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# GENETICS AND ANTHROPOLOGY[1]


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WHILE all scientific activity might well be regarded as a single enterprise, human limitations are such that individually we can reach the boundaries of knowledge in but few places. This handicap is offset in some measure by the fact that acquisitions laboriously achieved in one domain may be taken over in whole or in part by workers in other fields. Anthropology has profited much in this way, having drawn heavily on the physical sciences and mathematics as well as on biological specialties and the humanities. Through borrowing and mutual interchanges the forefront of scientific progress is kept from becoming ragged.

A survey of journals issued during the last few years shows that one of the important recent anthropological contacts has been with the field of genetics, which to anthropologists as a group is no longer quite *terra incognita*. Especially is this true with some of our European colleagues, among whom human genetics is coming to be regarded as a natural part of anthropology. In our own journals during the past ten or fifteen years there has occasionally appeared an article with a distinctly genetic background, and in several important monographs genetic aspects have received able consideration. Conversely, an easy-going assumption of a direct and immediate effect of climate or custom on the human germ-plasm has become less frequent. So it could hardly be said to-day, as with some justice it might have been only a few years ago, that the platitudes of genetics are the heresies of anthropology. But in place of the violent revolution in anthropological thought which some great exponent of the genetic point of view might have stimulated, we are witnessing a slow and

[1] Address of the vice-president and chairman of Section H—Anthropology, American Association for the Advancement of Science, Boston, December 29, 1933.

subtle infusion of genetic ideas suggesting one of those peaceful human infiltrations which have supplied anthropologists with many of their problems.

It is probably correct to state that the most far-reaching contribution of genetics has been the theory of the gene. One might say that the gene is to some of the biological sciences what the atom is to the physical sciences. Genes are believed to reproduce themselves exactly with each cell division, and so may be regarded as in effect permanent units which pass on from one generation to another unchanged by the vicissitudes of reproduction, combining and recombining, often with effects suppressed, but with no loss of individuality; much as atoms enter into one compound and then another but may always be recovered quite unchanged. Genes, like atoms, undergo mutations; and in the investigation of these respective units the logic, and in a measure the techniques, of the physicist and the geneticist have been strikingly similar. For present purposes we may think of the genes as minute, self-perpetuating particles located in the chromosomes and transmitted by them from one generation to the next. It is they that contribute the hereditary factors in the development of individual constitutions. What is of prime importance here is that these determiners of traits are particulate rather than diffuse or ethereal elements, that they are self-perpetuating and relatively immutable. This concept finds ready application in physical anthropology.

It is sometimes objected, however, that while the genetic approach may be a profitable one in studying some human traits, it must fail with others because of the multiplicity of genes and the complexity of their interactions. This objection is a very real one. As the number of genes influencing a trait becomes large, there is an approach to that "infinite number of agents" often assumed by the mathematician, and so it does not seem probable that genetics will completely emancipate certain phases of anthropological work from the relative crudities of the statistical method. But it is likely to contribute much toward clarifying postulates on which mathematical analyses are based. A hopeful trend is indicated by Laughlin's paper on the "General Law of Heredity" and such recent work as that of Fisher, Wright and Haldane. But whether genetics contributes much or little in this respect, the fundamental idea of a particulate rather than a diffuse physical basis of heredity is likely to stand.

Some of the more interesting implications of the genetic point of view may be indicated by considering in cursory fashion a few subjects of anthropological concern without being diverted for the moment by qualifications and reservations which might suggest themselves. A final estimate of the value of these considerations must be reserved for the future.

## Race Crossing

It is still customary to speak, and perhaps to think, in terms of common fractions when referring to racial inheritance. Some of us are not quite free from the notion that the "blood" of two races is blended in the offspring like two fluids in a beaker. If a mulatto were symbolized by a half-and-half mixture of milk and black coffee, the descendants of mulattoes, it is commonly assumed, should be represented by combinations of these fluids in amounts proportional to the number of white and colored ancestors. Terminology consonant with such a conception is convenient, so long as we are not subconsciously deluded into thinking that the simple fractions have a definite meaning with reference to particular individuals. Genetics has gone far to undermine any notion that a race cross is like the mixing of two liquids. Germplasms, it maintains, do not blend; their particulate elements mingle and, uncontaminated, segregate again. In any individual which is produced there may indeed be many kinds of blends and compromises in the effects which the genes condition, but the genes themselves remain unchanged. Nothing in genetics is more generally accepted than this.

So it would appear quite possible that a mulatto couple might produce a white child without a single Negro gene and a Negro child with no white genes. In view of the 48 chromosomes of man and with no crossing-over of genes between homologous chromosomes, the chances for the occurrence of two such unrelated sibs would seem to be approximately one in $7 \times 10^{28}$. If this is considered as negligible, it should be recalled that the calculation takes into account every chromosome and all the genes. It is probable that the vast majority of genes are the same in both whites and Negroes, which greatly reduces the odds against the mulatto couple producing a pure Nordic child. But, even so, the chances of such an event must be measured against figures with a magnitude to which most of us are unaccustomed. However, if we neglect racial complexes as a whole and consider merely individual traits, the situation is quite different. Many of the latter are conditioned by only a few genes, or even a single one, and naturally such traits do frequently segregate.

We should consequently expect our mulatto couple to produce children with prevailingly hybrid traits, but among them some who might be purely Negro or purely white in certain particular respects. Examples of this are often met. To cite a single one: I know a man who is as black as human beings often come, but in his ancestry there is much Indian and white blood. The shape of his head is unlike that of most Negroes and there are other features which are not characteristically associated with his color. The reasonable inference is that when his existence was initiated he received most or all of the Negro genes for skin color, while those for different traits came largely from the other two great races upon which he could draw. To describe his inheritance in terms of common fractions would be to make only a crudely statistical approach to the truth. Indeed, his sibs, with the same fractional formula, are of quite different types.

The expected, and on the whole the observed, result from mingling of peoples is a breaking up of racial complexes, but not of genetic traits. Long ago, before modern genetics could be considered in connection with anthropology, de la Pouge emphasized this point, stating in effect that all the types in Europe have existed for ten thousand years and intermarried continuously, but to-day are not one bit nearer than in the beginning to a common fixed type of mixed race. Such considerations impress one anew with the importance of the trait as contrasted with the complex in dealing with race and race crosses. In other words, our study promises to become more fruitful as it becomes more individual.

At the same time the genetic outlook affords a warning against the indolent use of some common methods. For instance, when the progeny of a race cross, or any other variable group, shows a rather wide dispersion in respect to a trait, the prevalent tendency is to arbitrarily seriate the observations into artificial categories such as "1, 2, 3," etc. The danger that inheres in this procedure may be indicated by reference to a field in which knowledge is relatively precise. In some of the laboratory animals where the heredity of hair color is well understood, there is to be found what might appear to be a continuous series of shades from pale yellow to pure black. Such a series would admit of several different and seemingly reasonable artificial subdivisions, but there is only one classification that coincides with the genetic background. If the hair colors of these animals had from the first been classified as arbitrarily as those of man commonly are, the records would no doubt be even more copious, and the significant facts still well concealed.

For the study of race crossing, genetics brings to anthropology a revised, and in many respects an illuminating, outlook. It also brings a demand for a burdensome and difficult addition to earlier techniques. Furthermore, it raises several general and rather fundamental questions relating to the underlying nature of the races which cross. Does a race represent anything more than an aggregate of independent traits? Have we reached the essentials when we identify the genes by which it differs from another race? There is much evidence that the latter may be so, and I know of little specifically to the contrary, but conclusions must be drawn with caution. The possibility of some underlying "matrix," which, while responding to the genes, is itself responsible for racial and specific characteristics, has not been wholly eliminated, however improbable its independent existence may now seem.

### RACIAL DIFFERENTIATION

The problem of race crossing and that of race in a more special sense is essentially the same. It is a commonplace that "there are no pure races." In other words, "purity of race" is only a relative term. This is an important fact, often emphasized. Still we do find that whole sections of the world are, or were, given over to one racial type and other sections to different types. Such local individualization of races presents one of the great problems of anthropology. One can only wish for more dependable information as to whether the main races of mankind and their major subdivisions were in fact biologically best adapted for their original homelands and, if perchance they were, then by virtue of which of their distinctive traits. One would wish to know how many racial traits are purely incidental to, and in a sense by-products of, traits of more crucial import—preserved and developed because some of the genes that help to determine them are also necessary to the production of genuinely vital characters. These are questions to which answers will probably come slowly, but of the modes of attack at present available, the genetic one seems most promising, since a particulate type of heredity appears to be the most favorable for the concentration and preservation of desirable attributes.

From an analysis of influences and tendencies active to-day and undoubtedly operative from time immemorial, we may hope to gain some inkling as to the manner of racial development. In the study of these problems and the principles which they involve, one need not go to remote places. The traits of civilized man are no less real than those of savages; indeed the former, reproducing at a rate of scarcely more than three generations to the century, may be even a bit closer to the common ancestor than are some "primitive" groups which reproduce at a more rapid rate. The significant contribution of genetics at this point is the notion of permanency of the gene. We may in fancy take a census of the genes in one generation and know that in the next we shall find the same ones, or their exact equivalents, all present but regrouped in new combinations. In other words, genetically each generation is in the aggregate, like the preceding; only individuals change as the *abc* and *def* of the parents become the *abf* and *dec* of the offspring, through endless groupings and regroupings of unchanging factors. Such at least would be the case (except for rare mutations) if all individuals were to reproduce at the same rate. But if reproduction becomes differential with reference to any trait, the ratio between the genes for that trait and their allelomorphs is altered. This seems to be the key to racial change. Genetics supplies what the older theories of natural selection did not offer, a basis for calculating the nature and rate of change. Useful methods for such computations have been devised and bring into relief some aspects of demography that might not otherwise have become apparent. Particularly they point to a conception of human populations in terms of their total germ-plasms, in which each gene and its allelomorph tend toward a state of random distribution. But such a distribution does not make for true uniformity; it merely decreases the frequency of extreme types. Uniformity, we are led to expect, will come only through differential reproduction with the elimination of gene lines.

Students of genealogy and of biological descent have heretofore used much the same criteria of relationship, but we must now differentiate between descent that is merely genealogical and that which is also genetic. The reason for the distinction may be indicated by considering the source of an individual's chromosomes. From each parent he receives 24. Of these each grandparent on the average contributes 12, each great-grandparent half that number, and so on until in the sixth generation one has more grandparents in his genealogy than he has chromosomes in his cells. Obviously, if there has been no "crossing-over" of chromosomal elements, some ancestors in the sixth generation back have been completely eliminated in a genetic sense. They are only empty forms that mean nothing in his heredity. Indeed the chances are that at least one ancestral line will be eliminated even before six generations have passed. Not all my father's ancestors are mine. It follows from this that one may have no more than 48 genetic ancestors in any one generation. If it should develop that there is much crossing-over of genes between the chromosomes in man, the fact would serve to make these figures somewhat less striking but scarcely less significant. The essential point is that genetically a man can be descended from only a very limited number of his genealogical ancestors.

Conversely, a man is entitled to claim real ancestry for only about three fourths of his descendants in the sixth generation, with possibly a small bonus, depending on the frequency of genetic cross-overs. Ultimately, if there is no differential reproduction, he might become the genetic ancestor of descendants to the number of 48 times whatever figure represents the ratio of the population in his own generation to that of the generation in question. But if his descendants do not scatter widely, they are likely in time to intermarry, despite civilized prohibitions or the most complicated taboos of the cleverest savage, and sooner or later genealogically remote grandchildren will be produced who are genetically more closely related to him than are most of his nearer descendants. Such partial "reincarnation" is often called "reversion." When it is frequent, so that many individuals not obviously related show the same traits, it implies paucity of genetic ancestry and suggests that only a few patriarchs supplied the genes for traits which now appear in oft-recurring combinations.

These genetical considerations, reinforced by various data of other kinds, suggest two modes of racial origin with results which need not in the end be essentially different. One produces individuals who, because of the fewness of their genetic and original genealogical ancestors, have relatively few gene lines which differ. Such, no doubt, are some of the distinctive groups within the three or four major races. The other, starting with many and diverse genealogical ancestors, produces a homogeneous group through differential reproduction and its resultant segregation and realignment of genes, to the end that ultimately these too have relatively few (but originally diverse) genetic ancestors. Such perhaps are some of the Pacific Islanders and, incipiently, a few modern nations. The thesis which genetics may be thought to present is that, as racial groups are found to be homogeneous, their genetic ancestors may be inferred to be few.

### Inter-racial Distribution of Traits

Delimiting of races is notoriously difficult. In general the fewer the diagnostic features, the more widely distributed, or the more "artificial' the group which they define; while the more numerous the criteria, the more uncertain and variable the racial limits. Particular types of build and hereditary peculiarities of various sorts appear again and again in different races. From almost any cosmopolitan group one can select black, white and yellow subjects with features in common. By employing criteria other than the conventional ones, it would be possible to classify some white men and some Negroes in a group from which other white men and other Negroes would be excluded. Indeed, it does sometimes happen that racial boundaries proposed by one student cut across those favored by another. It has even been suggested, half seriously, that no criterion based on more than a single character can be an infallible index of race.

In short, while there may be constellations of characteristics that tend to be associated, there are nevertheless many traits which are not limited by ordinary racial boundaries.

Genetics suggests that there are three ways in which the same sporadic trait might come to be present in different races: (1) It might have belonged to some common ancestor of these races, (2) it might have been introduced by race crossing, or (3) it might have arisen independently in the different groups. Probably each of these explanations is the correct one in certain cases. The genetical theory of population leads to the expectation that in the absence of differential reproduction, gene lines will continue with about the same incidence through innumerable generations. In the differentiation of races many gene lines may have escaped the effects of natural selection. It is not surprising that there are a number of traits appearing with varying frequency both in ourselves and in the anthropoids which are best explained on the assumption of a community of gene lines. In the races of man with their immeasurably long period of common descent, there might be expected to be a large accumulation of heritable variations which have never been of sufficiently vital importance to insure either their fixation or their elimination. Probably no one is more forcibly impressed by the great array of traits, which show scant respect for racial boundaries, than is the anatomist who has occasion to dissect bodies of diverse types. Many of the variations are known to be hereditary, so it might be said that in the dissecting room the brotherhood of man is insistently proclaimed.

The possession of a few traits in common need not necessarily imply recent or even relatively remote race crossing. Nevertheless, from the time when races of many began to be emancipated from their respective faunal limits, crossing has undoubtedly been an important factor in the dissemination of such traits as may once have been limited to particular groups. A geneticist would expect each "infusion" of foreign blood to bring into a community some genes which might differ from those of the original stock. In succeeding generations these new genes would become dissociated from each other and ultimately be disseminated at random through the germ-plasm of the community. Dahlberg has developed, in a way that is full of suggestiveness for anthropologists, methods for measuring the rate of such dissociation in human populations. With repeated, even though infrequent, infusions from different sources, followed in each case by an ultimate dissociation of genic complexes, the germ-plasm of the original group would become more complex and more cosmopolitan. Thus there would be provided a foundation for the sporadic appearance of some traits, even though they might be complex ones, in several different racial aggregates.

The genes 0, A and B, which are instrumental in the determination of blood groups, exemplify this type of dissemination. While the blood groups as traits are by no means unique in the nature of their distribution, they have fortunately caught the fancy of investigators in many lands, so there are now three genes on whose present distribution and probable history we are beginning to have a significant amount of information. Unfortunately there is a rather widespread misconception as to what anthropologists may expect from these genes. It has been hoped by many that a constant association would be found between one or another of them and other racial traits—that they would prove diagnostic of race. But this is the last thing to expect. One would suppose rather that these genes, like all similar ones, long since became completely dissociated from any original genetic complex that may have been introduced into modern strains in their remote past, and this supposition agrees with the findings. What such genes do offer is the possibility of tracing courses of dissemination in gene lines, as is indicated by some of Bernstein's analyses. When other genes shall have been studied with the same intensity, we may look with confidence for a picture of racial origins based on internal evidence that will probably be more accurate than any that can now be drawn from external evidences.

In the possibility of independent origins, or parallel mutations, the physical anthropologist and his colleagues in the cultural field find grounds for mutual sympathy. The same mutation like the same idea may perhaps arise more than once, and in far distant places. That some mutations do indeed recur has been established beyond question. Further it appears that different ones show widely varying frequencies. Some which produce teratological effects are relatively common, others must be exceedingly rare. For example, to recur to the blood groups, the infrequency or possible absence of B in American Indians suggests an extreme rarity of mutations from 0 or A to B. The question of parallel mutation in man needs to be explored more fully. It may not prove of very great importance in the study of racial development but, like parallel evolution, it must not be forgotten.

One of the most difficult obstacles to be met in any attempt to interpret racial origins and the distribution of traits in terms of genes is found in the wide-spread assumption that races have an intangible and elusive quality which can not be resolved into discrete elements. Whether this supposed quality is partially imaginary or not, there is one further aspect of genetics which should be considered in connection with it. It has been found that the expression of certain genes is contingent on the presence or absence of others which may serve to enhance or suppress the usual effects. Conversely, a few genes may influence the manifestation of many. Traits associated with sex furnish a case in point. The sexes differ somewhat qualitatively in a few respects and quantitatively in almost every respect, even to the incidence of morphological variations. Sex is generally conceded to be due ultimately to a difference of only a few genes. Racial differences show a certain parallel to sex differences—pronounced divergence in a few traits, slight variation in degree or frequency of many. It would appear from this that the distinctive genes of a race, like those of a sex, tend to modify in some measure the effects of those more widely distributed genes with which they come to be associated. To this extent there is a possible genetic explanation for some elusive racial "essence." This supposed quality led a few years ago to suggestions of a possible endocrine basis for racial differences. But the existence of any such basis has not been well established, and a primarily genetic explanation still seems the more plausible. This is particularly so since some comparative evidence, and a little from human sources, indicates that in so far as factors like endocrine secretions are involved at all in the production of racial peculiarities, the real differential is not so much in the hormones as in the responses to them. This is an inviting field for further study. Thus far the evidence indicates that genic factors are the important ones in establishing those generalized features which may seem to characterize a particular race.

## MORPHOLOGY

To-day the simple confidence which we once had in certain morphological concepts is replaced by a conservative scepticism to which a growing appreciation of genetics has contributed in no small degree. We can no longer regard homology as the simple thing we had thought. Instead, some think of it as distinctly relative and best measured by the number of genes that two or more individuals have in common. This outlook leads to the recognition of a class of conditions in which apparent homologies may be essentially spurious. Hyperdactyly will serve as illustrative of such cases. Man and other higher vertebrates normally have at most five digits on their limbs. Nevertheless, families with an excess number occur in many mammalian and avian species. Embryologically, the condition is apparently due to an early tissue overgrowth with a resultant segmentation into an increased number of digital rudiments. It is apparently relatively simple genetically, as one might expect, to effect changes that will be of a merely plus or minus nature, and mutations which do that are rather common. Such a change affecting the hand or foot in its initial stages of development would seem to offer an adequate explanation for hyperdactyly and leave no ground for homologizing the extra toes of men, cats and chickens. Nevertheless, two leading students of the foot have recently maintained that the presence of an extra toe is to be regarded as reversionary and indicative of a phylogenetic loss in normal lines. Such a conclusion fails, it would seem, to take into account genetic and other experimental findings.

Of all morphological concepts, perhaps the "biogenetic law" has suffered most from the rise of genetics. The notion which it involves has been a stimulating one with, perhaps, elements of validity, but it has proved a treacherous guide. So long as recapitulation was considered a "law" one could argue with Brandt that if Pithecanthropus had a beard, and was the ancestor of modern man, present-day infants would necessarily be bearded at birth. But long ago it became apparent to geneticists that the child develops as the parent does, not because it is his child, but because both parent and child come from similar germinal anlagen. The "biogenetic law" in its orthodox form is based on a failure to accept this point, a kind of hangover from the time when germ cells were supposed to receive their characters from the parental soma. From the present-day point of view, the situation appears rather more simple. So long as a stock is relatively unchanging, the offspring will develop as did their parents—will "repeat" the ancestral ontogeny. Depending on whether mutational changes affect processes occurring early or late in development, the "repetition" will be more or less modified. This, together with a possible tendency for genes to get in their effect as early as possible (Haldane *et al.*), may be all there is to the "biogenetic law." When its indications are positive, it may be useful; when they are negative, it is likely to be without significance. A single illustration may serve to emphasize the deficiency of the theory of recapitulation in human studies. All other Primates so far examined have a few hairs on the terminal segments of the fingers near the base of the nail. There can be little doubt that the ancestors of man had hair in this region long after they became primate and even anthropoid, so according to the "biogenetic law" at least rudiments of these hairs should occur in the human embryo. None have been found. There are many comparable cases, and also those in which a suppressing or modifying gene becomes effective after the first steps in development have been taken.

In connection with any criticism relating to ideas of homology and recapitulation, however, it could not be emphasized too strongly that the genetic point of view brings no threat to morphology. It does provide a possible escape from some of the impasses into which the older types of morphological reasoning led us.

Finally, if we ask just what genetics can contribute to an understanding of human phylogeny, the answer for the present must be tentative. Perhaps its greatest contribution is a point of view. Some botanical geneticists claim much for it in their field and write, for example, of such matters as the hybridization and genetics of Pleistocene roses. The cytological picture in man does not encourage the hope that anthropologists can soon parallel the botanists in this field. Frequently "Neanderthaloid" specimens are exhibited or described, and occasionally one meets in the flesh an individual who may show some approach to a preconceived notion of what Neanderthal man was probably like. Rather detailed measurements of a striking example of this sort who appeared a few years ago showed, in spite of his archaic aspect, a decided balance on the side of modern man. Do such cases really have any phylogenetic significance? Before answering this question we must have more information than at present. One naturally asks first if there is evidence of heredity in these "Neanderthaloids." In the case just cited there may have been, for the subject claimed close resemblance to a deceased brother. Granting that such a set of traits does in fact represent an hereditary complex, and one suggestive of Neanderthal man, it would still be hardly justifiable to assume that it implies descent from *Homo neanderthalensis* until the component elements of the complex have been determined and their distribution ascertained. But there is hope, in view of the increasing amount of available Neanderthal material, that enough may be learned about the types and range of variation in this form, as well as in *H. sapiens,* to warrant sound conclusions on the now debatable genetic relationships. Not until more has been done in this direction can opinions be passed with much assurance on a whole range of manifestations which are now rather casually assumed to be "reversions"—or, as the geneticist might prefer to express it, products of a recombination of genes long since dissociated.

### CONCLUSION

It would be unwarranted to claim too much for the contribution of genetics to anthropology. Genetics can not solve all the problems; it may give a final answer to none of them, but it does provide a point of view and a methodology which are of fundamental significance, and it furnishes an orientation which brings into relief a fresh and stimulating array of new problems. This revitalizing influence, even more than the immediate direct accretion of fact and method, may in the end prove to have been its greatest contribution. To widen the horizon and provide new problems, or a fresh approach to old ones, is a distinct service to any science.

# OBITUARY

## EDWARD WIGHT WASHBURN

DR. EDWARD WIGHT WASHBURN, chief of the division of chemistry of the National Bureau of Standards, died suddenly at his home from heart failure on February 6, at the age of 52 years.

Dr. Washburn was born at Beatrice, Nebraska, on May 10, 1881. He attended the University of Nebraska from 1899 to 1901 and graduated from the Massachusetts Institute of Technology in 1905. Here he continued his graduate work and received his doctorate in 1908.

Dr. Washburn's contributions to science include the writing of a text-book on physical chemistry, the editorship of the International Critical Tables, the publication of about 100 scientific papers and the direction and supervision of numerous researches. His professional career may be divided into five stages:

(1) As a graduate student at the Massachusetts Institute of Technology, 1905 to 1908, Washburn applied physico-chemical principles to analytical chemistry in the iodine-arsenious acid reaction, which resulted in the first thermodynamic treatment of the problem of "buffer" solutions, and later led him to a study of indicators. In this same period he made the first accurate measurements of true transference numbers and the relative hydration of ions in aqueous solutions of electrolytes.

(2) At the University of Illinois, 1908 to 1916, as a teacher and professor in physical chemistry, he produced his preeminent work in pure physical chemistry, including the thermodynamic treatment of the colligative properties of aqueous solutions; the development of a "simple system of thermodynamic chemistry" by means of his "perfect thermodynamic engine"; the measurement of Faraday's constant with the iodine coulometer, and the development of a high precision viscosimeter and of apparatus for the precise measurement of the electrical conductivity of aqueous solutions of electrolytes. In 1915 was published the first edition of his widely used text-book on "An Introduction to the Principles of Physical Chemistry." A second edition appeared in 1921, and a French translation was brought out in 1925.

(3) While head of the department of ceramic engineering at the University of Illinois, 1916 to 1922,