST

AUGUST 14, 1883, TO OCTOBER 27, 1941

IT is a sad task to write this short memorial of my former student, collaborator and friend, Professor E. E. Just, of Howard University in Washington. His death was premature and his work unfinished; but his accomplishments were many and worthy of remembrance.

Professor Just was of the Negro race and undoubtedly the best investigator in the field of biology that his people has produced in America. In person he was tall and slender, of dignified mien, with fine, sensitive features. He was born in Charleston, South Carolina, on August 14, 1883. His mother, who was a teacher, after providing him with the best elementary education that his state could furnish, sent him to Kimball Union Academy in New Hampshire, where he made a very distinguished record. He then entered Dartmouth College.

Just took his A.B. degree at Dartmouth College in 1907. While there he specialized in zoology under William Patten, made an excellent record in courses, and devoted a good deal of time to a research problem; he was elected to Phi Beta Kappa and received special honors in zoology and history, as well as the only "magna cum laude" in his class. He began his graduate training at the Marine Biological Laboratory in 1909 with the course in marine invertebrates, and in 1910 in embryology. In 1911–1912 he acted as research assistant to the writer on the subject of fertilization and breeding habits in Nereis and the sea-urchin Arbacia. These experiences focussed his interest on marine eggs, which remained the center of his investigations throughout life. His duties at Howard University delayed the completion of his work for the Ph.D. degree at the University of Chicago until 1916. In the meantime he completed six papers, based on work at Woods Hole in the summer. This work was so good, and his efforts during the academic years to improve medical education at Howard and other Negro universities so effective, that as early as 1915 he received the first award of the Spingarn Medal presented annually to "The man or woman of African descent who shall have made the highest achievement during the preceding year, or years, in any honorable field of human endeavor."

He was on the staff of Howard University from 1907 to 1941, since 1912 head of the department of zoology. From 1909 to 1930, with the exception of two years, he spent all his summers in work at the Marine Biological Laboratory.

His first paper (1912) was an interesting study in which he showed by an ingenious method that the plane of symmetry of development is determined by the polar bodies and the point of entrance of the spermatozoon in a meridian of the spherical egg of the annelid Nereis. This was followed by about fifty papers in the next twenty-five years dealing with fertilization and experimental parthenogenesis in marine eggs, mostly of annelids and echinoderms, in addition to a number of theoretical contributions. In 1939 he published two books; the first, on "Basic Methods for Experiments in Eggs of Marine Animals" (89 pp., P. Blakiston's Son and Company, Philadelphia), is an account of the very refined methods that he had developed for work in this field; the second, on "The Biology of the Cell Surface" (392 pp., same publishers), brings together his work and thought in the fundamental field of cellular physiology.

In the twenty summer sessions that Just spent at the Marine Biological Laboratory at Woods Hole he became more widely acquainted with the embryological resources of the marine fauna than probably any other person; and he learned to handle the material with skill and understanding. In consequence, he was in great demand, especially by physiologists who knew their physics and chemistry better than biology, for advice and assistance which he rendered generously. When he withdrew from Woods Hole to work in European laboratories, his loss to the scientific community at Woods Hole was deeply felt.

Just maintained a fine sense of balance in his biological work: he believed that "the study of the state of being alive is confined to that organization which is peculiar to it," but that "life as an event lies in a combination of chemical stuffs exhibiting physical properties; and it is in this combination, *i.e.,* its behavior and activities, and in it alone that we can seek life." These statements are taken from the introduction to his book on "The Biology of the Cell Surface" published only two years before his death. The emphasis in his studies was always on the biological plane, though in his experiments he availed himself intelligently of physical and chemical techniques.